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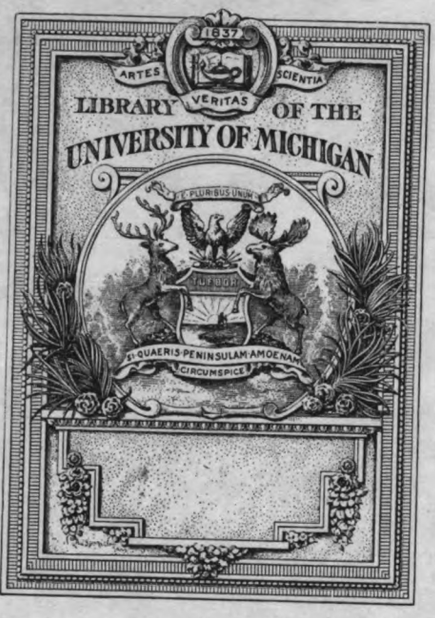

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"The Electrician"

INDUSTRIAL SUPPLEMENT.

MAY, 1907, TO SEPTEMBER, 1907.

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NOTES.

The Retirement of Mr. John Gavey, C.B.

THE complimentary dinner given to Mr. GAVEY last week was the occasion for a large gathering of his professional friends, and for hearty expressions of goodwill upon his retirement from the position of Engineer-in-Chief to the Post Office. During his long connection with the electrical profession Mr. GAVEY has made many friends, not only in the Post Office but in the larger sphere represented by the Institution of Electrical Engineers, and our readers will certainly join with us in wishing him God-speed in any new work he may now take up.

Electric Traction on Railways.

DURING the last few years electric traction has been remarkable for the rapid progress that has been made. Some years ago there was great activity in the conversion of the old horse tramways to electrical working, but the transition from the electrification of what our American friends call street railways to that of railways in our sense of the word has been somewhat slow. This, no doubt, is due to the fact that the problems involved are altogether more difficult. Very much greater power is required, and the financial results involved by success or failure are generally much larger than those which are likely to result in the case of a tramway. Naturally, therefore, there has been a tendency on the part of railway companies to avoid electrification until it was practically forced upon them, though in the case of new railways the position is different. Thus several railways have been laid down where electric traction afforded the only solution to the problem, and electric traction has been adopted in America and other countries to cope with suburban traffic. The third-rail system, until recently, has been the general solution, but the introduction of the single-phase system has now given a further impetus to electric traction, with the result that the electrification of railways in a more general sense has become one of the problems of the moment. Needless to say, this problem has a very large number of variables, some of which are appreciated by electrical engineers and some others appeal more to those who are responsible for the working of our steam railways. But some of the most vital points are often lost sight of, and for this reason we are glad to be able to publish in this issue the first of a series of articles by Mr. PHILIP DAWSON upon the subject of Electric Traction on Railways.

Multiple Unit Control.

IT is now a good many years ago since SPRAGUE introduced the idea of multiple unit control in electric traction, using an ingenious system of master controller, and subsidiary controllers on the different cars of the train. At that time the system was looked upon as ingenious, but as scarcely necessary. Since those days, however, the importance of sub-dividing the power on a train of any considerable weight has become more evident, as it not only permits of rapid acceleration with less dead weight, but trains are readily divided up to suit the requirements of the traffic, which is a point of some importance on suburban lines. But in using larger currents the ordinary style of controller has had to give way to control by means of contactors, with the result that two well-known systems have been evolved—namely, that which is worked by means of shunt solenoids operated by the line pressure, and that with low-voltage electromagnetic valves

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operating pneumatically-controlled contactors. In another column we are able to give an account of a third system which has now been designed by Mr. ZWEIGBERGK for Messrs. Dick, Kerr & Co. (Ltd.), and which is being used on the Lancashire & Yorkshire Railway. In this system, which works with remarkable ease, series solenoids are used for operating the contactors, these solenoids being energised by the return current of the train motors. By this means a considerable reduction in the number of parts necessary has been made, there is less liability to break down, and the action of the contactors is more prompt than with the ordinary shunt solenoids.

The Vacuum Tube in Chemical Research.

THE vacuum tube has every prospect of becoming a new kind of test tube if some recent developments are followed up. We publish in this issue an abstract of a Paper on "The Chemical Effects of the Electric Discharge in Rarefied Hydrogen and Oxygen," by the Rev. P. J. KIRKBY. It is interesting as showing that a simple chemical process like the combination of hydrogen and oxygen can be carried out under conditions which give us a grasp of the individual molecular events constituting the chemical action. It is the first step to that electrical theory of chemical action which is bound to evolve itself sooner or later—and the sooner the better. The supreme merit of the electrical method in chemistry is that, while a chemical atom is difficult to control and identify, it is completely at our mercy once it has become an ion by gaining or losing an electron. Hence it is that the various products of radio-activity can be closely followed up, though none reveal themselves to the most delicate chemical test except a few final products. The author determines the number of molecules of water formed by the passage of a known quantity of electricity, and finds that the water formed is strictly proportional to the quantity of electricity. This is a striking antithesis to Faraday's law of electrolysis, according to which the amount of water electrolysed is proportional to the quantity of electricity passed through, or, as we should say now, to the number of electrons passing any section of the wire. The author's calculation of the amount of energy necessary to break up a molecule of oxygen into atoms is of some importance, though we do not consider his conclusions from it as quite convincing. The superior limit given by him—viz., 5 billionths of an erg—happens to be almost exactly the amount of energy required to separate an electron from a positive atom whose centre is 10^{-8} cm. away from it; in other words, to separate two oxygen atoms when in contact, and when one of them has a charge of one electron and the other the lack of it. This suggests almost irresistibly that the oxygen atoms are held together as a molecule by electric force, and become ions after collision with an ionising electron. The author prefers to regard them as neutral atoms, but it must be acknowledged that he does not imply the absence of positive ions in the positive column. A new light is shed by these results on the constitution of "nascent oxygen." It is worth noting that very little ozone was formed in these experiments.

"Flexibles."

PROF. SCHWARTZ'S Paper on "Flexibles," following so closely on the publication of the Institution's revised wiring rules, serves to draw particular attention to the subject of electric wiring. Flexible wires should not give trouble when subjected to fair usage, except with adjustable pendants; but if a long length is attached to a portable fitting it is essential that all pressure should be removed from the wire when the fitting is not in use. For this reason switch lampholders should be abolished on portable fittings and only used in exceptional cases on ordinary pendants. A considerable number of the failures of insulation are, no doubt, caused by the use of very inferior rubber, and a considerable proportion of the flexible cables in use would fail when subjected to the tests described by Prof. SCHWARTZ. Flexibles form so subsidiary a part of an installation, and are so easily renewed, that they are apt to receive but scant attention.

McGill University, Montreal.—We regret to notice the severe losses by fire suffered by this University. Within the last fortnight both the engineering and the medical departments have been burnt down, probably the result of incendiarism.

University of London (University College).—The accommodation provided at University College, for the Schools of Engineering and of Architecture will be considerably extended before the beginning of the next session in October by the additional space which becomes available through the removal of University College School to Hampstead.

A New Tramway Journal.—A new technical paper has just appeared in France under the title of *L'Industrie des Tramways et Chemins de Fer*. It will be issued monthly, and will be chiefly concerned with tramway interests, although railways will also be considered. It is the official organ of the Tramway Union of France. All the members of the editorial committee hold prominent positions in the French tramway world. The editorial offices in Paris are at 15, Rue de Madrid.

Production of Tantalum in Australia.—The *Elektrotechnik und Maschinenbau* gives an account of the tantalum deposits in Eastern Australia. In 1894 tantalum was discovered in combination with iron and niobium near Bimburg. It was also discovered in combination with iron in the same district. Quite recently a mixture of manganese and tantalum has been found near Wodgina containing tantalum up to 70 per cent. It is found in the form of blocks weighing about 30 lb. In 1905, 70 tons of the metal, representing a value of £8,000, were exported from Australia.

New Method of Laying Cables.—A new method of laying electric conductors has lately been patented by Mr. J. S. Highfield. It is especially adapted for high-tension direct-current systems, and its object is to approach as nearly as possible the condition of overhead working with underground cables. The cables are drawn into iron pipes, and are supported therein on concentric insulators. A constant supply of dry air is forced into the system, and is allowed to escape through valves. As long as everything is in working order the leakage past these valves is constant, and the pressure, as indicated by gauges, is constant. If the pressure drops in any part of the line a fault may be suspected on that section. The advantages of using compressed air are that water can be kept out and the insulation is improved. Bare stranded conductors, coated with an insulating skin, are the best to use. The surface of the insulators is corrugated to reduce surface leakage, and at corners and bends the piping may be filled up with some hard material, such as asphalt. Boxes, where the cables are anchored, are laid at suitable intervals in the pipe line.

Cable Interruptions and Repairs.

Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
New Brunswick—Prince Edward Island	Jan. 9, 1907
Tenedos—Chio	Feb. 13, 1907
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907
Tangier—Cadiz	Mar. 20, 1907
Cadiz—Teneriffe	April 10, 1907

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Test on a Three-phase Motor.—An account of a rather unusual test, recently carried out before Profs. Eric Gérard and de Bast, of Liège University, is given in the *Engineering and Mining Journal*. A small three-phase motor was completely immersed in water and run for a quarter of an hour, after which it was stopped and remained submerged for 24 hours, being placed under seal. At the end of this time the motor was again run for a few minutes. It was then removed from the water, again put under seal and left to dry for another 24 hours. After this the insulation of the machine was tested and found to be in perfect working order. The motor was specially designed for use in a mine, where there was a great deal of dampness.

Submarine Telegraphy.—A lecture on this subject was delivered on Wednesday afternoon at the Royal United Service Institution by Mr. Charles Bright, F.R.S.E. The lecturer began by briefly discussing the instruments used in telegraphy and the way in which messages were transmitted by them. The construction of submarine cables was described, special stress being laid on the selection of suitable materials for this purpose. After detailing the substances which had been used for protecting the cable, the lecturer discussed the methods by which crude gutta-percha was purified, so that it could be used as an insulating covering. The whole process of submarine cable manufacture was then dealt with. After dwelling on the importance of a preliminary survey of the sea-bottom before cable laying was begun, the lecturer passed on to the details of the actual work. The ships and the various testing and laying apparatus used for this purpose were described and methods for landing and splicing the shore-end detailed. The lecturer concluded with a résumé of the history of submarine telegraphy, beginning with the attempts of the Bretts to establish electrical communication between England and France, and ending with the completion of the All-British Pacific cable. The lecture was illustrated by numerous lantern slides.

Mule Haulage v. Electric Haulage for Mines. — Mr. M. F. Peltier, in a Paper on the above subject read before the Illinois Society of Engineers, compares the cost of mule and electric haulage. The introduction of the electric haulage system has not only resulted in reducing the cost of production, but has also made practical the development of more extended operations, and increased the output from 1,400 tons to a daily average of 2,000 tons. The motors have hauled as much as 2,570 tons in eight hours. Prior to installing electric haulage, there were 33 mules for an output of 1,400 tons of coal. Owing to size of cars, grade and average haul of 1,800 ft., the output had reached its limit with mule haulage, so after careful examination of the existing conditions, it was finally decided to use electrical haulage. Two 15 ton Goodman electric locomotives with double-end control were installed. The electrical power for operating the motors in the mine is supplied by a 175 kw. generator belted to a 200 H.P. engine. The generator also furnishes light for the underground haulage ways. It is designed to meet the special requirements of mine service where frequent and extreme variations in load are the rule. From the switchboard in the power house the current is transmitted through a lead-covered cable running down the manway and to the main haulage way of the mine. Taking as a basis an output of 2,000 tons per day, the cost for electric haulage works out at $\frac{3}{4}$d. per ton. The cost for mule haulage on the same basis is 1$\frac{1}{4}$d. There is, therefore, a saving of $\frac{1}{2}$d. on each ton produced, and at this rate the electrical plant will pay for itself in four years.

The Application of Hydro-electric Power to Slate Mining.—A Paper on this subject was read before the Institution of Civil Engineers, by Mr. M. Kellow, on the 26th ult. The author states that, though steam has hitherto been chiefly used as a source of power in slate mines, there is an abundance of water-power, which, if applied, would supply all the needs of the slate industry in this respect. There is little doubt that, when the advantages of utilising water-power in conjunction with electric transmission and distribution are generally realised, it will be used almost to the exclusion of any other in slate mining. The author has designed and installed a hydro-electric plant which contains many features of novelty, the scheme having been carried out in the Croesor and Cwmfoel valleys in the vicinity of Snowdon, and includes all the essentials of a complete power system. The advantages and disadvantages involved in the use of continuous and alternating current respectively, as regards generation, transmission and distribution, are compared, and the author arrives at the conclusion that the three-phase alternating-current system is the one best adapted to slate mining. Considerations affecting the choice of frequency are discussed, and 40 or 50 cycles is regarded as most suitable. The essential qualities in mining plant are stated to be reliability, first-class mechanical construction and simplicity of operation, and as regards motors these conditions are best fulfilled by the three-phase induction type. The conditions prevailing in the slate mills are described, and group-driving by moderate-sized squirrel-cage motors is favoured. The peculiar requirements of winding up inclined planes, which are usual in slate mines, the character of the traffic, &c., are dwelt upon, and the conclusion is arrived at that three-phase motors are well adapted to the work. The types of motors most suitable to the driving of pumps, fans, winches, &c., and the influence of various starting devices used in connection with the motors, on the power-factor of the system are discussed. The advantages of the three-phase system as applied to slate mining are then summarised, and the plant installed for mill driving, winding, traction, pumping, lighting, &c., at the Croesor Slate Mine is described. Efficiency curves are given relating to every part of the system separately and in combination.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, April 19th (to-day).

MANCHESTER STUDENTS' SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

7 p.m. Meeting at the Municipal School of Technology, Whitworth-street, Manchester. Annual General Meeting.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:30 p.m. Meeting at the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Paper on "The Application of Electricity to the Driving of Pumping Machinery for Pontoons and Graving Docks," by Mr. W. C. Mountain. (Adjourned Discussion.)

SATURDAY, April 20th.

ROYAL INSTITUTION.

3 p.m. Meeting at Albemarle-street. Lecture on "Studies in Magnetism," by Prof. S. P. Thompson. (The Tyndall Lectures: Lecture II.).

WEDNESDAY, April 24th.

SOCIETY OF ARTS.

8 p.m. Meeting at John-street, Adelphi. Paper on "Rubber Cultivation in the British Empire," by Mr. H. Wright.

THURSDAY, April 25th.

LEEDS SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

7:15 p.m. Meeting at the University, Leeds. Paper on "Underground Mains," by Mr. W. M. Rogerson. (Adjourned Discussion.)

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Meeting at the Institution of Civil Engineers, Great George-street, Westminster. Papers on "Flexibles: with Notes on the Testing of Rubber," by Prof. A. Schwartz (Adjourned Discussion, if not concluded at the previous meeting), and on "Depreciation Provision on Electricity Supply Undertakings," by Mr. R. Hammond (if time permits).

FRIDAY, April 26th.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Papers on "Electrical Conduction Produced by Heating Salts," by Mr. A. E. Garrett; on "The Influence of Pressure upon Convection Currents and a Criticism of J. Stark's Relation between Cathode Fall of Potential and Temperature," by Mr. W. S. Tucker; on "Solenoids which are Turned by the Earth's Magnetic Field," by Mr. W. B. Croft; and on "Simple Apparatus for Mechanically Illustrating the Tangent and Sine Laws," by Mr. J. A. Tomkins.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street. Lecture on "New Illuminants," by Mr. J. Swinburne, F.R.S.

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ELECTRIC TRACTION ON RAILWAYS.*—I.

SOME GENERAL CONSIDERATIONS.

BY PHILIP DAWSON.

Summary.—**The Author first considers the various causes which have led to the electrification of railways, and classifies them accordingly. These causes vary in different countries, and thus the conditions which have led to electrification abroad do not necessarily apply in this country. Financial considerations are the governing factor. High acceleration is one of the most important advantages of electric traction, and another is the greatly-increased terminal facilities.**

This article will be concluded in our next issue.

A railway clearly means a way or road made of rails, and is generally understood in this country to mean a road specially built for the accommodation of one or more pairs of rails, and entirely reserved for the traffic on them. This is the main characteristic of a railway as compared with a tramway. "Tram" is a local term for coal truck, and the word "tramway" had its origin in the practice which existed in days gone by (some 200 years ago) of laying down planks from the collieries to the seaports to facilitate, under all weather conditions, the conveyance of coal from the mines to the port of shipment. Macadam roads were then unknown, and the planks were laid on the ordinary roads to prevent the heavily-laden trucks or trams from sinking into the ground. Hence the modern use of the word tramway in its application to the means employed to reduce the tractive effort necessary to haul heavy loads of people along the ordinary roads.

The word railway itself is also connected with the coal industry. About a century ago, when the collieries developed, it was found advisable to interconnect them by specially-built roads with easy gradients and no sharp curves, and it was on one of these (the Stockton & Darlington Railway), which was specially constructed for hauling coal waggons by means of horses, that one of George Stevenson's successful locomotives was installed to haul a train mechanically, instead of by horses as heretofore.

Although in England a railway is generally understood to mean a road specially built for the accommodation of rails and reserved to rail traffic alone, in the United States it signifies what in England is styled a tramway, but with "street" prefixed, and the American equivalent of the English "railway" is "railroad."

As regards the word "light railway," this originally implied a cheaply-built railway on which trains were worked at sufficiently low speeds to obviate the necessity for automatic signalling apparatus at level crossings, and the various restrictions rightly imposed by the Board of Trade on main line railways. Latterly, however, it has come to mean not only what has been described, but also an ordinary tramway (for light railway, under the Light Railway Act, simply means a tramway running through several districts).

It is largely owing to the tremendous success that electric traction has proved on tramways, and to the consequent revolution in tramway construction and operation, that electricity as a motive power occupies its present position. Not only is it capable of filling all the requirements of tramways, but, at the same time, the great railways of all countries are gradually, but in increasing numbers, being forced to adopt it on their lines in place of steam for a certain class of traffic.

It is not the intention of the author to deal with the application of electricity to tramway traction, important though this branch undoubtedly is. The numerous books and Papers on this subject which have been, and are being, published make further treatment superfluous. The writer himself, 12 years ago, was one of the first to publish a series of articles on that subject in *Engineering*, which was afterwards published in book form.

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Tramway traction is connected with railway traction in so far as the wonderful success of electricity, as applied to the former, has made it possible—nay, necessary—for it to be used for the much more arduous work which has to be performed by railways. The rapid growth of electric tramway traction has had two results: One has been the diverting of a large proportion of the traffic from existing steam railways to electric tramways running parallel to them; the other has been an enormous increase in the amount of travelling per head of population.

The injurious effect upon railways has been, of course, practically confined to suburban services on which, with existing steam methods, the service cannot be improved. It is now generally admitted, by all those who have thoroughly investigated the question, that in most cases the introduction of electricity for operating the suburban system of our railways is unavoidable, unless the suburban traffic is to be entirely given up to the tramways.

Before going further into the question of the alternative merits of electric traction and the reasons which should eventually induce railways to adopt it generally for certain classes of their traffic, it is desirable to form some classification of the different types of railways, so that a clear distinction may be arrived at as to what are the reasons which may, in any individual case, make it desirable for a given class of service to be operated electrically.

There are many classifications which can be made, but for our purpose it will suffice to consider two: One based on the type of traffic with which a railway has to deal, and the other on the type of country which it has to traverse. In any case, it may be advisable to divide the railways into three great classes, the two first of which need only, for the present, be considered. These classes are main-line railways, urban railways and mineral lines. The classification of the two former can be taken to be as follows:—

Main-line railways ...	Suburban traffic. Purely interurban. Long-distance traffic. Goods and mineral traffic.
Urban railways	Passenger traffic. Goods and mineral traffic. Connecting traffic (through traffic).

On the basis of the country traversed, the classification works out as follows:—

Main-line railways ...	In and round large towns, either with or without available water power Long-distance haulage in countries where fuel is abundant and cheap. In mountainous countries where fuel is expensive and water abundant.
Urban railways	Mostly above ground on elevated structures and in shallow tunnel, deep level or tube lines.

There is also another and most important fact which must be borne in mind when considering the possibility or advisability of adopting electric traction, and that is whether the line in question is one which is already constructed and operated by steam, or is an entirely new line on which a completely fresh start is to be made, so that it is not a question of electricity superseding steam, but what form of traction shall be adopted from the very commencement.

Before discussing more generally the future of electricity for railway purposes, and the probable causes which will induce railways to adopt it, it may be of utility to consider briefly what has so far been done as regards the application of electric traction to railway work, and what have been, in each individual case, the chief reasons for replacing steam by electricity, whilst other lines have adhered to the use of steam power. A short historical retrospect, therefore, may be interesting.

The commercial application of electricity to tramways goes back to nearly 28 years, the first electric tramway

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having been built by Messrs. Siemens in Berlin in 1879. Electric railways are of much more recent origin. The City & South London Railway, which was the pioneer both of electric railways and deep-level tube lines, was not opened until the year 1890.

A study of the following chronological list of a few of the more important undertakings will be interesting, when the reasons are considered which have, in each individual case, brought about electric traction. It may be stated at once that the reasons which have up till now carried the electrification of railways are, in the majority of cases, not those which will probably induce a more general application of electricity for operating portions of our large railway systems; but, at the same time, the success which has attended the adoption of electricity, and the improvements which the experience on already equipped lines has brought about, are important factors when considering the future of electric traction for railway purposes.

The following is a chronological list of some of the most important electric railways:—

Name of railway.	Year of opening.	Name of railway.	Year of opening.
City & South London..	1890	Berlin Elevated	1902
Liverpool Overhead ...	1893	Manhattan Elevated..	1902
New York, New Haven & Hartford	1894	Berlin–Lichterfelde...	1903
Baltimore & Ohio	1895	Mersey	1903
Burgdorf Thun	1896	Lancs. & Yorkshire ...	1904
South Side Elevated Chicago	1899	North-Eastern	1904
Central London	1900	Metropolitan District.	1905
Paris Metropolitan.....	1900	Pennsylvania, Atlantic City Branch	1906
Orleans–Paris.....	1900	New York Central ...	1907
West'n of France, Paris	1900	New York, New Haven & Hartford	1907
Milan–Varese.....	1901	London, Brighton & South Coast	1908
Valltelina.....	1902		

In considering the above list, the various lines at once group themselves into (1) lines which were being newly built and could not adopt steam, and in consequence adopted electric traction; (2) lines which, having been constructed for steam traction found it a financial failure, or were harrassed by competing electric tramways, and adopted electricity with the hope of improving their position; (3) existing steam lines replaced by electricity for experimental purposes; (4) lines replacing steam by electricity because of expensive fuel and plentiful and cheap water power; (5) steam lines adopting electricity for political or other reasons; (6) lines introducing electricity in order to utilise more fully their tracks and terminal facilities, and from a general appreciation of the advantages of electricity for suburban work.

As regards the first batch it is evident that, purely from the point of view of ventilation, no tube railways can possibly use steam, but, besides the tube lines, several other railways—as, for example, the Baltimore & Ohio tunnel line leading under the City of Baltimore, the Western Railway of France terminating on the Quay d'Orsay, as well as the Paris Metropolitan lines and the Berlin Underground and Elevated—adopted electricity for the same reason. The Liverpool Overhead Railway had to adopt electricity because, running close to the docks as it does, the risk of fire with steam traction put the latter out of court at once.

Examples of electricity replacing steam in the hope of improving a bad financial situation may be found in the Elevated Railway of Chicago, the Manhattan Elevated of New York and the Mersey Railway. Tramway competition was mainly responsible for the action of the North-Eastern, and in the case of the New York, New Haven & Hartford Railway, the equipping of their branch lines with electricity instead of steam was done for experimental reasons. The equipment of the Milan–Varese and the Berlin–Lichterfelde lines was also carried out as an experiment.

Under class 4, which includes cases of electricity having replaced steam because fuel was expensive and water power cheap, come such railways as the Burgdorf Thun and the Valltelina Railways.

Class 5, which deals with compulsory electrification, includes the Metropolitan District, the New York Central, and the New York, New Haven & Hartford electrification of the New York end of their lines.

In class 6, which comprises cases where electricity has replaced steam in order to obtain fuller use of existing facilities and to improve traffic, may be cited the Liverpool and Southport line of the Lancashire & Yorkshire Railway, the Pennsylvania lines from Philadelphia to Atlantic City, and the electrification of the London, Brighton & South Coast Railway, which is now proceeding under the Author's supervision.

On looking through the above classification we are at once struck by the absence of goods or mineral lines and long-distance lines, the great majority being either urban or suburban lines. It will further be observed that most of the lines which have been electrified are purely urban railways, such as elevated lines or tube lines, and that it is only of recent years that main line railways, like the Lancashire & Yorkshire, the North-Eastern, the New York Central, the Pennsylvania, the New York, New Haven & Hartford, the Prussian State railways in Berlin, the Italian Government railways, and the London, Brighton & South Coast have decided to go in for electrification.

The classification of railways which has been made and the list of lines that has been given does not by any means pretend to be complete. Rather it is intended to call attention to typical cases as evidence of the various causes which have brought about electrification in the past. We will now consider the probable course of events in the near future and, as far as possible, the determining factors influencing the action of railway companies.

With this end in view, it is necessary, first, to consider the several conditions under which different railways are operated, for it depends entirely upon these conditions as to whether electrification is or is not advisable. For instance, conditions of railway operations in Switzerland, Sweden, portions of Italy, and countries similarly situated, where coal has to be imported from abroad and is expensive, and large water powers are easily available, must necessarily be totally different from those which obtain in a country like England, where fuel is obtained cheap and where water power is for all practical purposes not obtainable, and therefore the conditions governing electrification cannot be compared on the same basis. Thus, in Switzerland a Special Commission has been appointed by the Government to investigate the possibility of utilising water power to drive all the railways of that country, which will shortly be owned and operated by the Government. In this case it is mainly a case of the capital cost of the station and distributing system as compared to the cost of operating by steam power.

Careful investigations are at present on foot as regards the advisability of electrification of such main line railways as the Vorarlberg, leading from Innsbruck to Zurich, and the St. Gothard between Lucerne and Milan, and, considering the abundance of cheap water power and expense of fuel, it would seem more than probable that the electrification of such lines will take place in the near future. Even if the working costs were the same with electricity as with steam, a great advantage would be gained by the fact that the railways would not be dependent on foreign countries for fuel, their requirements being entirely satisfied by local resources. Such examples of electrification cannot, how-

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ever, be brought forward in support of schemes for the electrification of such lines as from London to Manchester or Newcastle, the local conditions being entirely different. In the latter case water power is unobtainable and fuel is cheap, and with a steam-driven power station it is not only the interest on capital and maintenance of electrical installation which must be taken into consideration, but also the load factor or ratio of average to maximum demand, because upon this depends fuel consumption and economy of operating the steam station. All this is, of course, as regards the electrification of existing lines; if an entirely new undertaking has to be considered, conditions may be so different as to justify the electrification even on comparatively long-distance lines. Such, at least, have been the experiences in the United States of America in connection with many undertakings, amongst which may be particularly cited the interurban electric railways in the State of Indiania.

The whole question of the future of electrification may be summed up as entirely a financial one, depending on the capital cost involved by electrification, and the operating expenses when worked by electricity, taking into account, of course, the benefits and advantages which electricity will bring in its train.

It therefore behoves us to investigate very carefully what are the advantages which are claimed as regards the use of electricity as compared with that of steam, and how many of these can be substantiated.

(To be continued.)

THE PRODUCTION AND PRICE OF COPPER FOR THE PERIOD 1889-1906.

BY JOHN B. C. KERSHAW.

Electrical engineers are probably more interested than the members of any other branch of the engineering profession in the vagaries of the copper market. The price of copper is one of the principal factors in determining the capital outlay upon the distributing network, and the interest and maintenance charges upon this portion of the system are, in many cases, as large as the running costs of the generating station. One reason why the electric power schemes, which received Parliamentary sanction some years ago, have made slow progress is due to this difficulty with regard to the cost of distribution, the capital outlay required to cover a large manufacturing or colliery district with mains and cables being larger than that required for establishing the generating stations. With copper bars at £100 per ton in place of the £50 per ton which may be regarded as their standard value, the cost of mains and extensions for either power or lighting purposes has become almost prohibitive. The price of copper is, however, to some extent dependent upon the natural relations between supply and demand, and the following detailed examination of the statistics of the world's copper production for the last 18 years may prove of some assistance in determining whether the present reign of high prices is to be temporary in character like its predecessors or whether it is to be permanent. The two previous occasions in recent years upon which the price of copper rose to over £70 per ton were due to artificial causes—namely, the Paris corner in copper of 1888, and the formation of the Amalgamated Copper Co. of New York in 1899. There seems to be a general consensus of opinion, however, that the present period of high prices is due to natural causes, an unprecedented demand for copper having cleared out all the stocks of the metal and having exceeded the current supplies. If the mines at present producing copper are able to increase their output considerably in the coming years, the price of copper is likely to return to its normal level. As an attempt to supply the data required to answer this question the following examination of the production figures is of interest and value to electrical engineers. The figures used are taken from the latest issue of Messrs. H. R. Merton & Co.'s statistical circular.

Production Statistics.—The aggregate production of copper by all countries of the world in 1906 was 711,675 tons, being an increase of 29,500 tons over the total for 1905.

The totals for the past 18 years have been as follows:—

Table I.

Year.	Production.	Year.	Production.	Year.	Production.
1889	261,205	1895	334,565	1901	516,626
1890	269,455	1896	373,363	1902	541,295
1891	279,391	1897	399,730	1903	574,775
1892	310,472	1898	429,626	1904	644,000
1893	303,530	1899	472,244	1905	682,125
1894	324,505	1900	479,514	1906	711,675
Ave. for each six-year period	1889 / 1904 } 291,426		1895 / 1900 } 414,840		1901 / 1906 } 611,749

The averages for each six-year period have been 291,426, 414,840 and 611,749 tons respectively, and the average annual increase in the period 1901-1906 has been 32,818 tons, as compared with 20,570 tons in the period 1895-1900.

The increase of the year 1906 is, therefore, rather below the average for the six-year period of which it is the closing year. This fact, taken in conjunction with the inducement for large production offered by the abnormally high price of copper which has ruled all through the year 1906, would seem to indicate that the mines now being worked have nearly attained the maximum of their producing capacity, and that no great increase can be expected in the future unless new mines are opened up in hitherto undeveloped districts. In the 18 years covered by the figures given in Table I., the enormous total of 7,908,098 tons of copper has been extracted from these mines, and it is self-evident that this drain upon the earth's stores of copper cannot continue for an indefinite period.

Turning now to an examination of the figures for the more important producing countries, and placing them in the order of their present-day output, we have the figures given in Table II. The chief features of this table are the enormous increase in the output of the United States mines during the 18 years, and the rise of Mexico from a position of very slight importance to the second place among the copper-producing countries.

In the year 1889 the mines of the United States produced 105,774 tons, or 40·2 per cent. of the total output. In 1906 the production had increased to 408,475 tons, or to 57·3 per cent. of the total, and the predominant position of the States has thus been more than maintained. It is, however, in the highest degree unlikely that the mines of Montana and Arizona

Table II.—*Copper Production of the 12 Leading Countries for the Period 1889-1906.*

Country.	1889.	1895.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
United States	105,774	172,300	263,502	265,250	292,870	307,570	365,050	389,120	408,475
Mexico	3,780	11,620	22,050	30,430	35,785	45,315	50,945	64,440	60,625
Spain and Portugal	54,270	54,950	52,872	53,621	49,790	49,740	47,035	44,810	49,320
Japan	15,000	18,430	27,840	27,475	29,775	31,360	34,850	35,910	42,740
Australasia	8,300	10,000	23,020	30,875	28,640	29,000	34,160	33,940	36,250
Chile	24,250	22,075	25,700	30,780	28,930	30,930	30,110	29,165	25,745
Canada	2,500	4,000	8,500	18,800	17,485	19,320	19,185	20,535	25,460
Germany	17,356	16,555	20,410	21,720	21,605	21 205	21,045	22,160	20,340
Russia	4,070	5,280	6,740	8,000	8,675	10,320	10,700	8,700	10,490
Peru	275	450	8,220	9,520	7,580	7,800	6,755	8,625	8,505
The Cape	7,700	6,080	6,720	6,400	4,450	5,230	7,775	7,325	6,540
Norway	1,442	2,685	3,935	3,375	4,565	5,915	5,415	6,305	6,120

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can go on producing copper at the present rate for any long period of time, and a decrease in the output of these mines is certain to occur within a few years. The increase of the Mexican mines from 3,780 tons in 1889 to 60,625 tons in 1906 is the most striking increase contained in these tables, but the decline of 3,800 tons which has occurred in the 1906 production is an indication that the smaller mines of that country are now approaching exhaustion. The mines of Spain and Portugal continue fairly steady in their output of copper, although here again a small decline is visible if we compare the production of 1906 with that of 1889, the totals being 49,320 tons and 54,270 tons respectively. These mines are, however, being operated upon a more conservative basis than those of the U. S. A., and it is probable that they will be still producing copper at the present rate when the mining properties of the Western States of America are entirely exhausted.

Japan and Australasia both show notable increases in the period covered by this table, that of Japan being from 15,000 tons to 42,740 tons, and that of Australasia from 8,300 tons to 36,250 tons. It is probable that a further increase in the copper production of these two countries will occur as fresh mining properties are developed.

Chile is one of the countries that are declining as regards the copper mining industry—for the maximum output was attained in 1903, and since that year there has been a gradual decrease in the production.

The increase of the output of Canadian mines from 2,500 tons in 1899 to 25,460 tons in 1906 is striking, and further progress of Canada as a copper-producing country is probable. There are many districts of Canada that may contain valuable deposits of copper ore yet undeveloped, and the whole of the American continent, from the north to the south on the western side, seems to be richly provided with copper-bearing ores.

The copper mines of Germany, like those of Spain and Portugal, are worked in a steady non-sensational manner, and the increase of the yield from 17,356 tons in 1889 to 20,340 tons in 1906 is evidence that the rate of production will continue for a long series of years.

The production of the four remaining countries does not call for special comment, except in the case of Peru, which is another country located upon the western seaboard of the American continent that may possess undiscovered hoards of copper ore. The increase of output from 275 tons in 1889 to 8,505 tons in 1906 is suggestive that more copper ore is contained in Peru than has yet been found.

The 12 countries included in Table II. contributed 700,600 tons to the total of 711,675 produced in 1906, or 98 per cent. of the whole. The production of the remaining countries included in Messrs. H. R. Mertin & Co.'s return is, therefore, of little importance in determining the copper supplies of the near future, since 11 of them only produced 11,000 tons.

Summarising the position as regards production, one may state that Japan, Australasia, Canada and Peru are the countries from which increased output may reasonably be expected. The mines of Germany and of Spain and Portugal will most probably continue to produce copper at their present rate, while Mexico and Chile appear to have passed their period of maximum activity as regards the copper mining industry.

As regards the United States, the mines now being worked have probably attained their maximum output, and it is doubtful if the present dominating position of the States in regard to the world's copper supplies can be maintained.

Unless new mines are opened up in hitherto undeveloped districts the prospects of increased copper production are, however, not bright, and it is doubtful if the 712,000 tons output of the year 1906 can be greatly exceeded in future years.

Price Statistics.—The price of copper bars during the last 20 years has undergone many variations, there having been three periods when it has risen to over £70 per ton, with intervening periods in which it has fallen to £40 and £52 respectively. The average price for each year of the period is given in Table III.

In the year 1887 copper bars were selling for £42 3s. per ton; while for some months in the year 1888, as the result of M. Secretan's attempt to corner the copper market, the price was forced up to over £80 per ton, and the average for the year was £76. The collapse of this corner, however, speedily followed, and in 1889 the price had fallen again to £49. 10s. 6d. For the succeeding 10 years the price of copper averaged only £47 3s. per ton, and it was the formation of the Amalgamated Copper Co. of New York that initiated the second period of high prices. This company was formed in 1899, and for that year the average price of copper bars was £72. 16s. 6d., increasing to £73. 10s. 7d. for the year 1900. The fall which has always followed the attempt to artificially inflate the price of any commodity came in the year 1902, when copper was down again to what may be regarded as its standard price of £52. 13s. 5d. per ton The rise which has occurred since 1902 has been gradual until the autumn of 1905, when the metal once more passed the £70 per ton limit of value. By the end of the year copper bars were selling for £78 per ton, and by the end of April, 1906, the price had further advanced to £85 per ton. The prices since that date have been as follows:—

Table III.—*Average Price of Copper Bars for the period 1889-1906.*

Year.	Price.	Year.	Price.	Year.	Price.
1889	£49 10 6	1895	£42 17 6	1901	£67 19 3
1890	54 1 0	1896	47 4 8	1902	52 13 5
1891	51 3 0	1897	49 0 10	1903	57 18 8
1892	45 9 6	1898	51 7 10	1904	58 14 8
1893	43 6 9	1899	72 16 6	1905	69 2 6
1894	40 2 6	1900	73 10 7	1906	86 5 2

1906.		1907.	
Sept. 15th	£86 17 6	Jan. 8th	£106 5 0
,, 29th	91 2 6	,, 14th	108 10 0
Oct. 15th.....	99 5 0	,, 31st	106 10 0
,, 31st.....	97 15 0	Mar. 12th	110 10 0
Nov. 15th	99 15 0	,, 15th	107 10 0
,, 30th	102 12 6	,, 31st	97 10 0
Dec. 15th	105 15 0		

The rapid fall in value which has occurred during the second half of March may be ascribed to the fact that buyers of copper would not purchase supplies or enter into contracts while the price of the metal was over £105 per ton, and that they restricted all dealings to the lowest possible amount. For the time, therefore, the price of copper is on the down grade, but extensive purchases on the part of any industry are likely to send the price up again, many of the mines having disposed of the whole of their output for some months ahead. The gain to the owners of the copper mines by the rise of the past 18 months may be estimated at £30,000,000.

The Future.—The future of copper as regards both production and price depends largely upon the opening up of new mining districts and upon the discovery of satisfactory substitutes for the red metal in the arts and industries, especially in the electrical engineering industry.

The present period of high values has been due to the enormous increase in the demand for copper during the last 10 years, an increase which has been caused very largely by the consumption of the metal for electrical engineering purposes. The world's present annual consumption of copper appears to be in excess of the 712,000 tons produced by the mines in 1906, and as already pointed out, it is improbable that this total can be greatly exceeded, unless new mines are discovered in yet undeveloped districts of the world's surface.

Electrical engineers are, therefore, advised to restrict their purchases of mains and cables for the present to the smallest possible amount, and to try all substitutes for copper that are offered to them, in the hope of discovering some metal or alloy that may prove an economical substitute for copper for conducting purposes.

Some years ago the writer saw discarded steel rails being used for conducting purposes in a small electro-chemical installation, and in many cases there are, no doubt, other metals than copper that can be employed with advantage for electrical engineering work. Since it would seem probable that the present period of high prices in the copper industry will be more permanent than those which have preceded it, and that the price of the metal for some years may remain over £70 per ton, electrical engineers have every incentive for experimental work in this direction.

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ELECTRIC POWER SUPPLY IN LONDON.—IX.

BY R. L. PEARSON.

(*Continued from page 962, Vol. LVIII.*)

The Administrative County of London and District Electric Power Bill.

The preamble of this bill recites the necessity for providing a supply of electrical energy for power purposes in London and the adjoining districts, and proposes to empower the promoters to come to an agreement with the London County Council for leasing the powers obtained by the latter under its Electric Power Supply Bill. As far as the bill itself is concerned, there is little of interest in it. The authorised capital is £5,000,000, and engineering details are entirely absent. It is obvious, of course, that the promoters have come to an agreement with the L.C.C., and the bill, therefore, relates simply to company procedure in flotation and administration. Naturally, if the L.C.C. Bill falls through, the Administrative Company's Bill will suffer a similar fate, since the latter depends on the former. Thus there will be only one bill of any great importance left; that is the

London Electric Supply Bill.

This is the first organised attempt at amalgamation by the various electric supply companies in London. The companies concerned are: The Brompton & Kensington Electricity Supply Co., the Central Electric Supply Co., the Charing Cross, West End & City Electricity Supply Co., the Chelsea Electricity Supply Co., the City of London Electric Lighting Co., the County of London Electric Supply Co., the Kensington & Knightsbridge Electric Lighting Co., the London Electric Supply Corpn., the Metropolitan Electric Supply Co., the Notting Hill Electric Lighting Co., the St. James' & Pall Mall Electric Light Co., the South London Electric Supply Corpn., the South Metropolitan Electric Light & Power Co., the Westminster Electric Supply Corpn.

It is explained that the capital represented by these companies amounts to no less than £13,000,000, and that they are prohibited from amalgamating as the law stands at present. If this restriction were removed they would be able to work with more efficiency and economy, thus effecting a reduction in the prices which they now charge.

Sec. 3 provides for the London electrical supply companies, or any two or more of them, to enter into any agreement for mutual assistance and for combination among themselves, or for association with that object. This includes the giving and taking of a supply of electrical energy and the distribution of the energy; the provision of any new or enlarged stations by any one or more of the companies in combination; the laying of mains to connect stations together, &c.

Sec. 6 provides that not less than seven of the companies whose capital expenditure exceeds one-half of the aggregate capital expenditure of all the companies, may establish a joint committee consisting of representatives of such companies.

This joint committee is empowered to purchase or control the generating stations of the companies and to supply energy, if required, to certain authorised distributors referred to in the schedule. In short, its task will be to take such steps as will facilitate the generation and distribution of electrical energy by making suitable arrangements between companies.

Sec. 18 is important in that it enables any authorised distributor, as defined by the Schedule, to demand at any point within such distributor's area of supply, energy at a price not exceeding £4 per annum per kilowatt of maximum demand and 0·5d. per unit for all energy delivered at extra high tension and measured at the end of the Joint Committee's mains.

Powers are sought under sec. 16 to supply energy for traction, haulage, &c.

Sec. 18 withholds power to supply in the areas of the North Metropolitan Electric Supply Co., the Kent Electric Power Supply Co., the Metropolitan Electric Supply Co., the Charing Cross, West End & City Electric Supply Co. and the South Metropolitan Electric Light & Power Co.

The maximum price for electrical energy to be used by private consumers for power purposes is the same as that referred to above in the case of authorised distributors.

Sec. 21 is of very great importance and will probably meet with considerable opposition. Briefly, it stipulates that the purchase clause of the Electric Lighting Act of 1888 shall cease to apply to the London electric supply companies. It provides, however, that the "purchasing authority," meaning any public authority authorised by Parliament to purchase the undertakings, may purchase *at one and the same time all* the undertakings of the Joint Committee and Companies. Such purchase is not to take effect before January 1, 1949, and then only on condition that three years' notice is given. The purchase price, failing agreement, is to be the total capital expenditure, less an amount by way of sinking fund calculated on a 42 years' basis at 4 per cent.

Any officer at present employed by the Companies who may suffer by the establishment of the Joint Committee is to be compensated. Sec. 23 provides that any two or more of the Companies may amalgamate, subject to the consent of the Board of Trade.

Naturally the promotion of this Bill will raise a storm of objection. The public, or a certain section of it at all events, will at once conjure up in their minds a huge monopoly or "trust." But, of course, there will be nothing of the kind. Very few districts in the Metropolis are served by two or more competing companies, and therefore very few would be likely to suffer by amalgamation. Competition, little as there is, will not be destroyed, but the various companies will be placed in a greatly superior position with regard to generation and distribution. Indeed, it is practically certain that some stations would be shut down on light loads, if not altogether. This linking up and giving and taking of supply cannot fail to effect reductions in the cost of production. There is, of course, the serious objection that the systems differ very widely, but where connections between two networks may be impossible on the high tension side, there must be a large number where they will be possible on the low tension side, and even where both high tension and low tension differ it will still be possible to put down suitable transforming machines. This is admittedly expensive, but it must be remembered that the amount of energy interchanged will be small compared with the total output, and hence the capital expenditure on this item will be correspondingly small. Moreover, it will be more economical to put down transforming apparatus than to put down fresh generating plant to be run on a very poor load factor. Obviously, too, if the bill should pass, then the companies will find it to their own interests to bring their systems gradually into line, especially as their term of life will be extended. Considering that the companies have struggled through the initial stages of the electric lighting business, it would be highly gratifying if they were allowed to reap some little reward, and the present bill would undoubtedly have this effect, as well as to cheapen the cost of supply to the actual consumer. For some extraordinary reason the companies have been looked upon as the natural prey of the municipal people. From their inception they have never had a moment's peace, and the fight has been a one-sided contest all the way along. At their very birth they were hampered by ill-considered legislation, and ever since they have been threatened by "compulsory purchase." It is curious that these tactics were applied to electric light companies and never to gas companies. For the past few years the companies have been driven to fight for their lives in parliamentary committee rooms, and it is to their credit that they have acquitted themselves with no little success. Nevertheless, they have had to find huge sums of money in order to provide substantial opposition to inimical measures, and they cannot but have felt the strain. Surely, then, it is time that they were left alone, with the certain knowledge that they cannot benefit themselves unless they are prepared to benefit the consumers.

It is urged in some quarters that the supply of electrical energy is a problem akin to that of the supply of water, and there is a good deal of reason in the argument. The parallel cannot be pushed too far, but it is very obvious that the existing state of affairs is not a satisfactory one. Something must

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be done, and the companies themselves have been quick to realise this. If their bill does not become law, then things remain exactly as they were before. In the event of the bill being rejected, it is to be hoped that the Government will take some serious step to effect an improvement. The appointment of an electrical board, similar to the Water Board, would be an admirable plan, and would permit of the gradual absorption and amalgamation of the various undertakings into an organised whole. It is not that the existing undertakers are not doing the maximum possible in the circumstances, but the circumstances have differed from those of 20 or 30 years ago, whereas the conditions under which the companies labour have not differed, except for the worse, for they are nearer the day of compulsory purchase. Failing the formation of a board, the companies' present bill is the best suggestion for the solution of the problem that has been made.

A NEW MULTIPLE UNIT SYSTEM OF TRAIN CONTROL.

Summary.—A description is here given of a new method of multiple unit train control, in use on the Lancashire & Yorkshire Railway's, Liverpool-Southport electric line. It is the development of a principle introduced by Mr. T. von Zweigbergk, of Dick, Kerr & Co. (Ltd.) The main feature is the use of solenoid contactors with series, as distinct from shunt, magnets. These magnets are energised by the return current from the train motors, which is either passed through all the control magnets on the train to earth at the rear of the train or diverted to earth at the front of the train. No current is broken in the controller; only the contactors, with metallic shield blow-outs, interrupt the motor circuits. The control wires are also at earth voltage at all times. The description includes an account of the principle adopted, with simple diagrams and details of the parts employed to make up the control of a train. The application of the system to a four-motor coach is also described.

During the past nine months a number of trains of the Liverpool–Southport electric section of the Lancashire & Yorkshire Railway have been running with a new system of multiple unit train control. Our readers will remember that at the opening of the line (see *The Electrician*, Vol. LII., p. 940) we published a description of the train control adopted on the first service of trains. This control was a modification of that employed on tramcars, the main current of the motors passing through the controller, which was a combination of two large series-parallel controllers. Currents up to 2,400 amperes (full load) at 650 volts, were dealt with on these controllers, but the Zweigbergk metallic shield blow-out was made use of, and its

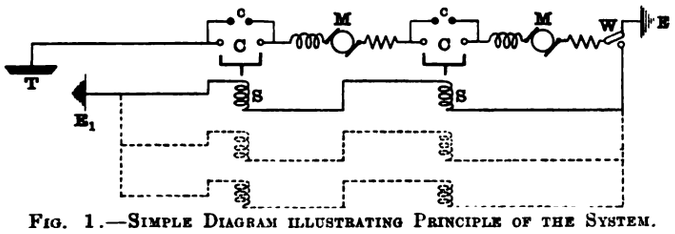

FIG. 1.—SIMPLE DIAGRAM ILLUSTRATING PRINCIPLE OF THE SYSTEM.

efficiency was in every way proved during the severe trials to which it was subjected. On the occasion of our inspection of the new multiple unit stock we had, by the courtesy of Mr. G. Hughes, chief mechanical engineer to the railway, a ride in the cab of a train fitted with the first pattern controller, and were surprised at the absence of arcing at the contacts or noise during the notching up of the motors from rest. There is an ammeter in the cab, and this reached 2,000 amperes when the controller was on the first notch in parallel. At the change from series to parallel the whole of the main current is interrupted at the controller, but without noise or flash. With this system only eight motors per train, four on the front car and four on the rear car, can be used, and although this control has given satisfaction and generally meets the requirements of the service, it cannot be extended to a greater number of motor cars than two. To obviate this difficulty a radical change to some form of multiple unit system was decided upon.

The principle of the multiple unit system of train control is now generally accepted as the best for continuous-current railway systems working suburban or stopping trains at pressures up to 700 volts on the trolley or third rail. Developed initially in the United States by Sprague, the system is represented in practice at the present time by three distinct methods: (1) Direct electromagnetic with shunt solenoids operated by the line voltage; (2) electro-pneumatic, with low-voltage electromagnetic valves controlling air pressure to pneumatic contactors; (3) direct electromagnetic, with series solenoids, actuated by the negative or return current of the train motors. The first and second are in extensive use in America, on the Continent, and a number of British electric railways; it is the third which has been adopted on the Lancashire & Yorkshire electric line. It has been manufactured and installed by Messrs. Dick, Kerr & Co. (Ltd.).

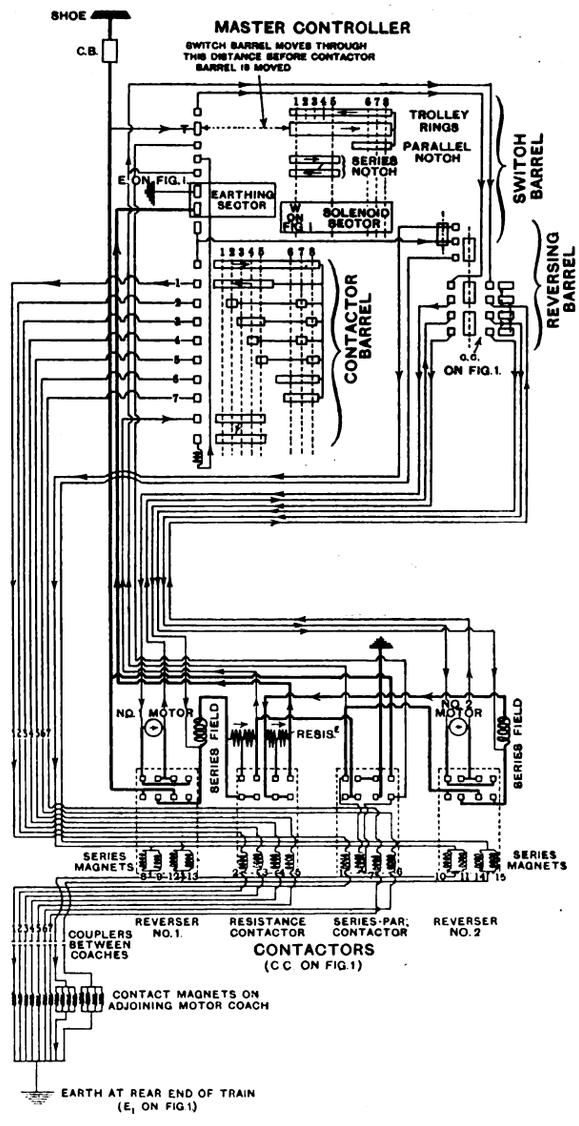

FIG. 2.—CONNECTION DIAGRAM OF MULTIPLE UNIT CONTROL OF TWO MOTORS. MOTOR CUT-OUT SWITCHES ARE OMITTED.

The idea of utilising the return current of the train motors to operate the control contactors is due to Mr. Thorsten von Zweigbergk, who has also effected its practical application to the electric motor-cars of the Lancashire & Yorkshire Railway. The system is, of course, applicable to any electric train using continuous-current motors with multiple unit con-

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trol, and in this respect we may mention that all patents are controlled by Messrs. Dick, Kerr & Co., Ltd.

It has frequently been urged as an objection against multiple unit motor control with shunt solenoids that high-voltage conductors must be run through the train to the various master controllers. As far as we are aware, experience with this system has produced no evidence to support this contention, though the use of low-voltage control-circuits is none the less advisable. The electro-pneumatic system employs such low-voltage circuits, fed from a duplicate battery on the train.

The employment of the motor return current for the contactor circuits has been carried out in a most ingenious manner with the Zweigbergk system. We can best explain the method employed by a simple diagram. This is shown in Fig. 1, and it represents a control circuit for two motors. T is the trolley shoe and M, M are the motors. E, E_1 are earth connections. The circuit between T and earth can be completed either by way of contacts c, c, and E, or contacts C, C_1, solenoids S, S, and E_1. The first thing necessary is to establish a circuit between T and E. This is done by closing c, c, through the motors to earth E via the two-way switch W. If c, c, are kept closed, and W is moved to divert current to earth E_1, through the solenoids S, S, and these solenoids close the switch contacts C, C, the motors will take the main current of the trolley circuit and start up. If the contacts at c, c, be opened no circuit is broken, as the same contacts are duplicated by C, C. Should, now, the switch W be moved to E, the current passing through the solenoids S will go direct to earth, and the magnets will become de-energised, and therefore open the total circuits at C, C. The circuit W, S, S, E_1 can be paralleled by others, as shown by the dotted lines, containing as many solenoids as are required for control purposes, and elaboration of W will cause these solenoids to be brought in and out of circuit. This explains simply the principle upon which the control is based.

Its applications to a two motor-car equipment is shown diagrammatically in Fig. 2, which has been specially drawn to simplify the wiring connections, and does not contain the motor cut-out switches. The main portions of this particular control are the master controller, and the contactors, the latter including reversers, resistance contactors and series-parallel contactors. The master controller is duplicated on each motor car, one controller at each end in the driver's cab, and the contactor boxes are hung beneath the carriage under-frame midway between the bogies. The master controller is made up of three distinct parts: (1) the switch barrel, (2) the contactor barrel and (3) the reversing barrel.

These are clearly designated on the diagram, Fig. 2. The switch barrel and the contactor barrel are in the same vertical plane, and are moved by the main operating handle, but the former travels independently of the latter through a certain arc indicated on the diagram. After the switch barrel has been turned through this arc, the contactor barrel turns with it, and both move together until the full running position is reached. There are eight notches on the controller, and these are numbered on the diagram to facilitate tracing the various connections. The path of the current with the controller on the first notch is marked by arrow heads, and if these are followed the explanation now given will be better understood. The reverser barrel has three positions: (1) Forward, (2) off, (3) reverse. It is in two parts, with a drum for switching in either the forward or reverse set of contactors and a drum for reversing the control circuit through both motors. In Fig. 2 the portions corresponding to the letters on the simple diagram (Fig. 1) are also shown for convenient comparison.

The first controller movement is made at the reversing switch, which is pushed from "off" to either "forward" or "reverse," according to the train direction required. This movement completes the control circuit through the motors to earth at the earthing sector on the master controller. At the same time the main handle is mechanically released and notching up can begin. We may mention here that the master controller handle is fitted with a mechanical regulator, which only admits of notching up a step at a time. The handle is locked on each notch, and is only released by slight backward pressure, after which it can be moved to the next notch.

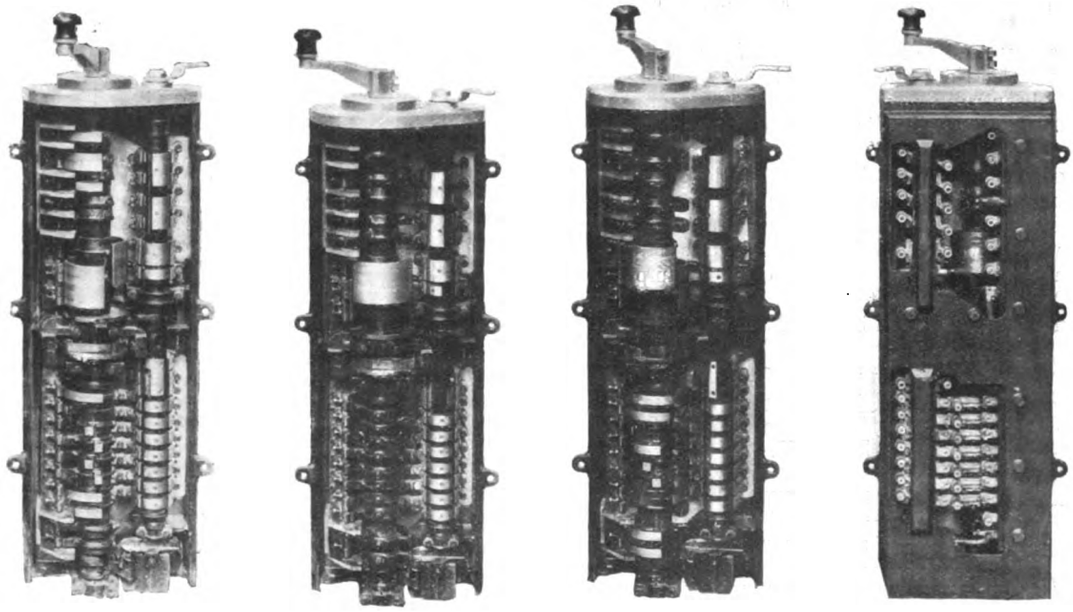

FIG. 3.—VIEWS OF MASTER CONTROLLER IN THREE DIFFERENT POSITIONS; ALSO BACK OF CONTROLLER, SHOWING TERMINALS.

On the first notch the earthing sector of the switch barrel is moved round, the trolley rings and the series notch and the solenoid sector complete their respective circuits, and at this moment the contactor barrel passes to the first notch. The path of the control current may be traced by the arrow heads. What happens is as follows: The trolley rings close a control circuit which includes the lower reversing barrel, the motors and their fields and resistances, the reverser solenoids 8, 9, 10, 11 and paralleling solenoid 1. All these are in series with each other and also with all the other control sections on the train, the final earth connection (E_1 in Fig. 1) being made at the rear of the train. Reference to Fig. 2 will make this clear. The completion of this circuit brings up the reversing and paralleling contactors, as we have already said, and the next four notches of the controller cut out the resistance in the series connection of the motors, by completing the resistance solenoid circuits throughout the respective motor combinations on the train. On notch 6 paralleling begins, but the interval between this notch and notch 5 breaks the circuit of the resistance solenoids and the series solenoid, the contactors of which fall out at once to the off position. The trolley ring

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and reverser contactor solenoid circuits are of course maintained in the meantime. The control circuit of notch 6 allows the paralleling contactors 6, 7 to come up and the two subsequent notches 7 and 8 cut out the motor-resistance contactors, which had fallen on the controller leaving the series notch, being again attracted. All the motors on the train will now be running at full speed.

To switch the train motors off, the controller handle is returned to the zero notch, a movement of which can be effected by a single sweep of the handle. This brings back the switch barrel of the master controller, independently of the contactor barrel, which remains at full parallel, and bringing round the earthing sector diverts the motor-return current from the solenoids to earth at the point E. Immediately all contactors drop off and break the motor circuits all along the train.

It is important to note that the earth connections for the contactor and diverter circuits are at opposite ends of the train.

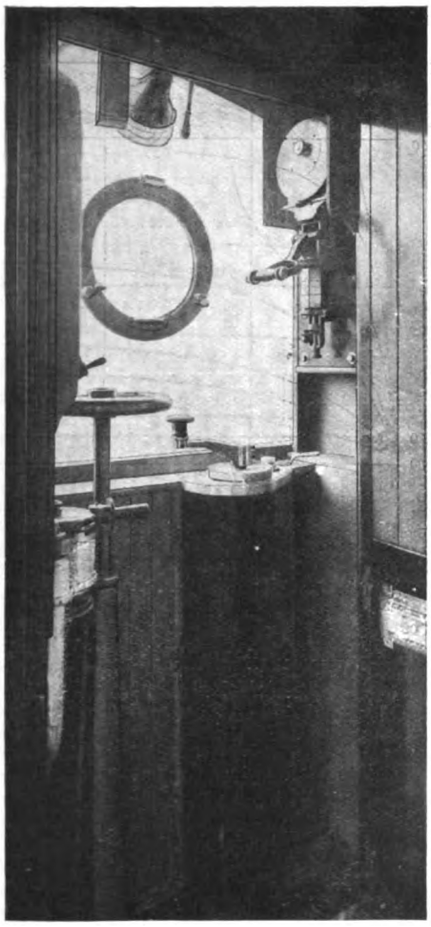

FIG. 4.—VIEW OF MASTER CONTROLLER AND CIRCUIT-BREAKER IN DRIVER'S CAB.

The former must, of course, be at the rear, as it is at this point that the return current is allowed to go to earth after passing through all the contactor solenoids in the motor cars on the train. The earthing point, to which this return current is diverted, in order to de-energise the contactor solenoids, is at the front of the train. To allow of control being effected from either end of the train, the entire control system is parallelled at the front and rear master controllers.

The master controller, several views of which are shown in Fig. 3, is comparatively small in size because it is not required to break any current, and consequently has no blow-out, which usually takes up much room. From the explanation we have already given of the operation of the system, the arrangement of the controller parts will be better understood. The position of the switch barrel, at the top, with respect to the contactor barrel, at the bottom, will be also clear from the view of the controller interior. The mechanical regulator, already referred to, for preventing the motorman going forward more than one notch at a time, is placed below the controller top, just above the switch barrel. This dispenses with the need of automatic notching up arrangements, which place the acceleration beyond the control of the driver. Similarly, it enables shunting to be done without special provision being made for it. In the base of the controller is a magnetic lock consisting of a small coil in series with the contactor solenoid, which determines the series connection of the motors. When this locking magnet is energised, it releases a catch and allows the motorman to proceed notching up to full series. If the series contactor is not pulled up for any reason the controller cannot be notched up, as it remains securely locked.

The arrangement of the controller in the driver's cab is shown by the view in Fig. 4, and in the same illustration the circuit-breaker and braking apparatus can be seen. We shall refer to the means adopted for braking later.

(*To be concluded.*)

"FLEXIBLES," WITH NOTES ON THE TESTING OF RUBBER.*

BY PROF. A. SCHWARTZ.

Summary.—In this Paper the author first deals with the causes of deterioration in flexible conductors. He then considers the method of insulating them, and describes in detail the properties of rubber. He also deals with the various mechanical and electrical tests to which flexible cables should be subjected, and concludes by describing various systems of surface wiring using flexibles, which have been more particularly adopted on the Continent.

I.—INTRODUCTORY.

The employment of twin flexible conductors for pendant lamps has been evolved from the early usage of bringing down the circuit leads and connecting to the platinum loops sealed into the lamp bulbs. The flexible thus filled the double rôle of supplying energy to the lamps and at the same time served as their support. The wires were twisted together to render them more sightly, and the conductors were stranded to ensure the necessary flexibility for the lamps to hang vertically without adjustment and to overcome the inherent mechanical weakness of a solid copper wire of small diameter when subjected to repeated bending.

At the present time flexibles are extensively employed for the following purposes: Pendants and clusters, counterweight fittings, portable lamps, wiring of fittings (electrolier and fixture wire), connections to radiators and portable heating and cooking apparatus, connections to brushes of dynamos and motors, special systems of interior wiring.

These manifold uses and the varied conditions of environment in actual practice have been responsible for the number of grades in which flexible has been put upon the market. The type of insulation employed may be either a simple cotton covering with a protective braiding as used for dynamo flexible, one or more layers of pure rubber tape put on spirally under tension, or of vulcanised rubber or a combination of pure and vulcanised rubbers, together with a protective braiding.

There is a general consensus of opinion amongst engineers that the flexible is the weakest part of an electrical installation. If this is so, we are ourselves largely to blame for our neglect of the matter. It is curious to reflect that after the elaborate care that has been exercised to keep well-insulated conductors apart (when not enclosed in non-flammable tubes) in all other portions of the installation, we should have come to regard with complacency the violent forcing together of two comparatively poorly insulated conductors in positions where they are exposed to considerable heat and are liable to mechanical strains, as in the lamp holder with single-hole cord-grip so commonly employed at the present time.

Faults in Flexible Installations.—On the Continent flexibles are employed more largely than in this country in that their use is not restricted to lamps and portable appliances, but the wiring of the building itself is often carried out with flexibles supported on insulators. In the early days, when 110 volts only had to be dealt with, flexibles insulated with lapped rubber tape were successfully employed. When, however, 220 volts came into use this class of insulation was found to be insufficient. The trouble was due not so much to short-circuits as to persistent arcs. These faults were found to occur most frequently in the switch wires, for the switch is then simply short-circuited, and the current in the arc is limited to that of the lamp or consuming device in the circuit. The arc thus formed

* Abstract of a Paper read before the Institution of Electrical Engineers, April 18th,

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travels slowly up the wires until the lamp leads are involved, when the fuses will blow. To obviate this trouble with the switch wires Coninx * proposes to have laid up with the flexible for the switch connection a third wire, which should, if the switch is in the positive wire, be connected to the negative main at one end, and be carried down to the switch and there sealed off without being connected to it. A short-circuit in the switch wires would involve this third wire, and thus ensure the fuses blowing, The arrangement is shown diagrammatically in Fig. 1.

It is not unusual in Lancashire cotton mills, where the air is highly charged with moisture, and the flexibles are regularly brushed down in order to rid them of the adherent fluff, with the brush used for cleaning down the machines, which is in consequence oily, to find that persistent arcs of low current value, and too small to blow the circuit fuses, are formed in the flexibles for pendant lamps. Moreover, it is impossible for economic reasons to employ only 5 ampere circuits where long aisles are to be lit, consequently the blowing of a fuse brought about by the failure of a flexible may extinguish a large number of lights, and result in the sudden throwing off of a large load and considerable confusion with the work. A return to the practice of fusing ceiling roses would, therefore, seem to be desirable in such cases, as the small fuse in the holder would, in the first place, be more likely to blow on the formation of the arc, and, secondly, would finally isolate the faulty flexible without interfering with the remainder of the circuit.

II.—Conductors.

The conductors for flexibles are usually all twisted in one direction; they are sometimes, however, not twisted at all. This latter form is not desirable for any conductor that has to work backwards and forwards over a pulley, as the stress is not distributed evenly over the wires, which, in consequence, are liable to break.

The author gives particulars of conductors recently agreed upon by the Cable Makers' Association as being standard for flexibles. These particulars show the number of wires of a given gauge with the equivalent solid wire, and the number of wires of given gauge with the equivalent total sectional area in square inches.

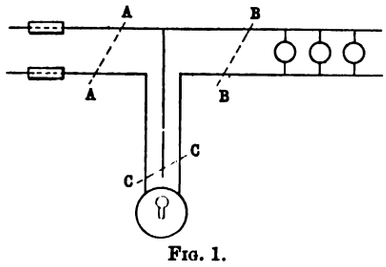

Fig. 1.

Conductivity of Small Stranded Conductors.—The diameters of the tinned wires were found to be slightly greater than their nominal gauges, the wires being drawn to standard gauge and then tinned. The thickness of the tinned coating varied with different samples from 0·0009 in. to 0·0002 in. in the case of a No. 36 S.W.G. wire. A series of experiments showed that in all cases for pure copper the conductivity of a stranded conductor with a large number of strands is higher than that of its equivalent solid wire. Assuming that the current flows not only along the twisted strands of the conductors, but also straight from strand to strand through the lines of contact, the effective conducting cross-sectional area will be greater than that of the equivalent solid section of its constituent conductors, and its resistance will therefore be lower. This assumption further accounts for the higher resistances of the tinned conductors, since the current flowing across the strands would have to encounter the higher resistance of the tin coating. If we assume that the current flows only along the separate strands, then the ratio† $\frac{\text{conductivity of stranded conductor}}{\text{conductivity of equivalent solid wire}}$ should be greater for tinned conductors than for pure copper ones, owing to the additional cross sectional area of the tinning, but the experiments show that this is not the case. In general the conductors for service with vulcanised rubber are tinned, whereas those for use with taped rubber are not.

There are four causes of weakness in the conductors which would appear to operate in actual practice: (1) Extension of the wires by bending when under small loads; (2) loss of tenacity due to increase of temperature at the lampholder; (3) corrosion of the wires due to sulphur from the vulcanising compound; (4) corrosion of the wires due to chemical fumes in the air.

1. *Extension of the Wires by Bending when under Small Loads.*—Ercolini‡ has recently investigated in considerable detail the extension of copper wire when wound and unwound under tension upon cylinders of various diameters. He experimented with copper wire 0·04 cm. (16 mils.) diameter wound upon iron cylinders 1 cm., 2 cm. and 4 cm. diameter respectively under tensions varying from 250 to 3,000 grammes (0·5 lb. to 6·6 lb.). He found that with successive winding and unwinding the wire stretched as much as 84 per cent. before breaking, and that under a tension which produces an insignificant stretching if applied in the ordinary way. It would seem probable that this cause would operate in the case of flexibles which are repeatedly bent at the lamp-holder or round any surface of small radius.

2. *Loss of Tenacity due to Increase of Temperature.*—The author gives a table showing the percentage loss of tenacity with increase of temperature. This shows 10 per cent. loss at 248°F. The temperature attained in lamp-holders is very much higher than is generally supposed. It is, of course, a very variable quantity, depending, not only upon the heat radiated and conducted from the lamp itself to the holder, but also upon the nature of the contact between the lamp terminal plates and the spring plungers of the holder. Some experiments made for the author by Prof. W. W. Haldane Gee and Mr. L. Henshaw show that the temperature of the lamp contact plates may even reach 300°F.

3. *Corrosion of the Wires due to Sulphur from the Vulcanising Compound.*—The vulcanising compound is usually put on in two layers, the outer one of which, or "jacket," may contain as much as 10 per cent. of sulphur, while the inner one, which is termed the "separator," may contain as much as 3 to 4 per cent. of sulphur. Then follows a layer of pure rubber tape on the tinned conductors An appendix to the Paper, which contains a detailed examination of old vulcanised flexibles, shows that in most cases the wires have been blackened by the action of the sulphur, and that in some cases they have been severely injured. A table also shows that the wires insulated with vulcanised rubber have become considerably more brittle than those insulated with pure rubber and within a shorter time.

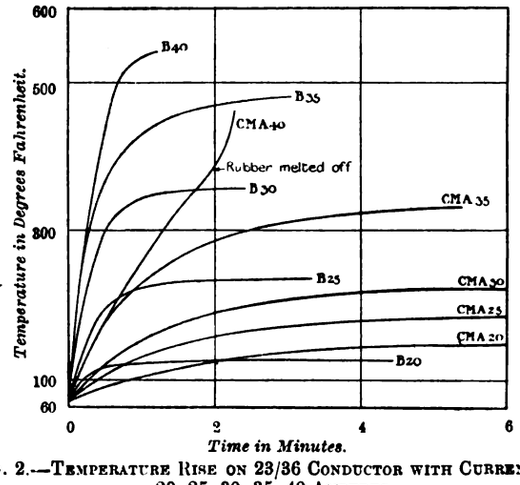

Fig. 2.—Temperature Rise on 23/36 Conductor with Currents of 20, 25, 30, 35, 40 Amperes.

B = Bare wire.
C.M.A. = Cable Makers' Association V.I.R. covering only, without braiding. Room Temperature, 60°F.

4. *Corrosion of the Wires due to Chemical Fumes in the Air.*—This is not usually a direct action, particularly in the case of vulcanised rubbers, but takes place in the presence of moisture, which leads first to the deterioration of the insulation, and subsequently to the corrosion of the wires by electrolytic action. In the case of flexibles this action is intensified by the juxtaposition of the conductors and the influence of electric osmosis.

Gymp Flexible.—This is a special flexible which was brought to the author's notice by Mr. Mervyn O'Gorman. Owing to the structure of the conductors, it possesses an extraordinary degree of flexibility. The conductors are composed of flat copper strips, 10 mils. wide and 1·5 mils. thick. These strips are each wound in a close spiral around a separate silk core, and 21 of these are then stranded together in sets of seven to form the complete conductor. The resistance of such a conductor is naturally high, that of the small specimen submitted to the author after it had run 1½ million times over a counterweight pulley being 1·72 ohms per yard of double conductor.

In general the question of conductivity of flexibles as applied to pendants, &c., may be considered as being over-ridden by the requirements of mechanical strength, which will dictate the minimum section to be employed, but the conductivity is of considerable importance in connection with the use of flexibles for wiring systems.

III.—Heating of Conductors due to Excessive Currents.

This matter is of interest in connection with the temperatures attained with flexibles due to short-circuit currents and the employment of heavy fuses on sub-circuits.

* "Handbuch der Electrotechnik," Vol. VI., part 2, p. 394.
† Calculated on the copper area of the stranded conductor.
‡ *Nuovo Cimento*, Vol. II., Series 5, 1906, p. 243.

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A series of experiments was made by the author and Messrs. F. Shaw and J. Davies on (1) the temperatures attained in a given time with bare conductors with various currents, (2) the corresponding temperature rises with the same conductor when insulated. The results of some of these experiments are shown graphically in Fig. 2.

IV.—Insulation of Flexibles.

Before dealing in detail with the insulation of flexibles it will be well to consider briefly the prominent characteristics of the materials employed.

Pure Rubber Strip.—The pure rubber strip which is used for insulation purposes is prepared by two distinct methods, and is known as "cut" or "spread" sheet, according to its mode of manufac-

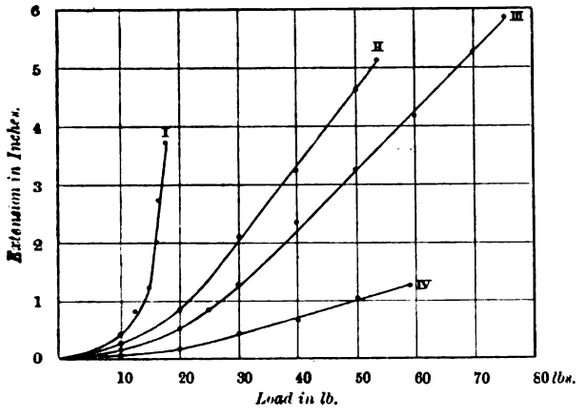

Fig. 3.—Tensile Strength of Differently Vulcanised Specimens of Para Rubber.

Sample.	Vulcanisation coefficient.	Sample.	Vulcanisation coefficient.
I.	1·78 per cent.	III.	2·87 per cent.
II.	2·14 "	IV.	4·44 "

ture. The raw material is the same in either case, and is first washed and dried. In the preparation of "cut" strip the dried rubber is, after being passed through compression rollers, put through a "masticator," and then formed into blocks under considerable pressure. These blocks are frozen hard and then cut into sheets by special machinery. The process outlined above is necessarily expensive, and is only followed by a few firms in this country. The manufacture of "spread" sheet is much simpler and less costly. The dried rubber is made into a paste or "dough" by means of a solvent and is then spread on a length of cloth. The solvent is then driven off by heat, leaving the rubber in the form of a sheet, which is then cut into strip. On the Continent, owing to the cost of fine Para rubber, foreign material is added with a view to producing a cheap article, which is put on the market as second or third quality sheet. "Cut" strip is generally used in this counry for the inner-

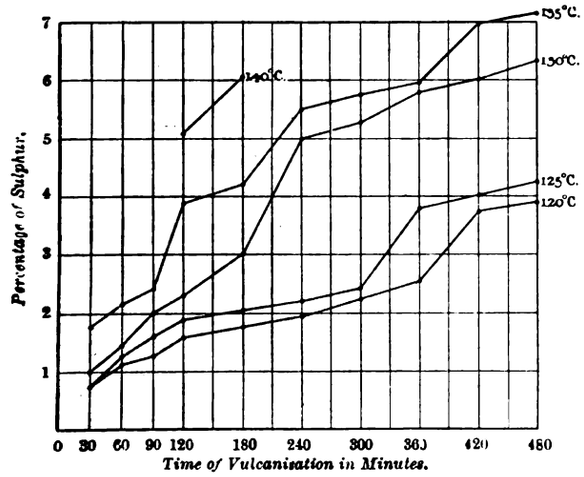

Fig. 4.—Vulcanisation Curves of Para Rubber at Different Temperatures.

most layer in high-class cable work, while "spread" strip is very largely used for rubber-taped flexibles, insulating tape, &c. The "spread" sheet should, in order to have the requisite mechanical and electrical properties, be "aged" by hanging in a dark room for several months. The strip may be artificially aged or cold vulcanised by treating the surface with a solution of chloride of sulphur in carbon bisulphide. As rubber tape is often used next to the copper conductors it is important that it should not contain sulphur. This cold vulcanised strip not only contains sulphur, but nearly always contains hydrochloric acid as the result of its chemical treatment.* Pure rubber has a great affinity for oxygen, and if placed in direct contact with copper, the latter will part with any oxygen it has to the rubber; it is therefore quite necessary that the wires should be tinned, or at least covered with a close wind of cotton when in contact with pure rubber.

Absorption of Water by Indiarubber.—Indiarubber will absorb about 25 per cent. by weight on prolonged immersion in water with considerable increase in volume. The amount of water absorbed is a very variable quantity, and depends very largely on the amount of oily and resinous matter contained in the rubber and also on the treatment that its surface has received. This question is of importance in connection with flexibles insulated with pure rubber, par-

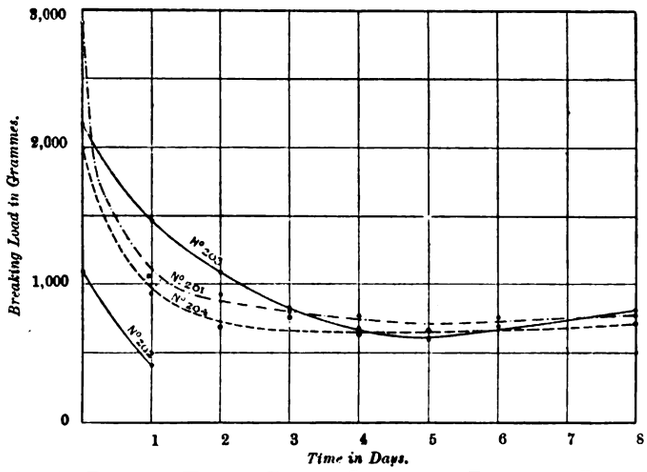

Fig. 5.—Effect of Heat on Tensile Strength of Vulcanised Rubber.
Heated in air for eight days at 100–105°C. Length of test piece 1·8 cm.

ticularly as under the action of electric osmosis the moisture of the positive conductor may be driven over and forced into the negative insulation.

Vulcanised rubber is much more homogeneous in structure than pure rubber, and the amount of water absorbed is, in consequence, very much less, but, nevertheless, the fact that it does absorb water must not be ignored. Immersion tests for flexibles are required in the United States, in Germany, and in France. The insulation resistance after immersion in water may be taken as an indication of the amount of absorption of water by V.I.R. flexibles, but can hardly be so taken when pure rubber tape is employed, as the water may enter between the joints.

Vulcanised Rubber.—Of all the constituents of manufactured indiarubber none possess such a paramount influence upon the

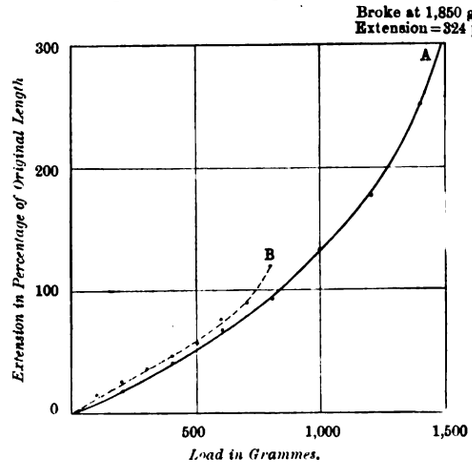

Fig. 6.—Effect of Heat on Vulcanised Rubber.

Curve A, Percentage extension of new sample at 60°F. Curve B, Extension of sample of same material after heating in air at 100°C. for eight days.

general excellence of the product as the sulphur of vulcanisation. The amount of sulphur employed in practice varies greatly from 4 up to 50 per cent., but the amount of sulphur fixed by the indiarubber (sulphur of vulcanisation) very rarely exceeds 3 per cent. in commercial rubber articles, and is generally less. Free sulphur in various proportions always forms a constituent of ordinary vulca-

* Atkinson and Beaver, "Some Points on the Selection of Electric Light Cables," Manchester Local Section, I.E.E., 1905; *The Electrician*, Vol. LIV., p. 702.

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nised indiarubber goods. C. O. Weber* states that the percentage of combined sulphur is no measure of its degree of vulcanisation. He obtains the degree of vulcanisation by calculating the percentage ratio between the amount of indiarubber and sulphur of vulcanisation present. As the coefficient of vulcanisation is increased, the tensile strength, elasticity, and distensibility are up to a certain point also increased; beyond this point there is first a rather rapid decrease in elasticity and distensibility, followed soon by a decrease of tensile strength. Fig. 3 (C. O. Weber) shows the elongation and tensile strength of four tyre covers of absolutely identical composition as regards the quality and proportions of Para rubber, total sulphur, and mineral matter, but cured under different conditions. Over-vulcanisation does not consist simply in a high coefficient of vulcanisation, but in one obtained under unsuitable conditions, either of temperature or of time, or of quantity of sulphur. Of these causes too high a temperature is the commonest one, while too short a time is the most usual case of under-vulcanisation. Flexibles as a rule are slightly under-vulcanised, as it is found that a few minutes more or less in the vulcanising chamber may make the difference between a bright or blackened conductor. The rate at which the sulphur enters into combination with the indiarubber hydrocarbon (polyprene) is characteristic for each brand of rubber. Fig. 4 (C. O. Weber) shows the vulcanisation curves for Para rubber. This point is of interest in connection with the high temperatures attained in lamp-holders and the possibility of the free sulphur present entering into combination with the rubber and producing an over-vulcanised covering.

V.—Oxidation of Rubber.

An appendix to the Paper contains a detailed examination of samples of flexibles which have been in use for a number of years,

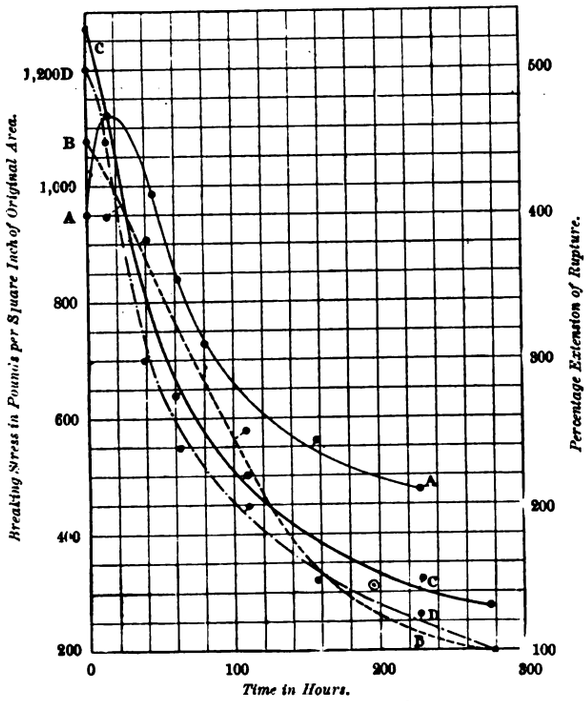


Fig. 7.—Effect of Heating Vulcanised Rubber at 150°F.

Curve A. Breaking Stress C.M.A. Flexible, Firm D.
" B. Per cent. Extension " "
" C. Breaking Stress " Firm C.
" D. Per cent. Extension " "

and shows that the vulcanised rubbers seem to have suffered most, but that the pure rubber also has in many cases perished considerably. This perishing, due to oxidation, although it no doubt takes place more rapidly in the high temperatures in the immediate vicinity of the lamp-holder, and to a lesser degree at the ceiling rose also, affects the whole of the cord, and in the author's view puts a limit of from 10 to 12 years as the safe life of an average flexible of good quality under favourable circumstances. The use of rubber substitutes will shorten the life of the flexible in proportion to the quantities of these substitutes that are present. There is no doubt that oxidation plays a prominent part in the deterioration of flexibles in warm situations, and it would be interesting to know if the "reinforced cord" used in the United States—consisting of a filling of rubber or bitumen which makes up the cord to circular form and completely encloses the insulated conductors—conduces to the longer life of the actual insulation by excluding the oxygen.

* "The Chemistry of Indiarubber," London, 1902, p. 283.

Recovered Rubber.—Recovered rubber undergoes vulcanisation just like fresh rubber, but it is not devulcanised by the recovery process; indeed, the sulphur of vulcanisation is increased rather than lessened. Consequently samples containing a large percentage of recovered rubber have usually a high coefficient of vulcanisation.

VI.—Effect of High Temperature on Rubber.

The high temperatures attainable in lamp-holders have already been mentioned. Under the influence of high temperature rubber develops many defects, of which the following are the chief:—

1. *Loss of Strength or Cohesion.*—Rubber with a comparatively low coefficient of vulcanisation is liable to develop this defect.

2. *Hardening with Brittleness.*—This defect appears in rubbers containing white substitutes (chlorosulphide), but more commonly is due to the presence of a considerable amount of free sulphur.

3. *Stickiness and Darkening in Colour.*—This defect is associated with rubbers containing mineral oils, large quantities of recovered rubber, or large proportions of sulphide substitutes.

The results of some tests made to obtain the effects of high temperatures are given in Figs. 5, 6 and 7.

The question as to which of the two classes of rubber gives the best results in such a high temperature is a debatable one. The author favours the view that pure rubber is best suited for high temperatures, since if it does soften and melt, it is absorbed by the cotton surrounding it, whereas in the case of vulcanised rubber it becomes hard and friable and disintegrates on bending.

VII.—Hysteresis of Rubber.

A number of experiments on the mechanical hysteresis effect in pure and vulcanised rubbers are described in the Paper and hysteresis curves shown, plotting percentage extension vertically and stress in pounds per square inch horizontally.

The author suggests that by arrangement with the Cable Makers' Association a standard hysteresis loop might be arrived at for given grades of insulation. Such standard loops would to a very considerable extent serve as vulcanisation standards, and would secure the necessary physical properties of the material which give an indication of its durability, while they would further undoubtedly conduce to uniformity of manufacture. The apparatus required is simple and inexpensive, and the test is quite easy to carry out. With regard to the relative methods of the hysteresis method, and the measurement of the permanent set on a sample that has been stretched a given length for a certain number of hours, the hysteresis test is certainly more trouble to carry out, but the results are available in a much shorter time, and, further, all the conditions of the test may be easily defined, whereas with the elongation test a good deal depends upon the rate at which the rubber is initially stretched as to its subsequent behaviour.

VIII.—The Stretching of Rubber.

Apart from the hysteresis test, the stretching of rubber in the author's view forms one of the best guides as to its quality at the outset, and also affords an indication as to its probable lasting qualities. It is curious that with the single exception of the test for Para rubber tape in the French regulations, the stretching test is omitted from the official regulations, not only in this country, but also in Germany and the United States.

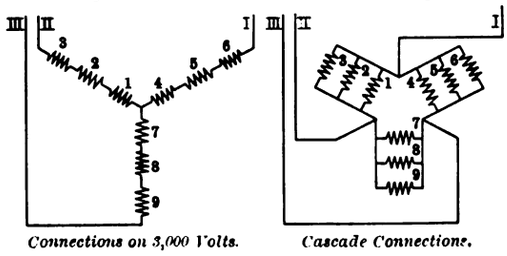
The author gives tables showing the effect of admixtures on the tensile strength and elongation; and also the effect of the dimensions of test pieces.

(To be continued.)

THREE-SPEED POLYPHASE LOCOMOTIVES ON THE ITALIAN RAILWAYS.*

BY BÉLA VALATIN.

An objection which is often urged against the use of polyphase motors on railways lies in the statement that they can only be



Connections on 3,000 Volts. *Cascade Connections.*

Fig. 1.—Connections for Starting.

economically employed at one particular speed, and that even if used on the "cascade" system or with devices for altering the

* Abstracted from the *Elektrische Kraftbetriebe und Bahnen*, February 23, 1907.

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arrangement of the poles, it has hitherto only been possible to use two economical speeds. It will therefore be of interest to describe results which have been obtained on main lines with the use of a locomotive having three speeds, which has been constructed for the Italian State Railways by Ganz & Co. Two motors are used, the one having 8 poles and the other 12, being wound for 3,000 volts at a frequency of 15. If each of these motors is used alone we obtain the two highest speeds, and by coupling them on the "cascade" system we get a further and lower speed. Koloman v Kando suggested an arrangement which has been employed on these locomotives. The stator of the 12-pole motor has three windings for each phase. Fig. 1 shows the switching arrangements for these windings. If the stator is connected to 3000 volts, the three windings in each phase are connected in series and the three phases are connected in star fashion. On the cascade system the three windings are in parallel, and the three phases in delta. The three speeds of 64 km., 42 km. and 25·5 km. per hour correspond to the numbers of the poles, which are 20, 12 and 8. At the higher speeds the tractive effort is 3,500 kg., and at the lower speed 6,000 kg. The advantage of the three speeds lies in the fact that the power consumed can be made to correspond with the weight of the train and with the gradients; in addition to this, the starting can be effected with smaller losses. The losses in the resistances being smaller, there is no necessity to design them on such a liberal scale.

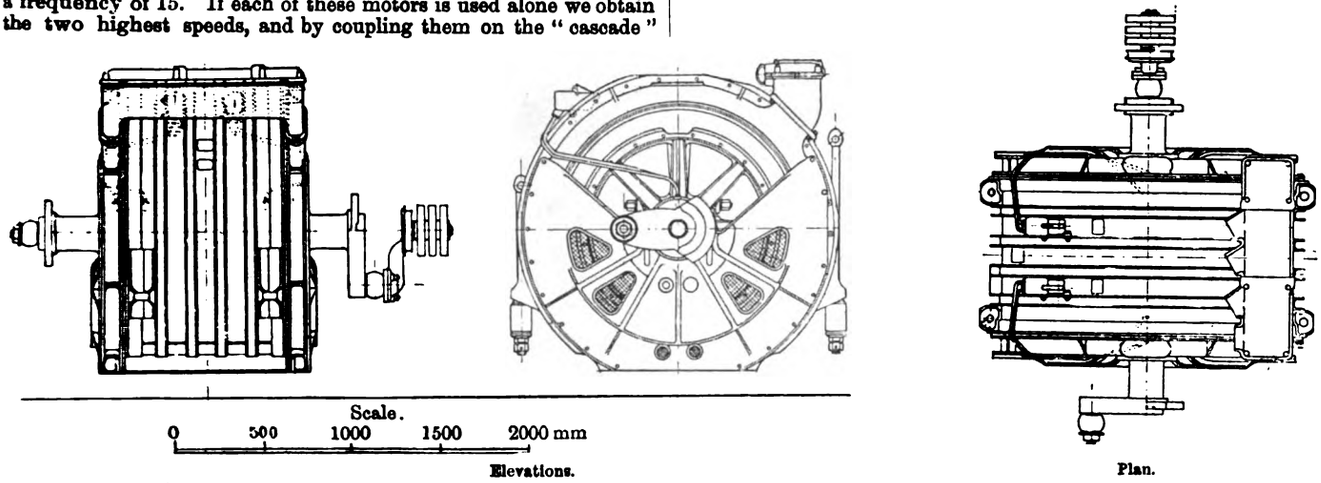
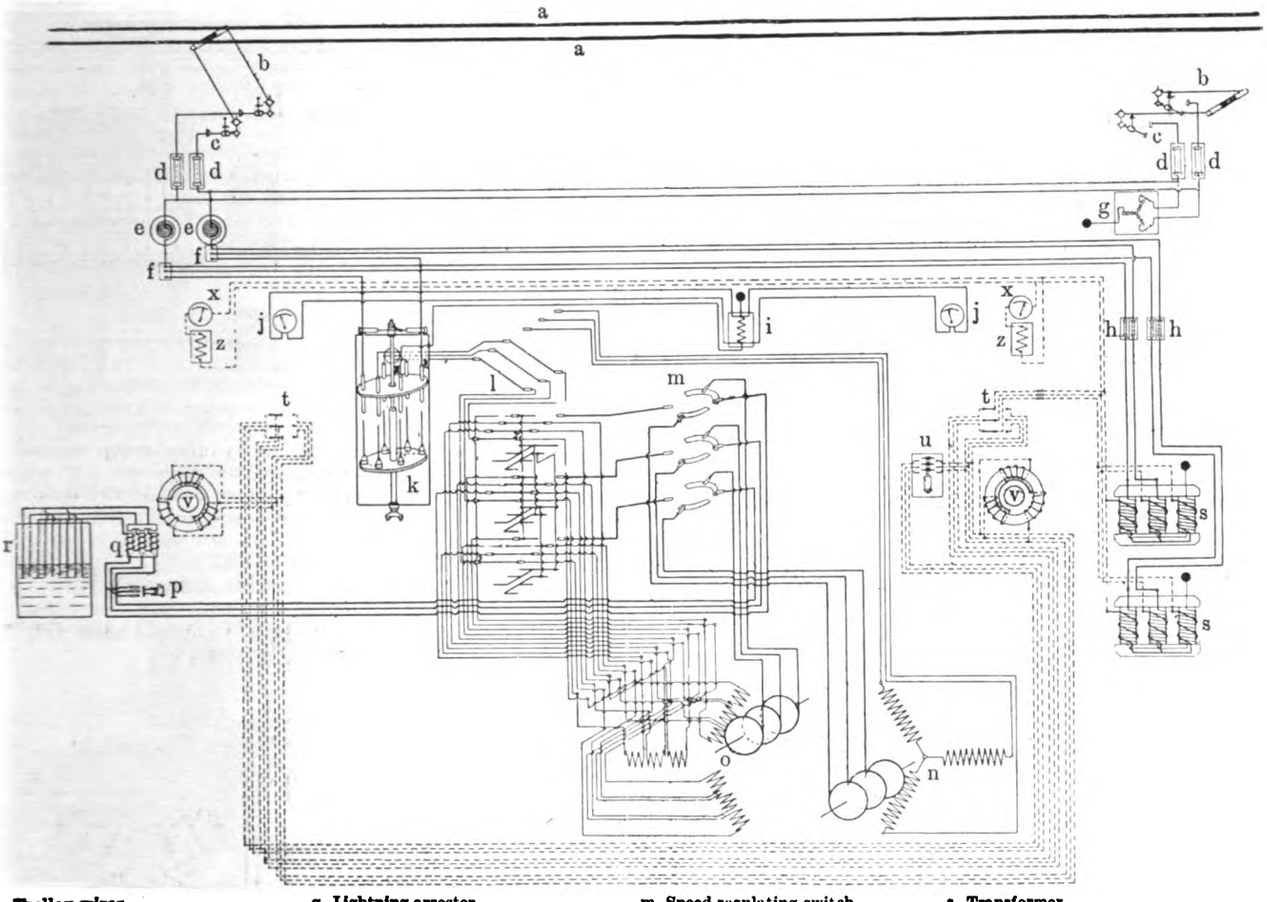


FIG. 2.—TWELVE-POLE THREE-SPEED INDUCTION MOTOR (Plan and Elevation).



a. Trolley wires.
b. Trolley arm.
c. Trolley arm switch.
d. Main fuses.
e. Choking coil.
f. Junction box.
g. Lightning arrester.
h. Transformer fuses.
i. Ammeter shunt.
j. Ammeter.
k. Primary switch.
l. 12-pole motor change-over switch.
m. Speed regulating switch
n. 8-pole motor.
o. 12-pole motor.
p. Short-circuiting arrangement.
q. Water resistance regulator
r. Water resistance.
s. Transformer.
t. Air pump hand switch.
u. Automatic air pressure regulator.
v. Air pump motor.
x. Voltmeter.
z. Voltmeter resistance.

FIG. 3.—DIAGRAM OF CONNECTIONS ON LOCOMOTIVE.

This system can equally well be applied to a combination of motors having the same number of poles; in this case, at full speed both motors would work in parallel. However, under normal conditions such an arrangement would present no great advantages,

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because the higher speed would only be available with a reduced tractive effort, and it would be better to take the whole load with half the number of motors. There are circumstances under which the lower speed might be employed as a useful auxiliary, as, for instance, in starting or shunting. The motors (shown in Figs. 2 and 4) are similar in design to those already built by Ganz & Co. for the Italian railways. The framework is of slightly different construction, being built up out of steel plate instead of cast steel. The slip rings are placed outside the frame of the locomotive, and the brushholders are protected by a removable metallic cover, which can be raised for purposes of inspection.

motor and very carefully insulated, having regard to the high pressure employed. The arrangement of the collectors together with the starting and regulating apparatus is very similar to that already in use on the Valtellina line, all of which have worked very satisfactorily. The collector and switches are operated pneumatically, the main switch being of exactly the same type as before, but being slightly altered in detail, in order to cope with the heavier load. The speed regulator is shown in Figs. 5 and 6.

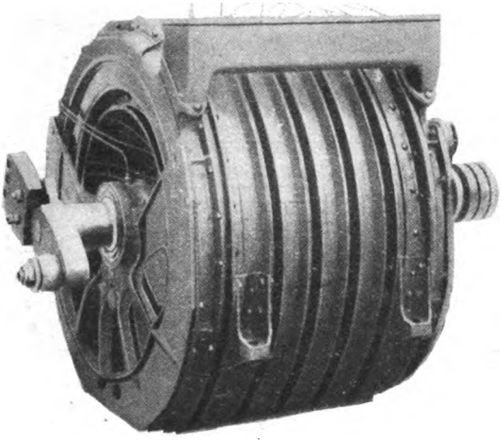

FIG. 4.—VIEW OF THE TWELVE-POLE MOTOR.

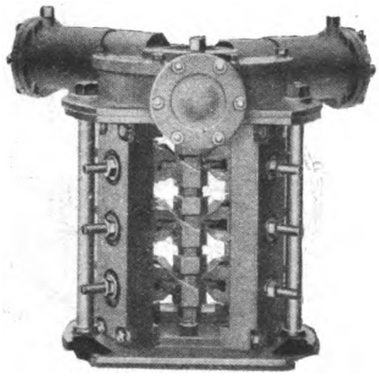

FIG. 5.—SPEED-REGULATOR.

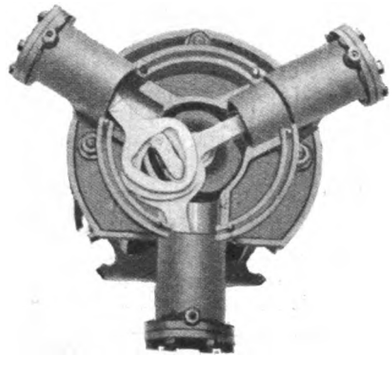

FIG. 6.—METHOD OF OPERATING SPEED-REGULATOR.

The diagram of connections (Fig. 3) shows that there is only one water resistance on this type of locomotive. A slight deviation has been made from the original design by introducing vertical tubes (seen in Fig. 7) in the water space. This is necessary on account of the greater output, and serves to produce a steady circulation of air, with consequent cooling of the water. The regulation of the water is effected by a device which is operated by the passage of the main current seen on the right of Fig. 8; this form of resistance has given very satisfactory results under working conditions.

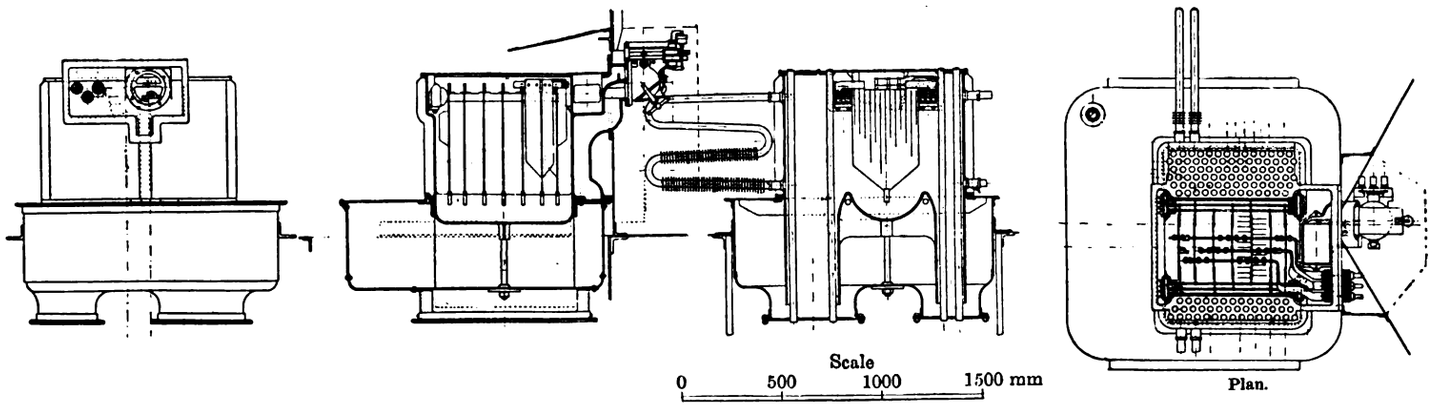

FIG. 7.—ARRANGEMENT OF WATER RESISTANCE.

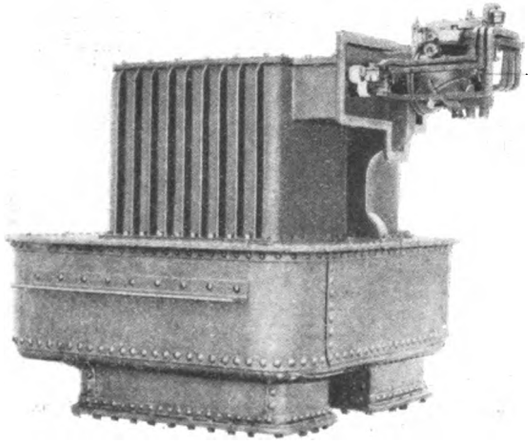

FIG. 8.—VIEW OF WATER RESISTANCE, SHOWING REGULATING ARRANGEMENTS.

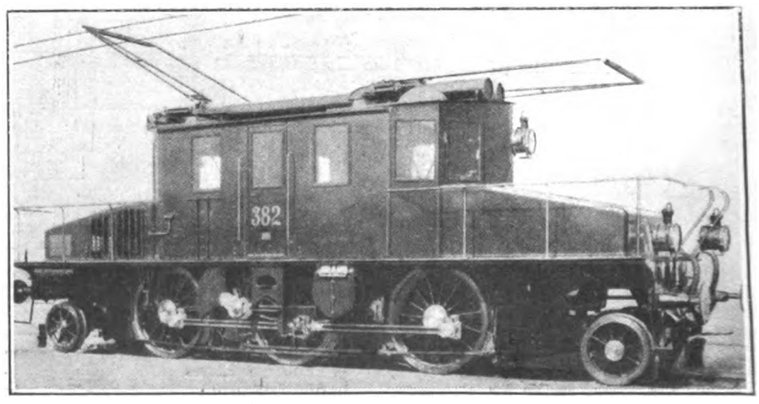

FIG. 9.—VIEW OF THREE-SPEED POLYPHASE LOCOMOTIVE.

The weight of the eight-pole motor is 13·4 tons, and of the twelve-pole motor 11·4 tons. As has been stated above, each phase of the motor has three windings, which can be arranged in series or in parallel; and for this purpose 18 ends are brought out from the

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If two locomotives of the same type and with driving wheels of exactly the same size are coupled together, the equal division of the load is simple enough, if polyphase current is used. But supposing the driving wheels to be of slightly different diameters, the load would be very unequally divided, seeing that with polyphase motors a very slight difference in the speed produces a large effect upon the output. Driving wheels will frequently differ in diameter by 2 or 3 per cent., and consequently there is some risk of the whole of the load being thrown on the one locomotive. About 8½ years ago on the Valtellina line an attempt was made to obviate this possibility by inserting resistances, which could be regulated in the rotor circuits. When the train was made up the difference in diameters of the driving wheels of the locomotives was noted; and a suitable resistance was then inserted in series with the rotor of the one which had the larger driving wheel so that at full load each did its share of the work. At smaller loads the division is not so exact, but no great importance attaches to this, seeing that neither is overloaded beyond its carrying power. On the newer type of locomotive a better arrangement has been devised by utilising the water resistance instead of inserting special resistances in the rotor circuits. A constant current in the motor corresponds to each position of the starting switch, and if the short-circuiting devices are put out of action, it is possible to regulate the output of the motor by means of the water resistance; and in this way, the load which is thrown upon the locomotive with the larger driving wheels can be regulated to any desired extent. Consequently, on this system, the load can be either controlled by the driver, who would then adjust the switch regulating the water resistance, or, on the other hand, the load on the locomotive having the larger driving wheels can be adjusted once for all, the balance of the working load therefore falling on the other one. The total weight of a locomotive of this type is 62 tons, and the adhesive weight is 42 tons.

Figs. 9 and 10 show a general view and drawings of the locomotives.

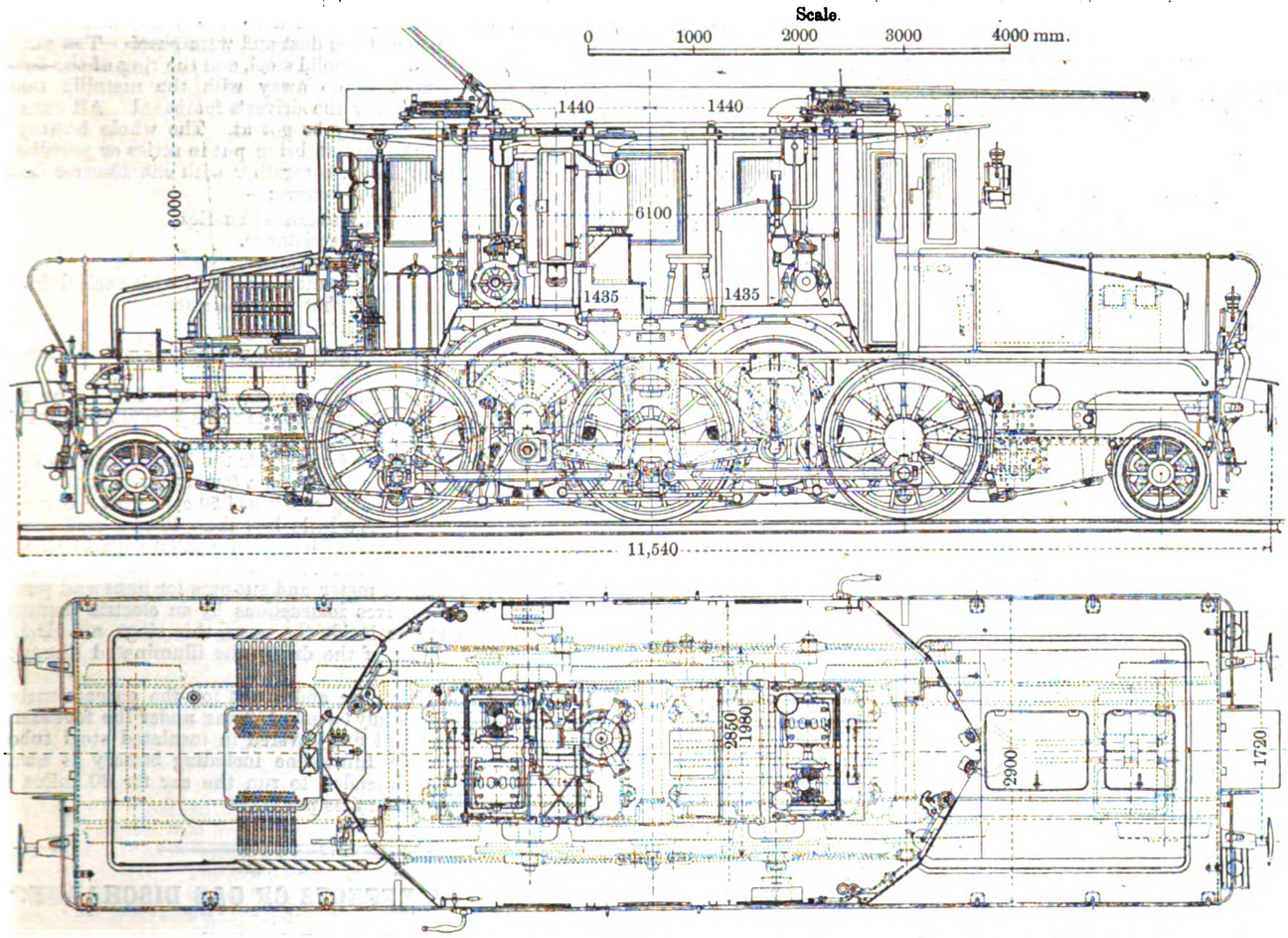

FIG. 10.—GENERAL ARRANGEMENT OF THREE-SPEED POLYPHASE LOCOMOTIVE OF THE ITALIAN STATE RAILWAYS.

CORDINGLEY'S MOTOR SHOW.—II.

Another petrol electric system exhibited in which accumulators are used is L'Auto-Mixte (Henri Pieper). A standard chassis and two vehicles with limousine body were on view, and, judging by appearances, attracted considerable attention. A four-pole shunt-wound dynamo, with interpoles, is driven by a four-cylinder petrol engine at speeds varying from 400 to 1,600 revs. per min., and the energy produced either charges the cells or drives the dynamo as a motor, or both. An interesting feature of the system is a solenoid governor acting on the engine throttle. A view of this is given in Fig. 1. The solenoid has shunt and series windings, the former being connected across the battery terminals and the latter in series with the cells. At starting, and when ascending hills, the battery supplies energy to the dynamo, which then runs as a motor, and in so doing the series winding of the governor solenoid neutralises the pull of the shunt winding and the counterbalancing spring opens the engine throttle, increasing the power developed. A reverse of these conditions also occasions the throttling of the engine, and while the engine is running the battery automatically adjusts the fuel supply to meet all the demands made upon it. A full description of the system appeared in *The Electrician*, March 3, 1906.

The Electric Vehicles Development Co. exhibited electric vehicles fitted with the "Vedrine" system of control. A single compound-wound motor is used and the battery is in two halves at the front of the vehicle behind the driver's seat. The usual drum-type controller is replaced by a pedal-operated multi-contact switch and a shunt rheostat actuated from a handle under the steering wheel. The pedal switch, when pushed forward to its fullest extent, gives a running speed of 5 miles per hour. All further increase of speed is obtained by the shunt rheostat, which is used to weaken the motor field. Provision is made for regeneration during braking and when descending hills. The motor is suspended on the rear axle, and drives it through helical gearing. The makers claim that their control method economises the energy of the battery, and in a catalogue distributed at their stand it is stated that a four-seated vehicle travelled at an average speed of 17 miles

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per hour 124 miles, between Paris and Trouville, without recharge. The publication is discreetly silent as to the condition of the cells after the run. Some interesting figures are, however, given comparing the operating costs of electric and petrol cabs, the figures being based on the Berlin experience of Mr. Thien with electric cabs.

These figures seem to be exceptionally low, and in the original pamphlet they are given to six and eight places of decimals, but we think our readers will be content with three places in the present state of the industry.

	"Vedrine" electric cab. Farthings.	Electric cab. Farthings.	Petrol cab. Farthings.
Depreciation	2·372	2·372	3·089
Maintenance of the accumulators	0·988	1·920	—
Power (current)	1·649	2·653	3·830
Tyres	2·780	2·780	3·089
Repairs	0·618	0·960	1·536
Oil, &c.	0·062	0·080	0·383
	8·470 equal to 2·12d.	10·765 equal to 2·69d.	11·927 equal to 2·98d.

These vehicles are fitted with voltage control from a sub-divided battery, and it is claimed that with the Vedrine system the comparison would favour the electric vehicle even more, as will be seen from the table. A four-seated vehicle has been run to Brighton with full load, a distance of 50 miles, on one charge of the battery. A net saving of 7½ per cent. over other methods of control is claimed for the Vedrine system.

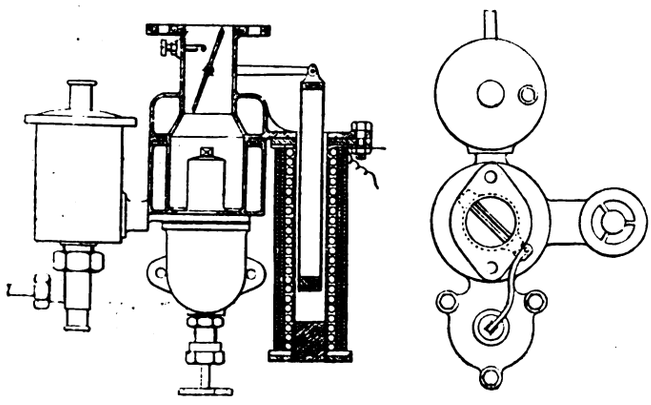

FIG. 1.—SECTION AND PLAN OF SOLENOID THROTTLE GOVERNOR ON AUTO-MIXTE CAR.

The Scheele Electric Carriage Co., of 41, Grosvenor-mews, New Bond-street, exhibited, amongst other electric carriages, the first electric Limousine. This car, which is shown in Fig. 2, was very well finished, with accommodation for seven to nine persons seated inside and two on the box. The battery is placed in front with a bonnet over it, thus giving the appearance of a petrol car. The drive is by two 8-H.P. motors fixed to the back axle, each driving one wheel by single-reduction gearing. In these motors, which are the result of many years' experience, the armature is ventilated, the coils are of copper strip and the construction is such that the spindle carrying armature and commutator can be removed by taking off a single nut. The motor has four poles which are laminated. The armature spindle runs in strong ball bearings. The motors are fixed on the back axle inside the frame at such a height that it is easy at any time to inspect brushes and commutator, and by loosening one thumbscrew only the cover can be removed. The motor is so sealed that it is impossible for any matter to enter, but any condensation of moisture in the atmosphere is drained off by means of ball valves fitted at the lowest parts of the motor casing. Each motor is sufficiently powerful to drive the car alone at a reduced speed. The armature spindle carries a pinion gearing with crown teeth attached to the road wheel. This gearing is covered in so as to be dust and waterproof. The pinion and crown teeth are cut out of solid steel, and the ring of the latter is filled in with cement to do away with the metallic noise. The controller is fixed under the driver's footboard. All connections are strong and can easily be got at. The whole battery is used always in series, the motors being put in series or parallel to give six driving speeds forward, together with one electric brake and three speeds backward, as follows:—

I. Armatures, fields and resistance in series.
II. The same, but with less resistance.
III. The same, but without resistance.
IV. The same, but with resistance in parallel with each field.
V. Both motors in parallel, but with resistance.
VI. The same, but without resistance.

Electric brake. Both motors as generators short-circuited through resistance.

The reverse speeds are similar to I., II. and III. The first speed gives 4 to 5 miles per hour and the top speed is 25 miles per hour.

The whole battery, being in front under the bonnet, can be lifted out and exchanged for a charged one in a few minutes, or it can be charged on the car. The battery consists of 50 cells with a capacity of 216 ampere-hours, weighs a little less than 18 cwt. and can be fully charged in 4½ hours. The Limousine is fitted with 11 electric lamps, six in front, four inside and one at the back. In front of the driver is a volt and ampere-meter and cut-outs for light and power circuits. The driver receives instructions by an electric arrangement worked by a button inside the car; this rings an electric bell outside, and in front of the driver the illuminated direction appears.

Battery fuses, charging plug and shunt for the ampere-meter, light fuses and plug can easily be got at, being under the footboard. All wires are well insulated and covered in insulated steel tubes. The weight of the whole Limousine including battery is about 2 tons. The battery is intended to run the car for 60 miles at least, with a speed up to 25 miles per hour.

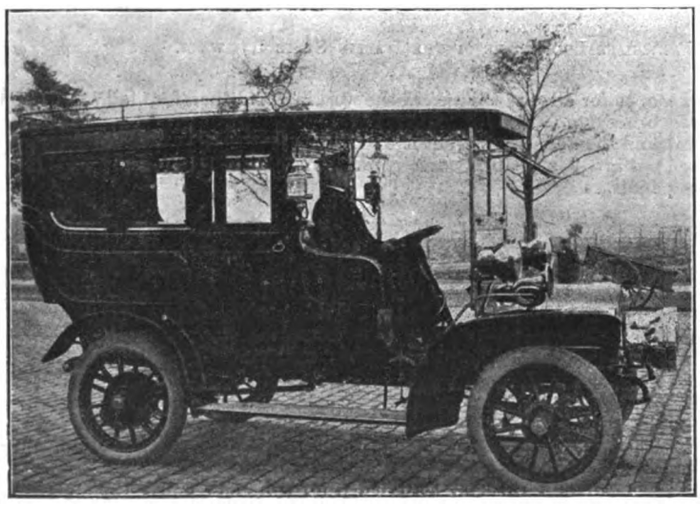

FIG. 2.—ELECTRIC LIMOUSINE, BY THE SCHEELE ELECTRIC CARRIAGE CO.

CHEMICAL EFFECTS OF GAS DISCHARGE.*

BY REV. P. J. KIRKBY.

When electricity is passed through a mixture of hydrogen and oxygen at low pressures, some of the molecules of the two gases are broken up into uncharged atoms, and these intermingle and give rise to the formation of water without any ordinary chemical action. The number of water molecules thus formed is proportional to the amount of electricity passed through, a fact which recalls Faraday's laws of electrolysis. The chemical action is greatest in the region of the cathode fall of potential, where there is a congestion of positive ions. To obtain some accurate quantitative data, the author examined the amount of water produced over a distance of 1 cm. This amount is too small for observation when the steady current is applied with the help of ultra-violet light. It is necessary to employ a glow discharge in order to get a measurable effect. The difficulty in this case is to find a cubic centimetre of uniform field, but the author finds this in the positive column, which is practically uniform near the anode.

The author used a Torricellian vacuum maintained by a mercury pump and furnished with a MacLeod gauge. The cathode was of zinc and was carried by an iron wire made air-tight in the glass by means of a mercury cap.

By keeping the current and pressure constant the potential difference between the electrodes is made a function of the distance between them. Hence, if with the distances between electrodes as abscissæ and P.D.s of electrodes as ordinates a curve is constructed corresponding to a constant pressure and current, the electric force

* Abstracted from the *Philosophical Magazine*, March, 1907.

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in the positive column corresponding to that pressure and current can be determined by the final slope of the curve when the curve becomes straight.

The chemical reaction in the positive column should be exhibited by a similar method. For the chemical reaction, represented by the fall of pressure Δp, is proportional to the quantity of electricity ΔQ passed during the discharge, the circumstances of the discharge being constant. Accordingly, $\Delta p/\Delta Q$ should be a function of the distance between the electrodes when the current and pressure are constant. This will certainly be the case if the author's hypothesis is correct that the chemical action is the outcome of the dissociation into atoms of the molecules of the gas by the impacts of the gaseous ions, for the motion of these ions is wholly determined by the electric force. If, then, a curve is plotted whose abscissæ are the distances between the electrodes, and whose ordinates are the values of $\Delta p/\Delta Q$ for a given pressure and current, the chemical reaction per centimetre in the positive column would be determined by the final slope of the curve, if the curve becomes ultimately straight.

To construct such curves the author found the chemical effects of passing the same current through hydrogen and oxygen at the same pressure, but with different distances between the electrodes, and determined the corresponding P.D.s of the electrodes.

The apparatus held 840 c.c. of the gaseous mixture.

The results show that when the distance between the electrodes is large the weight of water formed per coulomb passed through the gas is greater for the lower pressures than for the higher. Thus the amount of the chemical reaction is by no means proportional to the concentration of the gases. On the contrary, the amount of the reaction per coulomb is absolutely increased, and very substantially increased, by diminishing the pressure down to abont 1·4 mm. provided that the distance between the electrodes exceeds a certain value. When the pressure falls below 1·4 mm., the reaction per coulomb becomes less. The greatest effects were observed at 1·4 mm. pressure.

The author shows that the phenomena presented by the forms and relative positions of the curves can be completely explained on the hypothesis that the ions moving swiftly under the electric force dissociate into uncharged atoms those molecules which they strike under favourable conditions and with sufficiently high velocity.

When the current exceeds a certain small value, then, according to Townsend, there is an intense field of force near the cathode—namely, the region of the cathode-fall of potential, where ions are generated by the impacts of both positive and negative ions upon the neutral molecules of the gas. From this region of intense force—due to the accumulation near the cathode of the more slowly moving positive ions—the potential rises more gradually up towards the anode; and the electric force tends to become more uniform if the distance between the electrodes is great enough. In the case of a gas where no chemical action takes place far fewer positive ions than negative pass through the positive column per second. Any chemical action that occurs in the positive column is exclusively due to the impacts against the gaseous molecules of the negative ions (electrons). The electric force in the positive column is independent of the distance between the electrodes provided that the distance is great enough to allow the positive column to be established.

The chemical action cannot be due to any positive ions generated by collision within the positive column. If it were, the chemical action would be proportional to the square of the length of the positive column. Hence, unless positive ions are generated near the anode in large numbers, the chemical action within the positive column must be attributed exclusively to electrons; and then it is easy to calculate the number of molecules of water which result from the motion of a negative ion through a centimetre of the positive column.

Let W denote the number of molecules of water whose formation is the effect of the motion towards the electrodes of each pair of ions. Then the author shows that with his apparatus $W = 3\Delta p/\Delta Q$ almost exactly. For let N be the number of molecules in a cubic centimeter of gas under normal temperature and pressure; then, in a vessel of capacity S, a fall of pressure Δp means the disappearance of $N \times S \times \Delta p/760$ molecules, while ΔQ coulombs is carried by $\Delta Q \times 3 \times 10^9/e$ ions, e being the electrostatic charge on each. Since, according to Townsend, $Ne = 1{\cdot}22 \times 10^{10}$, and S = 840 c.c. in this case, the number becomes $4{\cdot}5\ \Delta p/\Delta Q$ But three molecules of hydrogen and oxygen go to form two molecules of water. Therefore $W = 3\Delta p/\Delta Q$.

The author is willing to admit that positive ions also take part in the chemical action to some extent. It would leave his explanation untouched.

He applies the above numerical relation to an estimate of the work required to dissociate a molecule of oxygen. The mean free path of an electron at 1 mm. pressure in a mixture of hydrogen and oxygen may be taken to be $\frac{1}{8}$ cm. At a pressure of 4·5 mm. an electron will, therefore, make 36 collisions in passing through a centimetre. During this passage it dissociates enough molecules of the gas to produce 0·75 molecule of water. If we assume that to be the result of dissociating 0·37 molecule of oxygen, it follows that one dissociating collision occurs out of nearly 100 collisions made by a negative ion in moving through the mixed gases at pressure 4·5 mm. and under a force of 50 volts per centimetre. Now one free path out of 100 is very nearly 4·6 times the mean free path, which, for a negative ion in the case under consideration, is $\frac{1}{36}$ cm. It follows that to dissociate a molecule of oxygen cannot require more energy than that due to a fall of a negative ion through a potential difference of $\frac{50}{36} \times 4{\cdot}6 = 6{\cdot}4$ volts. And since the charge on an electron is nearly 3×10^{-10} in electrostatic units, the work required to dissociate a molecule of oxygen cannot exceed $6{\cdot}4 \times 10^{-12}$ ergs, and this may be several times the actual work required.

Townsend has shown that the energy required to break up a molecule into ions is not greater than that gained by an ion in moving freely down a potential fall of 5 volts. Now the experiments recorded in this paper and previous papers prove that the breaking up of a molecule into atoms needs the expenditure of less work than the breaking of it up into ions, for the ions are generated by the collisions of the moving ions with the molecules of the gas, and at least five times as many molecules of water were always formed as pairs of ions. Hence the superior limit to the work involved in separating the atoms of a molecule of oxygen may be fixed at 5×10^{-12} ergs.

DIURNAL DISTURBANCES IN EARTHED WIRELESS TELEGRAPH SYSTEMS.*

BY K. E. F. SCHMIDT.

The system used had at its receiving end, where all the observations were made, an air-wire about 80 metres long with its upper insulated end suspended at a height of 41 metres from a building. A tuning coil, a capacity of 2,000 cm. and a sensitive barreter completed the receiver, which was earthed by connection to the town water-mains. The waves from a sending station distant 3·5 km. were used and were kept as constant in intensity as possible. After a number of preliminary experiments records were systematically made at four different times of day, namely between five and seven o'clock morning and evening and between twelve and two noon and midnight. The experiments carried out at these times consisted in moving the air-wire contact to a number of definite points of the tuning-coil and observing the galvanometer deflection at each. In other words, the resonance curve of the system was obtained at the stated times, and not once merely, but as often as possible in the time allotted.

The results show that the points obtained in plotting deflections against number of turns of tuning-coil in circuit lie, for the five o'clock to seven o'clock experiments, as a whole, close to a definite curve; but for the ten o'clock to two o'clock experiments the points obtained depart widely from the ideal curve—that is, very various deflections are obtained for the same length of tuning-coil in circuit. Thus some kind of disturbance is strongly in evidence about noon and about midnight.

Similar experiments performed when a balancing capacity was used, instead of an earth, give, on the contrary, much the same results at all times, so far as the variations here under consideration are concerned. It may be noted that this fact shows that the intensity of the radiation from the sending station is tolerably constant, and, therefore, that the variations discovered to exist with the earthed system are not attributable to variations in the energy despatched.

The double daily period just described is found to be very similar to certain periodic changes in the natural electric-displacement currents described by Zölss (*Physikalische Zeitschrift* 5, 1904). These currents are presumably connected with the movements of the ionised "ground air" in the soil, a phenomenon which has been studied by Elster and Geitel and others.

* Abstracted from the *Physikalische Zeitschrift*.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"City of London Directory." 1907. (London: W. H. & L. Collingridge.) 12s. 6d.

"Transactions of the American Electrochemical Society." Vol. X. 1906. (Philadelphia: The Society.) $3.00 net.

"Bulletin des Séances de la Société Française de Physique." 1906. (Paris: La Société.)

"Transformatoren für Wechselstrom und Drehstrom." By Gisbert Kapp. 3rd edition. (Berlin: Julius Springer.) 8m.

"Commutatrices et Transformateurs Électriques Tournants." By Jean Paraf. ("Enclyclopédie Scientifique des Aide-Memoire." Edited by M. Leáute.) (Paris: Gauthier-Villars.) 2fr. 50c.

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With the number of THE ELECTRICIAN for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with THE ELECTRICIAN. The eighth issue of the Supplement was published (Gratis) with the number of THE ELECTRICIAN for April 5th.

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The last of the Series of seven comprehensive Tables of Statistical and Engineering Data relating to Electricity Supply Undertakings of the United Kingdom for Lighting, Power and Traction, which are published annually with "The Electrician," was issued (Gratis) with the number of "The Electrician" for February 1st, and with the number for February 15th was published as a Supplement (Gratis) an Index to these Tabular Sheets. This Index enables easy reference to be made to the Tables, which are copyright.

These Tables have now been carefully corrected, and are obtainable complete in compact book form, printed on hard paper, price 3/-, post free 3/6. (The Set includes a good list of British Colonial Electricity Supply and Tramway Undertakings.)

SPECIAL NOTICE.

Last week's number of "THE ELECTRICIAN" completed Vol. LVIII. With next week's number will be issued (Gratis) the Index to the Volume.

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Cases for binding Vol. LVIII. are now ready, price 2s.; post free, 2s. 3d.

THE INSTITUTION WIRING RULES.

Once again a new edition of the wiring rules of the Institution of Electrical Engineers has been issued, and this, the fifth edition, marks the most serious attempt yet made to provide rules which may be adopted as the standard. For this instalment of their work the Wiring Rules Committee has been strengthened by including among its members representatives of the Municipal Electrical Association, the Electrical Contractors' Association and some of the principal Fire Offices. It is, therefore, to be hoped that we may yet see the day when Fire Offices will abandon their rules and even when the well-known Phœnix Fire Office Rules will cease to have any useful existence, for the electrical profession indirectly has every reason to avoid risks of fire from electrical work. We are also glad to note that the Wiring Rules Committee has been appointed a standing committee, which will consider any specific amendments that may be made from time to time, so that developments in the electrical industry will not be lost sight of.

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In looking over the new edition which has just come to hand, we find that a good deal of rearrangement has taken place and several important modifications have been introduced. The rules are no longer regarded as applicable to pressures exceeding 250 volts, and therefore for higher pressures reference is made to the Board of Trade Regulations. For ease in reference, these Regulations, together with the Home Office Rules for the Installation and Use of Electricity in Mines, have been included in the pamphlet.

The introductory part of the rules has been somewhat expanded, and includes additional rules which are already well recognised, such, for example, that radiator circuits must be protected by separate D.P. fuses; that arc lamps, Nernst lamps, and connectors must not be used where there is inflammable dust; and that, under such conditions, incandescent lamps and their holders must be enclosed in air-tight fittings of thick glass. The section on the size and conductivity of conductors remains practically unaltered, though the first clause as to size is a little ambiguously worded; we think, also, it would be well to prohibit the use of single wire for wiring installations.

In the section dealing with the insulation of conductors there has been considerable change, the most important being the tests specified for cables with rubber dielectric. According to the old rules, the test piece of insulated cable was immersed in water for 24 hours, and, while still immersed, was subjected to a pressure of 2,000 volts between the conductor and water for 10 minutes, and prior to immersion the test piece was bent six times (three times in either direction) round a smooth cylindrical surface having a diameter not more than 12 times that of the finished cable. This test has now been revised by omitting the bending part of the test and by increasing the duration of the pressure test to half an hour, the frequency to be 50, and the E.M.F. curve to be as nearly as possible a sine wave. In the case of flexibles, these, according to the old rules, were to be tested by twisting two sample lengths together, and applying for ten minutes a pressure of 1,000 volts alternating at a frequency of 40 to 100 between the sample lengths, at the same time subjecting them to the vapour arising from a pan of boiling water placed in position 10 minutes before the beginning of the test. The boiling water has now been dispensed with, and the test varies according to the nature of the insulation. If of pure rubber, the flexible is tested for 15 minutes with a pressure of 1,500 volts alternating between the conductors at a frequency of 50. But if vulcanised rubber is used for the insulation then the same test is applied after the flexible has been immersed for 24 hours in water, and while still immersed. Details of insulation of conductors is given in a table which has been extended beyond that given in the old rules, and which now includes details of flexibles.

Greater latitude is allowed in the fixing and protection of conductors than hitherto. Bunching is still allowed in wood casing for conductors carrying not more than 5 amperes, though it is difficult to see the logic of this permission. What is more important, however, is that conductors may, where not exposed to injury, be used without mechanical protection, being supported (not necessarily on insulators) so as to obtain permanent spacing from walls, ceilings and metal work. If the conductors carry more than 5 amperes they must be separated from each other as well. This clause is one that may require a little watching, as some contractors might possibly construe it into a permission to use unprotected circuits in the roofs of dwelling houses. A section is also devoted to the use of bare conductors for travelling cranes, locomotives, battery connections, &c., which, of course, is common practice.

Among the minor items we notice that in the case of switches for more than 5 amperes at pressures above 125 volts metal covers must be lined with insulating material, and that ceiling roses, unless specially designed for multiple pendants, must not be used for attachment to more than two pairs of flexibles. The overload capacity of fuses has been fixed at 200 per cent., which seems too high.

In dealing with the important subject of earthing steel conduit, the rules do not seem to be quite consistent. In clauses 24 and 46(*a*) it is stated that where metallic sheathing or tubing is used it must be electrically and mechanically continuous and connected to earth; whereas in clause 46(*a*) we find also that in dry places isolated single lengths of tubing need not be earthed if adequately enamelled, or otherwise insulated, externally. We presume that the latter must refer to the use of lengths of conduit occasionally with wood casing, but we find it difficult to define what is meant by adequate enamelling. There are, of course, two main reasons for earthing, the one being so that fire risks may be minimised, and the other so that shocks may be rendered impossible. But neither of these reasons are necessarily sufficient for universal earthing. The idea, from the fire point of view, is that if the insulation breaks down there will be a short circuit to earth, via the conduit, which will blow the fuse. But actually this does not always result, because the breakdown may be so situated that the current must traverse some lamps before reaching earth, in which case no fuse will blow. From the point of view of shock, on the other hand, if a conduit is continuous throughout and earthed it cannot possibly be of any danger, but since no shock will be felt in any case in dry situations there seems to be no reason for earthing, either on account of fire or shock, in such places. In damp places, of course, earthing is essential on account of shock. Defects, however, are often matters of detail; thus the ordinary branch switch can very well be a source of danger, under certain conditions, if not of such a kind that its casing in reality forms part of the earthed conduit. The same remark may be made as to plain pendants, and it might have been well to have given a word of warning as to the placing of switches and fittings in bath rooms of private houses, for a bath is apt to be exceedingly well earthed at times. Finally, we think a little more importance might have been attached to the style of earth connection than to specifiy that it shall be of copper and of a sectional area not less than that of No. 14 S.W.G. If an earth connection is made merely by a wire, it is apt to be removed in due time by some enterprising person who will regard it either as a useless absurdity, or as a piece of good material singularly wasted. Where an earth connection is of real importance it should be made solidly, and labelled as such. Possibly the Committee may consider such points as these for the next edition, which will doubtless be required in due time.

In our next issue we hope to deal with the rules in greater detail.

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MAJOR W. A. J. O'MEARA, C.M.G., R.E.

It is announced that Major W. A. J. O'Meara, C.M.G., R.E., has been appointed Engineer-in-Chief to the Post Office, in succession to Mr. J. Gavey, C.B., who retired from that position on the 15th inst.

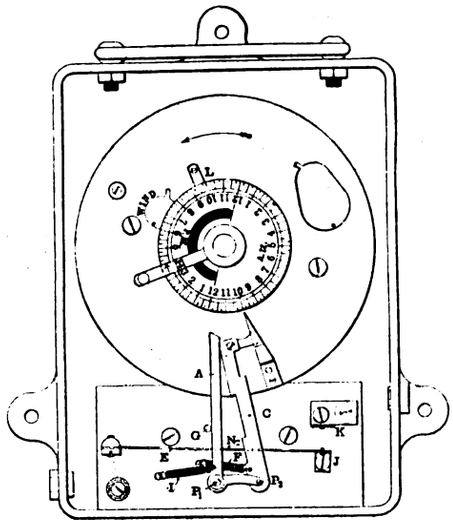
Major O'Meara was born at Calcutta on January 28, 1863, and after having been educated privately in England, entered the Royal Military Academy at Woolwich in November, 1880. He was gazetted a lieutenant in the corps of Royal Engineers in February, 1883, and was awarded the Fowke medal for Architecture on completion of a two years' course at the School of Military Engineering at Chatham. In March, 1885, he was posted to the 2nd (Telegraph) Company Bengal Sappers and Miners, and served in the Burmese war of that year. Mr. O'Meara soon afterwards joined the 5th Company of the same corps and was employed on the lines of communication of the expeditionary force to Burma. During this campaign, dacoits were frequently hunted, and in one of these raids Mr. O'Meara was so severely wounded that he had to abandon all idea of an Indian career and was invalided home. For his services in this campaign he was mentioned in despatches and received a medal. As soon as he was convalescent he was posted for duty at Portsmouth, and in May, 1889, was transferred to the 2nd (K) Telegraph Company R.E. for employment under the Postmaster-General. He remained on this duty till 1894, and among other work superintended the construction of the London–Paris telephone trunk line from London to St. Margaret's Bay. In July, 1894, he proceeded to South Africa for a tour of foreign service. He returned to this country in December, 1896, and studied for two years at the Staff College, where he passed successfully through the course. When the Boer war broke out Capt. O'Meara was in Kimberley and became senior officer on Col. Kekewich's staff. During the defence of Kimberley he not only undertook the duties of Chief Staff Officer, but also those relating to intelligence, telegraphs, and press censorship. After Kimberley was relieved he was attached to the Cavalry Division and proceeded to Paardeberg. He was at Army Headquarters during the last attacks on Cronje's laager and witnessed the surrender of the Boers on Majuba Day, 1900. He saw considerable service in Bloemfontein, and was promoted to his majority when Johannesburg was occupied. He was directed by the military authorities to take over the control of the municipality, and administered the affairs of the town single-handed for 11 months. In 1901 Lord Milner appointed Major O'Meara Government Commissioner for Johannesburg and district. After 2½ years' continuous service in South Africa Major O'Meara returned to England and was offered the post of Assistant Engineer-in-Chief at the General Post Office. He resigned his position in the Transvaal and took up these duties in April, 1902. He has occupied this appointment till his recent promotion to Engineer-in-Chief.

THE BUILDING EXHIBITION.

The number of electrical exhibits at the Building Exhibition now open at Olympia is not as great as it might have been, though it is probably sufficiently representative. To architects and surveyors the chief matters of electrical interest are connected with lifts, pumps, lighting and heating, also bells, fire alarms and intercommunication telephones. The electrical exhibits are indiscriminately dotted about the exhibition, but this is, if anything, an advantage, because the presence of an exhibit differing materially from those generally met with tends to increase the interest in that particular exhibit. In the classified section of the catalogue electricity is barely referred to, and such appliances as lifts, motors, lamps and pumps have to be sought under their respective headings.

The electric lift section is fairly well represented, and includes R. Waygood & Co., who have a large stand in the main hall, on which they show specimens of motor-driven builders' friction hoists and winches, a model of an automatic push-button passenger lift, and a large lift which is running to convey visitors to the gallery directly above the stand. This lift is driven by an 8 B.H.P. motor, and is operated from a small drum-type controller in the car. It has a carrying capacity of 10 passengers and works at a speed of 150 ft. per minute. The motor is started from a solenoid controller placed on the same bedplate as the winding gear. The controllers and resistances are manufactured by Messrs. Waygood. We understand that considerable interest has been taken in the small hoists and winches, which are very useful during building operations where electric power mains are available. Richmond & Co. show a working model of their patent push-button automatic electric lift (described in *The Electrician* for May 22, 1903,) and Medway's Safety Lift & Elevator Co. a number of electric lifts of their own make. These include a push-button service lift, an electric friction hoist, and the latest pattern direct-coupled lift gear mounted on a single cast-iron bedplate. These gears are suitable for control either by hand switch, rope or push buttons. Carl Flohr, exhibits a small electric push-button service lift. This is shown in operation, and the arrangement provides that when the doors opening on to the lift at the various floors are open the lift cannot be started. Similarly, when the lift is running the doors cannot be raised. On the same stand the electric riveting machine and portable control described in "The Electrician" INDUSTRIAL SUPPLEMENT for March, p. 289, are shown in operation. The riveting machine, it will be remembered, is driven by a small motor, and a push switch closes the circuit of a magnetic clutch which couples the motor to a coarse screw operating the riveting arm. The riveting is done cold, and the rivets are inserted from the top of the work.

An interesting exhibit of time switches is made by Venner & Co. in the Annexe. These include a complete range of switches for a large variety of purposes. A pattern for switching off only is shown, in which a substantial clock is fitted with a switch to carry up to 10 amperes in a neat box. When the switch is on, a simple catch engages with a pin on one of the switch arms and the other



INTERIOR VIEW OF VENNER TIME SWITCH FOR TWO-RATE METERS AND SMALL CIRCUITS.

end of this catch is extended behind the clock to a position which is within the travel of a release which is operated by the clock itself. When this comes into action, at a time which can be adjusted to any desired period, a chattering is set up which causes sufficient vibration to knock out the switch. Other time switches for making and breaking circuits at certain desired hours are enclosed in iron cases with carrying handle. We give an illustration of type B, which may be taken as fairly representative of this series of switches. It is intended for use with two-rate meters, or for circuits where the current does not exceed 1½ amperes. The action of the switch is as follows: The bell-crank lever A is pivoted at P_1, and the detent lever C is pivoted on to A at P_2. When the hand H of the clock engages with A, the latter, in being moved to the right, causes C to descend until the detent is below the projection N_2 on strip E, against which it is pressed by spring F. At this moment H releases A, which is returned to its original position against stop G by the spring I. In this position it carries C up again and E with it, thus making rapid contact with K. Later when the hand L engages with C, the latter is pushed away from E, which springs back rapidly to J.

Where heavier currents are dealt with, mercury contacts are fitted for the make and break. The principal elaborations of this form of switch provide for the introduction of certain selective devices. One of these arrangements is such, that should the switch be in use with a two-rate meter it will not operate on Sundays and early-closing days. The adjustment for this can be made quite easily by slackening a milled nut on the dial provided for the purpose. The switches are also made with a throw-over action for

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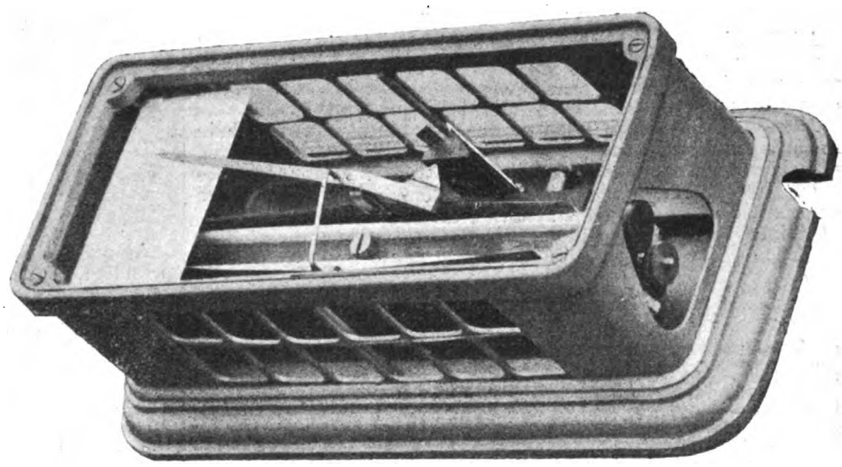
closing the circuits of arc and glow lamps respectively in cases where the street lighting is done from the distributing network. The mechanism is constructed to switch on the arcs at dusk, to switch them out at midnight, or any other time, and to switch on the incandescents at the same moment. At dawn the switch will also turn off the incandescents and the cycle of operations can be again repeated. The clocks fitted to these switches have a good quality movement with jewelled pallets, lever escapement and fusee drive. They will run over 40 days on one winding and are guaranteed non magnetic and dustproof. The clock movement is also insulated from the switch parts.

On the same stand was shown the Chamberlain & Hookham electrolytic meter which is made for 2½ and 5 ampere circuits. This is a non-chemical meter and depends for its action on the decomposition of water. It is stated that the drop across the meter terminals does not exceed 1 volt. An interesting meter intended for use in miners' cottages or installations where the expenses of a prepayment meter cannot be incurred was also shown. This is a standard C & H meter, but the counting train is fitted with an extra dial which registers the actual amount due from the customer in shillings. The meter reader collects the amount registered on the dial at certain periods, say once a week. This arrangement removes the temptation to break into prepayment meters which have been in operation for some little time, and may possibly contain a large quantity of money. The meter is provided with a simple resetting device by which the cash dial can be turned back to zero without interfering with the energy reading of the meter.

Dust-destructor exhibits were much in evidence and apparently excited considerable interest. Messrs. Heenan & Froude were showing a large model of their patent destructor arranged in sections to show the construction of the cells. We were informed that this is the first occasion upon which a model of a complete destructor installation has been shown. The model included the induced draught fans, the water-tube boilers and the inclined roadway to the tipping floor. This model was supplemented by large drawings of the destructor. We inspected these and were shown the special arrangements made in the destructor house by which the fans extract any foul air or fumes which collect in the building, from under the roof, and draw this into the furnaces where it will be consumed. By these means the fans provided for the boiler draught also serve the purpose of keeping the building well supplied with pure air. Messrs. Meldrum Bros. exhibited a full-sized Koker stoker and grate and also Meldrum's patent boiler furnaces of standard and low grade fuel types respectively. The exhibit also included models of regenerative destructors as built for use with electric power plants. One of these models is built of sections of aluminium which have been cut out of the solid. In addition to these exhibits there is a large selection of framed photographs showing various installations of Meldrum destructors, stokers, and furnaces in all parts of the world. We were informed by Mr. W. F. Goodrich, whom we saw at the stand, that the company has been recently given an order by the municipality of Seattle, Washington, whose engineer had inspected the best known forms of American and European destructors and finally decided on a Meldrum equipment without asking for further tenders. The Horsfall Destructor Co. (Ltd.), Leeds, also exhibited models of their latest patent system of tub feed-destructor. With this system the refuse is discharged from carts into a storage tub in a pit on the floor level. This tub has a hinged bottom, which is held shut by the suspending rods. The tub, when full, is lifted by an overhead travelling crane and stored until required. When a cell is charged a full tub of refuse is placed on a movable hopper on the top of the cell. The weight of the tub causes the hopper to descend. The charging door is lifted from its seat and pushed on one side, permitting the movable hopper to descend into the mouth of the hole. The crane continues to lower and the hinged bottom of the storage tub opens and the load is shot into the furnace. The refuse falls upon a slope of brickwork, which spreads it naturally over the grate, the thickest part being at the rear. No raking or pulling down is required. This type of cell is also fitted with the "Horsfall" latest side boxes and clinkering doors, the latter carrying an inspection door through which the trimming and management of the fires can be accomplished without opening the main door. Other exhibits on this stand include a forced draught smoke consuming furnace, a centrifugal dust catcher and a crushing and screening machine. The exhibit is well furnished with photographs of "Horsfall" destructor plants in all parts of the world. Another destructor exhibit was that of Messrs. Hughes & Sterling, Arundel-street, Strand, W.C. This comprised a new model of the latest type "Sterling" refuse destructor ($\frac{1}{12}$ in. full size). The system employed deals with the refuse by a travelling crane and buckets, which feed a large storage hopper over each cell. The hoppers will contain a day's supply of refuse. The capacity of the plant shown is from 30 to 40 tons of ordinary house refuse per day of 24 hours. The refuse storage bin, the sliding doors, and the special doors on the top of the furnace are in working order, so that the whole cycle of operations could be clearly demonstrated.

Messrs. Matthews & Yates, of Swinton, Manchester, have a small exhibit of their ventilating specialities, which include electric fans, blowers and exhausters. A working model of the "Cyclone" separator for the extraction and collection of shavings and sawdust was shown in operation. The adjoining stand is an exhibit of woodworking machinery, and the planers and saws are connected by pipes to the cyclone exhauster which feeds the separator. The exhauster is direct driven by a small motor, and the feed from this is connected to the separator, which is arranged to deposit the shavings and sawdust without air. A complete installation of this system has been recently put down for Maddock & Tunaley, of Manchester. Both the alternating-current and direct-current motors for these fans are manufactured by the company at the Swinton works.

An interesting exhibit of electric fire-alarm systems is made by Messrs. Stuart & Moore, of Ealing. The main feature of the exhibit is a complete fire-station board arranged on the central-battery system for connection to a number of street-call stations. The board is wired after the latest method of telephone exchanges, and the panels are hinged to swing forward for the inspection of the connections. The main-station board shown contains a section for calling up the firemen in the station and a section for the hand testing of the various outside circuits. The system provides that



STUART & MOORE AUTOMATIC FIRE ALARM WITH COVER REMOVED TO EXPOSE INDICATOR. Testing button is at right hand side.

when a call is received from a street box the man in charge answers on the telephone, and on receiving the location of the fire he pulls down the handle of a special switch, which throws on the station lights, rings the alarm bell, releases the stable doors and the horses from their stalls. The opening of the stable doors is accomplished by the electromagnetic release of a suspended weight. This weight is hung up on a special hook, and in falling it releases a catch on the stable doors. Special switches are fitted to the board for bringing in the station lights. On the same stand a new form of automatic adjustable fire alarm was shown. This is fitted with a simple device by which the temperature for the closing of the alarm circuit above a certain normal can be adjusted. The device depends for its operation upon the unequal expansion method. The thermostat consists of two thin hard-rolled copper plates slightly curved, and mounted one on each side of a heavy bar of the same metal. Non-conducting material is interposed to prevent the radiation of heat from one to the other. At one end both plates are attached to the heavy copper bar, and at the other extremity they are mounted on a block sliding in guides attached to the central bar. A contact arm is pivoted at the centre of one of the copper plates and from a point in the arm near the pivot connection is made to the centre of the other plate in such a way that any elongation and consequent curving of the plates rotates the arm and forces it against the contact springs. Any abnormal rise of temperature at once causes the copper plates to expand, and being held firmly at either end they take up a different curve, and their centres, to which the contact is attached, move apart in corresponding ratio, rotating the arm and sending in a signal. The heavy copper bar is prevented by its greater mass and the protection of the non-conducting shields from expanding at the same time, but in the case of normal and gradual variations of

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temperature from day to day, this absorbs sufficient heat to increase it own length by exactly the same amount as the thinner plates, and, the relation remaining the same, the instrument is unaffected and adjusts itself to the new conditions.

The contact piece is V-shaped, and this enters between two parallel insulated springs in such a way as to produce a rubbing contact. The motion given to the arm by the rise of a few degrees is so great that ample clearance may be allowed between the contact pieces when the instrument is at rest, while good contact is assured when operated. At the other end of the contact arm is a pointer working over a scale on which the increase of heat necessary to actuate the instrument may be read in degrees. The adjustment is made by a milled-headed screw by which forward or backward motion may be given to the sliding block to which one end of each of the plates is attached. This movement has the same effect as the expansion or contraction of the plates and the contact arm rotates accordingly, the pointer indicating at any position the number of degrees of rise required to give a signal. The instrument is made in copper, brass and phosphor-bronze, the contacts are of silver, and will not deteriorate through exposure to damp. The parts are enclosed in a substantial iron box with openings to allow of free access of heat.

ON THE VOLTAGE BETWEEN COMMUTATOR SEGMENTS AND THE CRITICAL SPEED OF SHUNT-WOUND MOTORS WITH WIDE RANGE OF SPEED CONTROL.*

BY W. OELSCHLÄGER.

All disturbances arising at the commutators of continuous-current machines under normal conditions of working may—apart from purely mechanical damage—be referred to one or other of two causes—reactance voltage and voltage between segments.

As regards the first, so much progress has recently been made in methods of securing sparkless running that little need be said on this point. On the other hand, comparatively little attention has been given to the voltage between segments. This comparative neglect is easily accounted for in view of the fact that in machines of ordinary construction, without forced commutation, if the winding

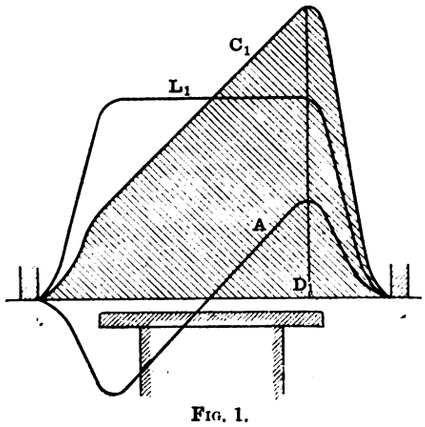

FIG. 1.

be so arranged that the conditions for sparkless running are fulfilled, the voltage between segments will be well within the limit of safety. But in machines where forced commutation is used, conditions may frequently arise which result in an excessive voltage between segments, causing the commutator to flash over.

In the above respect, special attention must be devoted to shunt-wound motors employing field control for speed regulation within wide limits. Such machines are almost invariably provided with reversing poles, but not with a compensating winding, as this latter would greatly increase the cost. The remarks which follow are intended to apply to commutating pole machines without a compensating winding.

In Fig. 1 the curve L_1 represents the flux-distribution curve when the motor is running light at its lowest speed. The field due to armature reaction when the machine is loaded is represented by the curve A. The resultant field is given by the curve C_1 which forms the boundary of the shaded area. The curves of Fig. 2 apply to the same machine, but when running at its highest speed, and therefore in the weakest field. Armature reaction then *becomes relatively* so powerful as to completely reverse the flux in the region lying forward of the commutating pole. It is easy to see from these curves that with increasing speed the maximum voltage between segments steadily increases, and may ultimately reach a dangerous value.

* Abstracted from the *Elektrotechnische Zeitschrift*.

The author recently had occasion to verify the above conclusion in the case of a 21 H.P. motor, designed for a voltage of 520 and speeds lying between 200 and 875 revs. per min. The field was a six-pole one, and as the total number of commutator segments was 254, the mean voltage between segments was about 12·3—a by no means excessive value. The motor was fitted with reversing poles, and ran sparklessly at all speeds, but when run up to nearly the upper speed limit it sooner or later flashed over.

The potential diagram around the commutator was investigated by the usual pilot brush method, when it was found that for a certain position of the pilot brush the voltage between it and one of the main brushes reached a value of 805 volts, showing the existence of a strong reversed field, as in Fig. 2. From the potential diagram the voltage between consecutive segments was determined, and was found to reach a maximum value of over 50 volts. This immediately accounts for the tendency to flash over, in spite of the fact that up to this point the running was perfectly sparkless.

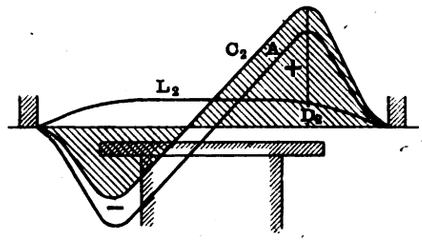

FIG. 2.

The author proposes the term *critical speed* for the speed at which flashing over takes place, and it is evident that a pre-determination of this speed is of the highest importance to the designer.

PHYSICAL SOCIETY.

At a meeting held on March 22nd, Prof. J. Perry, F.R.S., president, in the chair, a Paper by Mr. POCHIN on

"Experimental Mathematics"

was read by the Author. An instrument for describing logarithmic spirals was exhibited, and it was shown how the principal properties of logarithms and of the equi-angular spiral may be established as experimental results. A spiral was described with an angle of 45 deg., and the positions of the radius vector, representing the first 10 natural numbers, were drawn in. Cardboard sectors having been cut to fit the various angles, under the successive positions of the radius vector, it was shown that these sectors represented the logarithms of the numbers. Multiplication and division were illustrated by placing the sectors in juxtaposition, so that the angles were added or subtracted, the result being read off directly from the curve. A table of natural logarithms was also prepared from the spiral, by direct measurement with a foot-rule and a protractor graduated in radians. A geometrical analysis was given, confirming the accuracy of the experimental results and affording an independent proof of the exponential-theorem. A second spiral was drawn with an angle $\tan^{-1}M$, thus giving common logs. in terms of the radian; and it was shown that, by using a suitably graduated protractor or modulus, one system transformed into the other. A Boucher's circle and a slide rule were also derived practically from the spiral. The differentials $d \log_e r/dr$ and $d \log_{10} r/dr$ were shown graphically, as well as the properties of the evolute and involute. The Paper was put forward as an attempt to show how pure mathematics may be taught experimentally, and in the belief that many boys derive benefit from an alternative treatment which enables them to employ the sense of touch in addition to those of sight and hearing.

Mr. W. A. PRICE expressed his interest in the Paper and described an instrument, constructed somewhat on the lines of that described by the author, which could be used to draw the exponential curve $y = ae^{kx}$. He pointed out that any exponential law was a relation between two quantities changing in arithmetical and geometrical progression respectively. In an exponential curve in which the ordinates change in G.P. and the abscissæ in A.P., the formation of the logarithmic scale can be shown by marking on the scale of abscissæ the corresponding values of the ordinates. Logarithms should form part of the subject of arithmetical and geometrical progressions; the conception of continuous growth being added by interpolation of terms in the usual series.

The CHAIRMAN said the Paper was interesting to those acquainted with logarithms and logarithmic spirals, but in his opinion the methods described by the author were not the best for beginners. He pointed out that the early geometers used practical methods to check the results of their theoretical reasoning.

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A Paper entitled

"Logarithmic Lazy-Tongs and Lattice-Works"

was read by Mr. T. H. BLAKESLEY. If two straight rods AB, CD are jointed at E, and so related that the extremities ACBD lie in the circumference of a circle, they will fulfil this condition when the angle between is changed. Suppose that AE is taken as unity, and that $ED = n$, $EC = m$, m and n being quite independent. Then $EB = mn$ as a consequence. If another pair of rods, DF, BG, similar to the first pair but bearing the ratio $n : 1$ to it, be jointed at D and B to the first pair, and to the extremities FG of this pair a third pair be again jointed, and a fourth to this and so on, the ratio of each pair to the preceding one being $n : 1$, the resulting linkage is called by the author a logarithmic lazy-tongs. The points ADG... lie upon an equiangular spiral, whose characteristic angle a is given by the equation

$$\tan a = \frac{ECA - EAC}{\log n}.$$

By opening or shutting the angles at E, the numerator of the expression on the right is varied, but its denominator remains constant. It follows that the characteristic angle of the spiral (a) may be varied at pleasure, by causing the angles at E to change. A lazy-tongs constructed as above is said to be in the n direction. It is clear that any of the four sides AC, CB, BD, AD might be chosen as that to which the next pair of rods is to be attached, care being taken to make the ratio correspond to the direction chosen. If CB is chosen the ratio must be $m : 1$, and a lazy-tongs in the direction m will result, the angular shift at each step being $EAD - EDA$. Suppose pairs added in the m direction to both CB and BF; then it is easy to see that these two pairs will have, in addition to B, another common point—viz., that which is homologous to be in the m direction. In fact, the same pair is arrived at whether by moving once in the n direction and then once in the m direction, or vice versa. It is clear that a joint may be added at the common point, and that the rule is a general one, and that all plane space may be occupied by such a linkage, which is called a logarithmic lattice work. Such a lattice work moves so that the angles at E, and points homologous, will remain equal. An equiangular spiral also passes through AB and points homologous in the mn direction. Its characteristic angle a is such that

$$\tan a = \frac{BCA - ADB}{\log mn}.$$

Circles and straight lines, being limiting cases of equiangular spirals, will therefore occur with some arrangements. For instance, if $mn = 1$, the curves in the mn direction are circles. If the n curves are circles, by n being made equal to unity, the angle EAD is equal to EDA; and the difference between these angles being then zero, there will be no angular shift in the m direction, and the m curves will therefore be straight lines. The author indicated how, by controlling the three variables m n and the angles at E, a geometrical solution of such problems as occur in cables subject to alternating currents may be reached.

Mr. W. A. PRICE pointed out that the principle of extending a quadrilateral by constructing similar and similarly disposed figures on the sides, and thus covering an indefinite area, was not confined to inscribable quadrilaterals nor even to plane ones. A gauche quadrilateral with its diagonals is a tetrahedron and may be regarded as contained by three pairs of opposite edges. Any two of these pairs may be used to originate a set of quadrilaterals on the author's plan, which will lie on the surface of a helicoid, and whose sides and angular points will describe helical spirals. There will be three sides each of two pairs of edges from each of which may be developed a helicoidal surface with its families of helical spirals; so that from a single gauche quadrilateral three helicoids may be developed.

Mr. R. J. P. ROBERTS exhibited a compensated micro-manometer, described in the *Proceedings* of the Royal Society, section A, Vol. LXXVIII.

COMPLIMENTARY DINNER TO MR. JOHN GAVEY, C.B.

On Thursday evening a complimentary dinner was given at the Grand Hotel, London, to Mr. John Gavey, C.B., M.Inst.C.E., Engineer-in-Chief of the Post Office, on his retirement from that position after a long and honourable service. The company present included the Right Hon. Sydney Buxton (Postmaster-General), who presided; Mr. H. Babington Smith, C.B., C.S.I. (secretary to the Post Office); Sir John Denison-Pender, K.C.M.G., Sir Robert Hunter, Dr. Glazebrook, F.R.S. (President I.E.E.), Mr. M. F. Roberts, M.Inst.C.E., Major O'Meara, R.E., C.M.G., Mr. W. E. L. Gaine (general manager of the National Telephone Co.), Mr. Frank Gill, Mr. J. Ardron, C.B., Mr. A. F. King, Mr. A. H. Ogilvie, Mr. J. J. Cardin, C.B., Mr. J. C. Badcock, C.B., Mr. Alex. Siemens, Mr. R. K. Gray, Mr. H. R. Kempe, M.Inst.C.E., &c., &c., the company numbering 200.

After the loyal toasts, the CHAIRMAN proposed the toast of "The Guest of the Evening," and in doing so said letters of regret had been received from Earl Granard, Sir William Preece, Sir. J. C. Lamb, Mr. S. C. Hooley, and others; and cablegrams from Herr Sydow (Berlin), Mr. Phillips (Commercial Cable Co.) and Mr. Marconi. They were met to do honour to their friend and their guest, Mr. Gavey. Everyone who knew him personally had for him the greatest regard and warmest respect. He was glad they had such a representative assembly, and he was glad of the opportunity of welcoming Messrs. Gaine and Gill, representing the National Telephone Co. They, like the Post Office, were carrying out a public service and public duty. He had not himself a long personal knowledge and friendship of Mr. Gavey, but he had known him long enough to know that he was a man for whom one felt a personal regard and personal attachment, and a man who, in whatever he did, did it admirably and did it zealously. He was glad to have the opportunity of saying what he felt with regard to him. He would not give an historical review of Mr. Gavey's connection with the Post Office, for it was known to all of them that he had had some 45 years' service in electrical matters, and some 35 years' connection with the Post Office. Mr. Gavey had done great service in regard to telegraphs, telephones, and wireless telegraphy in the public service, and they, as citizens of this great Empire, were grateful to him for the work which he had done in improving these engineering works and engineering systems. Mr. Gavey had recently done admirable work at the Wireless Conference in Berlin and deserved their gratitude for that work. As showing the great strides that had been made in the engineering branch, largely under Mr. Gavey's advice and control, he mentionod that in 1870 there were 60,000 miles of telegraph lines while last year they had under Post Office management no less then 785,000 miles: 20 years ago the engineering expenditure was less than half a million, but during last year it was 2½ millions, an expenditure which he ventured to say was not an extravagant expenditure, but was on an economical basis; 20 years ago the Post Office engineering staff numbered only 700 persons, and now exceeded 2,000. They were glad to drink the health of Mr. Gavey, to feel that for 35 years he had given his best to the public service, and to wish him God-speed and good luck (loud cheers).

Mr. H. R. KEMPE said the task of seconding the toast was one of considerable pleasure to him. He felt that the selection was not altogether inappropriate, as he could claim to have officially known Mr. Gavey for a longer period, and in many matters to have been more closely associated with him than any other member of the engineering staff. It was now 35 years since he had the pleasure of making Mr. Gavey's acquaintance. At that period the telegraphs of the kingdom had recently passed into the hands of the State. Mr. Gavey was then superintendent with headquarters at Bristol. He had extremely pleasant recollections of the kindness and cordiality with which he was received. The fact that Mr. Gavey had not only attained the position of engineer-in-chief of the Post Office, but had also occupied the position of President of the Institution of Electrical Engineers, and that His Majesty had conferred a mark of distinction upon him, spoke volumes for Mr. Gavey's worth. Mr. Gavey had served his country well, and he was sure they would all join with him in wishing Mr. Gavey and his family many years of health and happiness at this the termination of his long, distinguished and honourable official career (cheers).

Mr. GAVEY, who on rising to respond to the toast was received most enthusiastically, said: It is difficult for me to find words to express fully my feelings for the kind reception you have given me to-night. If I were to take everything that I have heard said to-day at the Post Office seriously to heart I should go home a very vain man. All I can say is that in my small way I have attempted to do my duty, and if my efforts have been appreciated it is a source of great satisfaction to me. It is a source of immense pleasure to me that this meeting should be graced by the presence of so many men who are so eminent in the profession to one branch of which I have the honour to belong. My period of service may be said to date back to the early days of telegraphy. I received my first appointment in February, 1861, the very month in which the old semaphore telegraph then working between the Mersey Dock, Liverpool, and Holyhead Mountain was abandoned and replaced by the electric telegraph. I may, therefore, perhaps claim that my period of service extends from the death of the semaphore telegraph down to the latest development. Like land-line telegraphy, submarine telegraphy was also in its infancy. A certain measure of success had been attained in the laying of shallow-water cables, but submarine cable laying, so far as deep-sea work was concerned, had been a failure, and those interested in the enterprise had been confronted with disaster. The attempts to bridge the Atlantic in 1856 and the attempt to connect Great Britain with our Indian Empire had both come to grief. But, gentlemen, there were giants in the world in those days—giant capitalists who were prepared to risk their money in the development of great commercial enterprises, and not to form a corner in wheat or some other necessary article of commerce or consumption. There were giants amongst electrical engineers, names which were honoured in the early days, names that are honoured by the younger generation of to-day. The combined work of those giants led to the success which we all have lived to see. They established for the time being a great monopoly in submarine cable making, they laid cables (due to British enterprise and British capital) over the whole of the world, and for years they maintained a monopoly in cable communication that was the envy of every other nation. Whilst this was being done our system of land telegraphy was gradually growing, and a great step in advance was made when the Post Office acquired the telegraph service in 1870, and from that date until comparatively recently the history of the Post Office telegraphs was one of continued growth and development. Unfortunately, as the Postmaster-General has said, the youngest daughter of the telegraphs, the telephone, came in, and since then there has been a tendency to elbow the father aside, to encroach on his traffic, to encroach on his wealth, and what the outcome will be one cannot say; but there is no doubt that, for good or for evil, the great system of telephonic communication has not only come to stay but it will certainly grow to an extent

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that I think few of us can imagine. It has been my good fortune to visit the United States on two occasions in connection with the development of the telephone there, and within the last day or two I have received a return showing the growth of the Bell Telephone Co. The figures are marvellous. As recently as 1897 the number of telephones provided by the associated Bell companies was 350,000, whilst at the beginning of the present year the number was over 3,000,000, and this makes no allowance for telephones provided by independent companies in the United States.

Well, gentlemen, it has been my good fortune to witness this enormous growth of the telegraphic and telephonic industry, and to see the birth of what has been boomed as one of the greatest wonders of the age—wireless telegraphy. To my mind telephony is a far more wonderful feat than wireless telegraphy. Within the last 25 years electrical enterprise and electrical industry have spread into every branch of manufacturing work and there is no single branch of ordinary mechanical industry at the present moment in which electrical engineering does not take a more or less leading part. That this development will continue I think there is no doubt whatever.

Now, gentlemen, this great gathering is to a certain extent a personal one, in so far as you have honoured me by meeting me here to-night—not, I hope, to bid me farewell, but to bid me God-speed in any other work that I may eventually undertake, and I should like to express the warm feelings of gratitude with which I regard you all, and which I feel for the great honour you have done me. On another occasion in the course of to-day I had to express my gratitude for the warm feeling of friendship I entertain for my old colleagues at the Post Office, and more ~~especially for my able staff, without whose aid~~ I certainly could have done very little, and who have supported me most loyally from my early days in the Post Office service up to the present moment. To this larger audience I beg to express a similar feeling of gratitude. Turning for a moment to the great Institution which represents the electrical industry, I feel how much I am indebted to that Institution. For years I was buried in the provinces. An early member of the Institution, when I came back to London in 1892 I was almost a stranger to the then members of the Institution. Practically the old generation had passed away, and I was received by a new one; but that made no difference. My friends of the Institution took me by the hand, they honoured me by giving me office after office, until they promoted me to the highest honour they could confer by making me their president. Gentlemen, I thank you all most heartily for the many kindnesses and many evidences of friendship that you have showered on me, and I feel that this is the best and proudest day of my life (cheers).

Mr. W. E. L. Gaine, in proposing the toast of the "Post Office," asked by what irony of fate had he of all men been called upon to propose the toast (laughter). It had been his daily duty for the past 15 years to anathematise the Post Office and all its ways (laughter). If the Post Office had any faults he knew them. The chairman had kindly referred to the presence of the representatives of the National Telephone Co. there that night to do honour to their friend, their most esteemed friend, Mr. Gavey. He was not a little struck by the fact that the names mentioned all began with the letter G (laughter). He thought everyone would agree what a vast organisation the Post Office really was, and when one considered the extraordinary amount of work, the extraordinary organisation of the Post Office, how that work was done and how well it was done, he thought that one was justified in saying that the Post Office was a great and wonderful institution (cheers). He had found out that the first Postmaster-General was appointed by Henry KIII. at the high salary of £50 per annum. Sir Robert Hunter suggested that he eventually lost his head, but he (the speaker) could not say. The first secretary to the Post Office was appointed in the year 1694; he received the somewhat high salary of £100 (laughter). The Post Office now employed close on 200,000 people, and when they considered how smoothly the whole thing worked it spoke volumes for the organising power of the men who had built up that great institution, and he had no hesitation in saying that the Post Office telegraph system was superior to any telegraph system in Europe. He might say that the Post Office had also dabbled a little in telephones (laughter). A service like the Post Office demanded that the men at the head of affairs must be of the highest character, highest integrity, fair minded and broad of view. In his dealings with Post Office officals he had always found them perfectly willing to keep to their bargains, and he hoped that those with whom he had had dealings at the Post Office could say the same of him (cheers). Notwithstanding the enormous volume of business the Post Office already undertook, the department was going to take over another great business. The telephones of the country—Parliament had decreed—were to be in the hands of the State, and that would add something like 20,000 to the staff of the Post Office. That was not the time or place to discuss that transaction, but he would say this, that in the intervening period there were many and most difficult problems to be solved. He had the pleasure to couple with the toast the name of Mr. Babington-Smith, secretary of the Post Office.

Mr. Babington-Smith, in reply, said that he believed in some foreign watering places there was a method of treatment which consisted first in spraying on warm water, followed by an icy cold douche. That method of treatment was one to which the Post Office was accustomed. They had heard various criticisms of the Post Office, and the Postmaster-General had mentioned that telephones were responsible for bad language; but he was not sure that that complaint began with the telephone. Speaking very seriously, they had every reason to be grateful for the way in which the toast was proposed and the way in which it had been received. Mr. Gaine had referred to the sometimes difficult negotiations that have been conducted between the department and his company, and in thanking him for the way in which he had spoken, he could certainly say that, while they had endeavoured to conduct these negotiations straightforwardly and in a reasonable manner, they had met with equal straightforwardness on the part of the National Telephone Co. Whatever might be the merits or demerits of the Post Office, so long as they had men like Mr. Gavey at the head of great branches of the service, they were not afraid of public criticism. He (Mr. Babington-Smith) desired to take that opportunity of expressing once more his great feeling of regard and esteem for the retiring engineer-in-chief of the Post Office (applause).

Sir Robert Hunter proposed the toast of "The Visitors," and referred to the distinguished visitors present, amongst whom were Sir John Denison-Pender, who had done so much valuable work in connection with the development of submarine telegraphy, and Dr. Glazebrook, F.R.S., who was a distinguished luminary of the scientific world.

Sir John Denison-Pender and Dr. Glazebrook both replied, and expressed the greatest pleasure in being present to do honour to Mr. Gavey, who was an ornament of his profession and had the best wishes of all in his well-earned retirement.

This brought a pleasant gathering to a close.

CORRESPONDENCE.

ECONOMY OF REVERSIBLE BOOSTERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am not in a position to say whether Mr. Salter is right in assuming that your article on the "Economy of Reversible Boosters" was intended as an answer to the Paper he read before the Manchester section of the Institution, but, as I am responsible for supplying the figures on which the article is based, may I be allowed to say that these results were supplied under the belief that they might prove of interest to station engineers, and without any desire to controvert the opinions expressed in Mr. Salter's Paper, which I had not read at the time your article appeared.

Mr. Salter states that the figures have "little or no value" because:—

(*a*) The coal used during the two periods *may* have varied in quality.

(*b*) That the output from the station and the load factor varied considerably.

(*c*) That the capital charges do not include the cost of the buildings and switch gear, and that no provision has been made for depreciation of these items.

In reply I have to state:—

(*a*) The coal used during the two periods under comparison was of the same quality and obtained from the same pits.

(*b*) As Mr. Salter is anxious for accurate comparisons, I might point out that the figures he gives regarding output and load factor, which are taken from the *Electrical Times*, deal with the years ending June 30, 1905 and 1906 respectively, whereas the periods taken for comparison in your article are the nine months ending September 30th of the same years. Admitting, however, that the output and load factor increased (it is unfortunate for comparison purposes that two exactly similar periods cannot be obtained in the average central station), I cannot agree that the results given are more than slightly affected. I need hardly point out that fuel consumption is not necessarily reduced by an increased output; the reverse is sometimes the case, and so far as the periods referred to are concerned, the increased output need not be taken into account.

With regard to the improved load factor, I trust I will not be misunderstood if I refer Mr. Salter to the curve in his Paper (p. 237, *Journal* Institution Electrical Engineers, Vol. XXXVII.) showing the relation between load factor and total working costs. Taking this curve as a standard, I find that the increase in load factor at Greenock from 18·13 to 19·41 would result in a diminution of total working costs to the extent of 3 per cent. As the comparison in your article deals with fuel costs only, which amount to three-sevenths of the total costs, I can hardly understand how Mr. Salter arrives at the conclusion that the comparison "is rendered nugatory" because of dissimilar load factors during the two periods.

(*c*) The capital cost of the plant as stated in your article includes battery, booster and switch gear. The cost of buildings is not included, as an existing building has been utilised to house the battery. As a suitable building could be erected for £400, the capital charges would only be increased by £24 per annum, reducing the yearly saving claimed in your article

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from £616 to £592—a difference which does not appreciably lessen the value of the results.

The question of installing batteries at central supply stations is at present claiming more attention than at any time during the last 20 years, and the results obtained at Greenock from the use of a battery and reversible booster will, I trust, prove of interest to central station engineers who may have the matter under consideration. The undoubted advantages to be obtained from the use of a battery, such as improved voltage and reliability against breakdown, are, I admit, secondary to the question of economy. Mr. Salter's Paper went to show that in the station with which he is connected the capital cost of the battery had not been justified by the results. On the other hand, the economical advantage obtained at Greenock is beyond question, and I am certain that other central stations can show equally satisfactory results. In one case with which I am acquainted the installation of a battery on a three-wire lighting system has reduced the coal consumption by 18 per cent., representing a saving of £30 per week, the capital expended being approximately £3,000.

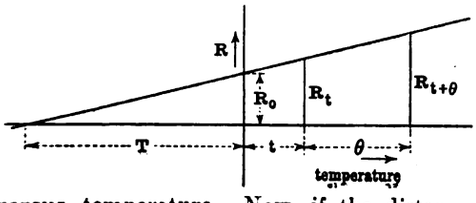
The results to be obtained from installing a battery must always depend on local and special considerations. The case cited by Mr. Salter, where a storage battery was recommended for use on a high-tension alternating system, is possibly an example of "extraordinary advocacy"; but what is to be said of engineers who, because of one or two failures under circumstances that may possibly be capable of easy explanation, indulge in wholesale condemnation of *all* batteries even when used under conditions with which they cannot possibly be acquainted?—Yours, &c., J. A. ROBERTSON.

Greenock, April 16.

RESISTIVITY-TEMPERATURE FORMULÆ FOR COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to Dr. F. B. Crocker's article on "Resistivity-Temperature Formulæ for Copper" in *The Electrician* of the 5th inst., p. 968, I should like to draw attention to a letter by Mr. Fritz Emde published in the *Elektrotechnische Zeitschrift*, 1903, pp. 818 and 819. In this letter Mr. Emde shows an easy way of obtaining the temperature coefficient α in the formula $R_{t+\theta} = R\ (1 + \alpha_t . \theta)$ for any initial temperature. This formula is graphically represented by the straight line in the accompanying figure, where the resistivity is



plotted versus temperature. Now, if the distance between zero temperature and the point where the curve meets the abscissa axis be called T we have the proportion

$$\frac{R_o}{T} = \frac{R_t}{T+t} = \frac{R_{t+\theta}}{T+t+\theta},$$

and from this the following equations

$$R_t = R_o . \frac{T+t}{T} = R_o\left(1 + \frac{t}{T}\right)$$

and

$$R_{t+\theta} = R_t . \frac{T+t+\theta}{T+t} = R_t\left(1 + \frac{\theta}{T+t}\right).$$

As will be seen from these formulæ, the coefficient α_t based on an initial temperature t is equal to $\frac{1}{T+t}$—*i.e.*, the reciprocal value of the temperature t increased by the constant T. Assuming the correct value of the coefficient for 0°C. is 0·0042, then the value of T would be 238°C. Such a figure can easily be remembered, and if using a slide rule it requires only a slight motion to get the coefficient for a given initial temperature.

I would further mention that the coefficient 0·004 which has been adopted by the Verband Deutscher Elektrotechniker in the German rules refers to 15°C. as stated in "Kupfernormalien" (Copper standards), §5. If this coefficient were reduced to 0°C. initial temperature it would be 0·004255 (corresponding with a value of T = 235°C.), which figure is not very different from the American and British standard, the difference from the American figure being only ¼ per cent. for 100°C.—Yours, &c., E. JASSE.

Stafford, April 6.

[Owing to pressure on our space we have found it necessary to hold over some Correspondence.—ED. *E.*]

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

The Select Committee of the House of Commons appointed to consider the Convention drawn up at the Wireless Telegraph Conference (Berlin), 1906, met again on Tuesday under the presidency of Sir JOHN DICKSON-POYNDER.

Mr. H. CUTHBERT HALL, managing director of Marconi's Wireless Telegraph Co. (Ltd.), was called as a witness, and said the company was formed on July 20, 1897. Its original capital was £100,000, and its present capitalisation was £500,000. The company acquired the Marconi patents throughout the world (with the exception of Italy), and the right to benefit by all improvements of apparatus, &c. The company was occupied during the first few years of its existence principally in developing inventions and endeavouring to secure the adoption of the company's system by Governments and Government departments. The effective range of the apparatus was increased from two or three miles in 1896 to about 250 or 300 miles in 1900. Mr. Marconi also invented tuning in 1900 and demonstrated the practicability of receiving simultaneously at the same station two messages from differently tuned systems. He carried on a service at the Goodwin lightship for Trinity House and the Board of Trade, but these bodies did not make any arrangement with him for a permanent service. The War Office decided to try his apparatus in South Africa, and two sets were taken off British battleships. The War Office were supposed to provide the masts and supports for the aerials, but no masts or supports were provided, and consequently no messages could be transmitted. The War Office then announced that the experiments were a failure. The Admiralty agreed to use 32 sets of the company's apparatus and pay a royalty of £250 per annum, but they afterwards objected to the royalty, stating that they considered it too high, and it was then fixed at £100, and an extra royalty was agreed upon for tuned apparatus if tuned apparatus was adopted. There was also the Marconi International Marine Communication Co. (Ltd.), which was formed in 1900, and acquired a licence from the parent company for ship-to-shore communication throughout the world, except the United States and Hawaii, where there was already a company working which had acquired rights. The capital of the Marine Company was £350,000, with £204,000 issued. There were on the board prominent men from all countries, and they thought that, through the influence of these gentlemen, the company would be able to make arrangements for the adoption of their system in the countries in which these directors were prominent personages. These included Frenchmen, Belgians and Germans, and four or five of the board of the parent Marconi's Wireless Co. This company did not start with any very coherent policy, except to get its system adopted. The method by which this was to be accomplished had not then been thought out. They tried to sell the apparatus to Governments and shipping companies. The North German Lloyd purchased a set of apparatus, and agreed to pay a royalty of £100 a year, and the company installed two stations in Germany (at Borkum lightship and Borkumriff); the Belgian Government installed the system on the Belgian packet boats, purchasing the apparatus and working it themselves. In 1901 the company decided to organise a company to carry on a public telegraph service by means of wireless telegraph apparatus, instead of confining themselves to making and selling the apparatus. The reasons for the change were, in the first place that, up to that time the International Company had achieved no success, and secondly it seemed clear that the shipping companies would not buy the sets of apparatus and organise the service themselves—in fact, it was hardly practicable for them to organise it. It was also necessary to provide coast stations. The company installed coast stations in the United Kingdom, two on the east coast, four on the south coast and others in the north and south of Ireland, at Rosslare, near Dublin, and at Holyhead. They established stations in the United States, and undertook to supply equipments to shipping companies, supplying the apparatus and installing it at their own expense and working it by their own operators. They also established a school for training operators and drew up regulations for the service. In 1901 the company made an agreement with Lloyds for 14 years and gave Lloyds an exclusive licence for maritime intelligence, Lloyds undertaking not to use other apparatus than Marconi's at their coast stations and not to communicate with ships fitted with apparatus other than Marconi's. Lloyds then held the opinion that there should be only one system in general use, and the Marconi system was in such general use. Lloyds not only made an exclusive arrangement with them, but attached to the agreement, dated Oct. 26, 1901, a recital pointing out the reason for that opinion. That agreement would expire in 1915. Lloyds pointed out at that time that it was desirable to join hands to strengthen themselves against the Government, as they told the company they anticipated the Government would want to

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take over the control of wireless telegraphy; but, on the other hand, there seemed to be some private arrangement between Lloyds and the Admiralty, judging by the evidence given by other witnesses, by which the Government hoped to secure the control of wireless telegraphy through Lloyds. Causes of the friction between the company and Lloyds had been the desire of Lloyds to obtain, through their contract, more than the company considered it gave them, and their entering into this understanding with the Admiralty regarding the control of the organisation.

Mr. LAMBERT: What evidence did you refer to as bearing out that contention?—Col. Daniell's.

The CHAIRMAN: Will you tell the Committee what took place with regard to the agreement with the Admiralty?—In 1901 we made the agreement with the Admiralty, to which I have already referred. I have stated that the royalty was reduced from £250 to £100. They wanted a further reduction, but we did not see our way to further reduce the terms, and they then sent our apparatus to manufacturers and had it copied. I think it was disputed at the time, but evidence can be produced if necessary that is conclusive on that point. We secured a copy of the specification that was sent out to manufacturers. Subsequently a new agreement was entered into in 1903, under which the Admiralty was to pay £5,000 a year royalty for all uses, so that no question might arise as to the number of sets in use. It was stated by the Postmaster-General in the House of Commons that the amount was £40,000.

The POSTMASTER-GENERAL: It was misreported, and the paper which published the statement corrected it afterwards.

Mr. LAMBERT: There is a particular feature of the 1903 agreement I wish to ask about. I believe prior to that the parties to the previous agreement with the Navy were supposed to disclose any improvements or inventions of wireless apparatus which they effected?—Yes, but in 1903 they felt that this was not necessary, and instructions were given to the Admiralty officials accordingly.

There was also an agreement with the Canadian Government?—Yes, in 1901, or early in 1902, we made an arrangement with the Canadian Government for a number of coast stations for communication with ships, and for a high-power station for communication across the Atlantic. Prior to that agreement we had made an arrangement with the Newfoundland Government for stations on the coast.

The CHAIRMAN: What about the Belgian and Italian Governments?—The Italian Government has an exclusive licence for 10 years for all purposes, and the Government agrees not to communicate with ships fitted with apparatus other than Marconi's. The agreement with the Belgian Government is in respect of the collection of messages and rates for the same. We made a number of similar agreements with the Western Union and Postal Telegraph companies, of the United States, who control the land work there; with the Canadian Government in respect of their system; with the Netherlands Government and with the British Post Office.

The CHAIRMAN: Will you explain what difficulties you have had in carrying out your policy? Competitors have sprung up, most of whom we regard as having copied our apparatus. The only important competitor, in my view, is Prof. Slaby. He came to England, I think in 1899 or 1900, and was shown the Marconi gear, and witnessed our experiments, and when he returned to Berlin he gave a lecture in which he said he had experimented with wireless telegraphy and detailed the chief results of any consequence, and we concluded that Mr. Marconi had placed some invention at his disposal. It was not known to anyone else that he had been to London and had seen what Marconi was doing. There was some secret correspondence between Prof. Slaby and Mr. Marconi on the subject, and subsequently Prof. Slaby caused wireless apparatus to be manufactured by a German company. He came here with an introduction from the German Government, but I do not know that he represented the Government. A member of the Post Office staff passed him on to us.

Mr. GWYNNE: He was shown the Marconi apparatus. Was the invention you refer to something he had seen or something he had not seen?—He came to England to see the Marconi experiments, and drew particular attention, after he went back to Germany, to the particular features of the Marconi invention.

Mr. LEE: Was he given by the Marconi Co. access to the secrets of the invention which would be sufficient to enable him to reproduce them?—Certainly, he saw the particular features, the aerial and the earth connection. The Hertz radiator is not earthed and the distance over which you can communicate by means of the Hertz radiator, other things being equal, is necessarily limited, owing to the absence of the earth.

The CHAIRMAN: When he returned to Germany did he take any advantage of the information he had secured?—Yes, and he proceeded to sell apparatus, and his system received the approval of the German Government.

Mr. GWYNNE: Is his system identical with that of the Marconi Co.?—It contains the principal features of the Marconi apparatus. The Lodge, De Forest, Slaby-Braun and Fessenden systems all contain the particular feature of the Marconi apparatus, and that feature is claimed in the Marconi patent, which was the first patent for wireless telegraphy. Since that time a great many patents have been taken out.

The POSTMASTER-GENERAL: Have you brought actions against these companies for the infringement in England?—We have brought no actions in England. We have brought actions in the United States—one against Dolbear, from which we retired, and one against the De Forest Co., which we won. De Forest was not concerned to show that he had a good patent himself, but merely that the Marconi patent had been anticipated, and he therefore cited any known instances of wireless which appeared to be anticipations. After Hertz's demonstrations nine years elapsed without any further successful results in wireless telegraphy, and Marconi was the first to receive a definite and intelligent signal by means of Hertzian waves. We brought no action against the German Co. as we had the German ships, the principal users of wireless, and if we won an action in Germany we should have to force our patent upon the Government, and Governments are in a very peculiar position as to patent rights. We believe the patent is a good one, because the Germans examine for novelty and utility, and the Lodge patent was cited as an anticipation of the Marconi patent. We, however, caused apparatus to be made from the Lodge specification and found that it would not work, while Marconi apparatus was constructed and did the work satisfactorily.

The CHAIRMAN: What experience have you had in relation to your agreement with the Colonial Office?—The Colonial Office took some action in regard to the Canadian Government—a communication was sent to the Canadian Govrenment, requesting them not to make an agreement without reference to the Colonial Office, but that suggestion does not seem to have been acted upon, as an agreement was concluded in 1901 or the beginning of 1902.

Will you tell us what has taken place with regard to your licences in foreign territory?—Anyone was free to establish apparatus in England. Foreigners could establish apparatus here without a licence, but we were not at liberty to establish stations abroad without licences. Foreign stations were established in Crown colonies and in a number of self-governing colonies at the instance of the Colonial Office.

You have had differences with regard to the Post Office in connection with private wires?—Yes, in 1904, when the Post Office agreement was made, we had been carrying on a service of ship-and-shore communication for three years, but there was no provision for the collection of messages and the rates for these messages at inland telegraph offices. We could send a message from ship to shore, because our own operators on the ships could collect the messages and the rates, but there was no medium for the collection of messages in the United Kingdom. All that anyone could do to communicate with anyone on a ship was to send a telegram to a coast station, leaving our operator to send it, and the wireless charge would be collected by our operator on board. These difficulties have been overcome in the United States, Italy and Belgium by agreements with the Governments.

Were there any foreign proposals as regards amalgamation?—Yes, from Braun and Slaby, and also proposals from the French Co.—the Popp Co. They were doing no business, and after examination we rejected the proposals. The Slaby-Braun system was afterwards incorporated in the "Telefunken" system.

Mr. GWYNNE: Do you mean they were selling no apparatus or were carrying on no wireless telegraphy?—They could not show us that they were doing any business at all. We knew Germany was rather a close field for us, and if they could have shown us any business we should have made an arrangement. We had got all the liners ourselves. They were manufacturing apparatus, I believe, for the German navy, but they had no other business. They were making instruments which we considered were copies of our instruments.

The CHAIRMAN: Since those days I believe their business has increased?—Very much, principally for naval instruments. They have practically no ship-to-shore communication work. They are not carrying on the public business of a telegraph company by means of wireless telegraphy.

Had you no proposals from Berlin?—No, but the German Government took action after the failure of these attempts at amalgamation by communicating with foreign Powers, and represented that England, through the operations of the Marconi Co., was trying to obtain a monopoly of wireless telegraphy, and suggested that these Powers should amalgamate to overthrow it. They proposed a Convention for that purpose, and at the first Wireless Conference at Berlin in 1903, the grounds for the Convention were represented to be the interests of humanity and the safety of shipping, but in the original note sent out to the Powers the reason for the necessity of action was that England was getting a monopoly.

Can the actual text of that note be produced?—I have published a translation of it.

Can you point out any tangible results that have been achieved by your policy?—Certainly. There are 180 stations in all. In most cases there are arrangements with the inland telegraph stations of the countries in which our stations are situated for the collection of rates and messages. The tonnage of the vessels equipped with our apparatus is 1,053,866, the passenger carrying capacity of those vessels is 3,043,600, and the number of words sent and received last year was 1,261,000. I know of no stations carrying on a public telegraph service by means of wireless apparatus other than Marconi stations. There are one or two cross-Channel steamers sending messages for shipping service purposes, coasting vessels of the United States, three or four liners coming down the Channel, and the Hamburg-American or some American liners, which receive and send messages, but they are not carrying on, nor are they organised to carry on, a public telegraph service.

Can you enumerate the countries in which your stations are established?—Of our stations in Great Britain nine carry on a public service, and there are a number of others that notify accidents of shipping to Trinity House. There are a station in Holland, two in Belgium, 15 in Italy and one each in Montenegro, Port Said and Port Tewfik. No ships passing through the Suez Canal are equipped with wireless apparatus. There are seven stations in the United States. It has been stated in evidence that we have no stations in the United States. We have several stations carrying on a public service of ship-to-shore communication. There are 24 stations in British North America—Canada and Newfoundland, and we have 96 passenger vessels equipped with our apparatus, including 39 English, 14 German, 9 Dutch, 6 French, 4 American, 10 Italian and 10 Belgian. That is a list of the stations carrying on a public service, but we have many hundreds of stations for other purposes. These may not, however, be considered relevant for the purpose under consideration, and the stations of other systems quoted at the Conference were not relevant because they carry on no public service, but are naval and experimental

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stations. I should like to emphasise this point, that the tonnage of the vessels equipped with our system is over 1,000,000 and the tonnage of vessels equipped with all other systems is only 182,000. Stations of other systems than ours which endeavour to carry on a public service, but which can hardly be said to carry on a public service at all, are only 40 in number.

The POSTMASTER-GENERAL: Does that include naval stations?—No.

Are there 39 stations in America carrying on commercial business?—I think not. I do not know of any Atlantic liners communicating with American coast stations other than those fitted with Marconi apparatus. There was a French station established for public service, but in the French Chamber there was an objection to the expenditure, because there was no public traffic for them to carry.

What about Nantucket?—We had a station on Nantucket, and the German Government made a protest because we would not agree to communicate with ships fitted with other systems, although, as we pointed out, there were no ships equipped with other systems. We took our apparatus to a station farther north, and we are doing all the work there. Sable Island is a station on Canadian territory, and does a lot of business with Atlantic liners. There are seven stations in the United States which announce themselves open for public service, but they are not carrying on any extensive public service. This applies to Nantucket, as well as the others, since we left it. The German ships do not now communicate with Nantucket, but with the station we have erected further north, and also with Sable Island. The percentage of error in the working of our whole service is 0·42 per cent. per word sent—about one word in 200.

The CHAIRMAN: Can you give us reasons which in your opinion justify the policy of your company?—It is a great disadvantage to have foreigners come here and establish stations without licences, while we cannot get licences on foreign territory. We have all the first-class liners, although the Governments have put a great deal of pressure upon them not to adopt our system. This has happened in Germany, France and other countries. The German Government has been in communication with the North German Lloyd with regard to the termination of their contract with us, which extends to 1908. If the Convention is ratified, I do not know how the Hamburg-American line, who have a contract with us and are under an obligation not to intercommunicate, will adjust matters. Each country that ratifies the Convention has to insist on intercommunication, but we have a contract with the Hamburg-American for ten years, and we do not agree to intercommunication.

The POSTMASTER-GENERAL: If we do not ratify, will not all these French, German and other ships belonging to other countries that do ratify be obliged to accept intercommunication?—Yes, with their own coasts and their own ships. The French Government reserves the right of exemption of certain stations. There is under the Convention a general right of exemption, but some of the delegates renounced that right at once.

Mr. LEE: While these foreign ships may be forced to intercommunicate, that will not deprive you of the right to a civil action for breach of contract?—Certainly, that would be the position.

In response to a request by the CHAIRMAN, the WITNESS, returning to the reasons which he considered justified the company in its policy of non-intercommunication, said Lloyds and the Admiralty had entered into contracts to communicate only with ships fitted with Marconi apparatus.

The CHAIRMAN: How does your policy affect the public interest, apart from the interest of your company?—Intercommunication is impracticable; it must result in disorganisation of the service; it is contrary to the public interest to have intercommunication. There is no public service in the world carried on upon the principle upon which this Convention service is based. All public services are under a centralised control, but the service provided for by the Convention involves working by Governments, companies, or private individuals at the coast stations and by shipping companies or wireless telegraph companies or private individuals on the ships. It is co-operation and competition together. Similar services were proposed with regard to railways when powers were first conferred on the railway companies. They were told that the railway lines would be highways, and that anyone would have the right to run a train on those highways, but that was found to be impracticable.

But that is not an analogy?—It is, I think, an analogy which is rather in our favour than in favour of the argument on the other side. It is practicable to exclude a train passing over a line by physical means, but not to exclude a wireless message being sent from a station. Therefore, the whole service will depend upon adequate control over a number of miscellaneous elements.

I understand the difficulty of identification of ships is not a great one?—No. If you get two ships simultaneously within range of the same coast station, say a French ship worked by a French company and a Belgian ship worked by a Belgian company, the coast station says: "We will take the French company's messages," and tells the other ship to stand by, but if the Belgian ship chooses to continue to send its messages the French ship cannot transmit its messages satisfactorily, because there would be received on the tape or the telephone a jumble of the two messages. By competition between two people the chance of a breach of regulations is very much increased. We have eliminated the element of competition between operators by a bonus system under which operators receive a bonus on every word sent, provided every rule and regulation has been observed.

If you substitute for the bonus a set of strict regulations which is complied with by all countries, would not the same result be obtained?—It would be like a telephone system without the intervention of an exchange. When you were talking with someone else I could call you up and anyone else could call you up. Any service so constituted must result in chaos.

Mr. LAMBERT: Suppose I were telephoning to you direct and could not make you understand, would I not be foolish to go on?—You would probably get impatient and ring again, but it would not prevent the existing connection. It seems a natural remedy to entrust the transmission of the messages to some organisation which has an interest in the combined traffic. We should say, "The principle upon which this service is constituted must result in confusion, and therefore we will trust the transmission to some company which has an interest in the combined traffic." Mr. Babington Smith expressed similar ideas at the Conference.

Mr. LAMBERT: You cannot imagine that the control of wireless telegraphy can be left in the hands of one company?—Not entirely one company, but a service cannot be carried on by the co-operation of a number of users, and that is what the Convention proposals amount to.

The POSTMASTER-GENERAL: Assuming that this country does not ratify and the other countries do, there will then be other commercial companies already started, or they will start, to carry on public commercial wireless telegraphy. How, under those circumstances, would you prevent interference with stations except by international agreement?—We have various ways, by tuning and by the fact that it is not open to people to erect stations in all places. At the present moment on the Channel we have all the stations except those operating the Newhaven-Dieppe route.

We have been told that there is a great danger of interference at present, which would be prevented by the Convention regulations?—If we agreed to intercommunication and allowed anybody to send messages to our stations, and encouraged them to instal apparatus on ships, on the ground that they had the use of our stations, there would be confusion at the stations and competition in the use of the stations, and we should have no control over the operators. At the present moment there is no confusion. We control the operators, and such small amount of competition as there is is eliminated by our bonus system. We cannot, under the Convention, eliminate the principle of competition, and I submit that with competition and common use under such circumstances one person would be sending a message and preventing another from sending one. The two things—competition and common use—are irreconcilable. The most striking instance of an international service is the cable service between London and Amsterdam, which is so slow that the arbitrage dealers prefer to send their telegrams via New York to Amsterdam rather than from London to Amsterdam direct. I attribute that bad service to the division of authority, the English and Dutch Governments having joint ownership.

Has not one of the companies a station in the stock exchange, while the Government has not, and has this not something to do with the preference for sending via New York?—Very likely, and it is the result of an arrangement by a commercial company. Attempts made by a number of Governments to carry on a public wireless telegraph service have had no result whatever.

The CHAIRMAN: In your opinion your intercommunication policy has been successful to that extent?—Yes. The Italian Government has an agreement with us, and as pressure has been put upon the Government, we offered to release them from the intercommunication principle, and their reply was that they refused to be released, because they realised that intercommunication would be impracticable. The Canadian and Newfoundland Governments took a similar view. The Admiralty took this view in 1903, when they made their contract with us, and they took the same view up to the eve of the last Conference. Lloyds also took that view when they made their contract with us.

Do you consider that the Convention will have any retarding effect upon technical developments in the future?—I do, because, before introducing an improvement which involved change of wave-lengths, it would be necessary to get the consent of all the Governments concerned, and that is a very inconvenient process of introducing improvements. I cannot see that the British Government has any interest in depriving a British company of the position which it has gained in open competition.

Will you tell the Committee what you consider objections to the Convention from the standpoint of British imperial defence?—It seems to me it must be a great advantage to have a large network of stations under British control, and we have also all these liners and the operators are ours on the ships.

Have you any other general criticisms?—The principle of one State one vote is inequitable. The relative maritime importance of the various States should be considered. Germany's vote was the signal for many smaller powers, which had no maritime interests, to vote according to what Germany desired. It also seems to me that the Marconi company ought to have been efficiently represented at the Conference. A matter which was discussed at the Conference was protection for patentees. The effect of the discussion was that only the Marconi company attaches any importance to this—that is to say, only the Marconi company have any patents of value.

Do you think the British delegates might have prevented any Convention?—Yes. I had the opportunity of discussing the matter with a number of the delegates of the Italian and Russian Governments and also a number of other delegates. All expressed the view that the Convention was an absurdity, and that the principle of intercommunication was impracticable.

Mr. LAMBERT: Do you think that refusal to intercommunicate would encourage the establishment of foreign stations?—Our experience is against that. There is greater encouragement to erect stations on the French coast if there is intercommunication. Also there must of course be more traffic for them. Since the Convention has been drawn up the French Government have authorised the erection of about eight stations on the French coast.

The POSTMASTER-GENERAL: I understand that lately your company has made an agreement with a Dutch company under which there will be intercommunication with the Telefunken system and with ships

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of other countries, and that their messages will be received by Marconi stations?—The agreement was made by the Compagnie Generale de Telegraphie sans Fils and we approved it.

Assuming that other systems made some progress, would it be necessary to have any other regulations than those of the Marconi Co.?—I think not, for we can alter our arrangements as we find it necessary. We can now do this very much better than we could if we were tied down by the regulations of an International Conference. If any difficulty is experienced there is nothing to prevent us adopting our own means of avoiding that difficulty. But under the Government regulations we could not.

Mr. LAMBERT: You say ratifying the Convention would be a disadvantage to British defensive interests?—I think so.

The Admiralty are of a contrary opinion?—I do not think their case is based on good grounds. They say there is a great deal of interference and confusion at the present moment. Mr. Babington Smith at the Conference pointed out that the very principle of intercommunication would very likely give rise to a good deal of difficulty. I had many conversations with the chief Admiralty delegate, Capt. Bethell, and he was strongly against intercommunication. There was a great difference in the view of the Admiralty delegates before and after the Conference. Capt. Bethell also mentioned Admiral Jackson as being of the same opinion.

Mr. LEE: You have stated that the Admiralty has changed the opinion it held in 1903. You are willing that Capt. Bethell shall be called, and you agree that it rests with the Admiralty to produce Capt. Bethell, or to accept your statements?—Certainly.

You are aware that Capt. Bethell placed certain views before the Conference?—Yes. I understood him to take the same view as I did, that we could not enforce intercommunication.

Do you consider the views laid by Capt. Bethell before the Conference are the same as he expressed to you privately?—I think he went a little further towards the Convention than in what he said to me privately.

Does the company propose to take up a position of hostility?—No. We could not carry on our own business at the same time if we were using our instruments to upset other people.

On the conclusion of Mr. Hall's examination, the Committee adjourned.

On the Committee resuming its sitting yesterday,

Mr. JOHN GAVEY, late engineer-in-chief of the General Post Office, gave evidence. He said he had, on behalf of the Post Office, to make a special study of wireless telegraphy from 1886 down to the present time. He was appointed a British delegate at the Preliminary Wireless Conference in Berlin in 1903, and also at the Wireless Conference held in Berlin in October and November, 1906. In June, 1896, Signor Marconi called at the Post Office with a letter of introduction and proposed his method of wireless communication. In 1886-7 Hertz had carried out a series of experiments, which showed that under certain conditions electric waves were radiated through the æther which might be reflected or polarised, and were of practically the same nature as light. In 1894 Sir Oliver Lodge exhibited a number of experiments, first at the Royal Institution, in London, and, secondly, at the British Association meeting in Oxford. He caused signals to be recorded at a distance of 40 yds. or 50 yds., and at a later period, with larger apparatus, signals were transmitted over a distance of half a mile. Signor Marconi then commenced his series of experiments. The Post Office provided Marconi with facilities for carrying out experiments, and in 1896 arranged for a series of trials on Salisbury Plain. In May, 1897, the Post Office carried out, under Marconi's supervision, trials to demonstrate the practical suitability of the system, when Marconi's connection with the Post Office ceased. Marconi's system was so constructed that every receiving station within range of the transmitting centre could read all the messages sent from that centre, and it was impossible for more than two stations within a given area to exchange signals at a given time without interference. All persons interested in the development of radio-telegraphy at once turned their attention to devise apparatus so adjusted that two sets would respond only to one another's radiations, while at the same time other apparatus not so adjusted were unaffected. Unfortunately, this ideal had not been fully attained. It was only when stations were at a considerable distance from one another, when the Hertzian waves differed considerably in length, that it was practicable to tune so as to prevent disturbance from other sources. On this subject, Dr. Fleming, in his recent work on "Wireless Telegraphy," said, speaking of disturbances from other installations, that "it was impossible yet to define precisely the limit of affectation, and that the degree of sharpness of tuning was to a large extent a question of skill on the part of the operator and of the adjustment of the appliances." In the narrow waters surrounding the United Kingdom it was practically impossible, with the methods in commercial use, to isolate all the wireless stations on either side of the English Channel or on the North Sea, or to limit their radius so as to obviate all interference. Much had been said in relation to so-called different systems of radio-telegraphy, but so far as the transmission of messages by Hertzian waves was concerned, it might be argued that there was only one system, and the different types of instruments might be classed under the heading of different methods. Unless suitable precautions were taken, interference between all systems working in a given area was not only possible but inevitable. For instance, signals from the Marconi Poldhu station to Atlantic liners are read, not only at all British stations, but he had himself received them at a German wireless station near Berlin, about 800 miles from Poldhu, fitted with "Telefunken" apparatus. They were also read by the Post Office stations fitted with the De Forest apparatus. A certain measure of success in obviating interference had been achieved in cutting out interference from neighbouring stations by a suitable limitation of wave-lengths, and by the adoption of receiving apparatus specially adapted for the transmission of particular wave-lengths. There were, however, certain distances within which interference took place notwithstanding these precautions. In considering the question of international wireless telegraphy, the recent Conference had to deal with the practical methods to be adopted in order to avoid mutual interference between neighbouring stations and to regulate traffic between ships. With these objects in view the Regulations were most carefully considered, and after a very exhaustive inquiry they were drawn up to guard against all difficulties to be foreseen by the delegates. It was specified that two wave-lengths should be devoted to the service of general and public correspondence, and lengths of 300 and 600 metres were ultimately selected. The normal wave-length on board ship was 300 metres. Wave-lengths between 600 and 1,800 metres were entirely reserved for Government purposes. He agreed with the evidence of Mr. Babington Smith that shore stations should be placed at a distance of 50 miles apart, so long as these shore stations were under the Regulations drawn up by the Convention. If there were not strict regulations of this kind, which all stations were bound to obey, there would be very serious interference between stations of 50 or even 100 miles apart. It was all a question of strict regulations and the power to enforce them. Without regulations limiting the amount of energy to be used, the wave length and other specific details, interference might extend over half the United Kingdom. Art. 30 of the Service Regulations was of very great importance in relation to non-interference, as it specified that a ship station must send its messages to the nearest shore station, and this removed the temptation to use enormously high power to transfer its messages to distant stations. It could only send messages to a distant station at the specific request of a passenger. There was little doubt that, when the Convention came into force, if it were not ratified by Great Britain, the large liners belonging to other European nations would be fitted with extra powerful apparatus to permit of their communicating (while skirting our coasts) with the Continental stations of Holland, Belgium and Germany, and in doing so they would render the working of the existing commercial stations in this country very difficult, if not impossible. There would be no redress for this interference. In the event of a general wireless war, England would be the principal sufferer, as England now did the greater portion of the radio-telegraphic traffic in Europe. There would be general chaos, and radio-telegraphy would cease to exist until peace was declared. If the Convention were ratified and its terms accepted by British stations, it would undoubtedly materially increase their work as radio-telegraphy developed.

Mr. GWYNNE: What is the ordinary range of a liner's apparatus?—It varies between 60 and 150 miles. The average might be taken, prehaps, at 80 miles.

Would not 150 miles be adequate?—I think there is no doubt the foreign liners would fit up more powerful apparatus, so as to be able to communicate with their own shores.

When Mr. Marconi came in the first instance to the Post Office with his apparatus did he offer his invention to the Post Office?—I think there was some conversation on the subject, and the matter was under consideration at the time Mr. Marconi announced the fact that he had joined hands with the Marconi Co.

How do you mean that he joined hands?—That he sold his invention to the company now known as the Marconi Co.

If England stood out, it is your opinion that all the other countries bordering on the narrow seas would sign the Convention? Do you take it as certain that if England refuses to ratify no other country would follow our example; France, for instance?—I feel morally certain that neither France, Holland, Belgium nor Germany would decline to ratify the Convention.

Mr. Gavey's examination was continued, and he was followed by Capt. Englefield, secretary to Lloyds, who was the last witness for the day. The continuation of yesterday's proceedings will be given in our next issue.

Tramway Brakes.—In reply to a question (by Mr. R. Bell in the House of Commons on Friday last) as to brake failures on electric tramways and as to the advisability of appointing a committee to inquire into the best system of brake power which should be adopted, with a view to its compulsory adoption, in the same manner as on railways, Mr. LLOYD-GEORGE said that he was aware that there had been several fatal accidents due to tramcars running away or leaving the rails, and that in some cases the brake mechanism was in fault. The whole question of tramway braking appliances was at present being investigated by committees appointed by the Tramways and Light Railways and the Municipal Tramways Associations, and the Board of Trade had expressed their willingness to assist in a joint inquiry at a later stage.

Patents and Designs Bill.—This bill was read a second time in the House of Commons on Wednesday.

Electric Supply Corporation Bill.—The whole of the opposition to this bill has now been withdrawn, but as the examiners of private bills of the House of Lords have found the Standing Orders not to have been complied with, it will be necessary for the measure to come before the Standing Orders Committee before it can be referred to the Select Committee on unopposed bills.

LEGAL INTELLIGENCE.

Bellamy v. Wakefield and District Light Railway Co.—This case was in Mr. Justice Joyce's list on Tuesday, but before it was reached Mr. Hughes, K.C., said it was a motion by the plaintiff to restrain defendants from committing a nuisance at their electricity works, and it had been agreed that the motion should stand over for two months, and then probably his Lordship would not be troubled with it.

Improved Electric Light Supplies (Ltd.)—On Tuesday Mr. Justice Warrington made a compulsory winding-up order against this company on a creditor's petition.

British Electric Equipment Co. (Ltd.).—Mr. Justice Warrington made a compulsory winding-up order against this company on a creditor's petition on Tuesday.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Weymouth and Melcombe Regis Council require an electrical engineer to take entire charge of the electricity supply department. Salary £200 per annum, with house and light free. Applications to the town clerk (Mr. H. A. Huxtable) by Saturday 27th inst. See an advertisement.

An experienced draughtsman is required for works in Manchester district; used to all types of a.c. and d.c. dynamos and motors. See an advertisement.

An electrician, competent to do armature winding and commutator repairs, is wanted in electrically-driven works. See advertisement.

The Municipality of East London (South Africa) want a thoroughly competent man to take charge of electric tramcars and to generally superintend work in the shed. Salary £28. 5s. per month, and free passage to East London. Applications before April 20 to Messrs. Dyer & Dyer, 17, Aldermanbury, London, E.C.

Salford Education committee require, in September, an assistant in the electrical engineering department of the Royal Technical Institute, Salford. Commencing salary £150 per annum. Forms from the director of education, Mr. Ogilvie Duthie, Education Offices, Chapel-street, Salford, to be returned by April 22.

Exeter Corporation want a tramways depot foreman at £2. 5s. per week. Forms from the Town Clerk. Applications by May 2.

Chester Corporation want a mains superintendent. £150 per annum, rising to £200. Applications by April 23.

Burnley Council have appointed Mr. H. Blakey, Guildford, as meter inspector.

Australasia.—The visit of the Colonial Premiers to this country gives interest at the present time to a graphic map of the Australian continent just published by the "Australian World," and which we reproduce herewith. The fact that the whole of Australasia is connected up telegraphically by exclusively British submarine telegraph cables is sufficient justification for the reproduction of this map in our columns, as showing the present and potential importance of these cables and the possibilities of telegraphic development over this immense area. The figures published in our contemporary are of interest in this connection :—

Australia Compared with Europe.—Some idea of the vastness of the Australian Continent may be gathered from the map which shows that Australasia could swallow up nearly the whole of Europe. Drawn to scale without alteration of their positions—with the exception of Sweden, Norway and Russia—the fringe will provide for Sweden and Norway and for more than two-thirds of Russia. The respective areas in square miles are :—

British Isles	120,994	Belgium	11,373
Germany	208,830	Denmark	15,360
France	204,092	Roumania	50,720
Spain	197,670	Norway and Sweden	172,576
Portugal	36,938		
Italy	110,646	Total	1,514,211
Switzerland	15,976	Russia	2,095,616
Austro-Hungary	240,942		3,609.827
Bulgaria	24,380	Australia	2,972,006
Turkey	65,752		
Greece	25,914	Difference	*636,921
Holland	12,048		

* Or 31,576 square miles less than the area of Queensland.

Antwerp.—In a report presented by the British Consul-General for Belgium (Sir Cecil Hertslet) particulars are given of the extensive works which have been carried out at this important shipping centre. The report states that in regard to the cranes which are to be ultimately erected the system to be adopted has not yet been definitely decided upon, but the choice lies between electric and hydraulic, the latter type having so far been used on the quays. It is expected, however, that electric cranes will ultimately be selected owing to their lower upkeep and working costs.

Ayr.—The Council have decided to reduce the price of electric current for private lighting to 3½d. per unit as from May 1.

Barnes.—£750 has been transferred from the profits of the electricity undertaking to relief of rates.

Bermondsey (London).—As the result of an inquiry held by Mr H. E. Kearley, M.P. (Parliamentary Secretary to the Board of Trade), on March 12 and 18, the Board of Trade have decided not to grant the Council's application for a provisional order for the St. Olave district.

The Electricity committee, in their report, stated that it was difficult to understand why the order was not granted, seeing it was clearly proved that the Council is supplying electricity cheaper in the parishes of Rotherhithe and Bermondsey than the London Electric Supply Corpn., and had the order been granted they would have been in a position to supply in St. Olave cheaper than a company.

There is now connected to the mains the equivalent of 80,435 8 c.p. lamps, including 4,662 8 c.p. for public lighting.

The Finance committee estimate that if the destructor was closed and all the refuse barged away a saving of £1,984 per annum would be effected. The matter has been referred to the General Purposes and Electricity committees.

Beverley.—The electric lighting order of 1901 has been revoked.

Blackpool.—An unopposed inquiry was held recently into the application of the Council for sanction to borrow £8,500 for additional plant at the electricity works.

Bradford.—The general manager of the tramways (Mr. C. J. Spencer) has prepared a report on the paying and unprofitable "routes" of the tramways department, as desired by the Tramways committee.

Mr. Spencer states that he has had some difficulty in fairly understanding the committee's wishes, and he has assumed that they required a return showing, as far as possible, the financial position of each route. In order to arrive at any results he had to make some fairly broad assumptions. The receipts on the whole tramway system were divided up as per the ordinary weekly traffic, but he had no means of accurately subdividing these receipts any further. He had therefore taken the receipts for 12 months for the whole system ending Jan. 31, 1907, the average working expenses per car mile being taken from last year's accounts (year ending March 31, 1906), and including "traffic expenses, general expenses, repairs and maintenance" and power expenses, but not the expenses of the parcels department, Bowling Hill, &c. On the other hand, no receipts other than traffic receipts were entered under the head of receipts. He had assumed that the average working expenses (7·36d. per car mile) were the same on every section of the tramways—that was to say, he had paid no regard to the nature of a section, such as gradients, curves, &c, which necessarily affected the operating cost. He had also assumed that the cost of construction per mile of route was the same all over the system (£7·5738 per yard of route) for permanent way, electrical equipment of line, office furniture and Parliamentary expenses. The expenditure had been allocated to the routes on a route-mile basis, while land, buildings and fixtures, workshop tools, &c., had been allocated to the sections on a car mile basis at £0·04501 per car mile. Where a common route was utilised by more than one section he had allocated the route mileage proportional to each section using the route. After arriving at the total capital expenditure of each individual route, he had taken as the annual payment for interest, sinking fund, income tax, &c., 6·176 per cent. The total operating expenses were arrived at by means of multiplying the cost per car-mile (7·36d.) by the car-mileage run. An examination of the return shows that on seven routes there is a loss, whilst on nine routes there is a profit. Mr. Spencer thinks it should be stated that in some instances the fact that the route includes both good and bad-paying line detracts from the better portions of the route, and consequently makes it as a whole look worse than the better portion if taken alone. The most serious item in the return is the £5,098 loss on the circular route, and he suggests that this calls for serious consideration.

With the report is issued a comparative table showing various items of cost, working expenses, &c., in connection with each route for the year under review. The total capital represented is £881,959.

Camberwell (London).—The Board of Trade have notified the Council that they have approved an additional system for the supply of electrical energy by the undertakers under the Blackheath and Greenwich district electric lighting orders (1897 and 1899), the Crystal Palace and District electric lighting orders (1890 and 1894), the Lewisham electric lighting order (1901) and the Penge electric lighting order (1901). Supply will be given from the generating station to sub-stations at 10,000 volts (alternating) and at a frequency not differing from 50 complete periods per second by more than 2½ per cent. The extra high-pressure mains will consist of insulated conductors laid together and enclosed in a

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lead sheath. They will be laid in troughs filled in solid with composition and covered with hard-burnt tiles or other suitable protection or will be drawn into pipes or ducts.

Colwyn Bay.—In reviewing the past year's work, the chairman of the Lighting committee (Mr. John Williams) stated on Tuesday that the electric lighting undertaking was a little works which laid golden eggs for the ratepayers. To begin with, there had been a saving to the public of £100 a year in respect of public lighting, whilst the ratepayers received another £300 by being charged only 2d. instead of 5d. per unit. The receipts were £3,148, or £178 more than the estimate. A profit of £700 or more on the year's working was anticipated. The new committee might consider the question of reducing the price of current by ½d. per unit to private consumers.

Corrupt Practices Prevention Act, 1906.—What is probably the first prosecution under this Act was heard at Manchester a few days ago :—

Defendant (M'Lean) was employed by a firm of cloth merchants, and the person alleged to have been bribed or corrupted was a carter named Webb, in the service of a firm of carriers at Manchester. Defendant was charged with having corruptly given or agreed to give Webb 3d. on Jan. 10 and on the following day 1s. The L. & Y. Railway Co. hired on each of those dates a horse, lurry and driver from the firm of carriers to carry cloth from their goods yard in Salford to warehouses in Manchester. Webb was the driver. On the first day he took a load of cloth to the warehouse of M'Lean's employers (Messrs. Marsland & Clarke), and from thence, at the firm's request (through defendant), to another warehouse in Sackville-street. For taking some bundles placed on the lurry at the Dickinson-street warehouse, in addition to the proper load, he was offered and accepted a gratuity of 3d. On the following day, at M'Lean's request, after delivering goods for the railway company at other warehouses, he called at Messrs. Marsland & Clarke's, and there 28 bundles of cloth were given to him to deliver at certain addresses. For that he was to receive 1s. He had, it was alleged, no business whatever to be carting goods about for Marsland & Clarke, his duty being, as soon as he had disposed of the cloth taken from the railway goods warehouse, to return there for further orders. The delivery of the 28 bundles would have occupied the horse and lurry two or three hours, for which the railway company were paying the firm of carters (M'Lean's employers). Before the job was finished one of the railway company's carting inspectors was on the man's track, and the company refused to pay for the use of the lurry after a given time in the day. This prosecution had been undertaken with the assent of the Attorney-General, whose fiat was produced. It was contended that the carter was an agent within the meaning of sec. 1 of the Act, and that the promise to pay 1s. to him was a corrupt promise, and therefore punishable under the Act.

After hearing the evidence, the stipendiary fined defendant 20s. and costs and £10 10s. extra costs on the second charge, the first having been withdrawn.

Customs Duties.—It has been decided that, under the New Zealand tariff, imports of antiseptic telephone covers are subject, as "parts of telephones, electric appliances," to a duty of 10 per cent. ad val.

Darlington.—The Electric Light committee have decided to grant the borough electrical engineer (Mr. J. R. P. Lunn) an immediate increase of £50 per annum in his salary, with an additional £50 per annum at tht end of a certain period.

Dublin.—In reference to the particulars of the tender accepted by the Corporation for steam turbine plant given on p. 1,028 of our last issue, we have received the following supplementary information :—

The Electric Lighting committee recently had under consideration tenders for steam turbine plant, and after giving the matter attention at several committee meetings, it was resolved to recommend the Council to accept the offer of Willans & Robinson for a 1,500 kw. steam turbine coupled to a Dick Kerr alternator at £10,043. When the matter came before the Council for confirmation it was found that considerable activity had been displayed in the direction of obtaining the acceptance of another offer in place of the one recommended by the committee and by the engineer (Mr. M. Ruddle), and finally, without referring the matter back to the committee for further consideration, the Council accepted the offer of the General Electric Co. at £8,725. The committee and their engineer are, we learn, indignant that their recommendation should have been over-ridden. It is alleged that statements (subsequently printed in the local press) were made to the effect that plant of a similar type to that recommended by the committee (namely, Willans Dick Kerr combinations) had given considerable trouble in Glasgow, and that the Glasgow authorities had decided, in future, not to entertain offers for this type and make of alternator. There is, however, we are assured, not the slightest foundation for these statements, and we are informed that it is not improbable that legal proceedings will be taken by the firm whose tender was passed over in order to vindicate their position.

East Stirling.—The Board of Trade have decided not to grant the Scottish Central Electric Power Co.'s application for a provisional order for the parishes of Falkirk, Larbert, Grangemouth, Denny, Dunipace, Kilsyth and Salamannan.

Egypt.—In a report on the trade of Port Sudan (the new name given to an inlet on the West Coast of the Red Sea, 700 miles south of Suez and 35 miles north of Suakin), Mr. T. B. Hohler, the British representative, states that when all the works at the Port are completed the quay will be over 1½ miles long with accommodation for 12 to 14 ships. Electric travelling cranes and coal hoists are being constructed here, and are expected to prove of great service. The importance of Port Sudan as a trading centre is regarded as considerable, and Mr, Hohler's report gives particulars of the prospects of the place for merchants desiring to establish a connection. The report altogether is an interesting one, and we may add that the British Vice-Consul at Port Sudan is Mr. Echlin, who is well acquainted with the local conditions.

Electricity in Mining.—At the meeting of the Balaghât Gold Mining Co. on Wednesday, the chairman (Lord Ribblesdale) said that the Kolar Mines Power Station (Ltd.) were making arrangements for increasing the scope of their operations. They had increased their capital by £25,000 in order to provide a plant to operate powerful underground hoists at the leading mines on the Kolar goldfield. The additional plant would be in use as soon as possible, and they anticipated it would prove an economical factor in the working of the mines at greater depths. Owing to the drought between March and June last year it became necessary to stop a considerable portion of the electrical plant operated under the Cauvery scheme and to substitute steam. Since then, however, the Cauvery system had been working satisfactorily. Warned by that failure, the Mysore Government were considering the question of enlarging very considerably the storage reservoir, at the Cauvery Falls.

Epsom.—An inquiry was held last week into the Council's application for sanction to borrow £3,600 for additional generating plant.

It was stated that the outstanding capital expenditure on electricity supply was £30,100. 10s., and the additional plant was necessitated by the growth of the undertaking and the increased demand for current.

The electrical engineer (Mr. H. Foster) supplied technical details, and said he thought 1908 would show a considerable reduction in the charge on the rates. Since last Christmas there had been a larger number of applicants for current than at any period of similar length.

Exhibition.—An electrical exhibition is to be held at Devonport in September.

Germano-Swiss Water-power Scheme.—The British Chargé d'Affaires at Darmstadt (Mr. F. D. Harford) reports that the Lörrach (Baden) Council have approved a scheme for the utilisation of the falls on the Rhine on the frontier between Rheinfelden and Augst, by the erection of a large hydro-electric power station. The undertaking is to be called the Augst-Wyhl-n power station, and the concessionaires are the canton of the City of Basle and the owners of the Rheinfelden (Baden) power station. The latter station already produces 15,000 H.P., but for the past six years the company has been obliged to draw largely upon the Swiss power station at Bettlau. The projected station is intended to generate from 24,800 H.P. to 30,000 H P., and a weir is to be constructed in such a manner that the works at the same time form separate Baden and Swiss undertakings. The cost is estimated at £860,000.

Hackney (London).—The Electricity committee have been in negotiation with the promoters of the North Metropolitan Electric Power Supply Bill, and as the latter have agreed to make such modifications in the bill as to prevent the company from supplying electricity in Hackney for lighting, opposition to the bill by the committee has been withdrawn.

Hammersmith (London).—The Electricity Committee recommend the Council to carry out the scheme prepared by the borough electrical engineer (Mr. G. G. Bell) for laying new feeders, &c., to meet next winter's demand, at a total cost of £2,413.

Application is to be made to the L.C.C. for sanction to a loan of £11,145, a portion of which is for extensions of mains.

Islington (London).—A low-tension distributing main is to be laid (at an estimated cost of £130) to the new slaughter houses at the Metropolitan Cattle Market.

Keady (Ireland).—The Council are considering the question of applying for a provisional electric lighting order.

Lambeth (London).—An agreement has been entered into between the Borough Council and the South London Electric Supply Corpn. for a supply of electricity to the new Town Hall buildings being erected on Brixton hill at 3½d. net per unit for lighting and 1½d. for power (ventilator motors), with meter rental 30s. per quarter.

Light Railways.—The Board of Trade have recently confirmed the Mansfield and District Light Railways (Extensions) Order, 1907, authorising the construction of light railways in the borough of Mansfield and in the urban districts of Mansfield Woodhouse and Sutton-in-Ashfield, and in the rural district of Skegby, &c.

L.C.C. Electric Power Bill.—A number of the Borough Councils are supporting the resolution recently passed by Fulham Council urging that the bill should be withdrawn.

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Liverpool.—The salary of the tramways traffic manager (Mr. C. W. Mallins) has been increased from £700 to £750 per annum.

Lytham.—A provisional electric lighting order has been granted to the Council.

Marylebone (London).—The Finance committee of the London County Council recommend that the electricity loan of £1,400,000 be placed upon a permanent basis from Dec. 31 last, with interest at 4 per cent. per annum. The Borough Council, however, are to bear the difference in cost of interest of bills now current, which were issued for the purpose of the loan at £4. 6s. 6d. per cent. discount. The Borough Council have agreed to this suggestion.

Mexico.—An instructive report has been issued by the secretary to the British Legation at Mexico (Mr. W. Max Müller) concerning the trade route of the Mexico Isthmus (Tehuantepec) Railway, a very important railway undertaking operating between the terminal ports and Coatzacoalcos and Salina Cruz, and regarded by Mr. Müller as the most important British enterprise in Mexico. These places are situate within the district so alarmingly affected by recent seismic disturbances. The undertaking of the contractors (Messrs. S. Pearson & Son) includes oilfields at San Cristobal, whence a 20 miles pipe line has been laid to Minatitlan. Messrs. Pearson have built general offices and shops and a hospital at Rincon Antonio at an elevation of 900 ft. and distant 125 miles from Coatzacoalcos. The shops are equipped with the most modern machinery, and every machine is direct driven by electricity. This is also the case at the company's extensive works at Salina Cruz and Coatzacoalcos. The generating plant is steam driven, crude oil being used as fuel. At both terminal ports the quays are provided with electric travelling cranes of great power, four to each wharf, with an operating reach from vessels to warehouses or cars of 86 ft., and with numerous capstans also worked electrically.

Middlesbrough.—At the meeting of the Corporation last week an effort was made to refer back for further consideration the agreement with the Cleveland & Durham Electric Power Co.

Councillor CALVERT said by the arrangement with the company the committee would be saved immediately a capital expenditure of £12,000. The position that the ratepayers would find themselves in if the agreement was entered into was this, that they would in the first year on which they entered into it be £1,000 better off than if they had spent the capital to produce the extra electrical energy which would be required next winter, and they would not have the burden of the capital to find or redeem. As the years went on it would be increasingly better for the Corporation than it would be in the first year. Even if the Council expended the money they could not hope to get more business than they were likely to get under the arrangement they had made, and they would get the business now, and be able to supply it at a greater profit than if they expended the capital to extend the plant. By 15 votes to 8 the amendment to refer the matter back was defeated.

Paignton.—Dolter Electric Traction (Ltd.) propose to extend the Torquay tramways system to Paignton, and the Council of the latter district have been asked to support the scheme.

Penrith.—A provisional order authorising the transfer of the Penrith Electric Lighting Order, 1900, to a company has been granted by the Board of Trade.

Personal.—Mr. R. N. Tweedy, A.M.I.E.E., of Stourbridge, has been appointed manager of the Dublin and South of Ireland branch of William Coates & Son (Ltd.), 5, Leinster-street, Dublin, and Belfast, and sole agent for the Westinghouse Co. for Ireland.

Poplar (London).—The electricity committee have decided to carry out extensions of the plant at the electricity works at an estimated cost of £2,550, to lay an e.h.t. feeder with switch panels, &c., at £1,800, and to obtain a motor converter and l.t. panel at £1,550.

Presentation.—The employés of the Bournemouth electricity and tramway departments have presented a silver salver and barometer to Mr. H. G. Andrews, assistant borough electrical engineer, on his marriage.

Swinton.—The Council have adopted the following scale of charges for electric current:—

Lighting: 4d. per unit, or (alternatively) 1s. per quarter per 8 c.p. lamp, or equivalent fixed, and 1½d. per unit for current. Power or heating: For first 1,000 units, 1½d. per unit per quarter and 1d. after. Meter rents: 1s. per quarter per meter for the equivalent of 300 8 c.p. lamps, and 2s. per quarter per meter for the equivalent of more than 300 8 c.p. lamps.

The Postmaster-General and Tramways.—A conference of about 50 local authorities took place at Westminster Palace Hotel (London) on Friday to consider certain clauses which the Post Office authorities wish to insert in tramway bills promoted by Manchester, Glasgow and Sheffield Corporations and the London County Council.

In the Glasgow and Manchester bills the Post Office proposes to insert a clause under which it shall be lawful for the Postmaster-General to use for the support of any telegraph the posts, standards and brackets erected in any street or public road by the Corporation in connection with the tramways, to lengthen, adapt and alter them for that purpose subject to the conditions that no obstruction shall be caused to the traffic along or user of the tramways, that not less than 14 days' notice shall be given, that the Postmaster-General shall pay the expense of altering such post, standard or bracket for the protection of the public, &c., and that the Postmaster-General shall, at his own expense, make good any damage or injury and shall indemnify the Corporation against any expense to which they may be put. If any difference arises between the Postmaster-General and the Corporation it is to be determined under sec. 4 and 5 of the Telegraph Act, 1878.

Ald. WAINWRIGHT, of Manchester, was in the chair, and among the districts represented were London County Council, Birmingham, Sheffield, Leeds, Bolton, Bury, Newcastle-on-Tyne, Oldham, Preston, Rochdale, Salford, Stockport and Warrington Corporations.

It was agreed that the Postmaster-General be requested to receive a deputation on the subject, and that London County Council and Glasgow, Manchester and Sheffield Corporations be recommended to strenuously oppose the introduction of the new clause in their respective bills.

Toronto.—The Provincial Parliament have refused to expropriate the local Electric Light Co., and the Electrical Development Co.'s contract has been confirmed.

Worthing.—An inquiry was held last week into the Council's application for sanction to a loan of £2,133 for extensions of the electricity undertaking.

The town clerk (Mr. W. VERRALL) said that the loan was required for suction gas plant (£473), water-softening plant (£160), extension of distributing mains (£500) and meters and house services (£1,000).

The electrical engineer (Mr. GEOFFREY PORTER) stated that it was anticipated that a saving would be effected on the running cost by the introduction of the gas plant. It would probably be necessary before long to obtain another feeder at a cost of £500, and he had suggested to the committee the possibility of a further loan having to be applied for. The number of private consumers was 146. The committee hoped to reduce the cost to private consumers next autumn.

The inspector (Mr. H. ROSS HOOPER) suggested that the committee should recommend the Council to apply for a further sum to be included in the present application, as it seemed reasonably clear that to meet their future requirements they had not got sufficient money.

Electro-Harmonic Society.—At the smoking concert this (Friday) evening (the last of the season) to be held at the Holborn Restaurant, London, commencing at eight o'clock, the chair will be taken by Major W. A. J. O'Meara, C.M.G., engineer-in-chief to the General Post Office.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Heywood.—It is reported that the profit on the past year's working of the tramways was £154, compared with a deficit in the previous year.

There was a profit of £241 on the electricity supply works, compared with a loss of £696 in the previous year.

Hoylake.—At the Council meeting last week Mr. G. J. Griffith, J.P., said the position of the electricity undertaking was most satisfactory.

The annual expenses had been £2,903. 8s. 9d. and £3,132. 19s. represented repayment of loans and interest of loans, a total of £6,036. 7s. 9d. The net profit was £726. 11s. 1d. They had increased the number of consumers by 100, or 14 per cent. In 1905-6 they sold 307,275 and last year 353,425 units, an increase of 46,104 units. They had decided to purchase a new battery to replace the one at present in use, at a cost of £304, but as they were having an allowance of £115 for the old one the actual expenditure would be only £189.

Leeds.—The net surplus on the past year's working of the tramways is £50,000, or £2,000 more than was anticipated.

The total income for the year amounts to £327,794. 3s. 1d., or 10·69d. per car mile, compared with £312,166. 12s. 8d. and 10·51d. The total expenses were £171,528. 15s. 10d., against £156,398. 12s. 3d. The increase in general expenses is mainly accounted for by rates and taxes (£19,471. 18s. 9d.), compared with £12,069. 6s. 2d. for 1905-6. Cars are chiefly responsible for the additional expenditure (£1,913) under the heading of repairs and maintenance. In regard to power, the cost of fuel rose from £8,402 to £9,896. Total working expenses were 5·58d. per car mile, against 5·26d. The gross profit is £156,265. 7s. 3d., compared with £155,768. 0s. 5d. Deducting £43,053. 6s. 5d. for interest, £3,945. 19s. 9d. for income-tax, £38,028. 18s. 1d. for sinking fund, £30,373. 19s. 1d. for reserve, and writing off one-fifth of the amount of provisional orders (£372. 18s. 4d.), the net surplus is £50,000, which will probably be transferred to the City Fund in aid of rates.

Manchester.—The Electricity committee propose to contribute £10,000 out of the past year's profits to relief of rates.

Last year's estimated expenditure was £341,300, but the actual amount spent was £347,047, including £40,000 transferred to renewals suspense account. £25,724 has been transferred to reserve. The cost of coal last year was £42,533, against an estimated cost of £45,700. The amounts received last year for current and in meter and motor rentals was £345,819, or nearly £7,000 in advance of the estimate. On capital account the committee purpose to spend in the current year £111,500, £46,000 for generating stations, buildings, machinery, &c., and £30,000 for buildings and transformers at distributing stations.

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TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

Cardiff Corporation invite tenders for an extra high-tension three-phase feeder cable and an extra high-tension three-phase switchboard. Specifications from the borough electrical engineer and tramways manager (Mr. Arthur Ellis), Central Offices, The Hayes, Cardiff. Tenders (which will only be received from firms who have had previous experience of extra high-tension three-phase work) to the Town Clerk not later than first post 26th inst. See also an advertisement.

Pembroke District Council invite tenders for supply and erection of a high-speed reciprocating engine, direct-current dynamos, switchboard and instruments, accumulators, tubular boiler, arc lamps and gear and arc lamp-posts Specifications may be seen at the office of the clerk to the Council (Mr. J. C. Manly), Town Hall, Ballsbridge, Dublin. Tenders to Mr. Manly before noon May 4. See also an advertisement.

St. Pancras (London) Council invite tenders for supply of arc lamp carbons for 12 months. Specifications, &c., at the electricity department offices, 57, Pratt-street, Camden Town, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras-road, N.W., by noon May 13. See an advertisement.

Malvern Gas and Electricity committee invite tenders for supply of stores for the electricity department for the ensuing 12 months, including bitumen, joint and junction boxes, oils, waste and cleaning materials, house fuse boxes and electricity meters. Further particulars from the chief engineer and manager (Mr. W. J. Rendell Baker), Council Offices, Malvern. Tenders to the town clerk (Mr. H. L. Whatley) by 29th inst. See also an advertisement.

Hull Electric Lighting committee invite tenders for supply and laying of high and low-tension mains, pilot and telephone wires, casing, boxes, &c., required in connection with the extensions of the electric lighting mains during the period ending March 31, 1908. Tenders (addressed and delivered under seal to the Chairman of the committee, Town Hall, Hull) by noon April 28.

Islington (London) Lighting committee invite tenders for supply and erection of a fan (12 ft. diam.) and a single-phase alternating-current motor. Tenders to the town clerk (Mr. W. F. Dewey), Town Hall, Upper-street, N., by noon May 8.

Glasgow Corporation invite tenders for supply of (1) main cables, (2) small cables and wires, (3) electricity meters and (4) arc lamp carbons for 12 months from May 31. Tenders to the town clerk (Mr. A. W. Myles), City Chambers, Glasgow, by 22nd inst.

Glasgow Corporation also want tenders by April 25 for stores to the cleansing department, including carbons, incandescent lamps, ironmongery, castings, india-rubber goods, &c.

Handsworth District Council invite tenders for supply, delivery and erection of extension pipework at their electric power station. Tenders to the clerk (Mr. H. Ward), Council House, Handsworth, before noon April 24.

Wolverhampton Electricity committee invite tenders for boilers, economiser, feed pumps, steel chimney and feed-water tank, and also for turbo-alternator generating sets and condensing plant. Tenders to Chairman by noon May 2.

Luton Corporation want tenders by noon May 8 for a boiler, stokers, 500 kw. steam generator, condensing plant, feed pump, pipework, coal bunkers, elevators and conveyors, &c. Specifications from the Borough Electrical Engineer.

Warrington Electricity and Tramways committee want tenders by noon April 23 for two water-tube boilers, stokers, economiser, &c., coal conveyor, induced-draught plant and three-wire balancer. Specifications from Borough Electrical Engineer.

Kirkcaldy Corporation invite tenders for a boiler feed pump of 3,000 gallons per hour capacity. Tenders by last post on Saturday, May 4.

Callan (co. Kilkenny) Town Commissioners invite estimates of the probable cost of the erection of plant for public electric lighting. Applications to Town Clerk before June 8.

Sheffield Electric Light committee want tenders by 10 a.m. April 25 for 12 months' supply of coal. Specifications, &c., from Mr. S. E. Fedden.

Portsmouth Corporation require c.i. columns and brackets by 10 a.m. April 25. Tenders to the Town Clerk.

Messrs. Preece & Cardew are instructed by *Shanghai* Municipal Council to invite tenders for the supply and delivery c.i.f. Shanghai of one 800 kw. horizontal steam turbo-alternator (single phase) with condensing plant. Specification, &c. from Messrs. Preece & Cardew, 8, Queen Anne's-gate, Westminster, S.W., to whom tenders before noon May 4.

The Provincial Government, *Liége*, want tenders by May 2 for the construction and working of an electric tramway. A deposit of 20,000fr. (£800) is required to qualify any tender.

TENDERS RECEIVED AND ACCEPTED.

Following is the complete list of tenders received by Dublin Corporation for a 1,500 kw. steam turbine set. Further particulars are given in another column :—

General Electric Co. (Westgarth turbine) (*accepted*)	£8,725
Maschinenfabrik Oerlikon	11,608
C. A. Parsons & Co.	11,553
General Electric Co. (Parson's turbine).....	11,385
British Thomson-Houston Co.	10,432
Brush Co.	10,194
Willans & Robinson (Dick Kerr alternator) (*recommended*)....	10,043
British Westinghouse Co.....	9,998
Willans & Robinson (Bruce Peebles alternator)	9,918
Do. (G.E.C. alternator).....	9,657
Richardsons, Westgarth & Co. (Dick Kerr alternator).....	9,426
Do. do. (Siemens alternator)	9,171
Do. do. (G.E.C. alternator)	9,026
Siemens Bros. & Co. (Rateau turbine) .... (Partial tender (	8,764
Do. (Westgarth turbine)) only (	8,491

Gravesend Council have accepted the following tenders for electricity stores for a year :—

Tomey & Sons, J. Stone & Co., W. H. Willcox & Co., F. Bird & Co. and Pryke & Palmer for engine-room stores ; W. Gray, A. Bond & Son, H. Cook, Stone & Co., H. Franklin, Jones Bros. and the British Electrical Trade Supply Co. for oils, &c. ; Siemens Dynamo Works for glassware ; Albion Elec. Lamp Works, Veritys Limited, A. C. Hands & Co. and the Electrical Co. for lamp stores ; W. J. Holland for meter boards, Ferranti Limited and Giepel & Lange for meters.

Amongst the recent orders received by the Empire Roller Bearings Co. for their patent roller bearing axleboxes are the following :—The fitting of 25 additional tramcars for the Brazilian tramways ; from the Madras Railway Co., for bearings for their main line rolling stock ; a further supply for Calcutta rolling stock, and for the fitting of new cars for the Liverpool Corporation tramways, the Great Grimsby tramways, and additional bearings for the L. & Y. Railway Co.

Poplar (London) Council have received the following tenders for cable :—

Western Electric Co., *£1,300 ; Siemens Bros. & Co., £1,335. 10*s.* ; W. T. Henley's Co., £1,340 ; British Insulated & Helsby Cables, £1,306. 4*s.* ; W. T. Glover & Co., £1,320 ; Callender's Co., £1,355.

For supply and erection of a boiler, with chimney and superheater, the following tenders have been received by Poplar Council :—

Clarke, Chapman & Co., *£2,100 (heating surface 4,150 sq. ft. and grate area 88 sq. ft.) ; Stirling Boiler Co., £2,800 (4,096 sq. ft. and 88 sq. ft., and superheater heating surface 550 sq. ft.) ; Babcock & Wilcox, £3,050 (4,000 sq. ft., 98 sq. ft. and 670 sq. ft.).

* Recommended for acceptance.

Annual contracts for lamps have been placed with Cryselco (Ltd.) by the following :—

G.P.O., L.C.C., Sheffield Corporation, Edinburgh & District tramways, the Corporations of Dewsbury, Salford, West Ham and Wigan, and the Mersey Docks & Harbour Board.

Hammersmith (London) Council have accepted the tender of the Fulham Steel Works Co. for erection of a steel shaft (100 ft. high) at the electricity works for £400. There were nine tenders, varying from £400 to £935.

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The tender of Pryke & Palmer at £23. 15s. 4d. for steam piping for the hot well at the Bermondsey (London) generating station has been accepted.

Aston Manor Council have accepted the tender of Johnson & Phillips for switchboard extensions, and that of the Adams Mfg. Co. for a year's supply of motor-starting switches.

Stockport Council have accepted the tender of Fildes & Barlow for wiring the new offices at £120. 14s.

Ryde Council have accepted the tender of Ashton & Holt for a motor and pump at £45. 10s.

Ashton-under-Lyne Council have accepted the tender of the British Thomson-Houston Co. for a year's supply of motors.

Handsworth Council have placed an order for the supply of cable with Johnson & Phillips.

Bruce Peebles & Co. have received from Manchester Electricity committee an order for two 250 kw. Peebles motor-converters.

Southport Council have accepted the tender of the Staveley Coal & Iron Co. for cast-iron troughs and pipes.

Redruth Council have accepted the tender of the Urban Electric Supply Co. for public lighting for five years.

Cardiff Council have accepted the tender of Bruce Peebles & Co. for a motor-generator for the docks sub-station at £1,030.

Carmarthen Council have decided to accept the offer of J. B. Saunders & Co. for public electric lighting.

Stokers.—The Underfeed Stoker Co. have received the following orders for the equipment of water-tube boilers with their stokers:—Stepney (London) electricity works (3 Babcock boilers, repeat), Islington (1 ditto), Beckenham (2 ditto), Norwich (2 ditto), Devonport (1 ditto), Hereford (1 Stirling boiler), Ferndale Collieries power station (2 ditto).

For the equipment of internally-fired boilers orders have been received from the City & South London Railway Co. (1 dry back marine), Hampstead (4 Davey Paxman economics, repeat) and Falkirk (2 Lancashire boilers, repeat).

Exhibition Contract.—One of the principal contracts which Messrs. Wm. Coates & Son, of Dublin and Belfast, have in hand at present is the complete electric light installation at the Irish International Exhibition, Dublin. The plant for this work is of 2,000 H.P., made up in 6 units of steam and gas. There are 600 arc lamps, 25,000 incandescent lamps, and about 50 motors driving various kinds of machinery in the stands. All the telephones, electric clocks, &c., are also being fitted by the company.

BUSINESS NOTICES.

Mr. John H. Harpin notifies that he has relinguished his position as manager for the Alliance Electrical Co. at their Birmingham depot in order to commence business as an electric lighting and power engineer, under the style of John Harpin & Co., at Bank-chambers, 47½, Temple row, Birmingham. He wishes to receive copies of manufacturers' lists.

The undertakings of the Kabelfabrik Aktien-Gesellschaft, Vienna, and the Mährish-Schlesischen Aktien Gesellschaft für Drahtindustrie have been combined under the title of the Kabelfabrik und Drahtindustrie Aktien-Gesellschaft, with head offices in Vienna.

The Union Electric Co. (Ltd.) have increased their number of exchange lines, and have established an isolated exchange at their London office with several lines serving the following departments: Secretary's office, technical manager, commercial manager, accounts office, arc lamp sales engineer, switch-gear sales engineer, dynamos and motors sales engineer, and order executing. The company's telephones are all under the same number, Hop 2,970.

Messrs. Pritchetts & Gold have now an additional telephone service. Their telephone numbers are 3,181 and 3,182 Victoria.

Messrs. Handley & Shanks, of Birmingham, ask us to announce that Mr. Marshall Osborne is no longer in their employ.

BANKRUPTCIES, LIQUIDATIONS, &c.

Arthur Blackburn, formerly in business as an electrical engineer at Batley Carr and Cleckheaton, has been discharged subject to his undertaking to pay £20 in three years. Debts £302. 3s. 4d., and a first and final dividend of 5s. 9d½. had been paid.

Harry, Aublet & Co. (Ltd)., 53 and 55, Curtain-road, London, E.C., is being wound up voluntarily.

Electricity Works for Sale.—An advertisement contains particulars of a valuable freehold property, situate on an important river in the South of England, comprising a large water mill converted into an electricity generating station, two private residences, a riverside garden of over 1 acre and suitable for building purposes, three islands, valuable fishing rights, &c.

Agents Wanted.—The sole agents for an important German firm manufacturing soldering and insulating compounds, &c., require pushing sub-agents in London and all important towns in the United Kingdom, having good connections amongst cable manufacturers, electric light companies, &c. See an advertisement.

Sales Agency Required.—A high-class German firm, manufacturing electric measuring instruments, wish to treat with a first-class English house for the general sales agency of its instruments for the United Kingdom and colonies. See an advertisement.

An advertiser desires an agency for Holland in electric light and gas fittings, &c.

Ediswan "Carbone" Arc Lamp.—On Friday evening last an opportunity was afforded members (and their friends) of the Royal Institution of examining and seeing in use the Ediswan "Carbone" white flame arc lamps, two of which were exhibited at the rooms of the Institution, in Albemarle-street, London. The lamps attracted considerable attention, and it was recognised that they marked an advance in the science of illumination. Their soft and diffused light and the steadiness of the flame were specially noted. We understand that the Edison & Swan Co. will be pleased to show the lamp in use to anyone interested at their showrooms, Queen-street, Cheapside, London, E.C.

CATALOGUES, &c.

Pyrometers.—The accurate measurement of temperature and the provision of means for recording temperature variations are absolute essentials to certain industrial and engineering operations. The thermo-electric pyrometer of Crompton & Co. has been developed with these objects in view, and we understand from their latest publication that it has been successfully applied in practice for all kinds of temperature measurement. The publication referred to (U 12) gives much useful information regarding the Crompton instrument and the illustrations of the thermo-couple and indicating instruments are well reproduced. The latest pattern is a portable type with instrument in carrying case.

Wiring Cables.—A "Silvertown" booklet, entitled "Cables for Electric Light Wiring," is just published, and a copy should be in the hands of every wiring contractor and wireman.

Circuit-breakers.—The demand for good circuit-breakers is evidently on the increase, judging by the many types at present on the market. The Moy type No. 37 maximum-current circuit-breaker is made for continuous-current circuits up to 600 volts, and capacities between 1,000 and 3,000 amperes. It is a carbon-break device and has a powerful magnetic blow-out. Beading contacts are also furnished to protect the main brushes when breaking the circuit. Sheet Nos. 37 and 38 recently issued give full particulars and prices.

Cranes.—J. M. Henderson & Co., of Aberdeen, are well known as makers of electric cranes and cableways. Their latest publication takes the form of a large fourfold postcard, containing some excellent illustrations of their electric and steam cranes, and a cableway as employed in a quarry.

Ammeters and Voltmeters.—Johnson & Phillips' latest list, which is of uniform size with their previous publications, is devoted to dead-beat moving iron ammeters and voltmeters for a.c. and c.c. circuits. This pattern of instrument is fitted either in round iron cases or sector pattern cases. It is also made up in portable form of polished walnut wood cases with carrying strap. Price list MI contains fully illustrated particulars and prices.

Hydro-Electric Power.—The latest Bruce-Peebles publication is a brochure containing a complete description of the hydro-electric installation of the North Wales Power & Traction Co.

A.C. Instruments.—The three-phase wattmeters, both portable and switchboard types, made by Elliott Bros., of Lewisham, are the subject of their pamphlet A.C. 84, of which a copy is just to hand. The section on three-phase measurements should prove very useful, as a number of handy formulæ are given. The diagrams of connections are very clear.

Fuse Boxes.—The Bowen & Odery Mfg. Co., of London, send a preliminary list of their SP ironclad disconnecting fuse box with ventilated and enclosed fuses. It is claimed that these are of simple and substantial construction and occupy but small space. Reliability and safety are also amongst their features.

Heating and Ventilating.—Messrs. Davidson & Co., Sirocco Engineering Works, Belfast, have just published a handsome booklet entitled "Heating and Ventilating," in which illustrations of ventilating fans and typical illustrations of the same are admirably displayed. The text of the catalogue is printed in blue, and the disposition of the illustrations amongst the reading matter is both effective and artistic. The publication is divided into four main sections: (1) Sirocco apparatus, (2) heating and ventilating of industrial buildings, (3) ventilation of public buildings, (4) ship ventilation. The field covered is very complete from the point of view of ventilation. Probably the company would find it useful to issue the sections of the booklet separately to circulate amongst the heads of the various branches of industry dealt with. The publication is one of the best arranged that we have recently seen.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which

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is not separately specified) from April 10 to 16 with the ports of destination :—

Aden, £54 (telegraph material). *Africa*—Alexandria, £152; Benguela, £94 (telegraph material); Cape Town, £141; Delagoa Bay, £10; Durban, £613 (including £540 telegraph material); East London, £494; Kilindini, £66; Port Elizabeth, £48; Suakim, £50. *Argentina*—Buenos Ayres, £1,408 (including £341 telegraph material). *Australasia*—Adelaide, £2,098 (including £65 telegraph material); Auckland, £75; Bluff, £60; Christchurch, £38; Fremantle, £60; Hobart £1,422 (telegraph cable); Lyttelton, £138; Melbourne, £1,652 (including £450 telegraph material); Otago, £1,025; Rockhampton, £14; Sydney, £2,006; Wellington, £1,747 (including £1,557 telegraph material). *Belgium*—Brussels, £217; Ghent, £56. *Berbera*, £112 (telegraph material). *Brazil*—Pernambuco, £252. *British Guiana*—Demerara, £62. *Burma*—Rangoon, £276 (including £86 telegraph material). *Canada*—Quebec, £33; Toronto, £43. *Canary Islands*, £116. *Ceylon*—Colombo, £74. *Channel Islands*, £80 (telegraph material). *Chili*—Valparaiso, £68. *China*—Kowloon, £340; Shanghai, £129. *Cochin China*—Saigon, £20. *France*—Boulogne, £83. *Germany*—Bremen, £41; Hamburg, £11. *Gibraltar*, £418. *Holland*—Amsterdam, £158 (including £133 telegraph material); Flushing, £25; Rotterdam, £5. *Hong Kong*, £456. *India*—Bombay, £1,492 (including £86 telegraph material); Calcutta, £2,583 (including £450 telegraph material); Madras, £157. *Japan*—Hiogo, £200; Nagasaki, £349; Yokohama, £1,700. *Mauritius*, £30 (including £10 telegraph material), *Peru*—Calloa, £41 (telegraph material). *Russia*—Kureh, £3,673; St. Petersburg, £26. *St. Helena*, £90 (telegraph material). *Siam*—Bangkok, £237. *Spain*—Carthagena, £33. *Straits Settlements*—Singapore, £260 (including £132 telegraph material). *Uruguay*—Monte Video, £706. Total, £28,117, against £10,924 for two days last year (April 11 and 12).

COMPANIES' MEETINGS AND REPORTS.

Cuba Submarine Telegraph Co. (Ltd.)

The seventy-first ordinary general meeting was held on Wednesday, Mr. CHARLES W. PARISH (chairman of the Company) presiding.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the auditors' certificate.

The CHAIRMAN : Gentlemen, we have a satisfactory account to lay before you, for our traffic during the last six months has been larger than for some years past. You will see from the comparative statement which we append to the report that the half-year ending June, 1905, gave £14,811, the following half-year gave £13,151, the first half of 1906 gave £17,638, and now we record for the half-year ending December last £18,458. This marked increase in traffic is partly due to the political rising which took place in the island, followed by the intervention of the United States Government, when a great deal of work was thrown upon our cables and we kept open the stations at night time to be of the best possible service to the authorities. Besides this exceptional cause of increase there has been going on a considerable movement in all business in Cuba, to which I alluded when I addressed you six months ago. Our cables have worked very well, and, luckily, our property did not seriously suffer from the terrible cyclone which occurred in October. Beyond the £18,458 of traffic, we have £1,549 of interest, &c., for the half-year, making together £20,007. Our expenses amount to £6,513, leaving a balance of £13,494 to deal with. We, therefore, are able to provide £3,000 for the preference dividend, £4,000 for a dividend at the rate of 5 per cent. per annum on the ordinary shares and place £6,000 to the reserve. The expenses amount to £6,513, while for the corresponding half-year in 1905 they were £6,257, an increase of £256, which was due to the local expenses at the various stations. Turning to the balance-sheet, we now increase the reserve to £98,000. It is the true corner-stone of every cable company to have a strong reserve, and we feel it is the only way by which the interests of the shareholders can be securely protected. I regret to tell you that we have failed in obtaining from the law courts in Cuba the due recognition of our claim for the subsidy granted us by the Madrid Government when we laid the coast cables. We think we have been very hardly treated, but I suppose that the authorities there take a different view of the matter. We are now going to make the claim in Madrid, and hope we shall be more successful there than we have been in Havana. It is one of those difficult questions which arise from time to time. The Cuban Government rightly say they never gave the subsidy. Why ask them for it? It is not their business. But we reply that the cables are there and of great use to them. They never could have been laid without the subsidy, and it is very hard upon us to be deprived of it. We are in communication with our Foreign Office, and I am sure they will do what they can to help us at Madrid. Our claim against the United States Government for the damage done to our cables during the Spanish-American war is, I regret, still unsettled. To get payments for even the most just claims out of Governments seems a terribly slow process, and all I can say is that we mean to go on hammering away and hope in time to receive what is due to us. I wish to refer to another matter, which is of some importance, or may be of very great importance. We understand that a cable is shortly to be laid from New York to Colon, in the Isthmus of Panama, touching at a point on the coast of Cuba. The communication between Cuba and the United States is also to be increased by the laying of a cable from New York to Havana. We do not, of course, know to what extent these new cables with affect our business, but we are carefully watching the position, and our policy of strengthening the reserve fund is one which we think will tend to the best interests of the Company. As you are aware, we have been left pretty well to ourselves for many years. I think this is the seventy-first half-yearly meeting that this Company has had; but, of course, as time goes on, we must expect that others will wish to lay cables to Cuba, or, as in the case of this cable to Colon, that new cables should touch at the Island of Cuba. I am afraid that we can say nothing in the matter. It is a sign of competition, and it is no good shutting our eyes to the fact. As far as we have gone in the present half-year, we have had a very good traffic to deal with. The earthquake in Jamaica brought us an unexpected amount of press and private business, and I hope when we next meet we will again be able to lay before you a satisfactory report. I now move the adoption of the report and accounts.

Mr. GEORGE KEITH seconded the motion, which after a brief discussion was unanimously agreed to.

Resolutions approving the dividends having been agreed to, a very cordial vote of thanks to the Chairman, Directors and staff terminated the proceedings.

BABCOCK & WILCOX (LTD.)—The net profit for 1906 (after deducting depreciation, &c.) amounted to £285,928. 9s. 11d., and with £31,966.14s.7d. from last account the balance is £317,895. 4s. 6d. Deducting interim dividends of 3 per cent. on the preference and of 8 per cent. on the ordinary shares (£69,400) the balance is £248,495. 4s. 6d. After paying the balance preference dividend, the directors recommend a final dividend for the half-year to Dec. 31 of 8 per cent. on the ordinary shares (tax free) with a bonus of 4 per cent. on the ordinary shares (also tax free). £100,000 is placed to reserve and £20,000 to the dividend equalisation fund, leaving a balance forward of £25,895. 4s. 6d. Further extensions at the works have been undertaken, for which it is expected ample employment will be found. The volume of the company's business during this year so far is increasing.

BRITISH ELECTRIC TRANSFORMER CO. (LTD.)—At the fourth ordinary general meeting, held on Friday last, Mr. E. Phillips presided, and said the debts owing by the company were £4,000 less, as they had bought sparingly, on account of the very high prices of material. They had increased the depreciation reserve by £1,500, in accordance with the resolution of the last general meeting. On the other side of the balance-sheet, patents showed a diminution of £146, although they now possessed several new and useful patents taken out by Mr. Berry during the year. On this point he might say they were being approached with a view to the purchase of their rights in several countries. Preliminary expenses had been reduced by £1,500, the account, which was originally £8,554, being now £2,720. Land, buildings, &c., was larger by £424, owing to sundry additions and alterations to plant. The item of debts due to the company was much less, owing principally to the large amount written off. Net profit for the year, after writing off the capitalised value of patents sold and all expenses incurred in obtaining them, was very nearly the same as for 1905. With regard to the writing off recommended in the report, this would leave them with a loss to carry forward. With regard to their investments, these from time to time included (1) shares in companies, either acquired with a view to facilitating or securing business, and (2) shares received in part payment for goods. Under the first category a considerable amount was invested as long ago as 1903 in a company whose shares have depreciated owing to the misfortunes of two of the power companies in which it was deeply interested. At the time this investment was made it was considered a thoroughly sound business transaction. In consequence of the depreciation of these shares the directors had written down the value of the original investment to a large extent. Under the second category—shares received in part payment for goods—these shares were sold as received when possible, but, unfortunately, they were left with some owing to the difficulty of finding buyers. These shares had been taken into the accounts at a merely nominal figure. The two instances of loss to their company were occasioned, primarily, by the failure of the South Wales Co. to meet its engagements. That company also owed them a large amount in cash, which they had been obliged to write off. The larger part of the balance of their total loss was incurred through orders received from a large company, which was likewise unable to meet its engagements in cash, and they had been obliged, in common with other contractors, to take shares in satisfaction. As these shares are not saleable at their face value, the directors had taken them at a considerable reduction. The companies referred to, at the time the directors entered into the contracts, were thought to be thoroughly good for their engagements, and were backed by some of the shrewdest financiers in the City of London, who put very large sums into them, and even bought shares at a premium. To mitigate as far as possible the blow that fortune had dealt them, the board had pursued a policy of severe retrenchment, so as to effect considerable economies. These economies consisted mainly of changes in the staff, which had not been brought about without serious thought. Thanks to the reserve of £6,000 and to the profit on the year's trading, it has been possible to provide immediately for close upon £17,000 out of the total amount they considered it advisable to write off. With regard to the present position of the company, he considered the business to be in a healthy condition. They had a great many new customers on their books, amongst them the Admiralty. Competition had been, and was still, extremely keen in the trade, but they held their own. Despite the high price of raw materials their works output during 1906 was nearly 50 per cent. more than for 1905, if they excluded orders from the South Wales Co. The ratio of profit was, however, somewhat less.

Mr. F. BIRD said there was something said last year as to the sale of the American patents. He saw nothing about this in the report. As to the alterations in the management, "swooping horses when crossing the stream" was not always beneficial or always wise.

Mr. WALTON asked what the additions to patents made during the year consisted of. He was one of the original men who went in with Mr. Billington, their managing director, in starting this company, with a view to making transformers, and, of course, improving upon transformers. He said that Mr. Berry had started an opposition company for the pur-

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pose of making heating apparatus, which consisted, so far as his technical knowledge guided him, in a short-circuiting transformer. Did this patent belong to this company or to the new company?

Mr. BERRY: The point raised by Mr. Walton and to which Mr. Bird has attached importance is one I welcome the opportunity to refer to. I have an interest in this company of 20 odd thousand pounds, and my relatives and my friends have rather more than this. With regard to the operations of the Berry Construction Co., they have no intention at the moment of manufacturing anything that this company can and is fitted to manufacture. I do not think it is a breach of confidence to say that a contract is now being entered into whereby I agree on behalf of the Berry Construction Co. to give to the Transformer Co. the order for all transformers required in connection with my heating and cooking patents. I am sorry, after all I have done in the past for the company, and shall continue to do, if this action on my part is misinterpreted.

Mr. WALTON: The point is do these patents belong to this company or not? Has our managing director taken counsel's opinion upon this point?

The CHAIRMAN: The question was referred to two counsel and they did not agree. Mr. Bird has asked the names of the companies which have caused our great loss. These are the South Wales Electrical Power Distribution Co., the Cleveland & Durham County Power Co., and the British Power Co. I think the latter was the originator of the other two concerns. With regard to the American patents, just before the last meeting we sold these patents, and part has been written off patents. The value of the patents to start with was £25,000 for four patents, and now they stand at about £28,000 for close on 100.

The report was then adopted.

Mr. A. M. BILLINGTON (managing director) said he must dissociate himself from the words in the second paragraph of the report "that the current year will show improving results." He did not think that statement justified in view of the increasing competition, cost of raw material, and other things. He did not approve the change of management. He thought it false economy. He had started this company, and for five years had worked nights and days in its interest. His agreement terminated at the end of April, and the suggestion was that he should be managing director, but not to be called managing director, a proposal he could not entertain.

Mr. WILKINSON then proposed that a committee of shareholders be formed, a suggestion which was adopted, Messrs. Marchmont, Beevor and Bird being appointed.

CITY & SOUTH LONDON RAILWAY CO.—A special meeting of the proprietors was held on Tuesday "to sanction the creation and issue of part of the additional capital authorised by the City & South London Railway Act, 1903, and to authorise the exercise of part of the borrowing powers in respect thereof." The meeting was presided over by the Right Hon. C. B. STUART-WORTLEY, K.C., M.P. The secretary (Mr. W. F. KNIGHT) having read the notice convening the meeting, the CHAIRMAN commended the resolution to the meeting, and in doing so said that the money was required in connection with their extension to Euston. He had been over the new line between Euston and King's Cross the previous day and found everything in a forward condition. If nothing unforeseen occurred, the extension would be opened about May 11 by Mr. Percy Harris, chairman of the London County Council. The City & South London line would then be linked up with the three great railway systems—the London & North-Western, the Midland and the Great Northern Railways; also with the Piccadilly Tube at King's Cross and the Hampstead Tube at Euston. The proposal before the meeting was (1) that £200,000 be created, and that the directors be empowered to raise such capital by the issue, wholly or partially at their option, of £5 per cent. perpetual preference stock or consolidated ordinary stock, in such amounts, at such times and on such terms and conditions as they may think fit; (2) that the directors be empowered to issue 4 per cent. debenture stock to the extent of £50,000 in such amounts, at such times and on such terms and conditions as they may think fit. The proposals were carried unanimously.

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—The revenue account for 1906, after providing £12,000 for interest on debentures and the preference dividend to Dec. 31, shows a surplus of £79,131. 2s. 6d., from which is deducted £2,104. 14s. interim dividend at the rate of 5 per cent. on the ordinary shares for the half-year to June 30, leaving £77,026. 8s. 6d. The directors now recommend payment of a balance ordinary dividend at the rate of 5 per cent. and a bonus of 5 per cent. (making 10 per cent. for the year). Capital expenditure during the year amounted to £3,634. 19s. An agreement was made with the Birmingham Corporation for the surrender to them of the lease of the Nechells horse tramway at Sept. 30 last. The lease from Birmingham Corporation of all the steam tramways within the city, with the exception of the Great Hampton-row line (at present unworked), expired on Dec. 31, when the tramways were surrendered to the Corporation. The only tramways worked by the company within the city are the cable tramway and the Bristol-road electric tramways, 4 miles 7 furlongs of route length. The repair shops and car sheds at Tividale, near Dudley, are now in operation, and an arrangement has been made with Birmingham Corporation for the passage over the Corporation's tramways to the depot of cars requiring repair. Negotiations have taken place with Yardley Council with a view to the sale to them of the company's undertaking and interests in Yardley, but it has not been found possible to come to any agreement. The tramway on the Stratford-road between the City Boundary and College-road, Yardley, has been reconstructed for working by electric traction, and an arrangement has been made by which Birmingham Corporation operate the section of this tramway. Current for working this section is supplied by the company from its power station in Yardley. The Coventry-road tramway, which is partly within the city and partly in Yardley, is worked jointly by the Corporation and the company on the basis of the receipts in each area belonging to the owner of the line. King's Norton Council have purchased for £26,000 the King's Heath depot and portions of the King's Heath and Moseley tramways within their district. All the lines in Aston worked by the company are now working by electric traction, with the exception of the Wheeler-street route. Negotiations are proceeding with Birmingham Corporation for the operation of through services between Birmingham and Erdington and Birmingham and Perry Bar, Handsworth. The surrender to Birmingham Corporation of 10¼ miles of tramway in Birmingham and the sale of the tramways in King's Norton has produced the following financial position: Assets, either in cash or easily realisable, consist of sums deposited with the trustees and invested by them (£187,134. 6s. 3d.) and the amount temporarily invested by the company (£211,650), total £398,784. 6s. 3d. In addition to the revenues till 1911 from the tramways under lease to the company and the overhead equipment of the Bristol-road and Coventry-road tramways inside the city, the company possesses nearly 5 miles of cable and electrically-equipped tramways outside the city, and generating stations, car sheds and rolling stock required in connection therewith. There are also 50,996 fully-paid preference and ordinary shares of £1 each in the Birmingham & Midland Motor Omnibus Co. The cash already realised is more than sufficient to pay off the whole of the £300,000 debentures, but cannot be applied to this purpose, as the debentures are not redeemable until Oct. 15, 1917, unless the company be wound up, or fail to perform the covenants of the trust deed. If the debentures are not paid off till 1917 there will be a continuing loss arising out of difference of interest and expenses of about £3,000 per annum, and the directors are, therefore, considering the question of winding up the company.

DUDLEY, STOURBRIDGE & DISTRICT ELECTRIC TRACTION CO. (LTD.)—The gross receipts for 1906 amounted to £46,282. 6s. 1d., and the expenditure to £32,138. 19s. 10d., including £500 placed to depreciation and renewals account, interest on debentures, cost of repairs and maintenance, &c., leaving a balance of £14,143. 6s. 3d. After deducting preference dividend and adding £506. 14s. 3d. brought forward, the amount available is £9,650. 0s. 6d. The directors recommend a dividend of 5 per cent. on the ordinary shares. Expenditure on capital account during the year amounted to £2,699. 10s. 5d. The number of passengers carried was 8,432,344, against 8,370,791 in 1905; average receipts per passenger 1·18d., against 1·32d.; average working expenditure per passenger 0·78d., against 0·84d.; proportion of expenses to receipts 60 per cent., against 63 per cent.

INDO-EUROPEAN TELEGRAPH CO. (LTD.)—The directors' report for the year to Dec. 31 last states that the lines of the company continue to work efficiently, and the direct Wheatstone working enables constantly increasing traffics to be dealt with without additional delay and with a minimum of errors. The revenue from message account and other sources amounted to £124,610. 4s. 7d., compared with £129,761. 18s. 11d. for 1905, a decrease of £5,151. 14s. 4d. Expenses were, on commercial and general account £46,675. 1s. 7d., and on maintenance account £26,968. 11s. 3d., total £73,643. 12s. 10d., against £70,792. 10s. 5d. for 1905, increase £2,851. 2s. 5d. The revenue account shows a balance of £50,966. 11s. 9d., and after deduction of income tax paid is reduced to £47,177. 13s. To this is added the balance of £16,698. 16s. 7d. brought forward, and £3,838. 5s. 10d. in respect of outstanding traffic receipts kept (with the approval of the shareholders) as an open balance in the accounts for 1905, which the directors have now decided to bring into profit and loss, making £67,714. 15s. 5d. The directors have also decided to provide £16,240 to meet the further depreciation to date which has unfortunately taken place upon the company's investments. Deducting this sum and the interim dividend of £10,625, already paid, the available balance is £40,849. 15s. 5d. The directors now propose to declare a dividend for the six months ended Dec. 31 of 17s. 6d. per share (making, with the interim, 6 per cent. for the year) and a bonus of 20s. per share, both tax free, carrying forward £8,974. 15s. 5d. They do not consider it necessary to re-invest the interest accrued during 1906 upon the unappropriated investments and upon the deposit of Russian Government Rente, and therefore propose to make a special distribution to the shareholders from these sources of £12,750, equivalent to 15s. per share. This distribution also will be tax free. The directors refer with great regret to the death in May last of Mr. W. S. Andrews, for upwards of 34 years connected with the company as manager, managing director and director.

OLDHAM, ASHTON & HYDE ELECTRIC TRAMWAY (LTD.)—Mr. E. Garcke stated at the meeting on Tuesday that the improvement foreshadowed by him at last year's meeting had been in large measure realised. They had carried over 6,000,000 passengers, about 200,000 more than in the preceding year. The average receipts per passenger were slightly up and the expenses were a little less. A satisfactory feature was that the proportion of expenses to receipts had been reduced from 72·4 per cent. to 67·8.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—In their report for the year 1906 the directors state that, including £1,737. 12s. 6d. from 1905, and after deducting interim dividends of 8 per cent. on both preference and ordinary shares, and making provision for redemption of debenture stock and share capital, and other charges, the amount to be dealt with is £13,133. 5s. 8d. The directors recommend payment of the final preference dividend and of 4 per cent. on the ordinary shares, tax free (making 7 per cent. for the year), and the transfer of £3,500 to reserve. The company's underground cabling operations in Madras, Moulmein, Rangoon and Singapore are steadily proceeding, and it is expected that these schemes will be completed this year. The electrical branch of the company has been worked to a moderate profit, but competition in the East, as elsewhere, has been very keen.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—The capital expenditure during 1906 was £12,699. 10s. 1d. on the extension of feeders, purchase of five additional cars, the acquisition of a new car-shed, &c. The total revenue amounted to £109,266. 14s. 8d. Traffic receipts were £94,877. 16s. 6d.,

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an increase of £4,609. 4s. 4d. over 1905. After deducting all expenses chargeable to revenue (including £11,229. 17s. 5d. interest) there remains £26,941. 19s. 1d., added to £724. 8s. 10d. brought forward, making £27,666. 7s. 11d. The directors recommend that £2,500 be placed to renewals fund, £2,500 be transferred to credit of depreciation and reserve, and that dividends be paid of 5 per cent. on the cumulative preference shares and 4 per cent. on the ordinary shares, leaving £616.10s.11d. to be carried forward. An application has been made for an extension of time for the completion of the Hanley to Bucknall line and a portion of the Longton Blythe Bridge route. The remainder of the latter route, as well as the Newcastle to Trent Vale route, are to be abandoned.

WOLVERHAMPTON DISTRICT ELECTRIC TRAMWAYS (LTD.)—The report for 1906 states the revenue was £24,279.14s. 5d. Deducting expenses (including interest, repairs and maintenance, and depreciation) the profit is £3,997. 13s. The available balance is £4,240. 1s. 9d. The directors recommend a dividend of 2 per cent. on the ordinary shares. Capital outlay during the year was £1,056. The arbitration proceedings with reference to the tramways in Dudley have not yet been concluded, the question of the price to be paid for Light Railway No. 5 of the Order of 1898 having been taken to the House of Lords from the Court of Appeal by Dudley Corporation. The tramways owned by the company in Dudley are about 7 furlongs in length, and the price has been fixed by the arbitrator at £9,086. The Corporation are under agreement to grant a lease of those tramways to the company for 21 years from date of purchase. Intercommunication has been established between Wolverhampton and Dudley and arrangements have been made with the South Staffordshire Tramways (Lessee) Co. for a through service of cars between Bilston and Walsall after May 1. The number of passengers carried was 4,102,874, against 3,640,275 in 1905; average receipts per passenger 1·39d., against 1·44d.; average working expenditure per passenger 0·89d., against 0·99d.; proportion of expenses to receipts 64 against 69 per cent.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

ALUMINIUM CORPN. (LTD.) (92,846.)—Reg. April 10, capital £500,000 in £1 shares, to acquire freehold lands, water rights and properties comprised in agreements with the North Wales Power and Traction Co. (Ltd.) and the Law Debenture Corpn. and with the Aluminium Synd. (promoters), and to carry on the business of manufacturers of and dealers in aluminium, electricians, electrical and mechanical engineers, generators and storers of electricity, &c. First directors, the Hon. Sir J. Sivewright, W. Beardmore, E. Manville and W. A. Smith. Reg. office, Basildon House, Moorgate-street, London, E.C.

ANGLO-NORWEGIAN ALUMINIUM CO. (LTD.) (92,830.)—Reg. April 9, capital £110,000 in £1 shares, to acquire and utilise water power at Vigeland Falls, near Christiansand, Norway, for the purpose of manufacturing aluminium or other electrochemical or metallurgical products, to adopt agreements with V. Brug and with J. C. Hawkshaw, and to carry on the business of winners, producers and workers of aluminium, sodium, iron or other metals and their alloys, explorers (particularly in relation to metals and minerals and the development of electricity), &c. The subscribers (each with 500 shares) are, E. C. Hawkshaw, C.E.; W. B. McNewan, N. Vannpaham, C.E.; F. R. Hodgson, Col. H. B. Jeffreys, A. A. C. Verinton, engineer, and O. Hawkshaw, C.E.

NEWARC LAMP SYND. (LTD.) (92,801.)—Reg. April 5, capital £6,000 in £1 shares, to carry on the business of manufacturers of and dealers in lamps, wires and lines, electricians, engineers, suppliers of electricity, manufacturers of and dealers in electrical apparatus, &c., and to adopt an agreement with R. P. Myers. Reg. office, Leadenhall-buildings, London, E.C.

PREMIER ACCUMULATOR CO. (LTD.) (92,855.)—Reg. April 10, capital £40,000 in £1 shares (11,000 7 per cent. cumulative preference), to acquire the business of electrical engineers carried on by A. Schanschieff and H. Stephens at Northampton as the Premier Accumulator Co., and to carry on the business of electrical and mechanical engineers and contractors, suppliers of electricity, manufacturers of and dealers in accumulators, batteries, railway, tramway, electric, magnetic, telegraphic, telephonic and other apparatus, &c. First directors, H. Stephens and A. Schanschieff. Reg. office, Cattle Market-road, Northampton.

STATUTORY RETURNS.

AFRICAN TRANSCONTINENTAL TELEGRAPH CO. (LTD.)—Return to March 11 gives capital as £300,000 in £1 shares, of which 226,850 have been taken up. £1 per share has been called up and £225,855 has been received, leaving £995 in arrears. A further £10 has been paid on 20 forfeited shares. Mortgages and charges nil.

CAMBRIDGE ELECTRIC SUPPLY CO. (LTD.)—Return to March 13 gives capital as £100,000 in £10 shares, 9,423 of which have been taken up. £9 per share has been called up, and £84,807 has been received. Mortgages and charges: £30,000 first debentures and one debenture with Capital & Counties Bank (Ltd.) to cover £10,000.

CHARING CROSS, WEST END & CITY ELECTRIC SUPPLY CO. (LTD.)—Return to March 19 gives capital as £2,100,000 in 130,000 preference, 130,000 ordinary, 80,000 City Undertaking preference and 80,000 City Undertaking ordinary shares of £5 each, of which 80,000 preference, 80,000 ordinary, 80,000 City Undertaking preference and 70,000 City Undertaking ordinary have been taken up. £5 per share has been called up on 80,000 preference, 80,000 ordinary and 80,000 City Undertaking preference shares, and £1,200,000 has been paid. £350,000 is considered as paid on 70,000 City Undertaking ordinary. Mortgages and charges: £445,736 4 per cent. debenture stock and £472,000 City Undertaking 5 per cent. debenture bonds.

ELECTRIC WIRING & FITTINGS CO. (LTD.)—The capital in return to Feb. 8 is £5,000 in £1 shares, of which 1,382 have been taken up. £1 per share has been called up and £1,375 has been received, leaving £7 in arrears. Mortgages and charges nil.

W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)—According to return to March 15, the capital is £400,000 in 40,000 preference and 40,000 ordinary shares of £5 each, all of which have been taken up. £5 per share has been called up on 39,880 preference and 32,616 ordinary, and £362,480 has been received. £37,520 is considered as paid on 120 preference and 7,384 ordinary. Mortgages and charges, £150,000.

LONDON ELECTRIC WIRE CO. (LTD.)—According to return to Feb. 25 capital is £150,000 in £5 shares (10,000 preference), of which 15,807 ordinary and 5,956 preference have been taken up. £5 per share has been called up on 8,087 ordinary and 5,956 preference, and £70,215 has been received. £38,600 is considered as paid on 7,720 ordinary shares. Mortgages and charges nil.

MUNICIPAL ELECTRIC LIGHT & POWER CORPN. (LTD.)—Return to Dec. 30 gives capital as £25,000 in 2,490 ordinary shares of £10 each and 100 founders' shares of £1 each, of which 37 ordinary and 30 founders' have been taken up. £10 per share has been called up on the ordinary and £1 per share on the founders', and £400 has been received. Mortgages and charges nil.

OXFORD ELECTRIC CO. (LTD.)—The capital in return to March 15 is £150,000 in 20,000 ordinary and 10,000 preference shares of £5 each, of which 20,000 ordinary and 3,000 preference have been taken up. £5 per share has been called up on 16,200, and £81,000 has been received. £35,550 is considered as paid on 7,110. Mortgages and charges, £50,000.

A. REYROLLE & CO. (LTD.)—The capital in return to March 5 is £20,000 in £1 shares (8,000 preference and 12,000 ordinary), all of which have been taken up. £1 per share has been called up on 8,000 preference and 5,000 ordinary, and £13,000 has been received. £7,000 is considered as paid on 7,000 ordinary. Mortgages and charges nil.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—Return to Feb. 26 gives capital as £300,000 in £5 shares (20,000 preference), all of which have been taken up. £5 per share has been called up on 39,650 ordinary and 20,000 preference, and £298,250 has been received. £1,750 is considered as paid on 350 ordinary. Mortgages and charges, £150,000 3½ per cent. debenture stock and £168,438 4 per cent. guaranteed debenture stock of the Central Electric Supply Co., being half loan capital.

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—Return to March 12 gives capital as £448,200 in 37,350 shares of £12 each, all of which have been taken up and paid for in full. Mortgages and charges nil.

MORTGAGES AND CHARGES.

BRITANNIA ELECTRIC LAMP WORKS (1905) (LTD.)—Particulars of £200 debentures, created by resolution of March 11, 1907, have been filed pursuant to sec. 14 (4) of the Companies Act, 1900. Property charged: Company's undertaking and property, present and future, except uncalled and unissued capital. No trustees.

THOMPSON, RITCHIE & CO. (LTD.)—£600 debentures, created March 19 and dated March 20, 1907, charged on company's undertaking and property, present and future, including uncalled capital, have been registered. No trustees.

CITY NOTES.

MEMORANDA (April 18).—Bank rate 4½ per cent. (since April 11, 1907). Price of silver 30⅛—30$\frac{5}{16}$d. per oz. Consols 86—86⅛ for money, 86⅛—86¼ for account; 2½ per cent. annuities 84½—84⅝. Consols Pay Day, May 3; Stocks and Shares Continuation Days, April 24 and May 13; Ticket Days, April 25 and May 14; Pay Days, April 26 and May 15; Mining Share Carry-over Day, April 23.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—Mr. John Gavey, C.B., late engineer-in-chief to the Post Office, has accepted a seat on the board of this company.

BRITISH COLUMBIA ELECTRIC RAILWAY CO. (LTD.)—An interim dividend has been declared on the deferred ordinary stock for the half-year ended Dec. 31 at the rate of 7 per cent.

COLOMBO ELECTRIC TRAMWAYS & LIGHTING CO. (LTD.)—The directors have declared a dividend of 2½ per cent. (tax free).

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The transfer books and register of second debenture stock will be closed from 22nd to 30th inst. inclusive, preparatory to payment on interest due May 1.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—The directors recommend a dividend of 10 per cent.

NORWEGIAN HYDRO-ELECTRIC NITROGEN CO.—This company, which was founded for the purpose of working the Birkeland-Eyde system for obtaining nitrogen from the air, has decided to increase its capital to 29,640,000 krone (£1,646,000). This increase in capital is necessitated by an arrangement with the Badische Anilin & Soda Fabrik, Ludwigshafen, which also possesses a patent for obtaining nitrogen from the air, and intends to work it in conjunction with the Birkeland-Eyde system. It is proposed, after further patents have been taken out, to exploit different waterfalls and to erect saltpetre factories.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	April 10	1,250	– 81	45	62,362	+ 1,958
Airdrie	,, 5	239	+ 14	13	2,923	– 1
Anglo-Argentine	,, 15	17,819	+ 2,235	15	243,611	+ 19,066
Ashton-under-Lyne Corp	,, 13	323	– 88	3	1,260	+ 251
Ayr Corporation	,, 13	237	– 27	48	13,650	+ 75
Baker St. & Waterloo Ry.	,, 13	2,380	+ 1,159	5	11,135	+ 3,586
Barnsley	,, 5	225	+ 57	13	2,127	+ 31
Barrow	,, 5	304	+ 82	13	2,943	+ 135
Bath Electric Trams, Ltd.	,, 13	706	– 39	15	10,066	+ 405
Birkenhead Corporation	,, 14	941	– 271	...	...	...
Birmingham Corporation	,, 13	5,275	...	2	11,158	...
Birmingham & Mid.	March 29	771	...	12	8,958	...
Blackburn Corporation	April 10	985	+ 49	§2	3,229	+ 1,187
Blackpool Corporation	,, 11	‖1,779	+ 913	‡2	1,779	+ 1,039
Blackpool and Fleetwood	,, 13	281	– 351	2	1,303	+ 385
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 14	2,036	– 853	2	4,279	– 785
Bournemouth Corporation	,, 10	1,622	+ 168	¶1	2,984	+ 824
Bradford Corporation	,, 13	3,884	– 655	2	9,549	+ 1,218
Brighton Corporation	,, 14	795	– 287	2	1,852	– 68
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 12	4,701	– 657	9	42,268	+ 1,260
Buenos Ayres & Belgrano	,, 7	4,173	+ 707	14	48,684	+ 3,600
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 13	1,118	– 477	2	2,453	– 425
Burton Corporation	,, 14	262	– 55	2	578	– 42
Bury Corporation	,, 7	1,048	...	1	1,048	...
Calcutta Tramways Co.	,, 13	¤44,132	– ¤1,927	15	¤772,163	+ ¤101,050
Camborne-Redruth	,, 13	100	– 29	15	1,628	+ 41
Cardiff Corporation	,, 13	1,905	– 44	2	4,356	+ 494
Cavehill	,, 5	300	+ 223	13	951	+ 283
Central London Railway	,, 13	6,127	+ 437	15	93,355	– 9,616
Chatham & Dist. Lt. Rys.	,, 13	666	+ 7	¶14	9,471	+ 940
City & South London Rly.	,, 14	2,988	+ 651	15	44,581	+ 474
City of Birmingham	,, 5	3,434	...	13	35,811	...
Colchester Corporation	...	...	...	...	...	...
Cork Electric Trams Co.	,, 11	444	– 52	15	6,018	– 132
Croydon Corporation	,, 12	1,244	– 450	‡2	2,629	+ 23
Devonport & Dist. Trams.	,, 5	565	+ 100	13	5,840	+ 353
Dover Corporation	,, 13	195	– 79	2	471	– 7
Dublin & Lucan Railway	,, 12	102	– 26	15	1,425	+ 38
Dublin United	,, 12	4,959	+ 409	†15	68,903	+ 2,639
Dudley Stourbridge	,, 5	1,390	+ 613	13	10,685	+ 536
Dundee Corporation	,, 10	1,196	+ 34	55	51,521	+ 7,092
East Ham Council	,, 13	816	– 240	2	1,808	+ 8
Exeter Corporation	,, 12	278	– 13	‡2	611	+ 114
Falkirk and District	,, 10	325	...	2	651	...
Gateshead & Dist. Trams.	,, 5	1,138	+ 197	13	23,047	+ 655
Glasgow Corporation	,, 13	17,060	+ 115	45	764,702	+ 61,121
Glossop	,, 13	121	– 21	15	1,901	+ 50
Gravesend—Northfleet	,, 5	338	+ 118	13	2,930	+ 240
Great Northern & City Rly.	,, 13	1,818	+ 195	15	27,701	– 76
Gt. Northern, Piccadilly, &c.	,, 13	3,910	+ 230	15	56,329	...
Greenock & Port Glasgow	,, 5	784	+ 140	13	7,064	+ 207
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 5	354	+ 80	13	3 359	– 78
Hastings Elec. Trams Co.	,, 12	943	+ 325	15	12,083	+ 6,386
Hong Kong	,, 13	$7,074	+ $1,075	2	$16,135	+ $2,768
Huddersfield	,, 13	1,340	– 189	2	3,378	+ 607
Hull Corporation	,, 13	2,194	– 173	2	4,582	+ 47
Ilford District Council	,, 13	422	– 145	2	1,033	+ 2
Ilkeston District Council	,, 10	116	+ 3	2	322	+ 99
Ipswich Corporation	,, 13	327	– 144	2	770	+ 7
Isle of Thanet Co.	...	...	...	...	...	...
Jarrow	,, 5	185	...	13	1,452	...
Keighley Corporation	,, 11	137	– 9	41	6,171	+ 547
Kidderminster & District	,, 5	211	+ 117	13	1,285	+ 56
Kilmarnock Corporation	,, 13	151	– 9	48	7,557	+ 163
Lanarkshire Trams Co.	,, 11	1,167	+ 293	15	15,130	+ 2,868
Lancashire United	,, 10	1,050	+ 215	§15	16,678	+ 5,254
Leamington	,, 5	247	+ 70	13	1,846	+ 40
Leeds Corporation	,, 13	5,683	– 563	2	12,997	+ 2,385
Leicester Corporation	,, 13	2,116	– 207	15	31,399	+ 745
Leith Corporation	,, 13	473	– 9	†48	24,232	+ 6,286
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 14	1,367	– 32	15	20,861	+ 81
Liverpool Corporation	,, 6	11,797	+ 1,186	14	145,286	+ 3,854
*London County Council	,, 6	29,467	+ 6,156	1	29,469	+ 6,156
London United	,, 12	5,247	– 2,029	†15	80,081	+ 5,966
Lowestoft	,, 13	140	– 6	28	4,312	+ 593
Maidstone Corporation	,, 13	100	– 20	2	225	+ 3
Manchester Corporation	,, 13	12,997	– 920	2	27,416	+ 3,630
Mersey Railway	,, 13	1,789	+ 56	15	27,647	+ 1,267
Merthyr	,, 5	315	+ 124	13	2,701	+ 310
Metropolitan Dist. Railway	,, 14	7,801	+ 929	15	117,376	– 2,893
Metropolitan Elec. Trams.	,, 5	6,294	+ 2,959	13	53,029	+ 14,905
Middleton	,, 5	647	+ 331	13	4,291	+ 459
Nelson Corporation	,, 13	123	– 73	3	477	– 63
Newcastle-on-Tyne Corp.	,, 13	3,786	– 263	2	8,717	+ 868
Newport (Mon.)	,, 13	598	– 66	2	1,402	+ 145
Northampton Corporation	,, 12	376	– 39	‡2	824	+ 128
Oldham, Ashton & Hyde	,, 5	873	+ 341	13	7,816	+ 904
Oldham Corporation	,, 14	1,730	– 226	3	6,223	+ 849
Perth (N.B.) Corporation	,, 10	162	+ 9	47	7,291	...
Perth (W.A.) Elec. Trams	,, 12	1,482	– 20	15	22,624	– 149
Peterborough	,, 5	225	+ 123	13	1,474	+ 157
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 13	1,653	– 464	2	4,016	+ 218
Potteries	,, 5	2,209	+ 378	13	24,315	+ 539
Preston Corporation	,, 10	655	– 11	2	1,651	+ 342
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 11	515	+ 56	‡2	1,017	+ 259
Rothesay	,, 5	357	+ 276	13	957	+ 285
Salford Corporation	,, 15	4,208	– 1,307	2	10,031	– 770
Sheerness	,, 3	80	+ 30	13	750	+ 19
Sheffield Corporation	,, 14	5,053	– 202	3	16,161	+ 931
Singapore Trams	,, 13	$10,311	+ $1,692	2	$21,105	+ $3,585
Southampton	,, 10	919	+ 6	2	2,088	+ 311
Southend Corporation	,, 10	299	+ 14	2	565	+ 145

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ‖ Plus 4 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southport Tramways	April 5	516	+ 225	13	3 129	– 9
South Metropolitan	,, 5	1,207	...	13	9,399	...
South Staffs	,, 5	1,435	+ 596	13	11,720	+ 1,263
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 13	642	+ 323	2	1,612	– 37
Sunderland and District	,, 10	406	+ 45	15	6,022	+ 998
Swansea Trams	,, 5	1,095	+ 325	13	10,669	+ 838
Swindon Corporation	,, 3	250	+ 62	2	400	+ 31
	,, 10	150	– 31			
Taunton	,, 5	61	+ 21	13	523	– 31
Tynemouth and District	,, 5	347	+ 147	13	2,215	+ 7
Tyneside Trams Co.	,, 10	372	– 30	15	5,986	+ 1,008
Victoria, Elec. Supply Co. of	March 10	857	– 51	...	...	...
Wallasey District Council	April 13	728	– 42	2	1,666	+ 154
Walsall Corporation	,, 12	410	– 99	15	7,061	– 110
Warrington Corporation	,, 4	455	+ 107	1	455	– 107
West Ham Corporation	,, 11	2,076	– 212	2	5,317	+ 896
Weston-super-Mare	,, 3	222	+ 178	13	531	+ 139
Wolverhampton Co.	,, 5	703	+ 319	13	5,614	+ 381
Wolverhampton Corpn.	,, 10	752	+ 15	13	11,037	...
*Worcester	,, 5	390	+ 145	13	3,249	+ 80
Wrexham	,, 5	132	– 5	13	1,258	– 9
Yorkshire W.R. Trams	,, 14	953	+ 28	15	15,987	...
Yorkshire Woollen District	,, 5	1,374	+ 513	13	12,264	+ 1,212

(a) These comparisons are with the corresponding period last year. * Partly electrical. ¶ Plus 3 days.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., April 17.	Rate % Yielded	Dividend Due.	Business Week to April 17. High- est.	Low- est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
£5	4/0	†Anglo-Argentine Ord. Shares	7 1/16–7 1/8	5 3 0	Ap, Oct	7 1/8	7 1/8
£5	2/9	Do. 5½ per Cent. Cum Pref.	5 1/16–5 1/8	4 14 6	..	5 1/2	5 3/32
St.	6%	Do. Permanent 6% Deb. Stock	132 –135	4 9 0	..	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	104 –107	4 13 6	..	105	..
£5	..	Brisbane Electric Trams. Invest. Ord.	2½–2¾	..	..	2 7/16	..
£5	2/6	Do. 5 per Cent. Cum. Pref.	4¾–5	5 0 0	..	4 1/16	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	98 –102	4 8 0	..	..	..
St.	6%	British Columbia El. Ry. Df. Ord.	126 –130	4 12 0	..	129	..
St.	5%	Do. Pref. Ord. Stock	105 –110	4 11 0	..	109	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.	103 –107	4 13 6	..	..	..
40	4½%	† Do. 4½ per Cent. 1st Mort. Debs.	99 –101¾	4 9 0	..	..	..
100	4½%	Do. Vancouver Power Debs.	102½–104½	4 6 0	..	..	..
£5	3/0	Buenos Ayres & Belgrano Ord.	3½–4	3 15 0	..	3¾	3 9/16
£5	3/0	Do. 6 per Cent. "A" Cum. Pref	5 –5½	5 9 0	..	..	..
£5	3/0	Do. "B"	4⅞–5⅛	5 11 6	..	4⅞	..
St.	5%	Do. 5 per Cent. Debs.	1 4 –106	4 14 3	..	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	1 1 –1 4	4 16 0	..	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	98 –101	4 19 0	..	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	100 –104	5 5 9	..	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	105 –105	5 14 0	..	..	..
£5	3/6	Calcutta Tramways (1 to 105,000)	8 –8½	4 14 0	..	..	..
£5	2/6	Do. Nos. 105,001 to 137,610	7⅞–8¼	3 0 6	..	8⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5¼–5⅝	4 7 0	..	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	105 –108	4 3 3	..	..	..
$5	..	Cape Electric Tram Shares	1/16–3/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db	93 –102	4 18 0	..	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 –20%	5 11 0	..	88	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 –95	5 5 0	..	..	..
£5	6%	Do. 6 per Cent. "B" Ditto	80 –84	7 2 6	..	..	..
£5	1/0	Lisbon Elec. Trams. Ord.	1 1/16–1 1/16	3 9 6	..	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16–1 1/16	5 1 0	..	1 1/16	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb	98 –101	4 19 0	..	101	98
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	98 –101	4 19 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 –104	4 6 6	..	..	..
St	5%	Perth E. Trams. 1st Mt. Db. Stock	102 –103	4 14 3	..	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	129 –131	2 19 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	95%–97%	5 3 0	..	96½	96½
		ELECTRICITY SUPPLY.					
£5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅝–5½	5 14 0	..	..	..
10	3/1⅛	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅜–8	5 16 0	..	8	7⅞
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	97 –100	4 10 0	..	98½	97½
£5	3/3	Calcutta Elec. (1-60,000)	7⅜–8⅜	4 17 0	..	8⅝	..
£5	0/3	Do. £4 paid	6¼–7¼	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 –51	4 13 0	..	..	..
..	5%	Cordoba Lt. & Power Co. 1st Mort. Stock £100,000 5 per Cent. Bds.	90 –92	5 9 0	..	..	..
£5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½–2¾	..	..	..	..
St.	5%	Do. 5 per Cent. Deb Stock	83 –92	5 8 6	..	..	..
St	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 – 98	5 2 0	..	..	..
St	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 –109	5 13 0	..	..	..
£1	0/7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	8 3/32–8 5/32	..	..	..	..
St.	5%	†Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½–97½	5 2 6	..	..	..
£1	1 6	Rand Electric	1 –1½	..	..	..	..
£1	..	River Plate Electricity Co. Ord.	3/32–7/32	..	..	..	..
£1	1 2½	Do. 6 per Cent. non-Cum. Pref.	7/8–1	6 0 0	..	..	..
St	5%	Do. 5 per Cent. Deb. Stock	97 –100	5 0 0	..	..	..
£5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 –5½	5 9 6	..	..	..
100	4½	*Royal Elec. Montreal 4½ per Cent. 1st Mort. Deb.	85 –99	4 11 0	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	98 –100%	5 0 0	..	98½	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHRE.	LAST DIVI-DEND	NAME.	Price Wed., April 17.	RATE % YIELD-ED.	DIVIDEND DUE.	BUSINESS WEEK TO APRIL 17. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	†Bournemouth & Poole Elec. Sup. Ord...	9¼ –10¼	6 16 6	..	10 ..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼ –9¾	4 12 0	..	9¾	9⅛
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10½ 10¾	5 11 8	..	10⅜ ..	..
St.	4¼	Do. 4½ per Cent. Deb. Stock (red.) ..	101 –104	4 6 6	..	.. ..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ –5½	5 5 0	..	.. ..	..
St.	4½	Do. Do. 1st Debs.	99 –101	4 9 0	..	.. ..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7¼ –9¼	6 1 6	..	7⅜ ..	..
5	3 6	Do. 7 per Cent. Pref.	7 –8	4 7 6	Mar, Sept	.. ..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	100 –108	3 17 6	..	.. ..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3 –3½	7 3 0	Feb, Aug	3⅜ ..	..
5	2/3	Do 4½ per Cent. Pref.	4 –4½	5 0 0	Feb, Aug	.. ..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 – 99	4 1 0	..	.. ..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ –4½	5 9 0	..	.. ..	..
5	2/3	Chelsea Electric Supply Ord.	3½ –4½	6 13 0	March ..	3⅞ ..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 –107	4 4 0	June, Dec	105½	104⅜
10	7/0	City of London Electric Lighting Ord..	10 –10½	5 14 0	Feb, Aug	10½	9⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	11 –12	5 0 0	Jan, July	.. ..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 –124	4 0 9	June, Dec	.. ..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	..	98⅜ ..	..
5	5%	County of Durham Elec. P.D. Ord. 4s pd.	4¼ –4¾	4 7 0	April, Oct	.. ..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾ –5	5 4 0	April, Oct	.. ..	..
10	6/0	County of London Elec. Supply Ord.....	8 –8½	5 17 6	..	.. ..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10½ –11½	5 4 0	Mar, Sept	.. ..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	1⅛ –1⅛	4 2 6	..	.. ..	..
St	4½%	Do. Second Deb. Stock Prov. Certs....	97 –100	4 10 0	..	.. ..	..
5	2/0	†Folkestone Electricity Supply Co. Ord	4¾ –5¾	5 2 0	..	.. ..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	..	.. ..	..
St.	4½	Do. 4½ 1st Deb. Stock (red).....	97 –100	4 10 0	..	99 ..	..
5	5 0	†Hove Electric Lighting Ord.	7 –7½	6 0 0	..	.. ..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ –9¼	5 5 0	..	.. ..	..
5	6%	Do. 6 per Cent. 1st Pref.	8¼ –9	4 5 9	Jan, July	.. ..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 – 100	4 0 0	..	.. ..	..
St	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 –100	4 0 0	..	.. ..	..
3	2 4½	London Electric Supply Ord.	1¾ –2½	5 6 9	..	.. ..	..
5	3 0	Do. 6 per Cent. Pref.	4¼ –5½	5 14 0	..	.. ..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	96 –98	4 2 0	Mr, Jn, S, D	.. ..	..
5	4/0	Metropolitan Electric Sup. Ord.	6 –6¾	6 18 0	April, Oct	6⅞ ..	..
[illegible]	2 3	Do. 4½ per Cent. Cum. Pref.	5 –5½	4 5 6	Jan, July	5⅜ 5	5
St	4½*	Do. 4½ per Cent. Deb. Stock 1st Mort.	106 –109	4 2 9	June, Dec	.. ..	..
St.	3½	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	92 –94	3 14 6	..	.. ..	..
100	4½	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98⅞	4 12 0	..	.. ..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8¾ –8¾	5 3 1	Feb, Aug	.. ..	..
100	4½	Do. 4½ per Cent. Deb.	100 –101	4 9 2	Jan, July	.. ..	..
5	8%	Newcastle Elec. Supply Ord.	7¾ –7¾	5 6 8	Feb, Aug	.. ..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5¼ –5¾	4 7 9	Feb, Aug	.. ..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 –100	4 0 0	Jan, July	.. ..	..
1	3%	Northern Counties Elec. Sup.	1 –1⅛	2 16 6	Mar, Aug	.. ..	..
100	4½	Do. 4½ per Cent Deb.	100 –101	4 10 0	Jan, July	.. ..	..
10	9 0	Notting Hill Electric Ord.....	12 –13	5 15 0	March ..	.. ..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	96 –99	4 1 0	..	.. ..	..
5	4 6	Oxford Electric Ord.	5¾ –6	5 16 9	March ..	.. ..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 – 98	4 1 6	..	.. ..	..
5	5 0	St. James' & Pall Mall Elec. Ord	8 –9¼	5 17 6	Feb, Aug	.. ..	..
5	3/6	Do. 7 per Cent. Pref.	6¾ –7¼	4 13 0	Feb, Aug	.. ..	..
St.	3½	Do. 3½ per Cent. Deb. Stock (red.) ...	93 –96	3 13 9	..	.. ..	..
5	.	Smithfield Markets Electric Sup. Ord...	1¼ –2¼	.. ..	..	.. ..	..
St.	4	Do. 4 per Cent. Deb. Stock	73 –77	5 4 0	..	.. ..	..
5	3 0	South London Electric Supply Ord.....	2¼ –2¾	6 8 0	..	2½ ..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝ –¾	3 6 9	..	.. ..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1⅜ –1⅝	4 15 6	..	.. ..	..
St.	4½	Do. 4½ 1st Db. Stk. Red.	100 –103	4 7 6	..	.. ..	..
5	2/6	Urban Electric Supply Ord.	2 – 3	8 6 0	..	.. ..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	3 –4	6 5 0	..	.. ..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb.....	95 –98	4 12 0	..	.. ..	..
5	6 6	Westminster Elec. Sup. Ord.	9¼ –9¾	6 8 0	Mar, Sept	9⅞	9⅝
5	2 3	Do. 4½ per Cent. Cum. Pref.	5½ –5¾	3 13 8	..	5⅝ ..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	91 –95	4 4 0	..	.. ..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ –⅝	5 3 6	..	⅝ ..	⅝
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ –1	5 0 0	..	.. ..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	95 –100	4 10 0	..	97⅜	95½
St.	4½	B'ham & Midland Trams 4½ 1st Db. Stk.	36 – 39	4 11 0	..	.. ..	..
10	9¼	Bristol Tramways & Carriage Ord.	14½ –14¾	6 8 0	Feb, Aug	.. ..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 –9¼	4 5 0	..	.. ..	..
St.	4%	Do. 4 per Cent. Debs.	100 –102	3 17 6	Feb, Aug	.. ..	..
10	6 0	British Electric Traction Ord.....	8 –8¼	8 0 0	..	8⅛	3⅜
10	6/0	Do. 6 per Cent. Cum. Pref.....	7 –7¾	8 5 6	Feb, Aug	7¾	7⅜
St.	5%	Do. 5 per Cent. Perpetual Debs.	101 –105	4 15 0	..	104½	101
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	93 –96	5 5 0	..	93¼	..
St.	4%	Central London Ordinary Stock	76 –78	5 1 9	June, Dec	77⅜	74⅜
St.	4%	Do. 4 per Cent. Pref. Stock	92 –94	4 5 0	..	93⅜	93
St.	4%	Do. Deferred Stock	53 –55	7 5 0	..	59½	54½
100	4%	Do. 4 per Cent. Debs.	103 –106	3 15 6	..	105	..
St	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	88 –96	4 18 0	..	.. ..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¾ –5¼	4 15 3	..	.. ..	..
100	4%	† Do. 4 per Cent. 1st Mort Debs.....	98 –101	3 19 0	..	100 ..	..
St.	2%	City & South London Rly. Con. Ord. ..	41 –43	4 19 0	Feb, Aug	42½	41½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ..	119 –122	4 2 0	Feb, Aug	.. ..	..
St.	5%	Do. (1896)	115 –118	4 4 9	..	.. ..	..
St.	5%	Do. (1901)	115 –118	4 4 9	..	.. ..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 4 –107	4 4 9	May, Nov	.. ..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	4½ –5¼	8 18 6	..	.. ..	..
10	6/0	Do. 6 per Cent Pref.	13¾ –14¾	4 1 3	..	.. ..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2⅞ –3	.. ..	..	.. ..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	..	.. ..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 –83	4 11 0	..	.. ..	..
St	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	98 –101	4 9 0	..	98⅜	..
10	9%	‡ Imperial Tramways Ord.....	12½ –13½	6 7 0	Mar, Sept	.. ..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11¾	5 6 6	Mar, Sept	.. ..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	100 –102	4 8 0	Jan, July	.. ..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref	1 –2	.. ..	..	.. ..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	72 –78	5 2 0	..	.. ..	..
St.	47/6	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 –93	.. ..	..	.. ..	..
10	..	Liverpool Overhead Railway Ord.	1⅜ –1⅝	.. ..	Feb, Aug	.. ..	..
10	5%	Do. 5 per Cent. Pref.	6 –7	7 3 0	Feb, Aug	.. ..	..
St.	4%	Do. 4 per Cent. Deb.	83 –90	4 9 0	Jan, July	.. ..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7¾ –8¾	5 14 3	..	8⅛	8⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	85 –90	4 9 0	..	89½	86
St	..	Mersey Con. Ord. Stock	5 –7	— ..	..	.. ..	..
St.	..	Do. 3 per Cent. Perp. Pref.	7 –10	.. ..	..	.. ..	..
1	..	Metropolitan Elec. Tramways Def.	1⅛ –1⅜	.. ..	..	.. ..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	2⅝ –3¼	5 3 0	..	.. ..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	97 –100	4 10 0	..	.. ..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜ –1¼	.. ..	May	.. ..	..
10	8/0	Potteries Electric Traction Ord.	4¾ –6¾	5 16 0	..	.. ..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 –7½	6 13 3	Feb, Aug	6⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	9¼ –10½	4 8 6	..	.. ..	..
1	3/56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref	⅝ –1⅛	5 10 6	..	.. ..	..
St.	38/3½	Do. 4 per Cent. Deb. Stock	81 – 87	.. ..	..	.. ..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	86 –90	5 11 0	..	87⅛	83½
..	5 .	Underground Elec. Rys. Co. of London...	76 –79	6 6 6	..	77⅛	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 –1⅜	— ..	..	.. ..	..
5	..	Do. 6 per Cent. Cum. Pref.	3¼ –3¾	.. ..	..	.. ..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 –93	4 16 9	..	.. ..	..

SHRE.	LAST DIVI-DEND	NAME.	Price Wed., April 17.	RATE % YIELD-ED.	DIVIDEND DUE.	BUSINESS WEEK TO APRIL 17. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	½ –¾	.. ..	..	.. ..	..
1	0 7½	Do. 6% Cum. Pf.	1⅛ –1⅜	7 7 9	..	.. ..	..
1	1/7½	Babcock & Wilcox Ord.....	8¾ –4⅛	5 2 6	..	4	3⅞
1	0/7½	Do. Pref.....	1⅞ –1⅞	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½ –7	7 8 0	July, Feb	6⅝	6⅛
5	3/0	Do. 5 per Cent. Pref.	5⅜ –6½	4 16 0	Jan, July	6⅛	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 –104	4 6 6	..	.. ..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 –98	4 14 8	..	.. ..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 –1½	.. ..	..	.. ..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	65 –69	5 15 0	..	.. ..	..
2	1/0	Brush Electrical Engineering	⅝ –	— ..	March ..	.. ..	..
2	2/1⅛	Do. 6 per Cent. Pref. non-Cum.	1⅛ –1⅜	6 17 0	Mar, Sept	.. ..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 –92	4 18 0	Mar, Sept	89⅜	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 –78	5 14 6	Jan, July	.. ..	..
5	5 0	Callender's Cable Con. Ord.....	10¾ –11¾	6 8 0	Jan, July	10⅜	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ –5⅜	4 7 0	Jan, July	5⅛	5⅛
St	4½%	Do. 4½ per Cent. 1st Mort Debs (red.)	106 –108	4 3 8	Nov, May	.. ..	..
1	0/8⅜	Castner-Kellner Alkali Co.	1⅜ –1⅝	5 14 0	..	1⅛	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	..	.. ..	..
1	0 0⅜	Chadburn's (Ship) Telegraph Ord.	1⅜ –1⅛	7 5 0	..	.. ..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅞ –1⅞	5 4 0	..	.. ..	..
3	1/6	*Crompton & Co. (Nos. 1 to 51,000).....	1⅜ –2⅛	3 13 8	Jan, July	1⅜	1⅛
100	5 %	Do. 5 per Cent. 1st Mort. Debs. (red.).	98⅜–99⅜	5 1 0	Jan, July	.. ..	..
5	2/0	Dick, Kerr & Co. Ord.	1¼ –1⅜	6 13 3	Sept	.. ..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜ –1⅞	6 17 0	Sept	.. ..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 –104	4 6 6	..	104 ..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1¼ –1⅜	9 8 0	Feb, Aug	1⅜	1⅜
5	4/2	Do. (£5 paid)	2¾ –2⅞	4 11 6	Feb, Aug	.. ..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	85 –87	4 12 0	June, Dec	.. ..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 –92	5 8 6	..	.. ..	..
5	4%	Edmundson's Elec. Corp. Ord.	1¼ –2¼	8 0 0	H'lf-yearly	1¼	..
5	3/0	Do. 6 per Cent. Cum. Pref.	3 –4	7 10 0	..	.. ..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	89 – 92	4 17 9	..	.. ..	..
2	..	Electric Construction Co.....	½ –⅞	.. ..	July	.. ..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅜ – 2	7 0 0	July	.. ..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. (red.)	84 –86	4 15 0	Jan, July	.. ..	..
10	5/0	General Electric (1900) 5% Cum. Pref.	8¾ –9⅜	5 7 0	..	.. ..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 –95	4 4 0	..	.. ..	..
5	10/0	Henley's Telegraph Works Ord.....	12 –13	5 14 6	Feb, Aug	12½	12
5	2/3	Do. 4½ per Cent. Pref.	4 –5⅛	4 18 8	Feb, Aug	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 –109	4 2 6	..	.. .07	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15½ –16½	6 2 6	Feb, Aug	16⅜	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 –100	4 0 0	..	99⅜	..
10	5/0	Mather & Platt 5 per Cent. Cum. Pref...	11½ –11¾	4 5 0	Mar, Sept	.. ..	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	⅞ –1	7 2 0	..	.. ..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞ –1⅜	5 16 6	..	.. ..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 –100	4 10 0	..	.. ..	..
1	..	Simplex Conduits Ord.	1⅛	.. ..	..	.. ..	..
5	..	Do. 6 per Cent. Cum. Pref.	½	.. ..	..	.. ..	..
12	24/0	Telegraph Construction & Maintenance	31 – 31	5 15 6	Mar, July	30⅜	30⅛
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100 –103	3 17 6	Jan, July	.. ..	..
1	2/0	Vickers, Sons & Maxim. Ltd., Ord.	2⅛ –2⅜	5 17 6	..	2⅜	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅝ –1⅞	4 1 0	..	1⅞	1⅝
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 –117	4 5 6	..	.. ..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red.)	103 –105	3 16 0	..	.. ..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 –107	4 4 0	..	.. .05	104½
10	6 0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½ –10	5 0 0	..	.. ..	..
1	..	Willans & Robinson Ord.....	1¼ –1⅜	.. ..	Apr, Oct	1⅜	1⅛
1	..	Do. 6 per Cent. Cum. Pref.	3⅞ –4¼	.. ..	Apr, Oct	4⅛	3⅞
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	77 –82	4 17 6	May, Nov	.. ..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3½	— ..	June, Dec	.. ..	..
100	5%	Do. 5 per Cent. Debs. (red.)	89 –91	5 10 0	..	.. ..	..
St.	15/0	†Anglo-American	60 – 61	6 4 6	F, My, Ag, N	62½	..
St.	30,0	† Do. Preferred	105½ –106½	5 13 0	F, My, Ag, N	106	105½
St.	1½%	Do. Deferred	22⅜ –22⅝	7 16 0	F, My, Ag, N	22⅜	21⅞
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	93 – 95	4 4 0	Jn, Ap, Jy, O	94½	93½
10	5 0	Cuba Submarine Ord.....	8¼ –8¾	5 14 3	Feb, Aug	8⅛	..
10	10/0	Do. Preference 10 per Cent.....	16½ –17½	5 14 0	Feb, Aug	17½	..
5	2/0	Direct Spanish Ord.....	3⅜ –3⅝	5 10 6	April, Oct	.. ..	..
5	5 0	Do. 10 per Cent. Cum. Pref.	8¾ –9¼	5 8 0	April, Oct	.. ..	..
5	4½%	Do. 4½ per Cent. Deb.....	9⅜ –10⅛	4 9 0	Jan, July	.. ..	..
20	4/0	Direct United States Cable	14⅜ –15½	6 3 6	Ja, Ap, Jy, O	15½	14⅜
100	4½%	Direct West India Cable 4½% Bg. Db. (rd.)	99 –101	4 9 0	June, Dec	.. ..	..
St	25/0	Eastern Ordinary	133½ –140½	4 19 6	Ja, Ap, Jy, O	141½	133½
St.	17/6	Do. 3½ per Cent. Pref. Stock	87 –89	3 19 6	Ja, Ap, Jy, O	.. ..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	106 –108	3 14 0	May, Nov	107⅜	..
10	2/6	Eastern Extension	13½ –13⅝	5 2 6	Ja, Ap, Jy, O	13⅝	13½
St.	4%	Do. 4 per Cent. Deb. Stock	105 –107	3 14 9	Feb, Aug	106⅛	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	93 –101	3 19 0	Feb, Aug	.. ..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	101⅜ –102⅜	3 18 6	May, Nov	.. ..	..
10	5 0	G.N. (of Copenhagen), with Coupon 69	36 –37	6 11 0	Jan, July	35⅜	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 –101	4 9 0	June, Dec	.. ..	..
25	12/6	Indo-European.....	53 –60	5 8 0	May, Nov	58½	..
25	4%	Mackay Companies Common	70⅞ –72¼	6 10 0	Jan, July	.. ..	..
100	4%	Do. Preference	71⅛ –72	5 11 6	Ja, Ap, Jy, O	.. ..	..
1	..	Marconi's Wireless Teleg. Co.	⅞ –1	— ..	..	1⅛	1⅛
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 –100	4 0 0	June, Dec	97	..
10	4/0	West African Telegraph Shares	10 –10½	8 16 0	..	.. ..	..
2½	..	West Coast of America	⅜ –⅝	.. ..	..	.. ..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	.. ..	..
10	..	West India & Panama	⅞ –1⅛	.. ..	May, Nov	.. ..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7½ –8	7 10 0	May, Nov	7⅞	..
10	..	Do. 6 per Cent. 2nd Pref	6 –7	.. ..	May, Nov	6⅜	..
100	5%	* Do. 5 per Cent. Debs.	99 –102	4 19 0	Jan, July	.. ..	..
10	3/0	Western Telegraph	13⅜ –14	5 0 0	Mr, Jn, O, D	14	13½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 –104	3 17 0	..	102½	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 –94	4 5 0	..	92	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. stk.	99 –101	4 19 0	..	.. ..	..
5	3 0	Chili Telephone	6¾ –7½	5 11 0	August ..	.. ..	..
1	0/7½	Monte Video Telephone Ord.	1⅜ –1⅝	4 14 0	..	.. ..	..
1	0/6	Do. 5 per Cent. Pref.	1⅜ –1⅝	4 17 0	..	.. ..	..
St.	6%	National Co. Pref. Stock	107½ –109½	5 10 0	..	1 9	1 8
St.	5½%	Do. Def. Stock.....	101 –103	5 4 0	..	1 6½	1 5½
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11 –13	4 12 0	Feb, Aug	.. ..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	.. ..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛ –5¾	4 9 0	Feb, Aug	5⅛	5⅛
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	9 – 98	3 13 0	June, Dec	97	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –102	3 19 0	..	100⅜	1 0⅛
1	0/7½	Oriental	1⅝ –1⅞	4 17 6	April, Oct	1⅞	1⅝
1	0 7½	Do. 6 per Cent. Cum. Pref.	1⅝ –1⅞	4 16 0	..	.. ..	..
St	4%	Do. 4 per Cent. Red. Deb. Stock	95 –93	4 2 6	..	.. ..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 –103	4 8 0	..	.. ..	..
5	3 0	United River Plate.....	6¾ –7½	5 9 6	July	7	6⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5	4 15 0	June, Dec	.. ..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	109 –112	4 9 8	June, Dec	.. ..	..
		FINANCIAL, INVESTMENT, &c.					
5	3 0	Elec. & Gen. Investment 6% Cum. Pref.	4 –5	6 0 0	..	.. ..	..
10	2 0	Globe Telegraph & Trust.....	10½ –10¾	5 0 6	Ja, Ap, Jy, O	10⅜	10⅛
10	3 0	Do. 6 per Cent. Pref.....	13⅜ 14½	4 4 0	Ja, Ap, Jy, O	14⅛	13⅞
10	6%	†Submarine Cables Trust (Cert.).....	125 –128	4 18 9	April, Oct	.. ..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The New Council of the I.E.E.

AT the meeting of the Institution of Electrical Engineers last night, the following list of nominations for the Council for next session were announced :—

As President.

The Right Hon. Lord Kelvin, O.M., G.C.V.O., F.R.S.

As Vice-Presidents.

Mr. F. Gill. — *Prof. G. Kapp.*
Col. H. C. L. Holden. — Mr. C. P. Sparks.

As Members of Council.

Mr. W. Duddell. — *Mr. W. M. Mordey.*
Mr. S. Evershed. — Mr. M. O'Gorman.
Mr. H. E. Harrison. — *Mr. W. H. Patchell.*
Mr. Ed. Hopkinson. — Mr. G. W. Partridge.
Mr. J. W. Jacomb-Hood. — *Mr. S. L. Pearce.*
Mr. Walter Judd. — *Mr. W. Rutherford.*
Mr. J. E. Kingsbury. — Mr. A. A. C. Swinton.

Mr. C. H. Wordingham.

As Associate Members of Council.

Mr. Albert Campbell. — *Mr. H. Human.* — Mr. J. Hunter Gray.

As Hon. Auditors.

Mr. H. Alabaster. — Mr. Sidney Sharp.

As Hon. Treasurer.

Mr. Robert Hammond.

The names of the new members of Council are in italics.

The L.C.C. Power Scheme.

AT the meeting of the London County Council next week the Highways and Parliamentary Committees will put forward final proposals as to the course to be adopted with the London County Council (Electric Supply) Bill, the views of the Progressives having been duly modified by those of the Municipal Reformers. Although the proposals are not officially known, they nevertheless appear to be common property. Apparently the object of the new Council is to avoid financial responsibilities by leaving the supply of electricity in the hands of companies, and at the same time to obtain all the advantages that might have been obtained otherwise by the scheme by securing a certain amount of control. The chief thing to control is, of course, the price at which electrical energy is to be supplied, and it seems that a suitably low price is to be secured by holding over the heads of companies a threat of purchase, which, however, is not likely to be enforced. If that is so, the companies need not feel very troubled. Existing undertakings are to coalesce, and by way of compensation for reduced prices it is suggested that the concessions granted to companies should be extended by 10 or 15 years. A maximum permissible charge of 1d. per unit is mentioned, but this can scarcely be considered seriously, and it has probably diminished very largely in percolating through to the unofficial daily press.

Intercommunication on Tramways.

MUNICIPAL authorities have often been criticised for not adopting some uniform gauge for their tramways, so that rolling stock on neighbouring systems would be interchangeable. As it is, the through running of cars has generally been impossible. As an example of this we may mention the tramways of the Leeds and Bradford Corporations, the rail gauge of the former being 4 ft. 8½ in. and the latter 4 ft. The tramway systems of these towns, which are about 9 miles apart, meet at Stanningley, and through-passengers have hitherto been obliged to change cars at that point. Through-running, however, has now been obtained by means of a special truck designed by the manager of the Bradford tramways. In this truck each wheel is fixed to a sleeve, which can slide and rotate on a fixed axle. The raising of a lever allows the wheels to slide along the axle as the car slowly moves along the tapering track between the two systems of different gauges, and the wheels can then be locked at either gauge. The pinions of the motors have to be made of sufficient width to permit of this movement. A car fitted up in this way is now running between Leeds and Bradford, and if it proves satisfactory, the new truck will be adopted for this part of the service. Although an arrangement of this kind permits through-

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running as different tramway systems are linked up, it is certain to cause some inconvenience, and only emphasises the short-sighted policy of local authorities in adopting different gauges, thus producing a state of affairs which it is practically impossible to remedy fully, owing to the great cost of altering the gauge once the track is laid.

Maintenance of Tramway Track.

THE general feeling that tramway fares in many cases have been so far reduced as not to allow an adequate reserve for repairs and depreciation is emphasised by the meeting of the Potteries Electric Traction Co. on Monday last when the Chairman, Mr. G. F. M. CORNWALLIS-WEST, remarked that if electrical engineers 10 years ago had known as much about electric traction as they do now they would never have suggested the life of permanent way to be from 17 to 20 years; nor would they have used 85 lb. rails, or single track with turnouts where double track was practicable. We need scarcely remark that at the present time the use of 85 lb. rail is rare, although it used to be general; but, nevertheless, even with the heavier rail which is now usually put down, the life of track is rather a matter of doubt. It would, therefore, be well for all tramway companies to pay greater attention to the provision of an adequate renewals fund, so that the evil day may be provided for in advance, for not every company is in a position to meet a 70 per cent. increase in expenditure on repairs.

Lifeguards on Electric Tramways.

IN the annual report of the traffic manager of the Liverpool Corporation Tramways particulars are given of tramway accidents at Liverpool during the past year. It appears that in 44 cases the lifeguards on the cars have come into operation, and in every case the obstructing pedestrian has been pushed clear of the track without any serious injury. This is a very good record, and is worth noting, as the Liverpool Corporation have adopted the plough type of lifeguard for all their cars. The pattern of lifeguard operated by a trigger, and in which the obstruction is picked up, seems to be the one which has been adopted by most other tramways; but the plough type is certainly worth careful consideration, in view of the results mentioned above.

Telephotography.—It is reported that Prof. Korn has successfully transmitted photographs from Munich to Berlin, a distance of 240 miles, and back again by means of his system of telephotography.

Obituary.—We regret to have to record the death of Mr. G. Hopkins, who was consulting engineer to the North Metropolitan Tramways Co. up to the time of its absorption by the London County Council. He devoted special attention to tramway construction and maintenance.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tarifa—Tangier	Jan. 18, 1904 ..	—
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
New Brunswick—Prince Edward Island.....	Jan. 9, 1907 ..	—
Tenedos—Chio	Feb. 13, 1907 ..	April 22, 1907
Panama—Buenaventura	Feb. 28, 1907 ..	—
Buenaventura—Santa Elena..	Feb. 28, 1907 ..	—
Tangier—Cadiz	Mar. 20, 1907 ..	—
Cadiz—Teneriffe	April 10, 1907 ..	—
Dakar—Konakry	April 24, 1907 ..	—

The Tramways and Light Railways Association.—The Official Circular for April deals very fully with the rating of tramways and the recent appeal of the London United Tramways Co. There is also a communication on "Corrugation" from the track superintendent of the Philadelphia Rapid Transit Co.

Electric Lighting in Dublin.—According to the *Dublin Evening News*, several improvements are now being made in the lighting of Dublin. All the bridges are to be lighted in future with electricity instead of with gas. The lighting of the Grattan statue in College Green, and that of other public monuments, is also being converted.

Wireless Telegraphy.—A wireless telegraph station has been established by the owners of the Red Star line of steamers on their quay at Antwerp in order to keep up communication with the company's vessels in the River Scheldt, where ships are often detained, more especially in winter, by fog. The station, however, only benefits a very limited number of vessels.

University College Engineering Society, London.—At the forthcoming dinner of the Past and Present Engineering Students of University College, London, Sir A. B. W. Kennedy, F.R.S., Sir W. Matthews, Sir A. Rücker, F.R.S., Prof. J. A. Ewing, F.R.S., and other guests are expected to be present. Application for tickets should be made at once to Mr. J. A. Smith, University College, Gower Street, W.C.

A New Glow-Lamp Tester.—In the *Elektrotechnische Zeitschrift* a description is given of a wattmeter fitted with lamp holders so that it can be conveniently connected to a lamp circuit, the lamp to be tested being fixed in one holder and the supply connected to the other. In addition to indicating the watts, the instrument can also be fitted with a second scale, calibrated to show the cost of burning the lamp for an hour at any particular price per unit.

Students' Section of the I.E.E.: Summer Tour.—It is proposed that this year, instead of making the usual visit to an engineering centre in England, a visit should be paid to the large engineering works in Switzerland. Preliminary arrangements have been made, and permission is being asked to visit several works, including those of Messrs. Brown, Boveri & Co. (Ltd.), the Maschinenfabrik Oerlikon and the Jungfrau Electric Railway Co. The visit will take place about the second week in July, and it is proposed to divide the time between Zurich and Interlaken. Messrs. Thos. Cook & Son have the arrangements in hand.

Cost of Coal on Steam and Electric Railways.—The cost of coal for steam locomotives is approximately 15 per cent. of the total operating expenses for steam railroads, and is the largest of the expenses for materials. According to the *Electric Railway Review*, data contained in the annual reports of a number of the larger systems indicate that the annual coal consumption is, on the average, about 2,500 tons for each steam locomotive. From the United States census report on "Street and Electric Railways," covering 799 operating companies, the cost of fuel for power for electric railways appears to be about £3,000,000, which is a little over 10·5 per cent. of the total operating expenses.

Electric Sand Supply Car.—The *Electric Railway Review* gives an account of a sand supply car used by the Knoxville Railway & Light Co. for sanding the track during bad weather and for replenishing the supply in the sand boxes of the regular cars. Along both sides of its interior, bins about 3 ft. high and having a capacity of 5 cubic yds. of sand have been provided. Leading from each of these bins, at a point midway from each end, is a sandpipe which conveys the sand from the hopper to the rails of the track. The flow of the sand is regulated by cut-off valves which are worked by levers located inside the car. In addition to these sand pipes there are four plug taps, one being located at each corner of the car.

Energy Lost in Electric Railway Motors.—In a Paper entitled "The Anatomy of a Railway Motor and Control Equipment," read before the Western Railway Club, Mr. James Lyman gives some interesting figures of the losses of energy in electric-railway motors. In a well-designed motor the losses at free running speed are given as the following: Copper losses,

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4 per cent.; iron losses, 6 per cent.; gear and bearing losses, 10 per cent.; leaving a total efficiency of transformation from electrical to mechanical energy of 80 per cent. During acceleration the distribution of losses is: Copper losses, 10 per cent.; iron losses, 2 per cent.; gear and bearing losses, 5 per cent.; leaving a total efficiency of 83 per cent. These figures only apply to small railway motors, much higher efficiency being obtainable in the larger motors.

The Electro-Harmonic Society.—The last smoking concert of this society's session was held in the King's Hall, Holborn Restaurant, on Friday evening last, under the chairmanship of Major O'Meara, C.M.G., Engineer-in-Chief of the General Post Office. During the course of a highly successful and very musical evening, the following cablegram, which was dispatched to Dr. Raymond, 29, West Thirty-ninth-street, New York, was read out by the chairman:—

While holding the last concert of their twenty-first season this Friday evening the 470 members and friends of the Electro-Harmonic Society of London, under the chairmanship of Major O'Meara, the newly-appointed Engineer-in-Chief of the General Post Office, send cordial greetings to those attending the informal smoker arranged for the same evening in connection with the formal inauguration of the United Engineering Building. Floreat. May the fumes of our tobacco be wafted west and commingle with yours on this auspicious occasion.

Electric Traction in Canada.—According to the annual report of the Department of Railways and Canals of Canada, there were in operation at the close of the fiscal year ending on June 30, 1906, 814 miles of electric railways, 195 miles being double-track. The paid-up capital amounted to £12,771,594. The gross earnings aggregated £2,193,374, an increase of £321,949, and the working expenses £1,135,007, an increase of £151,368, leaving the net earnings £858,366, an increase of £170,580. The number of passengers carried was 237,655,074, an increase of 34 187,757, and the goods carried amounted to 506,024 tons, a decrease of 4,326 tons. The car-mileage was 50,618,836, an increase of 4,659,735 miles. The accident returns show a total of 47 persons killed during the year and 1,653 persons injured. Power was supplied in 15 cases by water and in 41 cases by steam. Ontario has 441 miles, Quebec 198, New Brunswick 16, Nova Scotia 54, Manitoba 32 and British Columbia 72 miles. Returns were received from 47 companies.

Electric Traction in the "Cascade" Tunnel.—Plans for the substitution of electricity for steam have just been completed, according to the *Electrical World*, for the operation of trains through the "Cascade" tunnel, one of the longest railway tunnels in the United States. The electrical power will be obtained about 35 miles from the tunnel, where a large water power can be developed. By the construction of about 2½ miles of waterway it will be possible to obtain a head of 140 ft. The electric plant will be constructed in two sections, each one independent of the other, so that in case of a failure of a portion of the plant the rest can be used. The tunnel through the Cascade Mountains is built through solid granite in which scarcely a crevice can be found in the whole length of the tunnel. From portal to portal the tunnel is 14,400 ft. long, or between 2½ and 3 miles. The gradient is about 1·7 per cent., one end being 240 ft. higher than the other. It is possible for trains running down hill through the tunnel to run through by gravity. In the other direction there is, of course, a long pull up hill, which requires considerable power for the heavy freight trains. When electric power has been installed in the tunnel, locomotives will still run through it as hitherto, but not under their own steam. The whole train and the locomotive will be electrically hauled through the tunnel.

Crystal Palace School of Engineering.—The presentation of certificates, gained during the Easter term, to the students of the Crystal Palace School of Engineering, took place last Friday in the lecture room of the school. Sir A. B. W. Kennedy presided, and Mr. Maurice Wilson read the examiners' reports, which spoke very favourably of the students' work during the term. Sir Alex. Kennedy, in his address to the students, told them that it was a mistake to specialise in one particular subject too early in their careers. Specialisation was favoured both on the Continent and in America, the idea being that engineering was so vast a subject that it was impossible to be an expert in all branches of it; but it was even impossible to be an expert in a single branch. Most eminent English engineers at the present time are on very different work to that on which they started, and he cited himself as a "fearful" example of this. If the student specialises at first he may become the most efficient man in that one subject, but if that subject for any reason loses its importance he is "side-tracked" owing to his inability to turn to anything else. His advice to them was to obtain as great an amount of general knowledge as possible, so that whatever work they had to undertake, they could make it a success. This ability to do anything was, he felt sure, the reason of the universality of the English engineer. Sir Alex. Kennedy then distributed the prizes and certificates. The "Wilson" premium for the best Paper read before the Crystal Palace Engineering Society was awarded to Mr. J. R. Crisp, and the Medal of the School of Art, Science and Literature was gained by Mr. D. Hook.

The Annual Meeting of the German Bunsen Gesellschaft.—This society of electrochemists is holding its 14th annual gathering at Hamburg from May 9th to May 12th, under the presidency of Prof. Nernst. It is noteworthy that the most important subject down for discussion is "Radio-activity and the Theory of Atomic Dissociation," this probably being the first occasion in recent years on which German scientists have followed the lead of this country in the realm of scientific research. Upon this subject a group of Papers are to be read at the first business meeting of the members on Friday, May 10th, the authors of these Papers being Prof. Voller, of Hamburg; Prof. Markweld, of Berlin; Prof. Meyer, of Freiburg; and Dr. von Lerch, of Vienna; Dr. Hahn, of Berlin; Dr. Levin, of Göttingen; and Prof. Henrich, of Erlangen. There will also be several papers on Colloids, which should prove of interest to electrical engineers, since this is the form by which Kuzel obtains lamp filaments of the most refractory metals. Two "Festessen" and an excursion upon the Hamburg-Amerika Co.'s fine liner "Deutschland" form the lighter provision for the entertainment of the members, and, a sa set-off to the consideration and discussion of the 26 papers planned for reading and discussion at this year's meeting of the society, they will no doubt be fully appreciated.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, April 26th (to-day).

PHYSICAL SOCIETY.

5 p.m. Meeting at the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Papers on "Electrical Conduction Produced by Heating Salts," by Mr. A. E. Garrett; on "The Influence of Pressure upon Convection Currents and a Criticism of J. Stark's Relation between Cathode Fall of Potential and Temperature," by Mr. W. S. Tucker; on "Solenoids which are Turned by the Earth's Magnetic Field," by Mr. W. B. Croft; and on "Simple Apparatus for Mechanically Illustrating the Tangent and Sine Laws," by Mr. J. A. Tomkins.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street. Lecture on "New Illuminants," by Mr. J. Swinburne, F.R.S.

SATURDAY, April 27th.

ROYAL INSTITUTION.

3 p.m. Meeting at Albemarle-street. Lecture on "Studies in Magnetism," by Prof. S. P. Thompson, F.R.S. (The Tyndall Lectures: Lecture III.).

TUESDAY, April 30th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Meeting at Great George-street. Annual General Meeting of Corporate Members only, to receive the Report of the Council and to elect the Council and Auditors for the ensuing year.

WEDNESDAY, May 1st.

ROYAL INSTITUTION.

5 p.m. Annual meeting at Albemarle-street.

THURSDAY, May 2nd.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Extraordinary General Meeting at the Society of Arts, John-street, Adelphi, W.C. Papers on "Depreciation Provision on Electricity Supply Undertakings," by Mr. R. Hammond (Adjourned Discussion, if not concluded at the previous meeting); and on "The Use of Wooden Poles for Overhead Power Transmission" by Mr C. Wade (if time permits).

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ELECTRIC TRACTION ON RAILWAYS.*

I.—SOME GENERAL CONSIDERATIONS.

BY PHILIP DAWSON.

(*Continued from page 6.*)

Summary.—**The Author first considers the various causes which have led to the electrification of railways, and classifies them accordingly. These causes vary in different countries, and thus the conditions which have led to electrification abroad do not necessarily apply in this country. Financial considerations are the governing factor. High acceleration is one of the most important advantages of electric traction, and another is the greatly-increased terminal facilities.**

The first part of this article appeared in our last issue.

Probably the most important property of all possessed by electricity is the rapid acceleration which can be obtained by its use. With electricity the rate of acceleration is only limited by the question of the cost, whereas with steam locomotives it is very nearly an impossibility to obtain more than a very moderate rate, far inferior to that commonly used on electric railways. Rapid acceleration is a great advantage because by its use the maximum speed required for a given schedule is reduced, with a consequent reduction in the amount of energy which has to be dissipated in the brakes, and therefore of the energy required to run the train.

The accompanying diagram clearly shows what accelerations have been obtained, and experiments carried out by the General Electric Co., at Schenectady, clearly prove that it is perfectly feasible to attain a speed of 30 miles an hour 10 seconds after starting from standstill.

It will be seen that, whereas on the Berlin Stadtbahn in 10 seconds a speed of 5 miles an hour is reached, and on the Metropolitan District, with the old steam trains, 3 miles an hour, in the experiments carried out by the General Electric Co. at Schenectady, a speed of 30 miles an hour was reached in the same time, and on the Liverpool Overhead, in actual practice, a speed of nearly 19 miles an hour is attained.

The normal acceleration obtained on the Metropolitan District Railway steam system was about 6 in. per second per second, and the best results obtained during experimental running did not exceed 9 in. per second per second. Mr. Holden, the locomotive superintendent of the Great Eastern Railway, claims to have obtained an acceleration of 1·4 ft. per second per second from the Decapod locomotives which he designed, but though this is, doubtless, a good result from a steam locomotive, it appears very small when it is remembered that on the electrically-operated Liverpool Overhead Railway, with the equipments supplied by Messrs. Dick, Kerr & Co., the maximum acceleration obtained reached 4·2 ft. per second per second.

The recent experiments which have been carried out to obtain rapid acceleration with steam locomotives cannot be described as successful, and the enormous weight of the engines necessary to give the required result has practically prevented their adoption in regular service. It is also important to bear in mind that, though steam locomotives have been built capable of giving a starting acceleration as high as 16 in. per second per second, they by no means sustain this rate, which rapidly falls with increasing speed, instead of remaining practically constant, as would be the case with electric motors.

Exactly the same conclusions have been arrived at in Germany, where, after the most elaborate experiments, it has been admitted that rapid acceleration is impossible with steam locomotives having reciprocating parts.

As already pointed out, steam has reached its limits as regards acceleration, and, where the average distance between stations is short, rapid acceleration is of the greatest importance, as it enables a much higher average speed to be attained than can possibly be secured by means of steam locomotives.

The best results obtained with steam locomotives, as regards acceleration, average about ½ mile per hour per second. This figure is the average rate of acceleration, which means that for certain portions of the period the accelerations have been much greater. It is of the greatest possible importance to get a high average speed, and where stations are close together the only method of obtaining this is by using the high rates of acceleration which electric traction makes possible.

In addition to the fact that the high acceleration demanded for the proper operation of suburban traffic can only be obtained by the use of electric power, there are several further advantages possessed by the modern method of traction which render it greatly superior to steam haulage. Amongst these the following may be mentioned:—

Steam trains have to carry their own power—*i.e.*, a locomotive must not only be able to haul a certain weight of train, but it must carry coal and machinery to consume coal, and must convert its heat energy into tractive energy en route; and a steam locomotive for suburban work is a most uneconomical instrument for transforming heat into work for traction purposes. This adds to the weight of th etrain and greatly increases the weight to be hauled per passenger.

In the electric system the heavy locomotive is replaced by a series of motor cars, and energy is generated under the most economical conditions at a central power station, from which it can be transmitted many miles with but a slight loss.

Electric trains, with two or more motor cars on the multiple unit system, have the great advantage of distributing the weight of the train more evenly over the track, and also of permitting a smaller weight on each driving axle than would be the case with a locomotive, owing to a larger number of driving axles. A steam locomotive has to be heavy enough to give sufficient weight on the driving wheels to haul the heaviest trains up the steepest gradients at the highest required speed. This concentration of the weight is very detrimental to the track, and the bad effects are accentuated by the pounding action caused by the reciprocating motion of the engine.

For the same weight on the driving wheels an electric motor can exert a much greater tractive effort than a steam engine. This is because an electric motor exerts a steady torque upon the driving wheels, whilst the steam engine does not. In the case of steam locomotives the ratio of maximum tractive effort to the weight on the driving wheels is not much above 16 per cent., whereas experience has shown that with electric traction this is increased to from 25 per cent. to 30 per cent.

The cost of operating electric trains will also be reduced by the fact that only one man is required—that is to say, only a driver instead of a driver and a fireman. There is no risk in this, as, should the driver be incapacitated in any way, the method of control employed (the so-called "dead man's button") automatically brings the train to a standstill.

Electric traction is much more flexible than steam, and trains can either be split up into units of a few cars or joined up into trains the length of which is only limited by the length of platform available.

There are other advantages, but the crowning one is certainly the much higher average speed due to rapid acceleration and the economy of power and labour, as well as the reduced cost of production which is everywhere effected.

An incidental advantage in favour of the electric motor as compared to the steam engine is that the former can stand an amount of continuous service and hard usage

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which would be impossible with the latter, besides having far less internal friction.

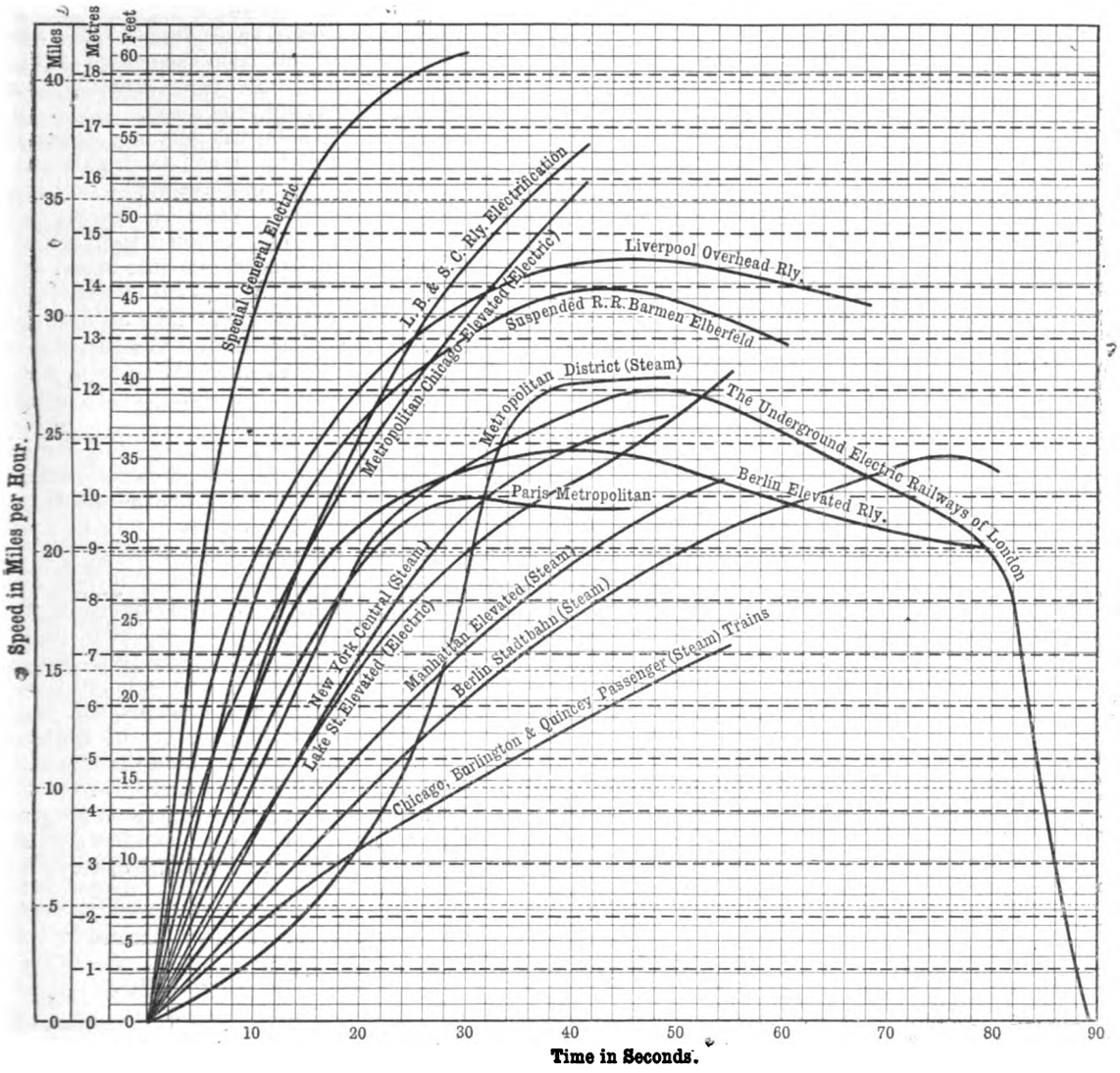
The cost of extending termini is perfectly enormous, and in some cases is impossible at any expenditure. The cost of any reasonable extension, such as for instance doubling the terminus at any of our big railway stations, will soon amount to millions. The electrification of the whole suburban system of one of our great railways would probably not cost much more than the extension of one single terminus, and electrification would not only practically double the capacity of the terminus, but also considerably increase the capacity of the suburban lines. In fact, in some instances it is purely a consideration of the great increase in terminal capacity which electricity will give which has been one of the chief causes to influence the decision in favour of electric traction.

A most important benefit resulting from the use of electric traction is the diminution of the present difficulties due to the lack of accommodation in termini. How this is brought about is easily seen when we consider the time wasted at present in getting a steam train out of a station after it has once entered. First the line has to be cleared to allow another steam locomotive to back on to the train in readiness to take it out, which it does. Then, before another train can be brought in, the line has to be cleared again so that the original locomotive which brought in the first train can run out. These various manœuvres occupy a considerable amount of time, besides necessitating a large amount of siding accommodation, not to mention possible blocking of other lines by the steam locomotives constantly running out and backing on to the other trains.

Thus the usual time it takes for a train to run in and out of a platform at a terminus, or the time that is required from the moment one train is run in until the platform is available for another train, varies between five and seven minutes.

Contrast this with what can be done in the case of a double-ended electric train. The train runs into the station, the driver walks from one end of the train to the other, and it is ready to start out again in from 1½ to 2 minutes after its arrival. It should be possible to save at least three or four minutes on each train entering and leaving a terminus, and naturally this would enormously increase the terminal facilities and prevent much of the congestion which is such a source of trouble and difficulty under present conditions.

The application of electricity to main-line traffic is quite a different matter to merely electrifying suburban lines, and need not be considered at this juncture. However, it is obvious that (other things being equal) the most advantageous system of electric traction for suburban lines is that one which presents the greatest possibilities of ultimate extension to main-line working.



ACCELERATION CURVES FOR VARIOUS STEAM AND ELECTRIC RAILWAYS.

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A large amount of valuable data, which are quite applicable to the conditions which would have to be met on our railways, have been supplied by interurban and electric railways in America, which operate trains of two or more carriages. From these can be obtained much useful information as to speed, number of passengers to be conveyed, weights to be handled, type of motor required, cost of locomotive power per ton, cost of generating and distributing power, and the load factors obtainable.

Although electric traction, both on railways and tramways, was first applied in this country, the strides made in America have been so rapid that, as in tramways 10 years ago America was far ahead of Great Britain, so now, in the installation of high speed elevated and interurban railways, America is the country to which we have to refer in order to ascertain what may be expected from the electrification of suburban railways in the United Kingdom, both as regards increase in traffic and operating expenses, cost of maintenance and probable net receipts.

It has been urged by many people that American experience in electric tramways would be of no use in this country, on account of the different conditions under which they would operate, but results have shown this contention to be incorrect. Therefore there should be still less hesitation in drawing on the experience of America in the matter of electric railways, since in this case the conditions in the two countres are much more nearly parallel than was the case with the tramways.

It is impossible to emphasise too strongly the fact that good and cheap travelling facilities create traffic. It is quite true that competing tramway lines, when electrified, have decreased the number of passengers carried by the railways, but it is erroneous to suppose that the bulk of the traffic of the tramways has been filched from the railways in this way. By far the greater portion has been created, and this is an entirely new traffic which hitherto has been lying dormant. This was amply demonstrated by the electrification of the Manhattan Elevated Railway, which resulted in an increase of 28 per cent. in the net revenue over what had been done under steam conditions. This result is a particularly convincing proof that traffic can be created, since, as a steam road, the line was operated under most favourable conditions, and it did not seem possible for it to carry any more passengers than it was then doing.

English railway companies have progressed very considerably of late; the track construction is probably better than any to be found in the world, and the locomotives, signalling apparatus and rolling stock are, as far as steam traction is concerned, nearly beyond criticism. At the same time, as already pointed out, the competition of electric tramways and the demands of the public for increased facilities for locomotion require a development on an entirely new basis. As trustee for many millions of the public money, it is evident that no railway company can take any action involving considerable expenditure, and the adoption of a novel system, except with the greatest care and most thorough investigation. Necessarily, the railway companies would prefer to be perfectly certain of the results before taking any important step, and to know what has been achieved financially by the electrification of other lines. The figures of the cost of operating and receipts on the tube lines and on the Liverpool Overhead are very instructive, but at the same time, owing to the different conditions under which they are constructed and operated, their results cannot be absolutely applied in all cases. It will be some years yet before reliable information is available of the results obtained on the Lancashire & Yorkshire and North-Eastern. But as regards actual results to be obtained either in increase in traffic or decrease in working expenses more will be said later.

The Royal Commission on London Traffic went thoroughly into the whole question of urban and suburban traffic, and all the results and conclusions which are applicable to London are also applicable to other large cities, not only in Great Britain, but throughout the world. There has never been a more thorough investigation, or one which has been more carefully carried out, and the members of the Commission (a great many of whom are intimately connected with railways) were most painstaking and thorough in their investigations, and their conclusions, therefore, should carry great weight.

In the Commission's report they call particular attention to the necessity of considering separately the requirements of purely urban and of suburban traffic; they lay emphasis on what has already been mentioned in these lines, that, for the purpose of travelling from the centre of London to the more remote districts, railways are essential, as no other mode of transport gives sufficient speed.

Electrification of the suburban sections of our railways would result in people living much farther from London than they dare do now, and there would be nothing to fear from tramway competition. This is obvious when we compare the time taken to get to town from a distance of, say, five miles. The maximum schedule speed of electric tramways probably does not at present exceed 10 miles an hour, and thus the journey would take 30 minutes. The electric train, on the other hand, could easily average 25 miles an hour, if not more, and would perform the journey in 12 minutes, thus effecting a saving of 18 minutes per journey or 36 minutes per day.

A more fitting conclusion to the discussion of the obvious necessity of our railways employing electric traction cannot be given than one of the conclusions the Royal Commission arrived at, and which runs as follows: "It is, we think, evident that the introduction of electric traction will lead to a great improvement of suburban and urban railway facilities in London. The speed of all trains worked by electricity, especially those which stop at many stations, will show substantial increase over the speed of steam trains. It will, we believe, also be found that electric traction, apart from its other advantages, will enable railway companies to increase the number of trains working in and out of the terminal stations, and thereby add largely to the facilities afforded for suburban traffic.

"We hope, therefore, that there may be no great delay before railway companies serving London adopt electric traction for the working of their suburban train service."

(To be continued.)

ELECTRIC LIGHTING.

[COMMUNICATED.]

MUNICIPAL V. COMPANY CHARGES.

It is claimed by many writers on municipal questions that as a fact municipalities supply electrical energy at a cheaper rate than companies, and that this is a conclusive argument in support of municipal trading in electrical energy. The fact that the terms on which the undertaking is held and on which capital can be borrowed are so much more favourable to the municipality are quietly ignored.

So long as municipal accounts are not required to be properly audited it will be impossible to inquire generally into the question. But every now and then we get a glimpse of the truth and can hazard a guess as to the general result. One such glimpse has just been vouchsafed, and we propose to refer shortly to it.

The Borough of Bermondsey was formed by a combination of the old parishes of Bermondsey and Rotherhithe and the old district of the St. Olave Board of Works (the latter district commonly known as "the Saints.") Bermondsey Vestry

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obtained an order under the Electric Lighting Acts for the parish of Bermondsey and subsequently as a Corporation for the old parish of Rotherhithe, and applied in 1902 and 1903 unsuccessfully to have the Saints added.

Throughout the whole borough the London Electric Supply Corpn. (Ltd.) possess an order, and in the Saints a second order was granted some years since to the County of London Electric Supply Co. (Ltd.). Both these companies opposed the application of the Corporation in 1902 and 1903. In 1902 there was a long Board of Trade inquiry, and the decision against the Corporation was based upon precedents. This year the Corporation applied again and the same companies opposed, but the Parliamentary Under-Secretary (Mr. Kearley, M.P.), who presided at the inquiry held by the Board of Trade, said that while he was well acquainted with the precedents, the determining question appeared to him to be who can give the cheaper supply, the municipality or a company, and the battle was fought on that issue.

Of the three competitors undoubtedly the Corporation showed the lowest published rates, as will be seen from the following comparative table:—

——	Private lighting.		Power.
	Maximum demand.	Flat rate.	
Corporation..	6d. to 2d.	3¾d. 3d. places of worship, clubs, &c.	1½d. to ¾d.
County Co...	7d. to 3d.	5d. business premises 5½d. private residences	2½d. to 1¼d.
London Co..	5d. to 3½d.	5d. to 3½d.	2½d. to ¾d. workshops 3d. to 1d. private residences

And it was not difficult for the Corporation to bring witnesses to say they would be glad to get their energy at the Corporation rates.

The companies were, therefore, somewhat outpaced at first, but proceeded to attack the Corporation accounts. These accounts, as audited by the Local Government Board, showed a large profit for the year ending March 31, 1906, the last completed year, enabling the Corporation to put £3,000 to reserve and carry forward a considerable sum, after payment of all interest and such return of capital as was required by the terms of its various loans, under £500 (for the sinking fund had been suspended for three years). Next year and each subsequent year the charge will be some £2,000 to £3,000.

On the face of these audited accounts the Corporation seemed to have a strong case. Admittedly their *rates* were lower than the companies, and accounts audited by the Local Government Board *must* be right (said the Corporation), and these showed large profits. Fortunately Mr. Kearley is a business man, and soon showed this by some questions put during the cross-examination of the Corporation witnesses.

The attack was first made upon the items charged for public lighting, in a two-fold manner:—

(*a*) As compared with the companies' offers.

(*b*) As compared with the actual cost to the Corporation.

The Corporation have supplied electrical energy to the public lamps in Bermondsey and Rotherhithe since 1902.

For the year 1902-3 they charged 3·06d. per unit.
" " 1903-4 " " 3·0d. " "
" " 1904-5 " " 2·98d. " "
" " 1905-6 " " 2·21d. " "
" " 1906-7 they are charging 1¾ per unit.

In each case exclusive of repairs and maintenance.

The County of London Company offered in 1903 to give a supply at 2d., and again in May, 1906, at 1½d. for a limited and 1d. for a comprehensive supply. The London Electric Company also offered a supply at lower rates than those charged by the Corporation. But all these offers were refused. The Corporation's engineer, Mr. Heenan, could give no reason for these refusals. So when the Borough Treasurer appeared the question was gone into in greater detail. And the following figures were accepted as correct statements of the total cost of the energy to the Corporation (apart from capital charges) during the periods given:—

For the year 1902-3..... 2·56d.
" " 1903-4..... 2·23d.
" " 1904-5..... 1·58d.
" " 1905-6..... 1·05d.

showing a charge in excess of cost of

0·50d. per unit for 100,165 units during 1902-3 = £208
0·77d. " " 199,555 " 1903-4 = £640
1·40d. " " 282,155 " 1904-5 = £1,645 and
1·16d. " " 361,662 " 1905-6 = £1,772

Total..... £4,265

But this was not all.

The accounts were actually credited with a sum equal to the cost of repairing and maintaining the arc lamps and standards charged on the other side amounting to £1,760. 16s. 1d. in 1905-6, though the Borough Treasurer could not explain where it came from.

Again the charge to the Corporation's buildings is 3½d. per unit for all purposes, and as the supply under this head amounted in the four years in question to 209,882 units it will be seen that here again the Corporation made a large profit, estimated at £1,583 in all, by supplying itself.

To come back to the profit and loss account, it must be remembered that, if a municipality admittedly makes a loss in one year, the loss is found by a rate and thus wiped off the account. Bermondsey in 1901-2 and again in 1902-3 made a loss of £1,200, or £2,400 in all, which was so dealt with. And if the electricity supplied to the Corporation's public lamps and buildings had been charged at cost and the expenses of maintenance and repairs had not been reimbursed from somewhere, the profits claimed for the undertaking would have been less by £5,848.

On the balance sheet for 1905-6 the profit and loss account stands thus:—

Loss 1901-2				£1,205	2	3
Loss 1902-3				1,200	9	3
Profit 1903-4	£512	7	7¾			
Profit 1904-5	818	1	6¾			
Profit 1905-6	3,705	5	0¼			
	£5,035	14	2	£2,405	11	6
Balance profit				£2,630	2	9

But if we deduct the above figure of £5,848 this profit of £2,630 becomes at once a loss of £3,218.

There is, however, another item to which reference was made. The capital account, 1905-6, showed an overdraft of £11,000, but no charge for interest appeared, and it was explained that the amount was not ascertained until after the end of the year, and that the proper item would appear in the 1906-7 accounts. But, unfortunately for this explanation, the accounts for 1904-5 were available, and showed an overdraft for that year exceeding £7,000, but no debit on interest account either in that account or in the account for the following year.

The decision of the Board of Trade just given in this case not to grant the Order may therefore be claimed as going a long way to show that municipal charges are not cheaper than a company's when the accounts are kept upon a proper basis. It may also open the eyes of some to the doubtful value of the Local Government Board audit.

Special Carbons for Photographic Arc Lamps.—According to the *Rundschau für Elektrotechnik und Maschinenbau*, Herr Auguste Kufferrath has lately patented a special method of impregnating carbons, which gives to an arc light all the special properties required in photographic work. This is done by impregnating the carbons with a 1 per cent. solution of an equal mixture of yttrium and lead nitrates. Carbons thus treated are not distinguishable from ordinary kinds as regards luminosity and current consumption, but they have a fairly large actinic power. They burn without forming any residue, and their light is particularly rich in violet rays.

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A NEW MULTIPLE UNIT SYSTEM OF TRAIN CONTROL.

(*Concluded from page 11.*)

Summary.—A description is here given of a new method of multiple unit train control, in use on the Lancashire & Yorkshire Railway's, Liverpool–Southport electric line. It is the development of a principle introduced by Mr. T. von Zweigbergk, of Dick, Kerr & Co. (Ltd.) The main feature is the use of solenoid contactors with series, as distinct from shunt, magnets. These magnets are energised by the return current from the train motors, which is either passed through all the control magnets to earth at the rear of the train or diverted to earth at the front of the train. No current is broken in the controller; only the contactors, with metallic shield blow-outs, interrupt the motor circuits. The control wires are also at earth voltage at all times. The description includes an account of the principle adopted, with simple diagrams and details of the parts employed to make up the control of a train. The application of the system to a four-motor coach is also described.

The contactors are built up in the form shown in Fig. 5, which is an outline of the complete solenoid and its switch with metallic shield blow-out. Four contactors are placed in a single iron box and the four boxes required for a motor car are hung under the carriage frame, as shown in Fig. 6. Referring to Fig. 5, A is the iron supporting box, B the series solenoid, C, C_1, the switch contacts and D the insulating supports for the switch parts. The lower end of the solenoid plunger may be seen at E, and the upper extremity which is not shown is connected to a lever, one end of which carries the contact finger C_1. When current passes round the solenoid the plunger E is drawn smartly up, and through its motion the contact lever is moved upwards until it presses on the upper contact C. This also is hinged in such a way that it tends to turn under the pressure of the solenoid plunger causing the two contact fingers to rub slightly as each connection is made. By this means the finger surfaces are kept clean and any copper globules which may form are always rubbed off. The self-induction of the solenoid is practically nil; consequently the contactor always makes prompt response to the movement of the master controller. A series magnet has no time element such as a shunt magnet with its high self-induction has, and the fact that with this system all the contactor magnets carry the main motor current ensures immediate switching action throughout the train of all the contactors, in accordance with the various positions of the master controller.

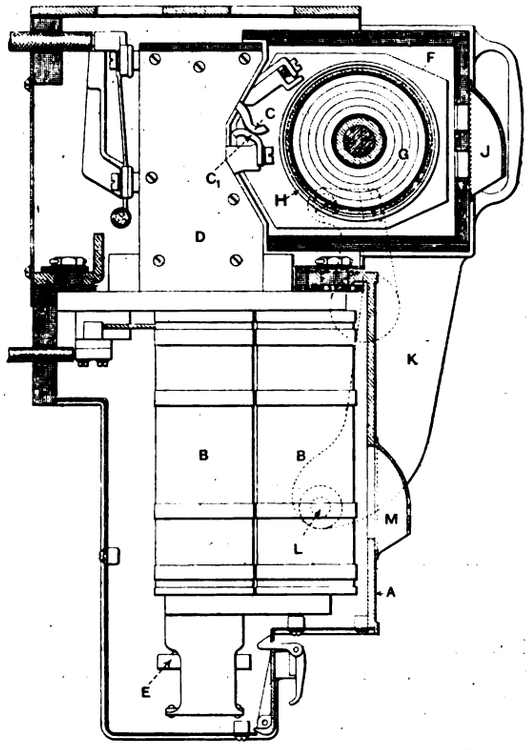


FIG. 5.—SECTIONAL VIEW OF CONTACTOR BOX SHOWING SOLENOID AND METALLIC SHIELD BLOW-OUT.

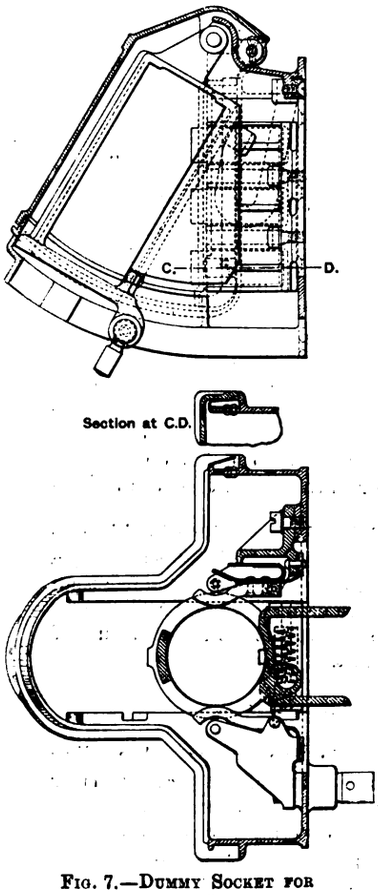


FIG. 7.—DUMMY SOCKET FOR COUPLER PLUG.

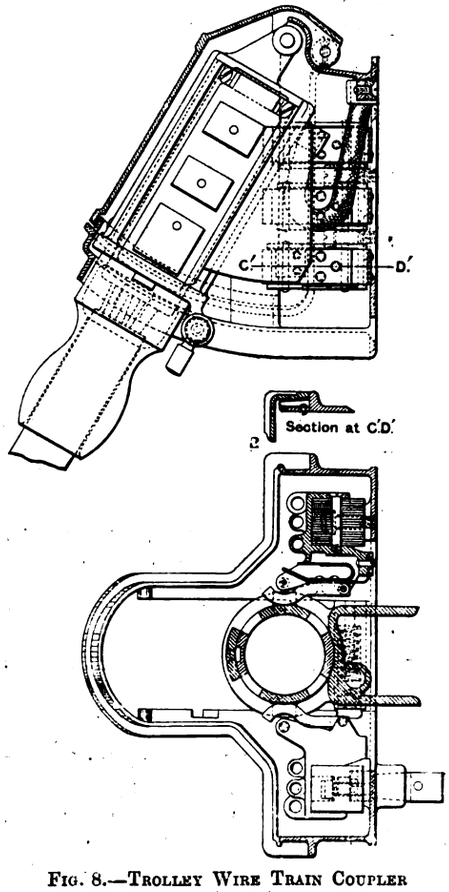
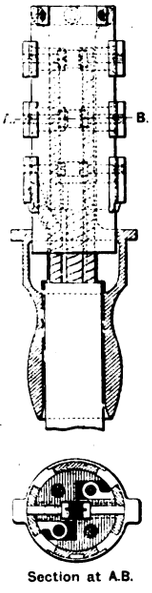


FIG. 8.—TROLLEY WIRE TRAIN COUPLER AND SOCKET.



The arc formed at the breaking of the circuit at each contactor is dispersed by the metallic shield blow-out F, which consists of a coil, G, surrounded by a short copper tube, H. The inside edge of this tube is adjacent to the contacts C, C_1, and the outer edge to the opening in the casing J. The arc formed at C, C_1, is at once attracted to the coil G, and, as it strikes the tube H, it is compelled to travel round it, being drawn away from the contacts and finally broken opposite the opening J. This metallic shield blow-out is another of the patents of Mr. Zweigbergk and has been applied to Messrs. Dick, Kerr's continuous-current circuit-breakers and controllers for several years past. The blow-out coils for the four contactors are wound on a common iron core supported by the carrier K, which is hinged on a pin at the point L to allow of all the contacts being inspected when the carrier is swung down to its lowest position. In Fig. 6 the carrier will be noticed in this position. Each blow-out holder is fitted with moulded

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vulcabeston division plates to divide off each contactor from its neighbour. These can also be seen in Fig. 6, attached to the coil-carrier; the ends of the blow-out coils terminate in knife contacts which plug into clip contacts when the carrier is in the working position. Each contactor is designed to carry a maximum of 300 amperes, and the solenoids carry a normal current of about 10 amperes each. A ventilating hole, M, to carry off any heat dissipated by the solenoids is cast in the contactor box opposite each solenoid. When the solenoids are de-energised the plungers fall by gravity and open the contactor circuits. In this respect the use of a series magnet favours the rapid opening of the circuit, as the coil, being free from self-induction, is unlikely to cause the plunger to stick at any time.

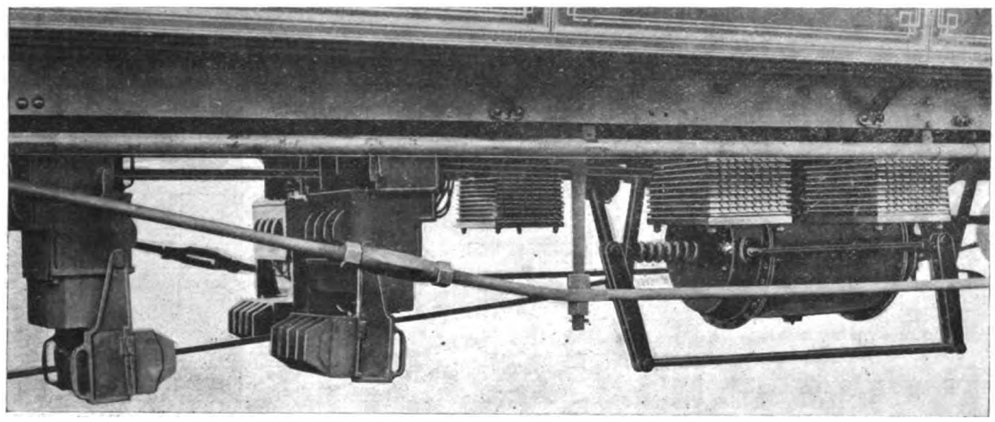

FIG. 6.—CONTACTOR BOXES AND RESISTANCE GRIDS UNDER THE CAR FRAME.

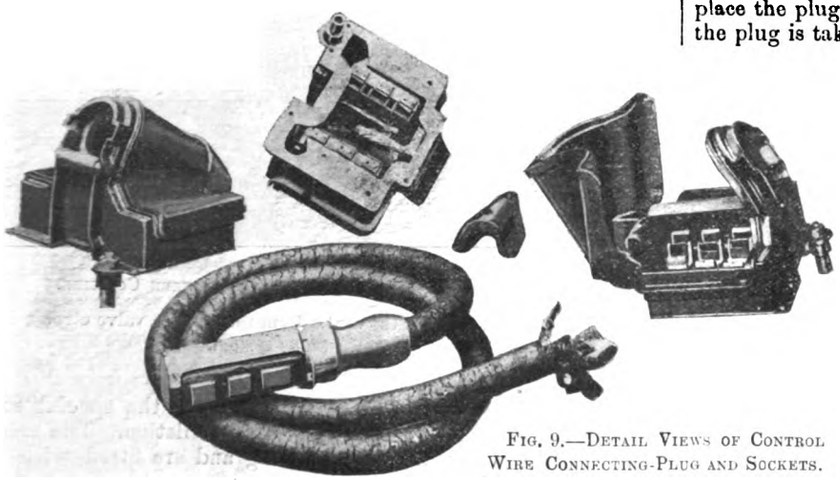

FIG. 9.—DETAIL VIEWS OF CONTROL WIRE CONNECTING-PLUG AND SOCKETS.

The remaining portion of the equipment is made up of iron grid resistances for the motors, these being bolted under the frame of the coach.

It will be noticed that the apparatus required for the control of the motors is very simple in construction and is divided into but few parts. The master controller is slightly larger than that usually employed for multiple unit control, but the switch mechanism beneath the train is correspondingly reduced. The actual notching up of the motors is entirely under the motorman's control, and does not depend in any way on automatic switches, which speed up the train as soon as the series or parallel points on the master controller are entered. This manual control places the driver at a distinct advantage when shunting or running slow, because the controller itself has notches for all speeds and auxiliary shunting switches are not necessary.

As the motor-control circuits throughout the train need to be coupled up in series in the manner already explained, special provision must be made at the ends of coaches to carry through the leads, so that the sets on each coach will correspond with one another. This is effected by the use of special plugs and sockets at each end of each coach, whether it be motor or trailer. Views of these plugs are shown in Figs 7 and 8. That illustrated in Fig. 8 is made for connecting the trolley wires of one coach with those of the next, while the one illustrated in Fig. 7 is only used at either end of the train to place the plug into. The couplers are so arranged that when the plug is taken out of the socket in Fig. 8, all the six train leads are earthed, while in the socket of Fig. 7 the matter is reversed, the six leads being earthed when the plug is in position. Each coach has one socket like Fig. 8 and one like Fig. 7 at either end, and the plug is placed immediately below the coupler shown in Fig. 7. It will be seen that as soon as the train is disconnected, the mere fact of disconnecting the plugs and placing them into the sockets above them, earths all the nine train wires. Fig. 9 shows the coupler plug and socket in detail.

Figs. 10 and 11 depict rear and side views of the ends of the motor coaches and serve to illustrate the position of the couplings between the coaches and also those of the plugs at the rear of the train. The dummy sockets and trolley plugs are clearly shown. The smaller intermediate cable couplings form part of a special circuit provided in connection

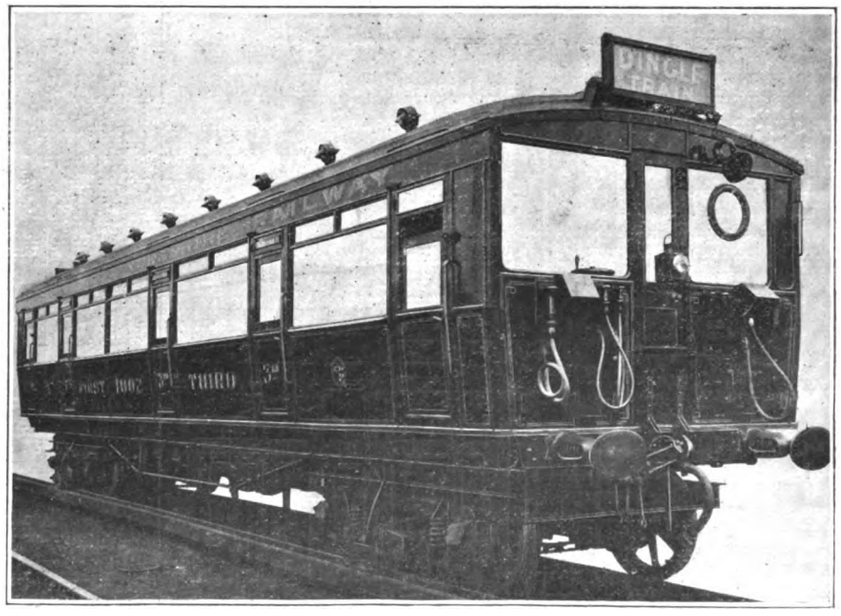

FIG. 10.—MULTIPLE UNIT COACH SHOWING HOW THE TROLLEY AND CONTROL PLUGS ARE TURNED BACK INTO THE SOCKETS AT THE HEAD OR REAR OF THE TRAIN.

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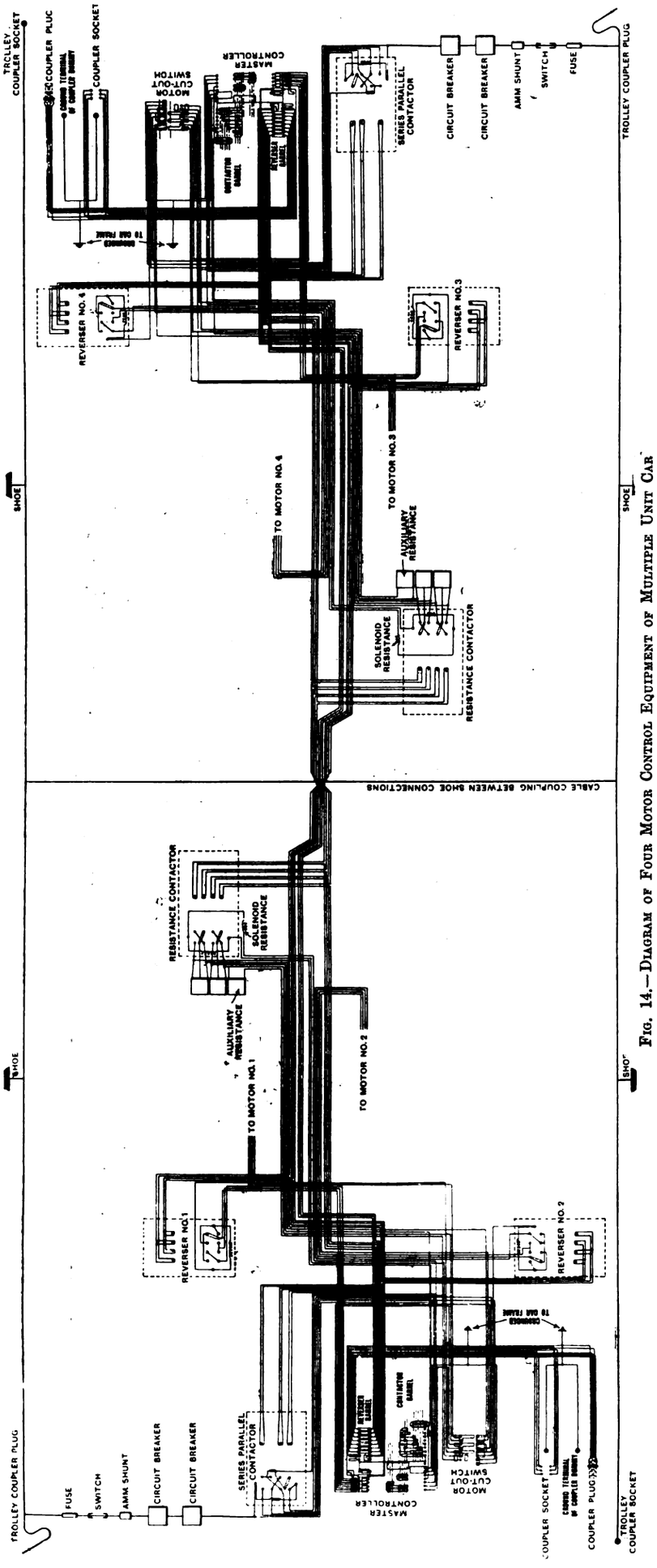

FIG. 14.—DIAGRAM OF FOUR MOTOR CONTROL EQUIPMENT OF MULTIPLE UNIT CAR

with the electrical control of the valve on the vacuum brake cylinder.

The motors on the multiple unit cars are also of some interest. Fig. 12 shows a train motor dissembled to illus-

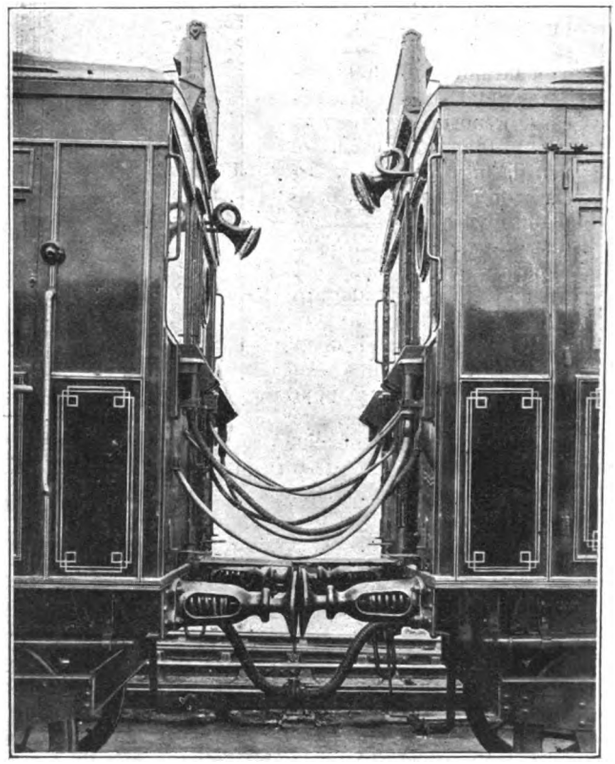

FIG. 11.—VIEW OF COUPLINGS BETWEEN COACHES.

The small wires in the centre form the magnet valve circuit for the brake system.

trate the method of construction and the special care taken to ensure accessibility and ventilation. The armature bearings are self-centering and are fitted with oil ring lubrication. The oil chambers are of large capacity

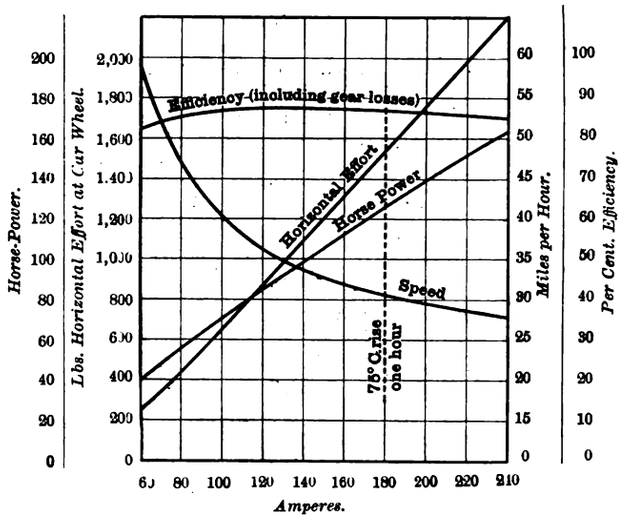

FIG. 13.—CURVES SHOWING CHARACTERISTICS OF DICK, KERR 5A RAILWAY MOTOR.

and when filled will run for a month, continuous running, without recharging. The axle bearings are also made very large and are provided with pad lubrications. The axle in this case is lubricated by a pad clamped to a pivoted arm.

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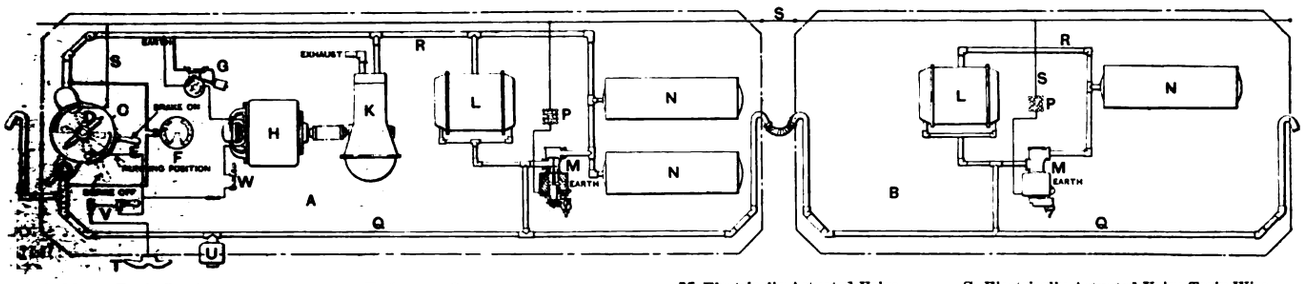
The duty of the motors is divided between service on the Liverpool & Southport Electric line, on which they operate at 650 volts, and the Liverpool Overhead Railway, where the pressure is 500 volts. On the latter a large amount of accelerating must be done, consequently the need to be well ventilated. Fig. 13 is a curve showing the characteristics of this type of railway motor. It will be noticed that the pole-pieces are provided with a large air duct, which passes right



A Motor Bogie Coach.
B Trailer Coach.
C Driver's Valve.
D Electric Valve Switch.
E Driver's Valve Handle.
F Vacuum Gauge.
G Automatic Starting Switch.
H Pump Motor.
K Pump.
L Vacuum Cylinder.
M Electrically Actuated Valve.
N Vacuum Reservoir.
P Lamp Resistance.
Q Train Pipe.
R Reservoir Pipe.
S Electrically Actuated Valve Train Wire.
T Contact Shoe.
U Drip Valve.
V Main Knife Switch.
W Motor Knife Switch.

FIG. 15.—DIAGRAM OF BRAKE EQUIPMENT AND ELECTROMAGNETIC EQUILIBRIUM VALVE.

through the pole to the motor shell. The armature also has a large ventilating duct built up with the core, and the rotation sets up strong air currents, which circulate through the iron of both armature and fields. Openings in the top of the shell allow for the entrance of fresh air. The field coils are enclosed in cast bronze castings secured to the frame by four bolts. These castings prevent the field spools working loose through vibration at high speeds. The gear case is also specially stiffened to withstand vibration. The brushes are arranged in four sets to reduce the current carried per brush, and also to lessen the spring tension needed to keep the brushes in contact with the commutator.

Generally speaking, the control system consists of nine train wires which are earthed at both ends of the train. Each master controller has a cut-out arrangement which opens up the train leads at the particular point where the master control is situated. This cut-out switch is combined with a reversing switch, so that if this switch be moved to either "ahead" or "reverse" the train leads are disconnected, thus leaving the nine train wires grounded at the farther end of the train, and the master switch is, therefore, ready to be operated.

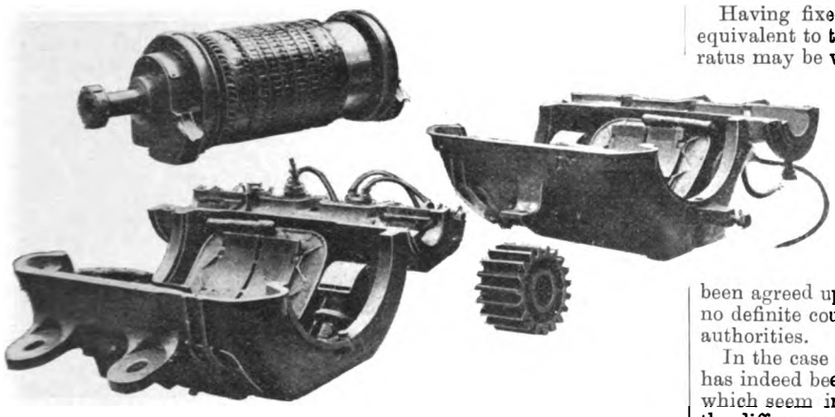


FIG. 12.—DETAILS OF TRAIN MOTOR USED ON MULTIPLE UNIT CARS.

In taking the reversing handle off the master controller the switch must be brought to the "off" position, which again connects the train leads, so that the train will be able to be operated from the other end, or any intermediate point.

In Fig. 14 a complete diagram of the control system adapted for four motors per car is shown. From the foregoing we think it will be possible to follow this particular development without a detailed description.

In conjunction with the usual vacuum brakes fitted to the multiple-unit trains an electrical method of equalising the vacuum throughout the train is in use. Each coach in a train is fitted with an electric actuated equalising valve, which is normally on its seat when the driver's brake valve is in its normal position or when he applies the brake. To enable trains to get quickly away from stations, by putting the driver's valve into what is known as the equalising position, a circuit is completed which lifts simultaneously all the electro-pneumatic valves in the train, equalising the vacuum and immediately taking the brakes off. The diagram in Fig. 15 shows the arrangement adopted for this purpose.

The new system is employed on the Lancashire and Yorkshire Railway Company's trains running over the Liverpool Overhead Railway, and also on the Lancashire & Yorkshire extension to Aintree.

In conclusion, we must express our thanks to Mr. Hughes for permission to inspect the new stock, to Mr. O'Brien and Mr. Arthur for showing us over the same, and to Messrs. Dick, Kerr & Co. for the data upon which our description is based.

DEPRECIATION.*

BY ROBERT HAMMOND.

In arriving at the net profits earned during any given period by an industrial undertaking it is obvious that a determination should be made of the extent to which the assets of the undertaking have depreciated in value during that period. Where machinery and apparatus are employed it is necessary to estimate their probable "life," which, in the case of undertakings working on well-established lines, may be easily arrived at.

Having fixed a definite figure for the life, the sum which is equivalent to the annual depreciation of the machinery and apparatus may be written off annually and debited to the gross profits, this book entry involving no withdrawal of money from the undertaking; or out of the gross profits, annual investments may be made of such sums as will, at compound interest, reach the amount of the original cost of the machinery and apparatus by the time that they are worn out.

Turning to electricity supply undertakings one finds that their development has been so rapid, and the working conditions have so greatly altered in so short a time that no standard method has yet been agreed upon for dealing with the question of depreciation, and no definite course has been pursued either by companies or by local authorities.

In the case of undertakings owned by local authorities the issue has indeed been somewhat obscured by the controversial questions which seem inseparable from all municipal undertakings, and by the difference between the financial basis of these undertakings and that of most other industrial concerns.

The object of the present Paper is to invite the members of the Institution to consider the question of depreciation in all its bearings as applicable to electricity supply undertakings, in the hope that some definite conclusion may be arrived at as to the proper provision which should be made in the case of undertakings owned, whether by companies or by local authorities.

The word "depreciation" is used in a wide sense, and it is desired to include in the inquiry not only the consideration of the provision which should be made to cover the depreciation in value of the assets of an undertaking, but also as to what other charges beyond

* Abstract of a Paper read before the Inst. of Elec. Engineers, April 25th.

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the ordinary working costs should be debited to the revenue account before arriving at the net profits of the undertaking.

Following these lines, we have first to consider the question of depreciation proper, then the advisability of creating a reserve fund to provide for unforeseen expenses which may be incurred owing to accident or other emergency, and, lastly, the provision of a further fund to cover antiquation of machinery, apparatus and mains, thereby preparing for the possible necessity of scrapping machinery, &c., which may be in good working order, but which may have become obsolete owing to improvements introduced in methods of generation and distribution.

In the case of undertakings owned by companies, the consideration of these questions resolves itself merely into what should be the amount of the provision to be set aside annually from the gross profits in connection with the above items.

In the case of undertakings owned by local authorities, on the other hand, not only is it necessary to consider the amount to be provided under the three heads of depreciation, extraordinary emergencies and antiquation, but a more controversial point arises—viz., the effect of the peculiar financial basis on which such undertakings rest upon the necessity for these provisions.

Companies.

Obviously the two classes of undertakings must be considered separately, though in many respects there are points common to both.

Whether the undertakings are owned by companies or by local authorities the conditions governing their working are such that in order to give a continuous supply of electricity it is essential that machinery, apparatus and mains should be kept in a high state of efficiency.

The cost of so maintaining the plant is, of course, regarded as part of the working costs, and is assumed to be so dealt with. Plant, well maintained as it may be, must, however, gradually depreciate, and a time will come when the frequency and extent of repairs and renewals necessitate so heavy an item of annual expenditure that it is preferable to replace it with entirely new plant.

In order to arrive at the amount with which the gross profits should be debited annually in order to cover this depreciation, it is necessary to settle the number of years which will elapse before the various classes of plant and apparatus in use will arrive at the scrapping stage and will require entire renewal.

On the basis that all plant would be carefully maintained and faulty parts renewed out of revenue, it is suggested that the periods named below represent a fair approximation of the life of the various classes of machinery and appartus, &c., named:—

Estimated Years of Life.

	Years.		Years.
Land and buildings	60	Accumulators	15
Machinery and plant:—		Transformers, static	15
Boilers	20	Converters, rotary	20
Pumps and pipework	25	Switching apparatus and instruments	20
Conveyors	10	Meters	10
Engines	25	Mains:—	
Turbines	20	Armoured	25
Dynamos and alternators	25	Solid system	30
Motors	20	Ducts	30
Tools and sundries	10		

The "lives" set forth will doubtless provoke some criticism, but it is repeated that the "life" largely depends upon the degree of thoroughness with which the plant is maintained.

With accumulators, for instance, it seems sanguine at first sight to give a life of 15 years. Further consideration shows, however, that for all practical purposes, with careful upkeep, the life given is merely that of the boxes containing the plates, connections, &c. There is no reason why a battery of accumulators should not last considerably longer than 15 years if the plates are regularly renewed out of revenue.

If the above periods be accepted, it becomes a simple calculation as to the amount which must annually be written off or set aside to a sinking fund.

Reference has already been made to the alternative methods of dealing with the depreciation fund. Of those methods doubtless the sounder is that which provides for the annual investment, outside the undertaking, of such sums as will, accumulated at compound interest, represent from time to time the actual ageing of the machinery, apparatus, mains, &c.

It is true that if this method were adopted, each extension of the undertaking would necessitate the raising of fresh capital, which would have to be subscribed either by the existing shareholders or by the general public. But the company, with such an asset at its back as invested funds, would be in a far more favourable position as regards the issue of fresh share capital than it would be if it had invested its depreciation fund in extensions.

One, of course, gets back to the fact that, for the purpose of extensions, fresh issues of capital would be required from time to time, and most directors would doubtless think it preferable to use the money which they had actually in hand before they made an appeal to their shareholders or to the outside public for further share capital. This, indeed, is the method that has almost universally been adopted by the electricity supply companies operating in the metropolis.

So far, the formation of a depreciation fund in the narrow sense of the word has alone been dealt with. The formation of such a fund, apart from the method of accountancy adopted, appears to be essential whether the company is working at a profit or a loss.

As regards the second item, to which reference has already been made as coming within the purview of the Paper—namely, the provision of a general reserve fund—it seems to the author that, however wise the formation of a general reserve fund might be for the purpose of equalisation of dividends, it nevertheless does not rank as a strict necessity, as does a depreciation fund. Further, he does not agree with those who hold that such a fund is necessary, not only for the equalisation of dividends, but for the purpose of providing against extraordinary expenditure due to unforeseen emergencies. Such emergencies are caused by accident in one form or another, and such risks should be fully insured against and the premiums regarded as part of the ordinary working costs. Lastly, there is to be considered whether a fund to cover antiquation should be deemed obligatory. It has been urged on the one hand that no provision whatever need be made under this heading. Those who hold this view contend that any great revolution in engineering methods which would cause their present plant to become obsolete would necessarily carry with it its own advantages either in the direction of a great improvement in efficiency or in an extension of the uses to which electricity might be put.

On the other hand, many hold the view that an antiquation fund is of vital importance. The author does not share this view to the full extent, but, on the other hand, he thinks that no electricity supply undertaking can be regarded as in a thoroughly sound position unless some provision has been made in the direction of an antiquation fund. At the same time this provision is, in his opinion, not one which would rank on the same footing as a depreciation fund per se, but is one which might wisely be contributed to out of profits as a sort of nest-egg for the future.

Local Authorities.

In considering the case of local authorities owning electricity supply undertakings, it is seen that their method of raising the capital precludes them from adopting the plan in vogue among the companies of writing down the value of their machinery, apparatus, &c., and keeping the money in the business.

In the case of loans authorised by the Local Government Board the practice hitherto has been to allow a period of 25 years for the repayment of loans required for electricity supply undertakings.

The period of 25 years is supposed to represent the average life of the plant and buildings. The method of arriving at the equated period, in common vogue, is to take the average of the lives, taking into consideration, of course, the different monetary values. As a matter of fact this method can only give a more or less correct approximation of the true equated period. When the rate of interest payable on the sinking fund is a comparatively low one, and the various periods are not greatly dissimilar, the result obtained by averaging the lives does not differ widely from the result obtained by calculating the true equated period. On the other hand, under other conditions which are quite likely to obtain in practice, the divergence may be considerable.

Perhaps it should be explained what the author means by the use of the words "the true equated period" In dealing with a number of loans for various periods of years two courses are open to the borrower. He may either deal separately with each separate loan and pay each off as it becomes due, or he may arrange with the lenders to equate the whole of the loans, and thus enable him to erect one sinking fund and to pay off the whole amount of his indebtedness at one time.

From both the point of view of the borrower and the lender it is, of course, an axiom that whichever of these two courses be adopted neither party shall be the loser from a financial point of view. In arriving, therefore, at the true equated period of a number of loans, it is not sufficient to take the mean value of the lives of the assets, and thus to ignore the compound interest question. The exact method is to arrive by calculation at a period of years such that, if the total amount of the various loans were repayable at the end of that period, the present value of that loan would be equal to the present value of all the separate loans repaid at their various individual periods.

When the periods to be equated differ widely, or when the rate of interest is higher than 3 per cent., considerable difference appears, as may be shown by the following example:—

Let the loans set out below be obtained and be repayable at the expiration of the periods named—

£20,000 repayable in 60 years	£10,000 repayable in 15 years
£30,000 ,, 25 ,,	£10,000 ,, 10 ,,

The average of the above periods is 31·43 years, whereas the equated period on the other basis works out to 26·92 years.

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In the past it has often been contended that in the case of local authorities no further provision for depreciation beyond the sinking fund payments is necessary in arriving at the true annual profits, owing to the fact that the annual contributions to sinking fund are such that, by the time the plant has been worn out, the indebtedness in respect of the capital expenditure on same will have been extinguished.

The opponents of municipal trading have not only strongly contested this view, but the discussion has been further complicated by attacks on the period of 25 years, arrived at by the equation of the lives of the various portions of the plant.

Apart, however, from the soundness of the basis taken in arriving at the equated period for repayment of loans, the opponents of municipal trading have contended that not only should annual contributions to the sinking funds be made of such amounts as will be sufficient to extinguish the indebtedness at the end of the loan periods, but that further contributions should be made either from revenue or from the rate fund of such amounts as would provide a fund sufficient entirely to renew the machinery, apparatus, mains, &c., without incurring fresh indebtedness when the original "outfit" is worn out.

The principle hardly seems sound. Assuming for the moment that the equated period in the case of the loans for electricity supply purposes were exactly correct, and that it truly represented the life of the plant, the undertaking at the end of the equated period would be free from debt by the operation of the sinking fund and would be then in just as good a position from the ratepayers' point of view as it was when the undertaking was first begun.

The question may be asked: Why is it necessary to consider undertakings owned by local authorities on a different basis from those owned by companies? If the sinking fund payments be regarded as part of the contributions to the depreciation and reserve funds, the two classes of undertaking might surely be considered together.

The question, however, does not present so simple an issue as this, since, in the case of local authorities, the period for the repayment of loans, is an equated one, and does not actually represent the period of time during which the whole of the "plant" used in the undertaking will continue in proper working order, though efficiently maintained. Certain portions of the plant have shorter lives than others, and when they are worn out it is necessary to incur further capital expenditure in order to replace them. As, however, the sinking fund remains intact until the end of the equated period of 25 years, no portion of it is available for the renewal of the short-lived portions of the plant when they are worn out. We have carefully to consider what effect these circumstances have on the building up of the depreciation fund. Should it make provision for the renewals of the short-lived portions of the plant in order to avoid the necessity for incurring fresh indebtedness before the original loans had been repaid?

In this connection it must be borne in mind that although this difficulty arises in the earlier years under the system by which an equated period is given for repayment of all the capital expenditure, nevertheless, a corresponding advantage is gained in the later years of the undertaking subsequent to the expiration of the equated period. The life of certain of the assets is considerably greater than the equated period of 25 years, so that after the expiration of the 25 years the total capital expenditure on this class of expenditure has been entirely wiped off, while no necessity arises for further capital expenditure in this direction till a later period.

In the hands of a company the sinking fund provided out of profits would without doubt be drawn upon for the purpose of renewing any portion of the machinery and plant that may have worn out; but this is not possible in the case of a local authority, whose sinking fund is earmarked for the purpose of the liquidation of a special loan.

It must be remembered that the annual contribution to the sinking fund in the case of equated loans covers the depreciated life of both short and long-lived assets, and in my opinion a local authority should be permitted to re-borrow for the replacement of worn-out machinery, apparatus, &c., provided that such re-borrowings shall from time to time never exceed the amount contributed to the sinking fund, and provided that the term of the new loan should coincide with the "life" of the new plant. If this were permitted a local authority would be placed in the same position as a company in respect of its depreciation fund.

The author's final contention, then, is that a local authority should treat depreciation exactly as a company treats it. It should set aside annually such sums as, properly invested, will enable it to wipe off the value of the machinery and plant at the end of its life. If the loan in respect of such machinery and plant is for a period similar to that of their life, then no further sum need be set aside annually. If, however, the loan, as in the case of some local authorities in the metropolis, be for a period of 42 years, whereas the equated life of the plant was agreed to be 25 years, then the annual instalments should be of such amount as would produce the capital sum in 25 years. The actual contributions to the 42 year sinking fund would be treated as part payments, and it would be necessary to set aside a further sum annually to bring the contributions up to a 25 years' basis.

Residual Values.

To arrive at an absolutely accurate amount of annual contribution to a depreciation fund it would be necessary to determine the residual value of the machinery, apparatus, &c., at the end of their respective lives. In the case of land it, of course, remains, and the scrap value of machinery, apparatus, mains, &c., containing a fair amount of copper and other metals, is appreciable. As, however, a depreciation fund must in its nature be based upon an estimate, it has seemed to the author wise to regard the residual value as an item which the undertaking would have to the good at the end of the respective lives, and one which to that extent would be in hand as a contribution towards the cost of new plant.

"FLEXIBLES," WITH NOTES ON THE TESTING OF RUBBER.*

BY PROF. A. SCHWARTZ.

(*Continued from page 14.*)

Summary.—In this Paper the author first deals with the causes of deterioration in flexible conductors. He then considers the method of insulating them, and describes in detail the properties of rubber. He also deals with the various mechanical and electrical tests to which flexible cables should be subjected, and concludes by describing various systems of surface wiring using flexibles, which have been more particularly adopted on the Continent.

IX.—Tests on Completed Flexibles.

The following series of tests on complete flexibles were made by the author last year:—

Table I.—*Mechanical Strength of Flexibl s.*

Size.	Breaking load on flexible in lbs.	Bending test on counter-weight fitting. Times up and down over 1½ in. pulley. (Up and down = 1.)
35/40	71 93	58,850
35/40	127 138	181,470
35/38	104 104	54,370
23/36	104 82	70,181
23/36	60 82	130,699
35/40	71 93	105,262
35/40	123 146	200,230
35/40	82 160	117,952
35/40	104 ..	17,736
35/40	93 194	9,560
35/38	104 ..	265,294
35/38	116 105	340,000
Special gymp flexible	..	1,500,000 (still unbroken)

A consideration of Table I. shows that the breaking force varies a good deal with different specimens of the same sectional area. This is probably due to the way in which the twin conductors are twisted together, for if one is slightly shorter than the other it will bear a larger proportion of the load. As might be anticipated, the copper in nearly every case breaks before the rubber. It breaks very cleanly right across all the strands with a considerable reduction of area, hardening and loss of flexibility. Where the copper breaks first and the load is removed, the rubber will contract and bring the broken ends of the wires into contact, and so give rise to arcing. This is not very likely to occur in practice, but the author finds as a result of a series of tests on repeated bending through a right angle at a lampholder, that the copper in this case also breaks first, and that the broken ends are almost invariably pulled together again by the contraction of the rubber when the weight of the fitting is taken off the cord.

* Abstract of a Paper read before the Institution of Electrical Engineers, April 18th.

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Bending Test on a Counterweight Fitting.—One of the severest conditions that a flexible conductor has to meet in house installation work is its use on an ordinary counterweight fitting. An apparatus was arranged to simulate as nearly as possible the bending met with under working conditions. The flexible was drawn down by an attachment to a small motor and drawn up again by the counterweight once in each revolution of the motor. The motor, which was ½ H.P., was fed through the flexible under test and the revolutions counted until a breakage occurred in the conductor, when the motor stopped. The following are the particulars of the apparatus :—

Diameter of porcelain pulley	1¼ in.
Length of pull	6 in.
Weight of counterweight	1¾ lb.

The results are incorporated in Table I., and are certainly surprising as the extent of the endurance of flexibles under such conditions. Since the conclusion of these tests the author received from Mr. Mervyn O'Gorman a specimen of special "gymp" flexible, the structure of which has already been referred to under the head of Conductors. After running over 1,500,000 times up and down over the counterweight pulley the condition of this flexible was, as far as one could see, quite unaffected, and the attempt to break it was abandoned. The author understands that this material costs about £60 per mile, and the resistance is very high, amounting to 1·70 ohms per yard of double conductor on the specimen tested. In connection with lifts and hoists, when the ordinary flexible gives a good deal of trouble the use of "gymp" flexible would appear to be advantageous.

Bending Tests through a Right Angle.—Flexibles in mills and factories are subjected to frequent brushing to rid them of adherent dirt, and this entails bending at the lampholder, also counterweight fittings are usually adjusted by grasping the lamp shade with a similar result. In order to ascertain the effect of repeated bending the author tested about 60 varieties of flexible in the following way: Five lampholders were mounted in a line on a wood batten with a short length of flexible depending from each, to which a 3 lb. weight was attached. The ends of the flexibles in the lampholder were connected in series, and a small motor (½ H.P.) was fed through this circuit. The motor was arranged to rock the lampholders through a right angle about the ends of the cord grips as centre once each revolution. When a conductor broke the motor stopped, and the reading was taken on the revolution counter attached to the motor. Considerable differences exist in the behaviour of different conductors of the same sectional area and gauge of wire. This may, of course, be due in part to differences of manufacture or material, but the author is inclined to attribute it to the position of the flexible where it entered the cord-grip and where the bending took place. The two conductors may have the axis of their cross-sections at right angles to the axis of bending, or parallel to it, or in any positions intermediate to these.

Dielectric Strength.—In the tests, the details of which are embodied in Table II., the flexibles were suspended from supports 3 ft. apart, and were at their centres about 4 in. from a pan of boiling water 14 in. in diameter. All the samples submitted successfully withstood the I.E.E. test, and were afterwards tested with a gradually increasing alternating-current voltage until they broke down.

Table II.—*Dielectric Strength of Flexibles.*

Thickness of rubber in mils.	Breakdown pressure, in volts.	Nature of insulation from observations.
16	8,000	Cotton over conductor V.I.R. only.
17	21,500	Pure rubber, two layers laid opposite ways.
27	24,200	V.I.R. separator and pure rubber with longitudinal joints.
34	23,300	V.I.R. separator and pure rubber. Poor and over-cured. No cotton next conductor.
35	26,000	V.I.R. separator and pure rubber of good quality No cotton next conductor.
19	21,000	Pure rubber, two layers.
8	5,100	Cotton braid, cotton yarn, single layer pure rubber. Cotton next conductor.
24	25,000	Cotton braid, double layer pure rubber. Cotton next conductor.
34	22,000	V.I.R. separator and pure rubber.
..	3,200	Cotton braid, single layer pure rubber. Cotton next conductor.
24	20,000	V.I.R. and separator. Cotton next conductor. Doubled braided. Five years old.

X.—Testing of Insulation.

Considering the features which it is desirable that the insulation should possess, and placing them in the order of their relative importance, we have: (1) Durability, (2) high initial insulation resistance, (3) dilectric strength.

The first is undoubtedly in the case of flexibles the most difficult to obtain, and also the most difficult to test for; while the second although very generally considered of small importance, often affords a safer guide to the real character of the insulation than the high-voltage puncture test would do. The puncture test for dielectric strength, while usually specified for flexibles, is very rarely carried out in practice.

Table III. gives the puncture voltage, insulation resistance and electrostatic capacity of some American cables containing definite relative amounts of rubber in their insulation.

Table III. (*Clark.*)*—*Significance of Electrical Tests.*

Relative amount of rubber.	Breakdown E.M.F. in volts.	Capacity microfarads per mile.	Relative percentage deterioration in one year in elastic limit.	Insulation resistance in megohms per mile.
1	17,000	2·0	66	534
2	19,000	1·2	30	1,185
3	18,000	1·0	20	1,150

The above figures are based on 12 tests of each class. They are quoted, not to show absolute values, but to make clear the point that the cheaper grades of insulation do not retain their elasticity. A consideration of the table shows that neither the puncture test values nor the initial insulation resistance afford accurate indications of the durability of the rubber.

In order that the tests specified for an insulating material may have any real practical value it is essential that they should be simple in character and easy to carry out. Viewed from this standpoint, any elaborate chemical analysis is out of the question, except in connection with large contracts; and we have to fall back upon the simpler chemical tests, such as the amount of acetone extract and the amount of ash, and the mechanical tests for tensile strength and elongation, the physical test as to the behaviour in dry and moist heat, and the electrical tests as to dielectric strength and insulation resistance. We have, by means of these tests, to discriminate between insulation in which a certain minimum quantity of fine Para, Ceylon or other good rubber has been employed and that into which recovered rubber and rubber substitutes and mineral matter too largely enter.

Pure fine Para rubber contains about 1½ per cent. of matter soluble in acetone, but during the process of vulcanisation this increases to from 3 to 4·5 per cent. Oxidised oils and rubber substitutes are soluble in acetone, so that the percentage of acetone extract above that due to good vulcanised rubber is a guide to the purity of the rubber.

In order to recognise the relation of the resinous extract obtained to the amount of indiarubber present, the percentage figures for these two constituents should always be calculated separately, so as to show the absolute percentage of resin contained in the indiarubber of the sample alone, and not in the whole contents of the compound.

The increase in the resinous extract only occurs in rubbers vulcanised by heat; cold vulcanised rubbers invariably show the normal percentages of resin.

Elongation Test (*Langan*).—The insulating material of every wire must stand an elongation test of stretching three times its length several times—that is, a piece 2 in. long must stretch to 6 in. and promptly return to within 20 per cent. of its original length. It must then stretch four times without break or rupture, and return to 25 per cent. of its original length.

The author has examined a number of specimens of flexibles purporting to be "new and old code wire" and has found them to be poor, hence the necessity for the addition of an elongation test to the tests specified in the national electric code.

Dry and Moist Heat Tests.—The following tests are generally referred to as "Admiralty tests," but must not be taken as officially representing the Admiralty specifications:—

The "dry-heat" test is carried out in an air bath and consists in exposing the samples for one hour to a temperature of 270°F. The "moist-heat" test is carried out in a digester at 320°F., the samples having to withstand this temperature for three hours without injury. This test is purposed to disclose the presence of rubber substitutes by their saponification. Pure rubber will not stand these tests, as it melts. The following elongation test is attributed to the Admiralty, and is certainly the best in common use at the present time: A 14 in. specimen to be clamped for 1 in. at the ends and stretched to double its length—*i.e.*, 24 in.—to remain in this state for 24 hours without breaking, and on release after a further 24 hours the permanent elongation on the 12 in. length should not exceed 15 per cent.

Existing tests show a great lack of uniformity and an undoubted want of a reliable "durability" test. The author suggests that a

* "Comments on Present Underground Cable Practice," Wallace S. Clark, *Proceedings* American Institute of Electrical Engineers, Vol. XXV., 1906, p. 207.

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comparison with a standard hysteresis loop, together with a carefully specified stretching test after heating at 150°F. for a given time in air, would give much greater certainty as to the probable durability of the material than any of the tests referred to above. The author hopes to investigate this matter further in the near future, as such a test should be applicable to the thick coatings of large cables as well as to flexibles.

XI.—Thickness of Insulation.

A specified thickness of insulation has long been regarded as a desideratum, and where a material of fairly constant composition, such as fine Para rubber, is employed, a specification of the thickness to be used may be of value.

The vulcanising rubber may be applied to the conductor in two ways. In the first method, which is most commonly adopted in this

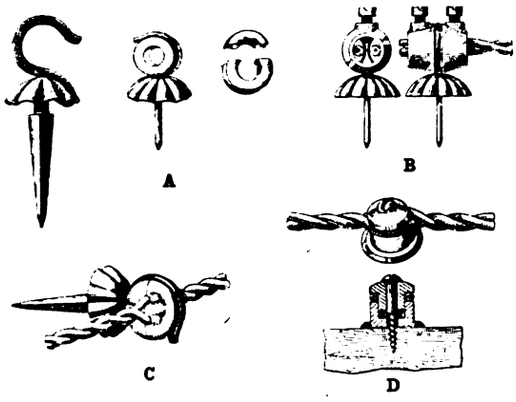

Fig. 8.

country, the conductor, after being lapped with pure rubber tape, is laid between two ribands of vulcanising rubber and passed between two grooved steel discs so placed that the grooves form a die of the required diameter. The discs are furnished with cutting edges which shear off the superfluous rubber and cause the freshly-cut edges to unite by pressing them together. After vulcanisation the joint is considered to be as strong as the remainder of the material. The author has tested these joints by removing a short length of the conductor and blowing out the tube of insulation thus formed by means of a bicycle pump and valve, and has found that in most cases the joint yields first.

The second method consists in forcing the vulcanising compound by means of a screw worm round the conductor as it passes through

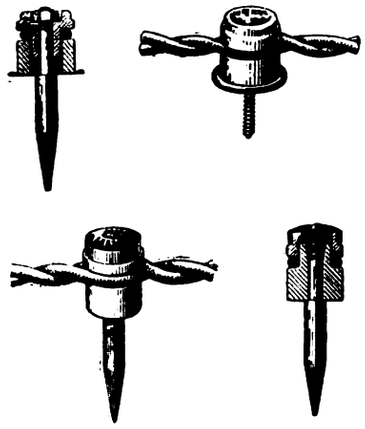

Fig. 9.

a die much in the same way as the lead covering is formed round a cable. In order that the rubber may flow freely the apparatus has to be warm, and the finished insulation must be allowed to cool and harden before coiling. The method is largely used on the Continent and in the United States, and although the joint is eliminated, which may be considered an advantage, the conductors will very frequently be found to be considerably decentred.

A cotton wind over the conductors, which is absent in the case of C.M.A. flexible, seems to be desirable, as it prevents the direct contact of the pure rubber and the conductor, which is injurious if the tinning is defective. It also prevents the insulation from sticking to the wires, which it does very tenaciously, making it difficult to get out all the wires for connecting purposes, and it further keeps these wires clean and free from rubber.

XII.—Flexible Wiring Systems.

The best known and most widely used of these systems is that of Peschel; it was introduced in Germany in 1893 as being cheaper than wood casing and having a less fire risk. Originally the so-called ring insulators were employed on this system, the conductors hanging from them in a series of loops, but they are now only occasionally used. They consist of grooved rings of porcelain or coloured glass, either in one piece or split, the latter being used in order to put in extra support to a wire which has already been run or for heavy cable. These rings are sprung into small spring hooks furnished with either pins, nails, screws or eyes, as shown at A in Fig. 8. To strain up the flexibles at intervals special clamp insulators are required. They consist of a short porcelain tube, in which the flexible is held fast by two screws forced down between two fibre strips, causing these to wedge the cord against the tube, as B in Fig. 8. Another form of grip insulator shown at C (Fig. 8) consists of a split insulator with two or three ribbed channels in which the cords are more or less tightly held when the insulator is clamped by the spring hook. The installation of the unsplit rings is inconvenient and unsatisfactory, in that the flexibles are frequently slack, and the wire is damaged when the rooms are cleaned, and, further, the supporting of the hooks by pins or nails is not very sound except when used on woodwork. A very much better job is made by employing the type of insulator shown at D in Fig. 8, where on screwing up the fixing screw, one part of the insulator telescopes into the other, gripping the cord between the edges. In the School of Technology, Manchester, a room has been wired as an example of this system, and has given no trouble during the six years it has been installed.

An improved form of insulator ("Reformrolle") has been placed on the market by Hartmann & Braun which possesses the considerable advantage that the pressure exerted on the flexible is quite independent of that required for the fixing of the insulator. The various forms are shown in Fig. 9. The clamp insulators with flexibles are very popular in Germany, one firm alone supplying many millions annually. They are also largely used in France, Italy, Belgium and Switzerland. There is a tendency now to run the wires in metal tubes, to secure additional mechanical protection, where the lowest prime cost is not an absolute essential. In Germany cotton-covered flexible costs from 2d. to 4½d. per metre and silk-covered from 4d. to 7d. The prices of the insulators vary from 6d. per 100 for white glazed porcelain to 4s. 10d. for the "Reformrolle," which are intended for well-decorated rooms. It is claimed that flexible wiring can be installed without making a mess or injuring decorations, and in Germany the cost per point exclusive of the lampholder, &c., varies from 10s. to 18s.

(To be concluded.)

A NEW TYPE OF INDUCTION MOTOR.*

BY L. J. HUNT.

The motor described in this Paper possesses all the characteristics of the ordinary type of slip-ring induction motor, but differs from it in the arrangement of the windings. These are arranged to permit of the starting or regulating resistances being connected to the stator windings instead of to slip rings in the ordinary manner. The machine is an improved form of "cascade" motor having two magnetic field systems superimposed upon one another in the same core body. The second field has its origin in the rotor, and consequently induces secondary currents in the stator windings.

The "cascade" system is well known, especially in connection with polyphase railway motors. The chief objections to a motor consisting of two stators and two rotors or one common rotor are—the high cost, low efficiency, owing to greatly increased copper losses, low power factor and small overload capacity. Patent Office records show that considerable attention has been given to the problem of producing a cascade motor which should be free from the objections enumerated above. The cascade system of control was devised independently by Steinmetz in the States and by Görges in Germany, in the year 1897. In 1901 Prof. Silvanus Thompson patented a motor which, although having only one stator and rotor, is equivalent to two cascade-connected motors. In this machine the stator is divided into several segments, alternate segments carrying primary and secondary windings. The primary windings are connected directly to the line and the secondary ones to the starting or regulating resistances. In 1902 Mr. Lydall devised a cascade motor having independent primary and secondary stator windings wound for different numbers of poles. The rotor is similarly wound and provided with six slip rings. In 1903 Steinmetz took out a patent for a machine somewhat similar to the one devised by Thompson, the primary and secondary stator windings occupying alternate

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segments of the stator. A German patent was granted in 1904 to Georges Meller for a disc type of cascade motor. In this machine the primary and secondary stationary windings are carried on separate stators in radial slots, and similar slots carrying windings are provided on both sides of the disc rotor. The machines mentioned, omitting the last, may be roughly divided into two groups, the first including motors depending upon suitable spacing of the stator windings to ensure non-interlinking of the two fields, and the second including machines provided with two stator windings wound for dissimilar numbers of poles.

The new motor, which has been developed by the Sandycroft Foundry Co. (Ltd.), belongs to the second group, the two numbers of poles being so chosen that when divided by their greatest common factor the quotient is in one case an even and in the other an odd number. This ensures non-interlinking of the two windings except by the agency of the rotor. Fig. 1 shows the general arrangement of this motor, from which it will be seen that it closely resembles in design the ordinary type of machine. The stator carries a single winding, and is provided with tappings which are connected in pairs through resistances whilst starting or when rheostatic speed control is desired, and are short-circuited at normal speed. The rotor is provided with a short-circuited winding without slip rings, unless designed to run at more than one efficient speed.

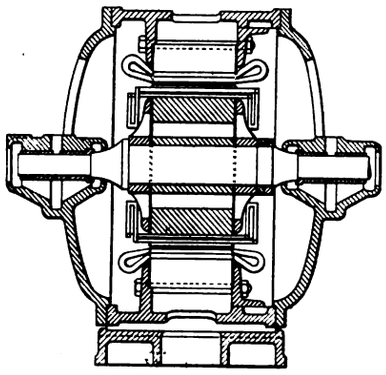

FIG. 1.

The chief difficulties to be overcome in the design of a "cascade" motor are greatly increased magnetic leakage and C^2R losses. Where two stator windings are used the inductance of the one occupying that portion of the slots farthest removed from the rotor is very large, owing to the increased leakage from tooth to tooth. In experiments, which were made on a motor wound with separate eight-pole and four-pole stator windings, the former being placed nearest to the rotor, it was found that the leakage per ampere-turn per inch length of core (after deducting the leakage of the end connections) was 7 in the case of the eight-pole winding and 11·4 in the case of the four-pole winding. The pole pitch of the four-pole winding was, of course, twice that of the eight-pole, and if the conductors had occupied the position of the eight-pole winding the leakage would have been certainly not more than 6 lines. By using one stator winding only, this difficulty was overcome, and experiments on the same motor showed that the power factor and overload capacity were much increased, although only two-thirds of the copper was used. The stator windings are parallel wound, and each pair of tappings connects two points of the winding between which there is no "primary" difference of potential. Fig. 2 shows diagrammatically a three-phase primary, six-phase secondary stator winding. The mains are coupled to the three terminals of the "star" and the starting resistances, arranged for two-phase currents, are connected to the tappings A, A′ and B, B′. The remaining tappings are connected to a four-pole switch mounted on the motor casing, and are short-circuited after the machine has reached its normal speed. The resultant stator current is equal to the geometrical sum of the primary and secondary currents, and may be anything in value between 1·07 and 1·2 times the primary current. In order to show how greatly the stator C^2R loss is reduced the author gives a table from which it is seen from the case taken that, with a single parallel-wound winding, the total stator RC^2 losses are 468 watts as against 988 watts in the case of separate primary and secondary windings.

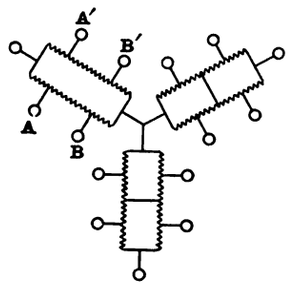

FIG. 2.

Referring now to the rotor, a large number of different methods of winding are possible. It is important to keep the rotor C^2R losses as small as possible in order to ensure a high efficiency and also to reduce the drop in voltage between the primary and secondary parts of the machine. The rotor may be provided with two separate windings, one wound for "x" number of poles and the other for "y" number of poles the two being inter-connected. In this case the currents induced in the "x" pole winding flow into the "y" pole conductors and produce the second magnetic field. It may be here stated that the objection raised to the two separate stator windings does not apply to the rotor, as the frequency of the currents is the same in both rotor windings. In fact, the local leakage lines are due to the resultants of the currents in the two sets of conductors, and by suitable arrangement the total inductance of the two windings may be made less than the sum of the inductances considered separately. Fig. 3 shows a rotor having two windings, one connected for four poles and the other for two poles. The former is "star" and the latter "mesh" connected. The four-pole ampere-turns are consequently equal to 1·73 times the two-pole ampere-turns. Only one slot per pole per phase is shown in the diagram.

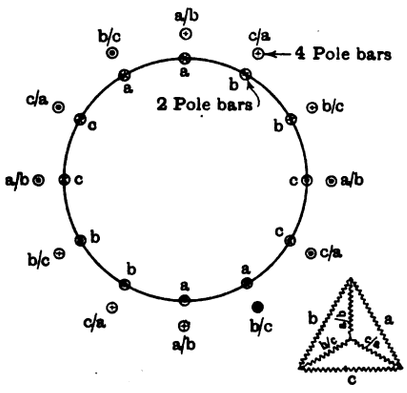

FIG. 3.

Instead of grouping the bars in two separate three-phase windings, the four-pole and two-pole conductors may be connected to form a winding, as shown in Fig. 4. This arrangement reduces the length of copper required in the end connections, and has the same effect as two separate windings. The two-pole bars are connected to form two "mesh" windings, as shown. Each four-pole bar is connected at one end to a two-pole bar, and at the other to a short-circuiting ring. There are two of these rings, one at each end of the rotor. Only the connections at one end of the rotor are shown. Those at the opposite end are duplicates of these. The outside circle represents one of the short-circuiting rings. The inner ring of small circles are the two-pole bars, the outer ring the four-pole conductors. A

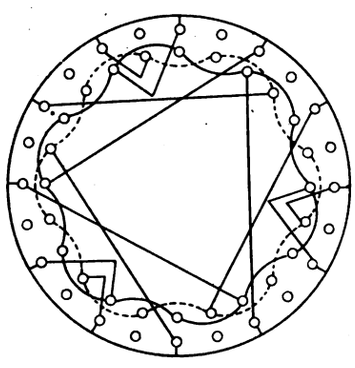

FIG. 4.

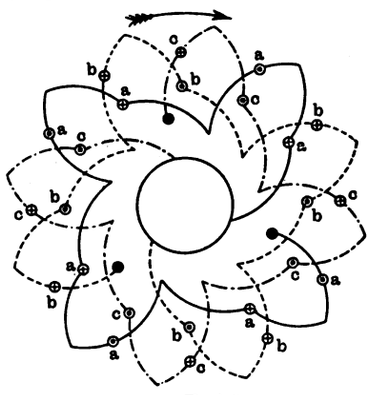

FIG. 5.

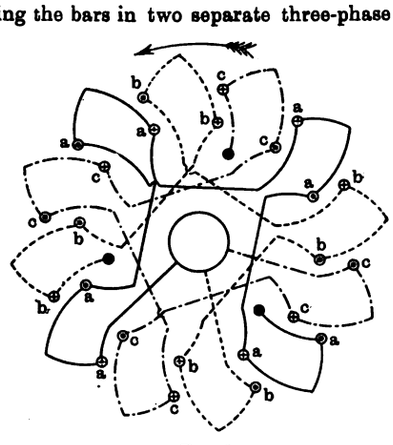

FIG. 6.

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(4+2) pole winding has been shown for simplicity, but it may be mentioned that, as the resultant magnetic field is not symmetrical, a motor having this number of poles is not satisfactory.

It has already been mentioned that the currents of the two rotor windings in any one slot may be algebraically added together and considered as one current. By a suitable arrangement of the connections, one winding may therefore be substituted for the two, and the total C^2R losses reduced to that of the "x" pole winding only. In the case of the four-pole and two-pole winding previously considered, the number of conductors and the total length of the end connections would be equal to those of the four-pole winding only. On the score of low copper loss this is a very good winding, but it has two serious faults: the slots are deep owing to the concentration of the conductors, and the inductance, for the same reason, is considerably higher than that of the windings already described. Experiments were made with a small 12-pole motor, the rotor of which was provided with double windings. After tests had been made it was re-wound with a single winding. The double winding gave a power factor of 0·78 and the single winding 0·72. These results were obtained with a double-wound stator. The eight-pole stator winding was then re-connected and provided with six phase tappings, and further tests showed a rise in power factor from 0·78 to 0·81. The efficiency was, of course, higher with the single than with the double rotor winding. One may extend the list of resultant windings indefinitely, but one further example will serve for the purpose of this Paper. Figs. 5 and 6 show eight-pole and four pole windings. The one shown in Fig. 6 is, strictly speaking, a six-phase winding, as there are six groups of conductors per pair of poles. The winding shown in Fig. 5 has only three groups of conductors per pole pair, each group being made up of currents belonging to two different phases. The resultant current in any one pair of bars of the eight-pole winding equals 1·73 times the current in one bar. By superimposing Fig. 5 on Fig. 6 the resultant winding, Fig. 7, is obtained, in which the currents are of the same phase in each slot. The winding is a simple non-overlapping one.

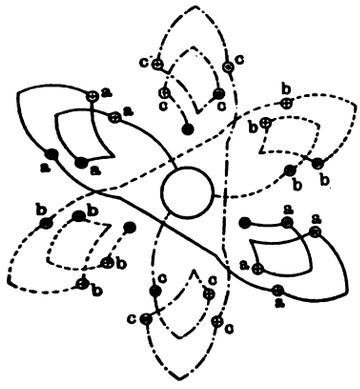

FIG. 7.

The rotor windings already described are suitable for motors having one efficient speed. Motors are being manufactured which may run at two, three or four efficient speeds, and it is clear that as these require the addition of slip rings, the number of phases for which the rotors may be wound must be limited to two or three. A 12-pole motor having a rotor carrying 8-pole and 4-pole windings may, if fitted with three slip rings, be run at speeds corresponding to 12, 8, or 4 poles without losses in resistances.

If the motor be wound for eight and four poles and the periodicity be 50 cycles per second the two efficient synchronous speeds will be 500 and 750 revs. per min. The "mesh" connected rotor windings are wound for four poles and the "star" windings for eight poles. Slip rings are connected to the three terminals shown. I regret that I am unable in this Paper to put before you detailed test figures of these new motors, but several machines are nearing completion, and results of tests will shortly be published in the technical press.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

Continuing the evidence of Mr. Gavey before the Committee on Thursday last, Mr. GWYNN asked—

Could not the Marconi stations on the Channel be increased without injuring the service?—I understand they are sufficient for the traffic they now carry, but under more exact regulations they could carry a great deal more traffic. A lot of the work at present done is idle work.

Would it be possible to exempt a station on the south coast?—Any station could be exempted.

Provided another station was opened to serve the same area?—Not necessarily in immediate proximity.

Suppose you exempt one of these stations, are you not obliged to provide a station to do the same work for the public that that station was doing?—You have to provide a station to serve the region. It is for the Government to define what the extent of the region shall be.

Would it be possible to exempt one of those stations and add another station without deranging the services in the Channel?—It would be possible. I do not, in fact, think there would be any great difficulty, if the whole of the British stations on the south coast were exempted, in providing alternative stations to do the work along the Channel. I agree it would be an unsatisfactory thing.

The CHAIRMAN: What is the cost of a station?—This varies according to range. I dare say the Marconi stations along the south coast would be provided for anything between £500 and £1,000, according to the nature of the business.

Sir W. HOLLAND: Did I understand you to say that, in your opinion, unless the Convention were ratified the present commercial use of our system of wireless telegraphy would be jeopardised?—There is the greatest danger of its being jeopardised by the Convention not being ratified. I have said that the use of powerful machinery would unquestionably interfere with the working of the commercial stations, and, I am afraid, would also tend to largely interfere with the naval stations along the south coast.

Do you go so far as to say that, in your opinion, a wireless war would be almost inevitable?—I do not see that any other course would be possible, because vessels fitted with foreign apparatus would interfere with the ordinary carrying out of the work of our stations, and this country would have no redress. One of the greatest benefits this country would derive from the Convention is that every station, whether a long-distance or an ordinary shore station, would have to conduct its business in such a way as to avoid interference as far as possible. If the Convention is not ratified, this country has absolutely no interest whatever in what other countries may do, either by ship-and-shore traffic or in the erection of high-power stations.

Sir GILBERT PARKER: What prevents interference now that the Convention is not ratified?—The circumstances do not exist at the present time to any material extent, because all the liners are fitted with the Marconi apparatus, manned by the Marconi operators, and are working under one administration. So long as that condition of things exists, there is no reason why disturbance should be anticipated. But we anticipate disturbance when each nation establishes its own wireless system, and all these vessels, fitted with different apparatus, traverse the narrow seas around our coasts.

There is no reason to suppose that the Government would accept the Marconi system as most Governments accept the Morse system in telegraphy?—I do not think the circumstances are quite parallel. The Marconi system does not differ largely from any other system. In the case of the Morse system, it is of great convenience for all countries to use the same system. In the case of the Marconi system, whether a country introduced the Marconi system, the "Telefunken" system, or any other system, it is not so much a question of the apparatus that is used, but a question of the regulations that are necessary to prevent the use of undue power, to ensure that skilled operators should be employed, and that the regulations which have been drawn up with such care shall be made perfect and flow smoothly.

Have other nations developed their own systems to any extent up to the present time?—I think they are all nearly on a par so far as perfection is concerned at the present time. It would be difficult to say that any one system is so above any other that it ought to be selected and all the others set aside. I observed in the United States there are some 43 ships skirting the coasts that are fitted with wireless apparatus, and that the Western Union Telegraph Co., the largest combination providing telegraphic service in America, undertake to transmit messages from all their stations to the wireless stations along the coast for transmission to ships. So that in that country they appear to have adopted a definite organisation for radio-telegraphic practice quite apart from instruments.

The CHAIRMAN: What is the system used in that organisation?—Mostly the Fessenden and the De Forest. They also have some "Telefunken" apparatus in America.

They intercommunicate there then?—They do.

Mr. ADKINS: Do you agree that the German liners have resisted pressure from their Government because they find it more convenient to retain Marconi apparatus?—I should say they find it more convenient to be able to communicate with British stations as they go through the English Channel. At the present time they can only do so by fitting their vessels with Marconi apparatus. I should say French steamship companies have adopted the Marconi apparatus for the same reason.

Supposing the Convention were ratified by Germany and France, for instance, and not by Great Britain, and that Great Britain continued its present arrangements, in your judgment would there or would there not still be strong practical reason for these great liners continuing to use Marconi apparatus?—I think that, whatever the German and French Governments may have done or not done in the past, if they ratify the Convention and Great Britain does not, they will bring greater pressure to bear on all the large steamship companies to adopt the systems in use in those countries.

Would there be any reasonable prospect of their resisting their own Governments' pressure?—If they had no other stations to communicate with but British stations, they would no doubt oppose any change. I think these other countries would establish their own stations. This would remove the commercial risk which might otherwise tend to prevent the steamship companies from abandoning the Marconi apparatus.

Why, in your judgment, has France not put up commercial stations hitherto, but would do it if she ratified the Convention and Great Britain did not?—I should say that France has not put up commercial stations because she thought they were not likely to pay. As a general rule, it may be taken that, at present, radio-telegraphic stations do not pay, either in this country or elsewhere.

Would they be more likely to pay if France and other countries ratified the Convention and we did not? Would it then be commercially a profitable thing for France to put up shore stations not now put up?—It would become an international obligation then to provide for ship-to-shore traffic. If the Convention is ratified, so long as traffic skirts the

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English coast stations it will have to pass through those stations rather than through stations on the French coast. I should like to add that, whatever advantages may be derived by the foreign steamship lines in the retention of Marconi apparatus, if this country fails to ratify the lines would have to abandon Marconi apparatus in order to comply with the terms of the Convention; in other words, they would have to communicate with all other international stations, and could only do that by abandoning the Marconi system.

Do you think France would be willing to ratify the Convention and put herself to unremunerative expense?—I think so, because, after all, a few shore stations is a very small addition to the coast telegraphic service in a great country like France.

If the Convention is ratified by Great Britain, all ships wishing to communicate with our shore stations can do so as usual with other than Marconi apparatus?—Yes.

It would let in competitors then?—For the supply of apparatus, yes.

The effect of the Convention on the Marconi Co., then, is one thing, and its effect on the Government of Great Britain is another question?—It remains to be seen whether the Marconi Co. would suffer by the ratification of the Convention.

Ship-to-ship communication in the narrow waters has been provided for in the Regulations, and one of these states that ship-to-ship communications must always cease when a ship-to-shore communication commences. Supposing a ship is communicating with another ship, would the Hertzian waves so used, or the communication, be received at shore stations?—Certainly.

Would this not embarrass those stations?—If working simultaneously, yes, but under the Regulations the ship-to-ship communication would have to cease until the ship-to-shore communication was finished.

Do you think the Regulations attached to the Convention will secure the organisation necessary?—I think so. They were most carefully considered by all the delegates and were drawn up with the utmost care. I have no doubt that, properly administered, they will prove effective. Each Government will have to establish some controlling body which will enforce the Regulations.

That is to say, either the Government must make a service for itself that does not now exist, or some company must come into existence which does not exist now?—That may be, but the Government will have to take supreme control in enforcing the Regulations.

The CHAIRMAN: Would you point out how the Regulations for ship-to-shore stations would prevent interference by ship-to-ship communications?—In every case the shore station controls the other traffic and regulates it. If a ship station interferes, the shore station simply tells the ship station it is interfering and requests it to stop until it has the shore permission to go on. If three or four vessels came within reach of the shore station at the same time and they all called the shore station in succession, the shore station, under the Regulations, will obtain from each ship certain particulars, and will tell each ship it will take its traffic in such and such order. The shore station has absolute control.

There is really no rerson why a ship should retire?—Yes, for this reason, that the ship will be licensed to carry wireless telegraphic apparatus, and that will necessarily compel her to obey all the Regulations of the Convention.

Mr. LEE: We heard in evidence from the Marconi Co. that France, by setting up stations on her coast, would practically be unable to interfere with the general traffic passing through the Channel, because it passes much closer to the English coast. Do you agree to that?—If the Convention is ratified France will not interfere. She must not interfere under the terms of the Convention. If Great Britain does not ratify the Convention I am afraid the endeavour to establish communications between French liners skirting our coast and French stations must interfere with the English stations, owing to the high power they would have to employ.

The CHAIRMAN: Would there be any obligation by France to avoid interference, assuming we do not ratify?—None whatever; the only obligation is under the Convention.

Mr. LEE: Assuming England has not ratified, would there not be the risk that a French ship, by using this additional amount of power, would actually interfere with countries that had ratified, say Holland?—It depends entirely on the geographical position of the ship. If you look at it from the practical commercial point of view, as vessels approach our coast they endeavour to despatch their telegrams, and it may be said that the order of importance of the wireless stations along our south coast is from westward eastward. These liners would not be using their apparatus very largely in the Straits of Dover, but they would be using them more extensively off the Fastnet and off the Lizard. Therefore, those would be the points where the largest amount of interference with British stations would take place.

You don't think it possible we should be able to make an agreement with France that would have practically the same effect as our adherence to the Covention?—I doubt it very much. There would be the practical difficulty that French vessels would have to be fitted with powerful apparatus to communicate with the French coast, and agreement or no agreement, the difficulty would arise.

If such a private agreement were arrived at, the status quo would be maintained so far as England and France are concerned?—Except that they would have to use higher power to work across the Channel.

Why should not the French vessels in that case use English stations?—There would be no intercommunication. The Marconi Co. would refuse to accept communications from the French apparatus.

If neither France nor England ratified the Convention?—I do not think there is the slightest doubt whatever that France will accept the Convention.

Would it be possible to make an arrangement between England and France, both not ratifying?—It would cut them off from every other station in the world.

Sir GILBERT PARKER: If France and Great Britain both stood out, do you think that other countries would also stand out?—I have no doubt whatever that the other nations will ratify, whatever this country does.

Mr. LEE: It is more convenient at present for other nations' ships to communicate through British stations. Is it not possible, owing to our geographical position, that even if there might be a great resentment in foreign countries at our refusing to ratify, the big commercial interests concerned would find they could not afford to boycott but would communicate through English stations?—From the very fact that they ratify the Convention they would have to license all their ships to intercommunicate, and that fact would bar them from communicating through English stations. If England declines to ratify, then England will suffer the consequences, which would be the loss of traffic.

What would be the objection to England, while not refusing to ratify the Convention, stating that she wished to reserve her decision for a period of years?—The effect would be equivalent to refusal, and the dangers that have been foreseen of interference and so on would arise. Personally, as one of the delegates, I feel very strongly on the points The English delegates went to the Convention with certain definite instructions, and they were able to induce the delegates of other nationalitie. to fall in with their views. They carried every one of those instructions, and in other minor points they modified both the Convention and the Regulations to a very great extent in matters of detail, with a view to improving this country's position, making the Regulations more stringent, and, generally speaking, making the Convention more workable. Now, if England either declines to ratify, or postpones her ratification so as to practically prevent the Convention coming into force, it will have to come as a suppliant by-and-bye, instead of being one of the nations regulating the Convention, and it may be that those clauses affecting this country may be reversed or revised, to the injury of this country. I think it would be a great mistake to either refuse or to defer ratification. The position of this country would be greatly prejudiced in all matters relating to radio-telegraphy.

Mr. GWYNN: Assuming England definitely said she would not ratify, what do you suppose would happen in the interval before another Convention could be organised?—I take it that those countries who are ratifying are already preparing for working under the Convention. If it were not for this inquiry, the British Government would be organising. Every country has to establish some organisation to control radio-telegraphy.

Mr. LAMBERT: Was every one of the objections of the British delegates to the Convention met by the Conference?—Absolutely so.

In your opinion Great Britain must ultimately join the Convention and will be prejudiced were she not to ratify at present?—Unquestionably.

It has been suggested that the Post Office delegates were too strong for the Admiralty delegates. Was that so?—No; the Admiralty delegates were able men, very unlikely to be unduly persuaded by their colleagues

Were the delegates unanimous or not?—We were absolutely unanimous from beginning to end. We went out with definite instructions from the Government, and there was no note of divergence.

Now, Mr. Gavey, you are an expert in wireless telegraphy. May I ask you, as you have left the Post Office, whether you see anything in this Convention to which you, as a patriotic Briton, would object?—I think that the national interests are not only fully protected by the Convention but they are more fully protected with the Convention than they would be without it.

The POSTMASTER-GENERAL: If we stand out and the Marconi Co. refused intercommunication, those Powers who ratify would be compelled to remove the Marconi apparatus from their ships?—I believe they would.

A strong point was made by Mr. Cuthbert Hall for the Marconi Co. on the ground of their stations carrying out a considerable amount of commercial work and that other stations are not carrying on much work. Can you give us any information as to that? Also that they have organised a wireless system and other commercial stations have not?—In view of the fact that there are 63 Marconi stations against 123 other stations all over the world, these 123 stations must have been established for commercial work. There must be some organisation in each country for the collection and despatch of telegrams.

As regards the Marconi stations, do you know whether the amount of work done is large?—The work done, is not very much, I think. From January to December, 1905, the total messages at all the Marconi stations in Great Britain amounted to the following: Messages to ships 541, messages from ships 10,297; from January to December, 1906, there were 1,026 messages to ships and 14,984 messages from ships.

Is there much traffic at some of our stations?—In 1905 the number of messages per month at the North Foreland, for instance, was: To ships 1, from ships 25; in 1906 the number per month was: To ships 3, from ships 45.

This concluded Mr. Gavey's evidence.

Capt. E. F. INGLEFIELD said he was secretary to the Corporation of Lloyds, and prior to taking up that position on Oct. 1, 1906, he had been in command of a large armoured cruiser which was equipped with wireless telegraph apparatus. After describing generally the business conducted by Lloyds, witness said they had watched the development of the Marconi system and had also tried experiments with other systems. They entered into an agreement with the Marconi Co. in September, 1901, but in 1905 its provisions were varied by terms of settlement arranged with the company in 1905, but which he was not at liberty to disclose without the consent of the company. Litigation had taken place between Lloyds and the company, but he did not think the points at issue had any direct bearing on the questions before the Committee. With regard to their agreement with the Marconi Co., referred to by other witnesses, and in which it was stated that Lloyds were of opinion that one system should be in general use, at the time the agreement was made

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Marconi's was the principal system before the public, and had advanced further than any other system, at any rate in the United Kingdom. It then appeared desirable, in order to avoid complications, to adopt one system. The statements in the preamble of the agreement appeared to have been made on the assumption, which perhaps even then was erroneous, that it would not be possible to effect intercommunication. Lloyds could use other systems in certain countries to which the agreement did not extend. They had religiously adhered to their agreement, and had not used other systems than Marconi's, nor allowed messages from ships equipped on other systems to be received at their stations. He considered it would be detrimental to the public interest if intercommunication were prohibited so that vessels equipped with other systems were debarred from communicating with Marconi-equipped stations. As an instance of danger to the public interest and jeopardy to human life caused by vessels equipped with other systems being debarred from communication with Marconi stations, he mentioned the case of a United States ship which was sent to destroy a derelict in the Atlantic. The ship found the derelict and got into wireless communication with a passing liner which, however, said she could not talk with them as she was under a Marconi contract.

The CHAIRMAN: Suppose the Convention be not ratified, would that act prejudicially to the collection of maritime intelligence?—Under No. 39 of the Regulations arrangements are to be facilitated for communicating to maritime agencies news respecting wrecks or matters of general interest regarding navigation, and we have made arrangements with foreign Governments for information from foreign stations to be forwarded to us. If Great Britain declines to ratify the Convention it is clear that, by way of retaliation, foreign Governments will decline to supply Lloyds with maritime intelligence from their wireless stations and possibly also from semaphore stations.

Mr. Cuthbert Hall, in alluding to the difficulties with Lloyds, made some remarks with regard to Lloyds' relations with the Admiralty. Can you say anything in regard to that matter?—The difficulties with the Marconi Co. are still complex and still sub judice, and perhaps it would be better not to refer to them. I may say, however, that when we took over the working of certain stations from the company they left nothing for our use or guidance, and when they made complaints about the working of our men they would not state specific facts, but merely made general statements that our operators were unsatisfactory. The fact was that the company were anxious to discredit Lloyds staff, in order to get the working into their own hands, which they eventually did.

The POSTMASTER-GENERAL: You would not enter now into a similar contract to that existing between yourselves and the company?—Certainly not.

Assuming the Convention is signed, you expect to obtain relief from your agreement?—Yes, but that was not proposed at the instigation of Lloyds.

Mr. LAMBERT: Do you think it would be advantageous to the interests of Great Britain as a whole that the Convention should be ratified?—I think so.

Mr. GWYNN: If you do not make a contract with the Marconi Co. after the Convention comes into force, with whom would you make a contract?—I do not think we should make a contract at all. It would depend on the circumstances.

Could not the business of Lloyds be internationally managed?—No, that does not appear to me practicable any more than the management of any Corporation internationally.

Your system is a real monopoly. Is not that monopoly due to the advantage of having a system of central control?—It is certainly necessary to have central control of Lloyds stations, but there the analogy with wireless telegraph stations ceases. With visual signalling there is no clashing, and international management is not necessary.

If wireless telegraphy could be managed by a company or central control that would be the ideal system?—Certainly. My view is that some controlling organisation is necessary, whether there is intercommunication or not.

I believe it is generally admitted that the Marconi people can do their business satisfactorily, and that the inevitable interference does not hamper them materially?—They owe their present position to having worked the thing on business lines.

Where there is a dual control of the operators I believe it would not work so satisfactorily as if the operators were under one control?—I am sure it might be managed with dual control if it were done in a friendly spirit. I agree, however, that having one operator belonging to a company and the other to a Government might lead to disagreement and conflict between the operators.

It is possible there might be friction between two Governments or two companies?—Yes, that is so.

This concluded Capt. Ingefield's examination, and the Committee adjourned.

Sir OLIVER J. LODGE, F.R.S., Principal of Birmingham University, was the first witness called on Tuesday. He said he had paid great attention to the subject of radio-telegraphy, not only before 1896, but before 1890. He had worked at the subject since the seventies, on the strength of Clerk Maxwell's theory. He wanted to be the first to produce electric waves in accordance with that theory, and in 1887 or 1888 he nearly did so. He detected the waves running along wires, and published the idea of getting them across space by the discharge of what was virtually a Leyden jar, but in 1888 Hertz quite independently transmitted them across space, and they were properly known by his name—Hertzian waves. Witness continued to work at them, however, and published Papers on the subject in 1888, 1889, 1890 and 1892. He devised several means of detecting the waves, one of them a point coherer, which he afterwards replaced by a Branly filings tube. Since then he had returned to something more like his original form of coherer. He had nearly every kind of Hertz oscillator working at Liverpool, from small to big ones, which emitted waves 100 yds. long and caused sparks on the roofs of neighbouring buildings, as well as in water pipes and gas pipes. Some of these sparks were seen publicly at the Royal Institution and also at the hall of the Institution of Electrical Engineers. They occurred high up on the wall paper. He used earthed as well as insulated collectors. This effect was published in a book of his in 1892. In 1894, with the help of the Branly filings tube, the matter became much more definite and easy. In 1894 witness gave a couple of demonstrations—one in June at the Royal Institution, and one in August at the Oxford meeting of the British Association—using Hertz oscillators for transmitting and a Morse key, in connection with a sending coil, and a Thomson marine or speaking galvanometer for receiving. He sent the signals from one room to another, through walls, and so on. He sent them across the quadrangle of the College at Liverpool, but he applied very small power, and did not try for big distances. At that time Dr. Muirhead was struck with the applicability of the method to wireless telegraphy, and when in 1896 Sir William Preece told the British Association meeting that an Italian gentleman, at that time unknown, was interesting the Post Office in a secret box, witness knew practically what the box must contain, and immediately afterwards, on the same day, he showed to a few friends the Morse tape instrument, very roughly, working on the same plan. Mr. Marconi and Sir Wm. Preece together interested the whole world in the subject; great power was applied to the sender, and the matter then became of financial importance. He would say, however, that the American Patent Office gave him later a telegraphic patent based on his work as published in 1894, after proof that his book had reached America in or before 1895. His first English patent was taken out in 1897. He was not the first English patentee on the subject, but he regarded that as the first tuned patent. He there stated clearly and patented the fundamental method on which all tuning must be based, utilising for the purpose the ideas contained in his sympathetic Leyden jar resonance experiments. The Muirhead Company had taken out a great many patents, beginning with that of 1897. He had not a list of them, but they could be put in. In explanation of the principle of tuning he would only say the difference between a tuned station and an untuned station was that in an untuned station you tried to concentrate all the energy in a single snap, like a whip-crack, by which means you could go great distances without discrimination or selection, but for tuning you tried to produce a continuous succession of impulses each too weak to achieve anything by itself—that was essential—too weak to achieve anything at a reasonable distance by itself, but a tuned accumulation of impulses would give the signal. It was analagous to stretching a string on a sound board and plucking or bowing it instead of using it as a tail of a whip. You got much less noise, much less disturbance, but its definite pitch or frequency could make a similarly-tuned string at a distance respond, and if the other string was not properly tuned there would be no response. To justify the tuning in the case of the string you either slackened its tension or loaded it by coiling wire round it, and you could thus add capacity and adjust to any time required. If stations were properly tuned they were able to speak to each other without fear of disturbance from neighbouring stations, under certain conditions, but if the neighbouring stations was exceedingly neighbouring—in the same place—he took it there would be disturbance.

The CHAIRMAN: However well tuned?—However well tuned, and if they were exceedingly close together, but you would not then call them two stations. If you have two stations at a moderate distance, one of them is able to speak to a station at a much further distance without being disturbed by the near station.

How many miles do you describe as a moderate distance?—My experience leads me to say that a station at a distance of 10 miles can have its disturbance completely cut out, and can, nevertheless, speak to a station 60 miles off across land. Across sea you can speak further.

Without disturbing the station 10 miles off?—Yes, and without being disturbed by it if it has properly tuned appliances.

Mr. LAMBERT: Would that ratio be the same supposing you multiplied the distance by 10?—I have no experience of very long distances, nothing more than 200 or 300 miles, but I think they could communicate. I might perhaps say more than that; I have been rather cautious in my statements.

The CHAIRMAN: The Committee are anxious to know to what extent a station in comparatively close proximity might be disturbed or be responsible for disturbance. We have had different distances given by different witnesses, some have given 50 miles and some more?—It is a question of tuning, and I do not think anybody has had quite such perfect tuning as we have now. I am not sure about that, but we have very perfect tuning and are able to work on a certain note and make our apparatus so sensitive that it will not "hear" any other station although the other station may be making a great disturbance, say for experimental purposes. I will give an instance: Working at Hythe we were receiving from 60 miles distant—from Elmers End, Kent. The station at Dover was "shouting," so to speak, for all it was worth. That was only 9 or 10 miles from Hythe, and we found that if we wanted to hear Dover we could hear it, but we could also arrange so as not to hear it—so as, in fact, to "tune it out."

Sir EDWARD SASSOON: By your own system?—We were working with our own apparatus. Elmers End was sending to Hythe, and Dover was also sending to Hythe. We could hear both messages if we wished. We could hear the tuned messages from Elmers End without having any disturbance whatever from Dover, and not by the operators picking out the notes, though that could also be done.

Mr. GWYNN: If both were on the same tenour?—Yes, I am told so; but I do not mean that, I mean recording it on the tape. There is not a great difference between one system and another except, perhaps, in the tuning arrangements.

(PARLIAMENTARY INTELLIGENCE *continued on page 67.*)

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WIRING WITH "FLEXIBLE."

In the early days of an electrical undertaking the small consumer is of comparatively little importance; there is more profitable ground to be worked upon, and, therefore, he may be more or less neglected. But as time goes on, and the more important consumers have been connected up, the curve of connections may tend to bend over to some extent, indicating a kind of saturation, and the small consumer then becomes of much greater importance if the rate of increasing connections is to be maintained. There is, however, a well-known difficulty; namely, that the cost of wiring is regarded by the prospective consumer of small means as an almost insuperable difficulty. This has been remedied to some extent by systems of free wiring, but the results thus obtained have not been altogether satisfactory, and, when all is said and done, the consumer

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who takes advantage of such a system has to pay for his current at a higher rate, and thus finds his quarterly bill larger than he would like to see it.

One of the most noticeable features of electricity supply on the Continent is the number of very small towns which are successfully lighted, and the number of very small consumers that take advantage of the supply. As far as the small consumer is concerned this is accounted for very largely by the use of "flexible" for wiring. Flexible is used throughout, carried on the surface, in the way described by Prof. SCHWARTZ in his Paper read last week before the Institution of Electrical Engineers. The cost of such wiring is necessarily very low. Prof. SCHWARTZ mentions that the cost in Germany is 10s. to 18s. per point, excluding fittings. This, however, we think, must be a mistake, for we understand that in other parts of the Continent such wiring is carried out at a cost of 8s. to 10s. per point as a regular thing. Since labour is more expensive in this country, corresponding prices here would probably be 10s. to 12s. per point. Compared with the price of about 20s. per point to which we are accustomed for ordinary wiring, carried out by responsible contractors with the best materials, we see that there is a saving of, say, 8s. or 10s. in favour of the flexible system. It should also be borne in mind that not only is such wiring suitable for wiring premises of small consumers, but also those of consumers who are by no means in that class, simply because surface work carried out by means of flexible is unobtrusive. Moreover, cutting away and making good is a much less serious matter, and there is the further advantage that the quality of the workmanship can be seen at a glance because nothing is covered up.

As a rule flexible is not run throughout, ordinary low-grade cable, carried on porcelain cleats, being used in those parts of the house where appearance is not important, and flexible being reserved for the rooms. In order to avoid the numerous leads that would be rendered necessary by running circuits back to a distribution board, the flexible is run from the heavier cables with branch fuses.

There are, of course, several objections which have been urged against the use of flexible in this way. One is that the flexible is so exposed that it can be easily damaged. That, however, is equally the case on the Continent, and we do not suppose that the inhabitants of this country are really much more destructive than those in other civilised countries. Most of the flexible is naturally out of reach, and if necessary the runs to the switches could easily be protected by means of light metal shields fixed to the wall. Another point against the use of the system in this country is that our climatic conditions are not very good.

A more serious objection is that although the system has been found satisfactory for low pressures, such as 100 volts, it has not been found equally so for the higher pressures which are now so usual. This, of course, is quite possible if ordinary flexible is used, though we know of towns where it is quite satisfactory at the higher pressures. But even if the system has proved unsatisfactory in certain cases, we do not think that this is a sufficient reason for entirely discarding a system which has such very marked financial advantages. Our tendency in recent years has been to make everything more and more solid and more costly, though we are often apt to pass over weak spots in a system because the greater part of it is robust. If the flexible which is at present on the market is unsuitable (which we doubt) for a general system of wiring at 200 volts, then we think that cable-makers should be induced to turn out a stronger type of flexible which would meet the requirements. Flexible at present used for pendants is necessarily slight on account of the use to which it is put, but there is no reason why flexible used for general wiring should not be a good deal more bulky, and therefore much stronger from the electrical point of view than that which is now in general use.

THE WIRING RULES OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

In our last issue we commented critically upon the revised edition of the Wiring Rules which has just been issued. In what follows we give the chief differences between the old and the new rules.

The Rules now apply only up to pressures of 250 volts, higher pressures being provided for by the Board of Trade Regulations, which are now appended. There is considerable rearrangement and enlargement under the various headings. The definitions are now placed first instead of last, and new definitions are included as follows :—

12. *Grade of Insulation.*—A cable is said to be of I.E.E. 600 or 2,500 megohm grade when its minimum insulation is that shown in columns 5 and 6 respectively of the Table when tested at 60°F (15·6°C.) after one minute's electrification and 24 hours' immersion in water.

13. *Ventilated Motors.*—A ventilated motor is one in which, while ventilation is provided for, access to the armature, field coils, and other live parts is only to be obtained by opening a door in, or removing a part of, the enclosing case.

14. *Totally Enclosed Motors.*—A totally enclosed motor is one in which all the live parts, whether insulated or not, are totally enclosed, as in paragraph 13, but without provision for internal ventilation.

Under "General Arrangements," the chief alterations occur in the following clauses :—

21. The sub-circuits for small heaters must not carry more than 15 amperes up to 125 volts, or more than 10 amperes from 125 to 250 volts, and they must be protected by a fuse on each pole. Heaters and apparatus exceeding the 10-ampere limit must comply with paragraph 91 (*e*) (1) and (2).

24. Where metallic sheathing or tubing is used it must be electrically and mechanically continuous and connected to earth. The conductor (earth-wire) used for the purpose of earthing must be of copper and of a sectional area not less than that of No. 14 S.W.G.

29. In places where inflammable or explosive dust, gases or vapours are liable to be present, dynamos, arc lamps, Nernst lamps, and connectors must not be used. In such situations, incandescent lamps must, with their holders, be enclosed in air-tight fittings of thick glass ; switches, fuses and resistances must be enclosed in gas-tight boxes or break under oil ; and motors, with their live parts, starters, terminals and connections, must be completely enclosed (par. 91 (*d*)) in flame-tight enclosures made of uninflammable material.

CONDUCTORS.

Under this heading a note is put to the effect that "It must be assumed that at least 60 watts may be consumed at any point." Copper conductors are to have a conductivity not less than the E.S.C. standard, instead of Matthiessen's standard as formerly. The temperature of the insulation of paper or fibre insulated cables must not exceed 176°F. (80°C.) instead of 170°F.

The insulation test is now modified by the omission of the bending, and an increase in the duration of the pressure test, the paragraph now reading as follows :—

39. The dielectric must be such that when the insulated conductor has been immersed in water for 24 hours it will, while still immersed, withstand 2,000 volts for half an hour between the conductors or between the conductor and the water, the test pressure being applied with alternating current at a frequency of 50, the E.M.F. curve being as nearly as possible a sine-wave.

CONDUCTORS—FLEXIBLE.

The rules for flexibles have been added to, and are now put under a separate heading. In view of the interest which has been aroused by Prof. Schwartz's Institution Paper, we give

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the new section in full, and also the following paragraphs specifying the systems on which conductors may be fixed.

44. Flexibles must be of a sectional area not less than that equivalent to No. 22 S.W.G.,* and they must be made up of wires twisted together on a short lay, the sectional area of each wire being not greater than that of No. 36 S.W.G. The insulating material used as the dielectric must be pure rubber equal to washed Para rubber of the best quality or vulcanised rubber of the best quality. Pure rubber insulation is best suited for flexibles intended for use with pendants. Pure rubber must be laid on in two layers, care being taken that each layer overlaps, and the radial thickness of the dielectric must not be less than 26 mils. Each coil of pure rubber flexible must be tested for 15 minutes with a pressure of 1,500 volts alternating between the conductors at a frequency of 50. Vulcanised rubber flexible must be insulated with one layer of pure rubber and two layers of vulcanised rubber, and the radial thickness of the dielectric must not be less than 34 mils. Each coil of vulcanised rubber flexible must be tested for 15 minutes with a pressure of 1,500 volts alternating at a frequency of 50, after 24 hours' immersion in water and while still immersed. When sulphur is present, the insulating material must not be in direct contact with the copper wires.

45. Flexibles may be used only for attaching to pendant or portable appliances, or for sub-circuits under the conditions of paragraph 46 (*c*). They must not be used in any position out of sight, except where passing directly through walls, when they must be protected by incombustible water-tight conduits. They must not pass through floors. The connection between flexibles and hard wires may only be effected by means of screw-down terminals in junction boxes or ceiling roses, and where flexibles from fittings must pass into a ceiling they must be enclosed in conduits up to a metal junction box.

Conductors—Fixing and Supporting.

46. Conductors (excepting flexibles) insulated as in Classes A and B (par. 37):—

(*a*) May be enclosed in steel conduits with details and accessories complying with the British Standard Specification for "Steel Conduits for Electrical Wiring" or in brass or copper conduits; but all conduit systems must be electrically and mechanically continuous throughout, have all outlets bushed to prevent abrasion, and be connected to earth (pars. 25 and 26). In dry places isolated single lengths of tubing need not be earthed if adequately enamelled, or otherwise insulated, externally. In damp places the conduit system must be watertight. Conduits must be efficiently drained if liable to internal condensation. Sharp bends or elbows are prohibited, but inspection elbows are permissible.

(*b*) May be enclosed in wood casing in dry places where not buried in plaster or cement nor exposed to moisture. Unless efficiently protected from drip, wood casing must not be fixed immediately below, and in no case must touch, water pipes. Conductors carrying more than five amperes must be laid singly in separate grooves.

(*c*) May be without mechanical protection (*i.e.*, without conduit, armouring, &c.) where not exposed to injury, but they must be supported in such a manner as to secure the permanent spacing of the conductors from walls, ceilings, and all structural metal work and metal piping. When carrying more than five amperes they must also be spaced from each other, unless they are of the multiple core or concentric types. Such spacing is not, however, necessary if the conductors are lead covered (par. 25).

47. Unenclosed lead-covered conductors must be supported on a continuous wood fillet, or fastened by broad clips, which, in damp places, must be of lead.

Conductors—Bare.

The use of bare conductors is now allowed under special circumstances as follows:—

52. Bare conductors without any insulating covering may be used indoors—

(*a*) As collector wires for travelling cranes and similar appliances, but they must be so supported upon insulators as to prevent contact between the conductors themselves or between the conductors and the walls or the structural or other metal work, should a collector wire be displaced from any insulator. The insulation at each straining point (*i.e.*, at the end of each wire) must consist of two strain insulators placed in series. The current must be under complete control by means of a switch and a fuse, or a switch-fuse, in each supply conductor. Lightning arresters must be fitted if the bare wiring extends to an exposed position in the open.

(*b*) As trolley wires for locomotives, jib cranes and similar appliances, but they must be insulated by means of two strain insulators placed in series between each wire and "earth" at their points of support. Wall rosettes or brackets used as supports for span wires should not be fixed within 1 ft. of any gas pipe. Controlling switches and fuses, or switch-fuses, and lightning arresters must be provided as under (*a*).

(*c*) As battery connections, but such conductors must be well spaced from each other and from all structural or other metal work and be rigidly supported on insulators.

(*d*) For other purposes, under special circumstances and in positions inacessible to unauthorised persons, but permission for such use should be previously obtained from the fire offices insuring the risk.

Under the heading "Switch and Distribution Boards," the most important addition is that combination switch and fuse boxes must be arranged so that a switch may be operated without uncovering the fuses, if of the open type.

* The following have a sectional area equivalent to No. 22 S.W.G.: 34/50, 22/38, 14/36.

The new regulations for switches specify that for currents over 5 amperes, at pressures over 125 volts, metal covers must be lined with insulating material. The regulation forbidding the use of a fuse under a switch casing seems to have been omitted from the new rules.

The regulations for fuses have chiefly been altered by the substitution of an overload carrying capacity of 200 per cent. instead of 100. "Branch fuses must be grouped together in accessible positions in sight, and should be symmetrically placed and labelled for each circuit.

An additional regulation for ceiling roses is "that they must not be used for attachment to more than two pairs of flexibles, unless specially designed for multiple pendants." Lampholders must not now contain a switch if for pressures above 250 volts. Celluloid or other inflammable material must not now be used for the candle tubes of incandescent lamps, and combustible shades must be kept clear of lampholders. The rule for guarding arc lamps by globes arranged to intercept falling particles of carbon has been modified to suit present day requirements by the following note:—

Lanterns or globes may be dispensed with where an open arc is essential, as in photography, and where no combustible material is present, as in a foundry; but the flooring immediately under the lamp, if of a combustible nature, must be protected from falling particles of carbon. Open inverted arc lamps, in the presence of combustible matter, must have metal reflectors rigidly attached beneath the arc, which at all times must be below the level of the upper edge of the reflector. The reflector must project at least 15 in. measured horizontally beyond the arc on all sides.

Resistances, Choking Coils and Alternating-current Transformers.

Transformers are not now given a paragraph to themselves, but are included with resistances and choking coils. In this clause no maximum temperature is now specified for resistances, but the temperature of the cases must not exceed 176°F.

90. The live parts (par. 29) of the above [transformers] must be—

(*a*) Carried on frames or supports and enclosed in cases. These frames, supports and cases must be of incombustible material efficiently insulated from the conductors.

(*b*) Amply ventilated. Where there is danger of inflammable dust or flyings entering, apertures in the cases must be protected by fine-mesh wire gauze or by finely-perforated sheet metal.

(*c*) So proportioned that their cases cannot attain a temperature exceeding 176°F. (80°C.)

(*d*) So fixed that no unprotected combustible material is within 6 in. of the frames or cases containing them, or within 24 in. measured vertically above them.

Dynamos and Motors.

In the revised rules "Dynamos" and "Motors" are now separated, so that the rules more particularly applicable to each are more clearly shown. There is practically no change in these rules, but an addition to them is as follows:—

(*h*) Every alternating-current motor must be provided with a suitable starting device and with a no-volt release. Large motors should have linked circuit-breakers on the conductors.

Testing.

In the section on testing, an additional regulation is that the insulation of any individual sub-circuit must not fall below 1 megohm. Also motors, heaters, arc lamps, &c, must have an insulation resistance to the frames or cases of at least 1 megohm each, instead of 500,000 ohms as formerly.

Particulars of Conductors.

In the table giving particulars of sizes and insulation of cables the minimum insulation resistance is now given for pressures up to 250 volts, and also pressures up to 650 volts. The columns giving carrying capacities, &c., for conductors exposed to high external temperatures are omitted, but the table is increased in length by the addition of a number of additional sizes of cables. A table giving details of flexibles is also for the first time included, and this we reprint in full.

The following paragraph is inserted at the end of the rules, giving particulars of the standard on which the table is based:—

113. The data for the resistances and weights of copper conductors are based on the E.S.C. standard as defined by the Engineering Standards Committee as follows:—

A wire 1 metre long, weighing 1 gramme and having a resistance of 0·1539 standard ohms at 60°F. (15·6°C.) is taken as the Engineering Standards Committee (E.S.C.) standard for hard-drawn high-conductivity commercial copper.

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Table.—*Showing Maximum Currents, Thickness of Dielectic, and Insulation Resistance for Insulated Copper Conductors.*

Number of wires and gauge in S.W.G.	Maximum amperes permissible.	Approximate amperes per square inch.	Approx'te total length in circuit (lead & ret.) for 1 volt. drop at max amperes.	Minimum insulation resistance. Vulcanised rubber. Up to 250 volts.	Conductor resistance in B.o.T. ohms per 1,000 yards.	Minimum radial thickness. Up to 250 volts.		Weight of copper conductors per 1,000 yards.	Nominal sectional area of conductors.	Number of wires and gauge in S.W.G.
						Pure rubber.	Vulcan'd rubber.			
	Amperes.	Amperes.	Yards.	Megohms per mile	Ohms.	Mils.	Mils.	lbs.	Sq. inches.	
34/40 = 1/22	1·7	2,750	15	1,200	39·04	20	34	7·12	0·00062	34/40 = 1/22
36/38 } 23/36 } = 1/20	2·6	2,550	16	1,200	23·62	20	34	11·77	0·00102	36/38 } 23/36 } = 1/20
70/40 = 1/19	3·2	2,550	16	1,200	19·13	20	34	14·53	0·00126	70/40 = 1/19
64/38 } 40/36 } = 1/18	4·2	2,300	18	1,200	13·29	20	35	20·92	0·00181	64/38 } 40/36 } = 1/18
136/40 = 1/17	5·4	2,200	19	1,200	9·761	20	35	28·48	0·00246	136/40 = 1/17
114/38 } 70/36 } = 1/16	6·8	2,100	20	1,200	7·473	20	36	37·20	0·00322	114/38 } 70/36 } = 1/16
225/40 } 90/36 } = 1/15	8·2	2,000	21	800	5·905	20	37	47·08	0·00407	225/40 } 90/36 } = 1/15
178/38 } 110/36 } = 1/14	9·8	1,980	21	800	4·783	20	38	55·12	0·00503	178/38 } 110/36 } = 1/14

Hard-drawn copper is defined as that which will not elongate more than 1 per cent. without fracture.

A wire 1 metre long, weighing 1 gramme and having a resistance of 0·1508 standard ohms at 60°F. (15·6°C.) is taken as the Engineering Standards Committee (E.S.C.) standard for annealed high-conductivity commercial copper.

Copper is taken as weighing 555 lb. per cubic foot (8·89 grammes per cubic centimetre) at 60°F. (15·6°C.) which gives a specific gravity of 8·90.

An average temperature coefficient of 0·00238 per degree F. (0·00428 per degree C.) is adopted.

A variation of 2 per cent. from the adopted standard of resistance is allowed in all conductors.

A variation of 2 per cent. from the adopted standard of weight is allowed in all conductors.

An allowance of 1 per cent. increased resistance, as calculated from the diameter, is allowed on all tinned copper conductors between diameters 0·104 and 0·028 (Nos. 12 and 22 S.W.G.) inclusive.

For the purpose of calculation of tables, a lay, involving an increase of 2 per cent. in each wire, except the centre wire, for the total length of the cable is taken as the standard.

The legal standard wire gauge, as fixed by order in Council dated August 23, 1883, is adopted as the standard for all wires.

The rules are followed by the Board of Trade Regulations relating to pressures between 250 volts and 650 volts and by the Home Office rules for the installation and use of electricity in mines. The latter are given in full in the Electrical Trades' Directory. The former are as follows :—

MOTORS.

1. The frame of every electric motor shall be efficiently connected with earth.

2. The consumer's wires forming the connections to motors, or otherwise in connection with the supply, shall be, as far as practicable, completely enclosed in strong metal casing efficiently connected with earth, or they shall be fixed in such a manner that there shall be no danger of any shock.

3. The supply to every motor shall be controlled by means of an efficient cut-off switch, placed in such a position as to be easily handled by the person in charge of the motor, and connected so that by its means all pressure can be cut off from the motor itself, and from any regulating switch, resistance or other device in connection therewith.

4. Switches, efficient fuses or other automatic circuit-breakers shall be provided, so as to protect the circuits from excess of current, and all switches and cut-outs shall be so enclosed and protected that there shall be no danger of any shock being obtained in the ordinary handling thereof, or of any fire being caused by their normal or abnormal action.

5. A notice shall be fixed in a conspicuous position at every motor and switchboard in connection with the supply forbidding unauthorised persons to touch the motors or apparatus.

ARC LAMPS IN SERIES.

1. The consumer's wires forming the connections to the arc lamps, or otherwise in connection with the supply, shall be, as far as practicable, completely enclosed in strong metal casing efficiently connected with earth, or they shall be fixed in such a manner that there shall be no danger of any shock.

2. The supply to every arc lamp shall be controlled by means of an efficient cut-off switch, placed in such a position as to be easily handled by the person in charge of the arc lighting, and connected so that by its means all pressure can be cut off from the arc lamp itself, and from any regulating switch, resistance or other device in connection therewith. Provided that where the arc lamps are connected in series across the outer conductors of a three-wire system, it shall be sufficient if one such switch be provided for each series of arc lamps.

3. Switches, efficient fuses or other automatic cut-outs shall be provided, so as to protect the circuits from excess of current, and all switches and cut-outs shall be so enclosed and protected that there shall be no danger of any shock being obtained in the ordinary handling thereof, or of any fire being caused by their normal or abnormal action.

INCANDESCENT LAMPS IN SERIES.

1. The consumer's wires forming the connections to the incandescent lamps, or otherwise in connection with the supply, shall be completely enclosed in strong metal casing, and this casing together with the switches and lamp holders, if metallic, shall be efficiently connected with earth.

2. Switches, efficient fuses or other automatic cut-outs shall be provided, so as to protect the circuits from excess of current, and all switches and cut-outs shall be so enclosed and protected that there shall be no danger of any shock being obtained in the ordinary handling thereof, or of any fire being caused by their normal or abnormal action.

A NEW GALVANOMETER.*

BY J. K. A. W. SALOMONSON.

A short time ago Einthoven described a new and extremely sensitive galvanometer, in which a thin silvered quartz fibre was stretched across a magnetic field, and the bending of the thread when carrying a current was observed with a microscope.

Prof. T. Place constructed experimentally a galvanometer whose magnetic field was not produced by a magnet or an electromagnet, but by two parallel current-bearing wires. The thin wire was also deflected in consequence of the electrodynamic attraction and repulsion exerted by the parallel wires.

Since the principle appeared to me highly interesting, I have got an instrument of this kind constructed with great care.

On a base-plate, provided with levelling screws, is mounted a column carrying a horizontal microscope. The column is capable of lateral displacement by a micrometer.

A strong frame is also mounted on the base plate, and a vertical carrier for the string is introduced from the back of it, and this carrier is capable of micrometric adjustment forward and backward. At each side of the frame is an adjustable slide, each slide bearing a vertical ebonite rod capable of micrometric adjustment about an axis parallel to the microscope. Each ebonite rod bears a binding screw at each end, and between these binding screws a copper wire is stretched quite straight, without touching the ebonite. Hence these wires can be placed accurately parallel to the string and at any distance from it, and the string can be placed accurately midway between the wires.

Another micrometer serves for adjusting the tension of the string.

The ebonite rods each carry a light ebonite plate, with a central opening closed with a microscope cover-glass to keep air currents away from the string.

The galvanometer may be used in the following ways:—

1. *As a Galvanometer.*—The two upper binding screws of the two field wires are connected by means of a stranded copper wire. A current of 1 to 20 amperes is sent through the lower binding screws. If, now, a feeble current flows through the string, the latter is bent aside, and the deflection can either be measured by means of the eye micrometer of the microscope, or projected on a screen. On the other hand, if a current of known strength is sent through the string, then a strong current traversing the field wires can be measured; in this case the field wires may be ranged in parallel, giving a superior limit of 40 amperes.

2. *As an Electrodynamometer.*—In this case the end of the string is connected with one of the lower binding screws, and the same current is passed in succession through the field wires and the string.

* Translated from the *Physikalische Zeitschrift*, April 1, 1907.

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3. *As a Wattmeter.*—In this case the main current is sent through the field wires, while the P.D. current is sent through the string, with insertion of a sufficient resistance.

4. *As an Electrometer.*—In this case the two field wires are not connected; each of them represents a pair of quadrants, while the string represents the needle. All schemes of connection usual in the quadrant electrometer are admissible here.

The advantages of the new galvanometer are great and numerous. Its sensitiveness as a galvanometer is best expressed by comparing it with Einthoven's string galvanometer.

In the latter, the transverse force experienced by the string is

$$K = Hli,$$

where H is the magnetic field, l the length of the string, and i the current.

In Place's instrument the field is formed by the two parallel field wires. If the distance of the string from the axis of these wires is z, and a current, J, traverses the field wires, the magnetic field at the string is

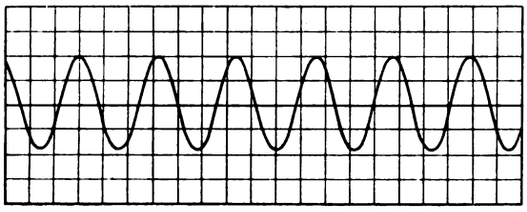
$$H = \frac{4J}{z}.$$

In Einthoven's string galvanometer the maximum field intensity may be taken to be 20,000 C.G.S. units. In our galvanometer J may at the most be 20 amperes, while z may be brought down to a little under 1 mm. This gives a field intensity of

$$H = \frac{4 \times 2}{0{\cdot}1} = 80 \text{ C.G.S. units.}$$

Hence Einthoven's instrument is some 250 times more sensitive than Place's pattern. Since, according to Einthoven, a sensitiveness of about 10^{-11} amperes can be attained, we may put the limit of sensitiveness of Place's instrument at $2{\cdot}5 \times 10^{-9}$.

Used as an electrodynamometer, with a current of 2×10^{-4} ampere, it gives an easily measured deflection. Many other electrodynamometers are far superior to this, but here we have an instrument absolutely free from inductance and of infinitesimal capacity—as far as I know, the only inductionless instrument of its kind. Still it will hardly be much used as an electrodynamometer, since handier hot-wire instruments can be constructed of the same sensitiveness.



But the greatest advantages are offered by the instrument as a wattmeter. The sensitiveness is in any case considerably above that of any reflecting wattmeter known to me, and, besides, it possesses neither inductance nor capacity. It may, therefore, be used in the presence of any phase displacement, and it is easy to measure with it the watts consumed by a condenser or a choking coil in an alternating circuit with considerable accuracy.

As an electrometer it is very satisfactory. Thus I found with a Wollaston thread 0·003 mm. in diameter, with a contact lasting 0·12 sec., that 1 volt gave a deflection of 1 mm. with a magnification of 250 and idiostatic connections. If the thread is made as loose as possible—which necessitates a contact of 2 seconds—a P.D. of 0 25 volt gives a deflection of 1 mm. If the thread is made so tight that it takes up its final position in the least possible time and with critical damping, a P.D. of 3 volts produces a deflection of 1 mm. But in this case the sensitiveness may be doubled by bringing the string to within 0·2 mm. of the field wires. This, of course, incurs the danger of the string adhering to one of the wires, when it will be difficult to detach it without tearing it.

With the greatest possible relaxation and a contact of 1 second, we may obtain a deflection of 1 mm. for 0·001 volt. In the case of a quartz fibre 0·001 mm. in diameter we may expect a sensitiveness at least 100 times greater.

The accompanying diagram shows the P.D. curve obtained with a small alternate-current dynamo giving almost a pure sine current.

The sensitiveness may probably be increased in another way, viz., by increasing the length of the string. The deflecting force is proportional to the length, so that if the length of the string and of the field-wires is increased n times the deflecting force is increased to the same extent. But for the same tension a string n times longer will be deflected n times as much by the same deflecting force. Hence the sensitiveness is increased n^2 times.

In my apparatus the length of the string is only 11 cm., but it could easily be increased to 40 or 50 cm. But then another valuable property would be lost. The greatest advantage of the instrument lies in the extraordinary rapidity of reading, and if this is required the greatest sensitiveness must be renounced. For if the tension is increased the sensitiveness decreases, whereas the reading is more rapid. The time of reading can in the case of linear variations of the current be reduced to a few thousandths of a second without much trouble.

The damping is due almost solely to the air. In the weak magnetic field the electromagnetic damping is negligible in comparison. We therefore require a strong air damping and this increases as the string is made thinner. If we use a silver wire 0·02 mm. in diameter it is impossible to relax the string to such an extent as to get an aperiodic motion. In a Wollaston wire 0·01 mm. in diameter this succeeds under favourable circumstances. A Wollaston wire 0·003 mm. in diameter may be considerably stretched before oscillations appear.

The apparatus only attains its full sensitiveness on employing a thin silvered quartz fibre, as used by Einthoven in his excellent string galvanometer. Such fibres have notable advantages over equally thick wires. Thus a quartz fibre 0 01 mm. thick easily gives a slow reading of several seconds, and thus a sensitiveness about 100 times greater than a platinum wire of the same thickness.

If we have to deal with measurements of current, potential and power for accurate instantaneous values—*i.e.*, for oscillograms—we must see that the reading is "critical," or that it lies at the limit of aperiodicity, and that the oscillation is very short. This can probably only be done by making the silvered quartz fibres very thin and very short—at all events, not thicker than 0·001 mm. This sacrifices the maximum sensitiveness, and it might be better to stretch an aluminium wire of somewhat greater diameter, say 0 03 mm., through an oily liquid, and to reduce its length. Such an instrument, though little sensitive, might be technically useful.

The diameter of the field wires may in special case be varied. When the string is under strong tension, and the field current need not be very large, thin field wires are better, since they may be brought closer to the string. But if the sensitiveness is to be increased by using a very strong field, the field wire may be thickened, but not beyond 2 mm. diameter.

CORRESPONDENCE.

ECONOMY OF REVERSIBLE BOOSTERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should not have troubled to address you again upon this subject if I had not felt that I have been misunderstood.

In the first place you insinuated that my criticism was unfair, and after having read through my letter I certainly cannot see anything which could warrant this accusation. I maintain most unreservedly that if conditions, which ought to be beyond doubt similar, are brought into a comparison, and there is even a possibility of those conditions varying, the comparison is of little or no value. This may not be your view, but that does not make the criticism unfair.

My position in regard to this matter is simply that, so far as my experience goes, I have found that the advantages to be derived from the use of batteries and boosters are not justified by the cost at which they are obtained. I have seen no figures which go to the contrary other than the figures in the Greenock case (which you state were given to you by the Chloride Company, and which Mr. Robertson now states were supplied by him), and these figures, in my opinion, are not sufficiently comprehensive to enable a proper comparison to be made. The best answer to my criticism would have been to publish the detail figures and not to have accused me of unfairness.

Even if the coal was of the same quality, and obtained from the same pits, in the working with and without the battery respectively it does not follow that the quality of the stoking was the same or that the draught was the same. You might get the same stoker, with the same quality of coal, and get widely different results from day to day. I, therefore, simply suggested that the coal test was not reliable and that it would have been better to have taken tests of the steam consumption.

It is admitted that the load factors were dissimilar, and although Mr. Robertson calls my attention to the fact that an improvement in the load factor does not materially reduce the costs, the result may be largely different when not only is the load factor increased but the output as well. I am glad to note that the buildings at Greenock cost nothing, and I would add that if other portions of the equipment were supplied upon

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the same terms it is quite likely that the battery will justify its installation.

I can only repeat that I should be just as pleased if figures can be produced to show that the opinions which I have expressed are erroneous; but until such figures are forthcoming, and in such a form that there can be no doubt as to their accuracy, I feel that I am entitled in maintaining those opinions. I am glad to hear that in one instance, with an expenditure of £3,000 on a particular battery, a saving of £1,500 a year was effected, and I should revel in delight in the actual figures in this case if they were only forthcoming. Why this remarkable result should be clothed in mystery I fail to understand. Why hide such a light under a bushel?—Yours, &c.,

Atherton, Lancs., April 22. J. R. SALTER.

[We did not "insinuate" at all, but stated quite openly that we did not think the criticism quite fair, and this opinion we still hold. The criticism made by Mr. Salter to which we referred was that the quality might have varied, but for all practical purposes Mr. Robertson has shown that the quality was the same. We quite agree that differences in stoking would be eliminated by taking tests of steam consumption, but that is another question, and was not the one originally put forward.—ED. *E.*]

RESISTIVITY TEMPERATURE FORMULÆ FOR COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of April 5th contains an interesting Paper by Prof. Crocker on the temperature coefficient of change of resistance of copper, and raises the question of the value which should be adopted. The original experiments are, of course, those of Matthiessen, and the formula he gave in his Paper in *Phil. Trans.* for 1862 is

$$C_t = C_0\{1 - 0{\cdot}0038701\, t + 0{\cdot}000009009\, t^2\}.*$$

From this formula the corresponding one for resistance can be found, as is done by Prof. Crocker, but there is a zero too many in the coefficient of the term in t^3, while the coefficient of t^4 is incorrect as given in the formula (2), and the difference is just sufficient at a temperature of 100 deg. to be appreciable. The correct formula is

$$R_t = R_0\{1 + (387 \times 10^{-5})t + (5{,}968 \times 10^{-9})t^2 - (1{,}177 \times 10^{-11})t^3 - (993 \times 10^{-13})t^4 - (278 \times 10^{-15})t^5 - \ldots\}.$$

The important question, however, concerns the formula to be adopted for practical calculations, and I quite agree that the linear expression $R_t = R_0(1 + \alpha t)$ is sufficient for most purposes. As to the value of α which fits the experiments the following table may prove of service:—

Table I.

Observer.	Range.	Value of α.
Matthiessen, *Phil. Trans.*, 1862; mean coefficient deduced from formula	0° – 50°C.	0·00412
	0° – 100°C.	0·00422
Dewar and Fleming, *Phil. Mag.*, 1893	0° – 18°C.	0·0042$_4$
	0° – 60°C.	0·0042$_7$
	0° – 100°C.	0·0042$_8$
	0° – 200°C.	0·0042$_6$
Shaw and Rhodin, *Proc.* Roy. Soc., 1894	13° – 90°	0·0040$_8$
	—	0·0041$_6$
Fitzpatrick, B.A. Report, 1894	—	0·0040$_5$

The value of α appears to depend to some extent on the exact treatment of the copper. The Engineering Standards Committee adopted Dewar and Fleming's value 0·00428. Prof. Crocker's reasons for accepting a number somewhat lower—0·0042—undoubtedly have considerable weight, but the important point is to agree to work to the linear formula $R_t = R_0(1 + \alpha t)$.

In using the formula to obtain the rise of temperature corresponding to a measured change of resistance it is simplest to put it in the following well-known form. Let R_t and $R_{t+\theta}$ be the resistances corresponding to two temperatures t and $t + \theta$; thus we have

$$R_{t+\theta} = R_0\{1 + \alpha(t + \theta)\},$$
$$R_t = R_0\{1 + \alpha t\};$$

whence, eliminating R_0, we find

$$\theta = \frac{R_{t+\theta} - R_t}{R_t}\left(\frac{1}{\alpha} + t\right).$$

If we take $\alpha = 0{\cdot}00428$, then $\frac{1}{\alpha} = 234$ and $\theta = \frac{R_{t+\theta} - R_t}{R_t}\{234 + t\}$.

If we take $\alpha = 0{\cdot}0042$, the 234 becomes 238.

Thus the rise of temperature is found by multiplying the ratio of the change in resistance to the resistance at the cold temperature by the factor $(234 + t)$ [or taking the lower value for the coefficient by $(238 + t)$], where t is the cold temperature.

—Yours, &c., R. T. GLAZEBROOK.

National Physical Laboratory, April 18.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. F. B. Crocker states in his article on "Resistivity Temperature Formulæ for Copper" (*The Electrician*, April 5th, p. 968), "the German rules adopt 0·004 instead of 0·0042 as the temperature coefficient." I should like to draw your attention to the fact that this statement is not correct, inasmuch as the coefficient 0·0042 adopted in the A.I.E.E. standardisation rules refers to an initial temperature of zero, as will be seen from Dr. Crocker's formula (5), whilst the coefficient 0·004 adopted in the German rules refers to a mean air temperature, which is always taken as 15°C. It must be admitted that this is not clearly stated in the wording of the German rules.* However, it can be seen from Mr. G. Dettmar's "Erläuterungen zu den Normalien," given in *E.T.Z.*, 1903, p. 662, and also from Mr. Fritz Emde's letter published in *E.T.Z.*, 1903, pp. 818-9.

Taking the coefficient 0·004 for 15°C., we find that it will correspond to a coefficient of 0·00426 at 0°C., from which you will see that it is not very different from the American coefficient and very near to the coefficient 0·00428 which is used by the British Standards Committee in certain calculations. With this correction, of course, the curve VI. given by Dr. Crocker will now be of quite a different character and will lie slightly above the horizontal line V. Its formula can be given either in the form

$$R_t = R_o\,(1 + 0{\cdot}00426t)$$

or

$$R_t = R_{15}\,(1 + 0{\cdot}0040\,(t - 15)).$$

Stafford, April 18. M. KLOSS.

ELECTRONS AND ELECTRIC DISCHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There does not appear to be any generally accepted theory of the conditions obtaining in a vacuum tube when the cathode rays are being projected from the negative pole. That the passage of the rays depends in some way upon the condition of the residual gas in the tube is quite clear; for the potential that is required to break down the resistance of a vacuum tube sheltered from violet light or Röntgen rays is much greater than is required to maintain the rays when once started.

It seems reasonable to assume that the true explanation should be applicable to the leak which a charged body suffers when exposed to the action of an ionised gas. In such a case it has been contended that each molecule (or atom?) of gas may be split up into two or more portions, one or more particles, the negative ions, being the electrons, having masses about 1,000 times less than hydrogen, and the other a positive ion, having a mass nearly equal to the ordinary molecule. The negatively charged plate has an excess of these negative particles or electrons, and the positively charged body has a number of ordinary molecules minus the electrons required to neutralise them.

When a molecule of a gas between two plates of different polarity is split up into ions by Röntgen rays or other means, the electron moves to the positive pole and helps to make up the deficiency of electrons there, and the positive ion moves to the negative pole and picks up an electron from the solid and partly discharges it. Will this theory of what takes place in a gas at ordinary temperatures and pressures apply to the conditions in a highly-exhausted vacuum tube?

* In the copy of Prof. Crocker's Paper referred to the first coefficient is printed by an oversight as 0·0038901.

* See paragraph 16 of "Normalien für Bewertung u Prüfung von Elektr. Machinen, &c."

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Suppose that in a vacuum tube a particle of gas (molecule) is split up into ions by Röntgen rays or other means. The negative ions or electron make their way to the positive pole, and the heavy positive ions make thier way to the negative pole to pick up electrons. It has been shown that the velocity of an electron varies with the density of the gas and the intensity of the electric field, also that electrons when moving slowly are not capable of ionising a molecule. When, however, the gas is very rare the positive ion as it approaches the negative pole comes under the influence of a very violent gradient of potential, and it is very important to understand what actually takes place under such conditions. It has been suggested that the positive ion rushes against the negative pole, and by its momentum knocks off electrons, which then escape. I would suggest that the heavy positive ion moves slowly towards the negative pole, and that the electrons are drawn out of the solid towards it. The positive ion being heavy and the electron very light, the latter acquires a very high velocity, frequently fails to be stopped by the positive ion which loosened it, and darts into space.

The reason why the surface action near the negative pole at atmospheric pressure does not give rise to further ionisation, as in a vacuum tube, may be that owing to the density of the gas the electrons do not acquire sufficient velocity. Violet rays, on the other hand, so modify the surface conditions that continuous ionisation more easily takes place.—Yours, &c.,

Derby, April 11. R. M. DEELEY.

[It all depends upon what is meant by a "slow" motion. The velocities of positive ions have been measured by Wien and found to be from a thirty-thousandth to a thirty-millionth of that of light. Even the latter is a speed of 10 m. per second. Electrons are not as a rule "drawn" out of the cathode, unless the latter is red hot or illuminated by ultra-violet light. In very high vacua, where ions are scarce, it is almost impossible to coax electrons out of the cathode. Most of the ions are formed by collision, and this requires sufficient of a free "run" down the potential gradient. The latter is about 100 volts per cm. near the cathode.—ED.]

JOINTING LEAD-COVERED CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 12th inst. you state that the most favoured method of making a joint in an underground insulated cable is by means of a compound gland joint box. With all respect to you, Sir, and to those of your opinion (and I fully recognise that every cable engineer is entitled to hold and express his own views), I venture to disagree with you.

In my experience, this type of joint has been much more fruitful in causing breakdowns than has the straight-through hand-made joint, whether on lead-covered paper-insulated or on bitumen-insulated cables. I cannot recollect any contract carried out by us in this country in which joint boxes have been used for jointing up factory lengths of cable during the past four years.

I do not wish to imply that satisfactory joints cannot be made with a box in which compound is depended on for keeping out water. I know it can be done, but it demands the services of a very careful and conscientious workman. Some engineers seem to think they can use less expensive, and less skilled, labour if they use joint boxes with glands, both filled with box compound. A greater fallacy never existed. Look at the avoidable box breakdowns which occur on many networks where cheap men are employed. They can usually be traced to the careless filling in of the compound.

The cables in an electricity undertaking represent a considerable percentage of the total capital employed. Why, therefore, should they be treated in a penny-wise pound-foolish way? Surely it is cheaper to pay good wages to a capable jointer and have reliability of supply through sound mains than to have a so-called cheap man, frequent breakdowns and, at the end of the year, a total expenses account of larger dimensions.

For straight joints on paper-insulated lead-covered cables, there is nothing, in my opinion, to come up to the hand-made soldered joint, protected by a lead sleeve wiped on to the cable sheath, for all-round reliability. It has the great advantages of compactness and of making the lead sheath automatically continuous. Troubles due to defective plumbers' wipes are few and far between, and negligible in number when one considers the thousands made yearly.

Finally, I would express a hope that Mr. Rogerson's Paper will be re-discussed in London. It contains several controversial points, and would afford ample material for a London meeting. Only seven speakers are reported as taking part in the discussion at Leeds, and of these only two, apart from the author, appear to have spoken at length. All the ground was not covered, and there must be many South Country engineers who would like to have the opportunity of fully discussing this essentially practical Paper.—Yours, &c.,

Prescot, April 15. B. WELBOURN.

CORRUGATION OF TRAM RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To my mind this is brought about in the following manner: In rounding a curve, as you mentioned in your leading article, a certain amount of slip takes place owing to the outer rail being longer than the inner one. If the axles were absolutely rigid and allowed of no twist or spring due to torque caused by the tendency to unequal revolution of the inner and outer wheels, then there would be no corrugation.

This tendency to unequal revolution is resisted by the axle, and either the inner or outer wheel must slip a little in order to equalise matters. Now the inner wheels, working on a curve of smaller radius, will, by reason of the flanges fitting more tightly in the groove, offer more resistance to slipping than the outer ones; consequently the torque or torsion of the axle will accumulate until the outer wheel offering the least resistance will slip, when matters will be equalised, and this will be repeated all round the curve at regular intervals, which will be shorter or longer according to the rigidity of the axle, and if all the car axles have the same torsion moment the intervals of slip will be the same; consequently the outer rail will be worn bright at these regular intervals, which will cause the outer wheels of all the cars to get into step or rhythm as it were, and always slip at the bright and smooth places and consequently increase the wear at those places. Once this has begun, the tendency is to continue and increase, as when the wheel is on the rough crest of the wave it will bite keener than when crossing the smooth hollow, and the axle consequently takes the opportunity of relieving itself of the stress. And these two factors, the hollow of the wave and the brightness or smoothness at this point, together with the similarity of axles coming together, cause all the outer car wheels to slip and wear the rails at every hollow and thus increase the trouble. If the axle happens to be driven at the inner wheel end there will be more tendency to corrugate the outer line, as the twist in the axle comes more into play.

This theory of the twisting of the axle, together with the end drive of the same will also account for corrugation of straight lines and curves of comparatively large radius at certain places. Imagine a car commencing to ascend a gradually increasing gradient, at first there will be a comparatively small amount of slip, and any wear due to the readjustment of the wheels caused by the tendency of the one farthest from the drive to lag, will be at such long intervals as not to appear in the form of corrugations; as the grade increases both wheels will slip more, the one at the driving end of the axle will have an even and continuous slip by reason of its contiguity with the driving cog wheel, and the even and continuous nature of the driving power, but the one at the other end will be subject to the springy torque of the axle and will alternately bite and slip and thus produce the corrugation of a certain pitch; when the grade increases still further the slip will be more and the alternate biting and slipping will be at such short intervals apart as to cease to take the form of corrugations, thus accounting for their absence on heavy gradients. This theory also explains why no corrugations are formed by other than electric cars, in none of which the drive is at one end of the axle. If this theory is correct the remedy would appear to be found in stouter axles, or driving either at the centre or both ends of the axle. The first mentioned being simplest and most efficient.—Yours, &c.,

Leeds, April 15. J. H. BRIGGS.

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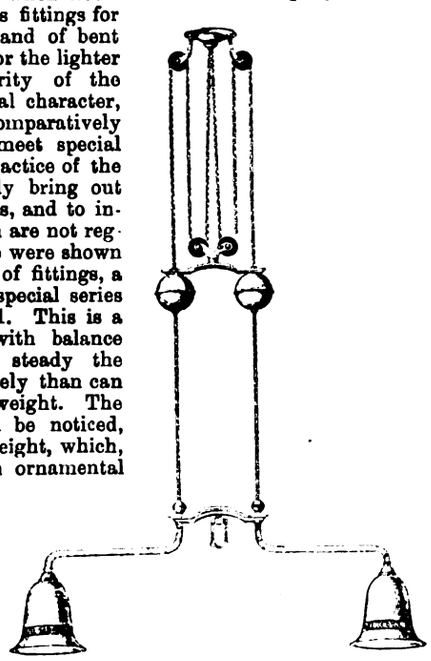
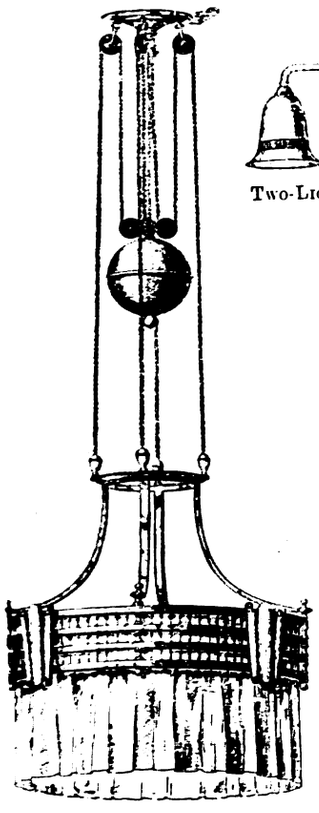
NEW ELECTRICAL FITTINGS.

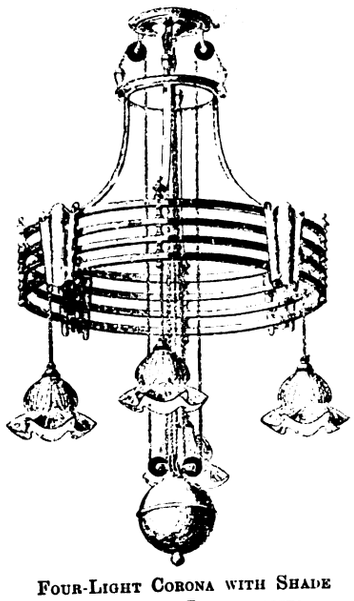
We have been recently afforded an opportunity of inspecting the new show-room of the Electrical Fittings Co. (Ltd.), 15, Newman-street, London, W. This company has moved from Soho-square to these premises, which occupy a more central and accessible position A very effective display of fittings is made in the entrance hall and in one large show-room and a smaller one. The walls have been artistically set out in panels, and conveniently wired for lighting up the fittings. A row of wall plugs is fixed at a convenient height in the various show-rooms, and the flexibles of the fittings are run at the back of the panelling down to a wall plug which can be hidden out of sight when not in use. The company makes a speciality of solid brass fittings for the heavier patterns and of bent and hammered brass for the lighter designs. The majority of the designs are of a special character, and are built in comparatively small quantities to meet special demands. It is the practice of the company to frequently bring out new designs of fittings, and to introduce patterns which are not regularly obtainable. We were shown some very neat forms of fittings, a typical example of a special series being shown in Fig. 1. This is a three-light pendant with balance weights arranged to steady the pendant more effectively than can be done with a single weight. The flexible cord, as will be noticed, passes through the weight, which, in addition, gives an ornamental appearance. Fig. 2 illustrates a corona pendant intended for dining-room use. This is balanced by a special central-ball weight, which is made to pass through the ring supporting the pendant chains when the fitting is raised above a certain height. The shade ring is easily detachable by the removal of four pins. This feature has been provided with the object of allowing the fitting to be raised close to the ceiling, so that if the centre of a room is required for a dance or a party the fitting can be lifted clear, but it may still be turned on to illuminate the floor below. The lamp and shade ring is built up artistically of a number of rings of oxidised brass, these being spaced apart to give an ornamental appearance.



TWO-LIGHT PENDANT WITH BALANCED WEIGHT SUSPENSION.



FOUR-LIGHT CORONA WITH SHADE IN POSITION AND FITTING LOWERED.



FOUR-LIGHT CORONA WITH SHADE REMOVED AND LAMPS RAISED.

The small show-room contains a number of fittings in the French and Adam styles. These are of correct design and include pendants, brackets, corner fittings and radiators. In the hall several specimens of fittings in the Dutch style are displayed, and when shown lighted give a very pleasing effect.

The company is also showing a number of accessories such as switches, ceiling roses, wall plugs, &c., which are manufactured by the Wandsworth Electrical Mfg. Co. This series includes a number of artistic switch covers, which enclose the switch entirely and add considerably to its ornamental appearance.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

(*Continued from page 59 of the present issue.*)

Sir EDWARD SASSOON: Will you tell us what it was that enabled you to debar other stations from creating disturbance?—I will. If you have a tuned station the lower-pitched notes produce little effect and the higher notes also produce little effect, but the notes on the right scale produce a very large effect, and one particular note reaches the maximum. Suppose signals were being received at once from a tuned and an untuned station, you can make the apparatus more and more insensible. You can make an apparatus insensitive by separating the inductive connection so that nothing below a certain intensity will produce any effect. What you require can thus be received and the other is tuned out. At any moment you can restore the sensitiveness and pick up all the stations in the neighbourhood.

The CHAIRMAN: Is this common to all systems, or only your own?—I have not experimented with any other, but I am sure the other systems could do the same if they had the proper tuning arrangements. I do not think the word "systems" is very good really, although it is the word commonly used. There is no great fundamental difference in the different methods.

Mr. GWYNN: Supposing Dover and Elmers End were using the same wave-length, could you obtain the same result?—No; if Dover wished to cause disturbance it could, but in times of peace each station should have its own note, and then you could speak to one and not to another.

Can you have the same note without having the same wave-length?—No, it is the same thing.

The power of preventing interruptions depends on a free choice of wave-length?—It depends on some control over the wave-lengths which different stations use.

The CHAIRMAN: The Committee gather from what you say that with proper tuning there need not be any undue interference between stations, even if situated comparatively close to each other, and that the system has been perfected to that extent?—That is quite true, if the "systems" are willing to work harmoniously. For hostile purposes it would be possible to produce disturbance. A station might run up and down the scale and produce all wave-lengths, and so produce disturbance.

If stations are tuned together as you describe, what would be the effect on stations untuned or otherwise tuned? Could you get messages from the otherwise tuned or untuned stations?—The tuning is easily adjusted. It is only putting in a few pegs to alter from one tune to another, or the same effect may be produced by switching over a handle, and you can restore the sensitiveness and do away with the tuning when you wish and pick up every kind of signal. A coast station which speaks to some land station on a certain note, so as not to interfere with other stations, could, when not so speaking, receive every kind of disturbance, tuned or otherwise from passing ships—that is, could throw itself out of tune altogether, and it can instantly restore the tuning when it wants to. It can also use different tunings for speaking to different stations—tune A for one station and tune B for another.

Mr. GWYNN: Could it simultaneously be tuned A for one station and B for another?—No, but it can be changed by a switch; it is very quick work to change from one tune to another.

Can two stations speak over the same route as two other stations at the same time?—Suppose there are four stations along the coast, A, B, C and D. Speaking in the same direction is possible, if on different tunes—that is, A with C and B with D, but not in the opposite direction. Speaking in the same direction is called diplex telegraphy, and in the opposite direction duplex telegraphy, and I do not think the latter has been accomplished yet in wireless telegraphy.

What amount of difference is necessary to provide for distinct tunings?—My assistants assure me that they can alter the tuning with 1 per cent. change, but I have no experience of any other system than the Lodge-Muirhead.

The CHAIRMAN: Have you any stations at work which demonstrate the accuracy of what you have told us?—Yes, those at Hythe and Dover and at Elmers End; have all been shown to Government officials. Mr. Gavey himself saw the demonstrations I speak of when Hythe received from Elmers End, and the messages were not received by Dover, though Dover was making a great disturbance.

Do you consider that a wireless station should be able to receive messages from ships and other messages when it wishes? I mean intercommunication between all systems?—I hope every system will intercommunicate.

Would it be possible for a station to select out of neighbouring stations first one and then another?—Yes, that can be done by adjusting the wave-lengths to suit the members of the group.

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Do you claim novelty in the tuning methods in your patent of 1897?—Yes, I think I was the first to get a tuning patent. A great deal depends on the syntonic Leyden-jar experiments. The sympathetic connection between one circuit and another is that when they are accurately tuned one station can respond to another, and not otherwise.

Do you think your system or any other system should be granted a monopoly?—No. Taking into account all the work that has been done there is no legitimate ground for such a grant.

Have you any evidence that your system is efficient as regards small power for considerable distances?—Yes. The evidence of the Andamman Islands, where signalling is carried on commercially and for Government purposes between Burmah and the islands.

Mr. LEE: What distance?—300 miles across the sea. We have also largely worked across land because we realised that that was much more difficult and better worth scientific attention. In these sea experiments I am told we use 1¼ H.P.—an absurdly small power.

Sir EDWARD SASSOON: It is worked by the Indian Government?—Yes.

The CHAIRMAN: Is 300 miles the greatest distance transmitted by this station?—Yes, so far as I am aware.

How does the power of that station compare with that of a high-power station like Poldhu?—There is no comparison possible. It is an advantage to have very little power, as it makes for less liability to disturbance. Poldhu is an experiment for trying to get across the Atlantic, which we have never tried. We have not had the necessary capital. I think long distances can be covered by increased power.

Do you attach importance to the earth connection both for sender and receiver?—The earth connection we have learned to regard as bad. In my 1897 patent I did not use the earth connection. In old experiments in 1899, 1890, 1892 and 1894 I seldom used earth connections; sometimes I used it for collecting, but seldom for sending and never for tuned syntony or anything like it. I do not want to speak of other systems, particularly the Marconi, who use the earth and seem to get great distances and to attach considerable importance to it. I was tempted to attach considerable importance to it also, but we have found it unsatisfactory for a tuned system. For an untuned system I should use the earth as a help, but for real tuning the earth is deleterious, and we consider we have obtained our best results, and singularly good results as regards tuning and distance in the Andamman Islands, with very little power by discarding the earth and using two insulated aerials, one above and one below. One method of throwing a station out of tune is to connect the lower aerial with the earth. Directly you do that the tuning is gone and you can then pick up a lot of disturbance—insulate it and you have the means of sending out one definite wave-length, which by a tuned receiver can be picked up at a surprising distance with very little power. I rather think Braun has done the same—discarded the earth connections. Marconi retains the earth connection so far as I know, and if they use the whipcrack method they may be right in retaining it.

The CHAIRMAN: Is it easier to signal across the sea?—Yes.

Sir EDWARD SASSOON: Why?—It is a question whether the inductive power of the sea helps you. It may reflect the waves, much as the upper regions of the air may reflect the waves, and enable great distances to be obtained, but on land you have not that assistance, as there are hills and houses and irregularities of all kinds, and so the same power which would give 50 miles across land would give some hundreds of miles across sea.

Mr. LAMBERT: What happens to a radio-telegraphic wave when it comes up against a hill?—I suppose it goes round it. When you are working under the lee of a hill it is certainly a considerable obstruction, and if you can get outside the shadow of the hill it is easier. Some waves may go through a hill, but I think most of them go round. There is, however, some difference of opinion on the subject. I think Lord Rayleigh, who is a great authority on mathematical physics, feels doubtful about the matter.

Would a tramway system affect the signalling?—No. An obstacle like a single hill close to either station would cause great disturbance, yet half-way between the stations causes practically no harm, but a range like the Himalayas might cause disturbance half-way between the stations. I think the upper regions of the air may have a useful reflective influence on the waves. The waves may get up there and then come down again by reflection over very large distances, but this is all theory.

Sir EDWARD SASSOON: Have wireless messages been transmitted from one closed room to another?—Yes, brick walls are not much obstruction, but metal walls would be.

The CHAIRMAN: You claim, as representing the Lodge-Muirhead Co., to have made substantial advances in the perfection of wireless telegraphy on certain other systems?—I think the company claim to have the best system of tuning and the best coherer. I claim to have done scientific work of a pioneering kind before 1896. These would be our chief claims.

Sir EDWARD SASSOON: That would be in connection with the Hertzian wave principle?—Yes, pioneering work in connection with Hertzian waves, to some extent with regard to their detection, and after wireless telegraphy became financially important we pursued the researches on scientific lines, working on a small scale to get it into a state of greater perfection, and I think we have succeeded in getting the best coherer and the most accurate method of tuning.

The CHAIRMAN: Are you in a position to increase your stations if existing obstacles are removed?—It is simply a question of capital and such like. Personally, I have nothing to do with deciding that.

From your point of view, are you willing that the Convention should be ratified?—Yes, it seemed that the delegates were very sensible, and I did not detect any of the foreign dominance of which some of the newspapers speak. It seemed to me that the British delegates looked after the interests of this country very well, and that the conclusions arrived at were of a very satisfactory character.

You do not anticipate that there will be any difficulty in enforcing the regulations embodied in the Convention with regard to prevention of interference and confusion?—No; on the other hand, they are all most necessary to prevent interference and confusion when wireless stations are multiplied.

Mr. GWYNN: When was your first intelligible message transmitted?—The first intelligible messages on the Morse code which were transmitted were in my early experiments. In those experiments, and in my demonstrations in 1894, I did not attempt to transmit words by the Morse code, but I used the Morse key and the mirror signalling instrument, and if I had been an expert telegraphist it would have been easy to make a code. All I used were the short and long signals which comprise the Morse code.

The idea of using Hertzian waves for practical telegraph work did not occur to you until after you heard of Marconi's achievement?—Dr. Muirhead spoke to me about it, but it did not specially interest me.

It occurred to you before 1896?—Yes, after the 1894 demonstration.

In your system you employ some form of upright wire at both transmitting and receiving stations?—We employ the Hertz emitter, two plates one above the other, and we have used these all along.

You did not use the antenna or aerial?—I have used collecting wires, but we do not use them now. We have gone back to two tuned Hertz vibrators, the receiving and sending ends being the same.

Your system does not employ any form of elevated wire or antenna?—It employs an elevated aerial which is made of wire, but it is not a wire up the mast. I used to employ plates, but when these were placed out of doors they caught the wind too much, and we now use a wire frame.

Wire frames at both stations are essential for wireless telegraphy?—Yes, for tuned wireless telegraphy. For the whipcrack method the single elevated wire would be probably the best. It was by that means Marconi got big distances at first. The perfection of tuning has been only obtained comparatively recently on the principles laid down in my 1897 patent. Since we have the wheel coherer tuning is becoming much more satisfactory.

I asked you about the necessary variation of the limits of wave-lengths to separate stations. You said your operators put it as low as 1 per cent. A station using a 300 metre wave-length could work near a station using a 295 metre wave-length?—Yes, if the other station was near it; but if it was distant I do not think that would be sufficient discrimination.

Do you think the limits provided by the Convention do not injuriously restrict power of selection of wave-length?—It seems to me we are all working within those limits at present, but I suppose they could be enlarged if necessary.

You do not think the reservation of the 600 metres to 1,600 metres wave-lengths for the Navy would interfere with commercial working?—No, but Poldhu, it seems to me, would be rather liable to interfere.

Would it be possible for low power stations to tune out the Poldhu messages if they had a considerable range of selection?—Yes, if they were not too near. I understand you mean that the margin allowed for commercial work is rather narrow.

Would a station lose in efficiency by shortening the wave-length?—No, I have not found that.

In answer to questions of some members of the Committee as to the effect of the ratification of the Convention by other countries and not by Great Britain, Sir OLIVER said we should be at a disadvantage, and would have to come in later on worse terms. He meant that regulations would be agreed upon by other Powers, and if we wished to come in later we should have to accept regulations in the preparation of which we should have had no voice.

Sir EDWARD SASSOON: Would the provisions of the Convention lead to an increase in the number of wireless stations on the French and Dutch coasts in the Channel, and would these not cause greater interference than exists at present?—The multiplicity of small stations is not a bad thing if their power is limited. They cannot produce so much disturbance as a few very large power stations.

Do you consider that the common use of stations with different apparatus would be harmful to the existing organisation of wireless telegraphy in this country?—I do not think it should be.

My point is that intercommunication is required by the provisions of the Convention. Would this not disturb the present service?—I should not think it would, any more than receiving foreign telegrams does. I take it there is an International Telegraph Convention, and I should think the same thing would, in times of peace, extend to wireless telegraphy also. If the control of wireless telegraphy were left to private enterprise, and the conflict of private interests, there might be confusion, but if it is taken up by a central organisation, I think there would be less confusion.

I want to know whether the means provided by the Convention are sufficient to enforce the carrying out of the regulations?—I think we can adapt ourselves to the regulations, and others can adopt themselves if they so desire.

Could anyone hand in a message at a telegraph office in this country for transmission by your stations?—No, I do not think we are developed to that extent on the commercial side.

Mr. LEE: Why can messages be transmitted better at night than by day?—That applies chiefly to long distances. It seems to me a rather interesting discovery of Mr. Marconi's that sunlight interfered with the transmission of long-distance messages. I did not experience that, and it would not have been expected, but as it has been observed it is not unnatural to explain it by the ionisation of the air. The air in sunshine becomes a partial conductor, and any conductor is opaque, and any conducting power added to an insulator tends to increase its opacity; hence, air full of sunshine, being very weak, is slightly more opaque than it would be if the sunshine were eliminated. But it has not come within my experience, and I think only applies to very long distances. It has not produced any obvious difficulties over 200 or 300 miles.

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Is the wireless system in its infancy?—Most scientific inventions are. I have not regarded it as a system that would supersede telegraph cables, but I think it will supplement cables as the telephone supplements the telegraph without superseding it. I think the method of communication will become more easy, practicable and exact. It is this improvement which monopoly would tend to diminish.

Suppose one of the Powers had an interest in creating confusion in the Channel, would it be impossible to guard against this?—Any power that was outside the Convention could send a warship with sufficient power into the English Channel to produce disturbances that would make it extremely inconvenient for everybody.

Mr. LAMBERT: Could a station be erected in Germany or France which would interfere with British wireless telegraphy in the Channel?—We have not been interfered with by the Poldhu messages, which are the most powerful messages at present. We can always get rid of them whenever we want to. Assuming that the Poldhu station wanted to make itself a nuisance, I do not think it would be possible to stop the communications of other stations, but it might make it more troublesome. The Convention would make for civilised treatment and contribute to peaceful development.

The POSTMASTER-GENERAL: I gather that the systems have now got to such a pitch of perfection that the limits under 600 and over 1,600 metres would be sufficient for all commercial purposes?—I think there is sufficient margin, but the limits could be altered from time to time if the margin was found insufficient.

Mr. ADKINS: Can either the Marconi or the Telefunken Co. get rid of messages they don't want to hear as quickly as you can?—I think that with Prof. Braun's invention the Telefunken can, but I cannot say anything about the Marconi.

I understand that it is in the development of this power that we are to look for the further improvement of wireless telegraphy?—Yes; I think it would be impossible to work and develop a system without this power of selecting. The changing from one wave length to another quickly is important.

Mr. GWYNN: I understood you to say that the Marconi Co. have not the same power of tuning out messages that you have?—I did not intend to say that. I meant that I did not know. If they use the earth I feel doubtful whether they can do it as well.

If two stations near one another are both to use the same length, will they not find it difficult to avoid interference?—I should not fix any station to one wave-length; each station should have its normal wave-length, but it should be able to vary it. You can always tune out untuned interruptions, but I do not think any amount of tuning will get rid of very violent and very near interruptions.

This concluded Sir Oliver Lodge's examination.

Sir Oliver Lodge was followed in the witness chair by Mr. Henry Muirhead, whose evidence was concluded at Tuesday's sitting.

The Committee resumed its sitting yesterday, the witnesses being Mr. Nevil Maskelyne, technical adviser to the Amalgamated Radio-Telegraph Co., and Mr. J. Henniker Heaton, M.P. The report will be continued in our next issue.

LONDON TRAFFIC BOARDS.

In the House of Commons on Wednesday the PRIME MINISTER stated, in reply to a question by Sir Wm. Bull, that the question of London traffic was engaging the careful attention of the Government. He did not concur in the suggestion as to the detrimental effect of the competition existing between the transport authorities of the metropolis.

Tramway Bills.—The Rawtenstall Corporation and the West Riding Tramways Bills have been read a third time in the House of Commons.

Great Northern and City Railway Bill.—The preamble of this bill, which extends the time for the construction of the extension of the Great Northern & City Railway from its present terminus at Moorgate-street to Lothbury, has been found proved by a Select Committee of the House of Commons.

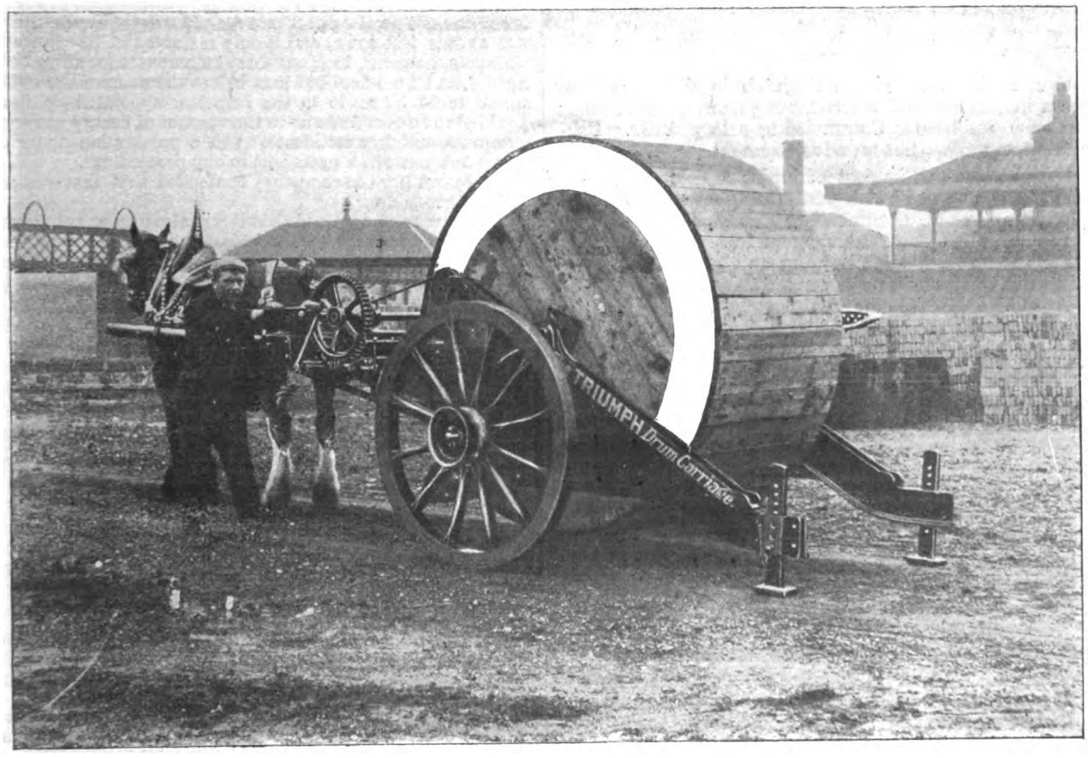
Watford and Edgware Railway Bill.—A Committee of the House of Commons has declared the preamble of this bill (which songht to extend the time for the construction of the Watford & Edgware Railway) not proved.

Richmond (Surrey) Electricity Supply Bill. This bill has been read a third time in the House of Commons.

A NEW CABLE DRUM CARRIAGE.

The cable drum carriage has not suffered from undue attention on the part of inventors, and probably the types available could be numbered on the fingers of one hand. The latest addition to the limited stock is shown in the accompanying illustration, which is self-explanatory.

It will be seen that the drum is rolled into the space between the inclined sides of the carriage frame and the bar pushed through two blocks, one on each incline, and through the drum. The worm-driven hand winch on the cross frame serves to haul the drum clear of the ground for transport. We are informed that one man can load up the heaviest drums in this way. John Ruscoe & Co., of Hyde, are the makers.



A New Cable Drum Carriage.

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LEGAL INTELLIGENCE.

Agincourt Steamship Co. (Ltd.) v. Eastern Extension Telegraph Co. (Ltd.) and Great Northern Telegraph Co. (Ltd.)

This case came before the Court of Appeal (Sir F. Gorell Barnes and Lord Justice Kennedy) on Saturday on the appeal of the first-named defendants from an order of Mr. Justice Bray in the Commercial Court. The facts were given in *The Electrician* for March 1.

Mr. J. A. HAMILTON, K.C. (with him Mr. Bailhache), in opening the appeal, said that the other defendants (the Great Northern Telegraph Co.) were not touched by the decision of the learned judge appealed from, who had decided the preliminary questions of law which were tried in anticipation that if decided in one way it would make it unnecessary to go to Shanghai to enter into some complicated questions of fact. The matter was interlocutory because there had been no final judgment.

The PRESIDENT said the appeal was in reality a final appeal, and he thought they ought to have the full Court of three judges to dispose of it.

Lord Justice KENNEDY said it appeared to him that the question raised was an important one.

Mr. HAMILTON replied that it was of great importance to telegraph companies who had acted on the Convention of 1884.

It was arranged that the case should be taken before a Court of three judges next week.

Bournemouth Corporation v. Poole & District Electric Traction Co. (Ltd.)

On Friday this case came up for further consideration before Mr. Justice Joyce. The question for further consideration arose out of the agreement for the purchase of the company's undertaking, and concerned £7,000, a bank loan. The point was whether the loan was incurred in the ordinary course of business, and was outstanding at the appointed day of the transfer—Dec. 31, 1903. The matter had been referred to the Official Referee.

After legal arguments Mr. Justice Joyce decided that the matter must be referred back to the Official Referee to give a clear indication as to what his report decided.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Governing Body of the Battersea Polytechnic (London) invite applications for the position of principal, to date from September next. Commencing salary £800 per annum, increasing to £1,000. Particulars from the Clerk to the Governing Body. Applications by May 25. See an advertisement.

The Governing Body of Battersea Polytechnic also require an assistant lecturer in physics and electrical engineering; full time; teaching experience essential. Commencing salary £180. Particulars from the Secretary. See an advertisement.

Applications are invited for the post of junior assistant engineer in the business development branch of Birmingham Corporation electric supply department. Commencing salary £100, rising to £150 per annum. Applicants must have good technical knowledge of the applications of electricity for lighting and power. Applications to city electrical engineer and manager (Mr. R. A. Chattock, M.I.E.E.) by April 30. See also an advertisement.

A general assistant (35s. to 45s. per week) and a station improver (10s. per week) are wanted in Bexley Council's tramways department. Apply to Tramways Manager.

An electrician, competent to do armature winding and commutator repairs, is wanted in electrically-driven works. See advertisement.

An assistant foreman is required by makers of electric switchboard instruments. See an advertisement.

A competent electrical engineer is wanted immediately for a town in South America, to manage the electric lighting undertaking and to superintend the construction of a small electric tramway. See an advertisement.

An assistant signal and interlocking engineer is required for the Great Indian Peninsula Railway. Salary R 400 per month, rising to R.700. Applications to Sir Geo. B. Bruce, 3, Victoria-street, S.W.

The Uganda Co. (15, Old Jewry, London, E.C.) want a mechanical engineer with experience of engines, dynamos, &c. Commencing salary, £3 to £4 per week.

Alexandria (Egypt) Municipality require a chief assistant mechanical and electrical engineer (salary £(Eg.)420, rising to £(Eg.)480 p.a.) and an assistant mechanical and electrical engineer (salary £(Eg.)264, rising to £(Eg.)312). Applications to Mr. W. P. Chataway, Municipal Offices, Alexandria, by June 6.

West Ham Council have appointed Mr. Blake, late of the County of London Electric Supply Co., as mains assistant at £150 per annum; Mr. Mackenzie, of Glasgow, as boiler-house foreman superintendent at £3 a week; and Mr. J. H Eades, of the Charing Cross, West End & City Co, as mains draughtsman at 38s. per week.

EDUCATIONAL NOTICES.

Technological Scholarships.—The West Riding (of Yorks.) County Council offer three technological scholarships, each of the value of £60. These are open to residents within the administrative area of the West Riding of Yorkshire and are available for courses of instruction in connection with textiles, dyeing, engineering (mechanical or electrical), metallurgy, or other approved industry. These scholarships are intended for young artisans who already have a suitable amount of mill or workshop experience, and the awards will be mainly on the results obtained at the examinations of the Board of Education (South Kensington) and City and Guilds of London Institute. Application forms, &c., from the Education Department (Technical Branch), County Hall, Wakefield.

Heriot-Watt College, Edinburgh.—All students who wish to enter the different classes of this College will be requised to pass the entrance examination, or to satisfy the Principal as to their previous training. This entrance examination will be held on May 7, and also on Sept. 23. A short preliminary course in pure and applied mathematics, physics and applied mechanics, electrical drawing and machine drawing for those who wish to prepare for the different courses will commence on May 14 and close on July 12. Further information from the principal, Mr. A. P. Laurie, M.A., B.Sc., F.R.S.E.

Crystal Palace Engineering School.—The Wilson Premium for the best Paper read before the Crystal Palace Engineering Society during the present session has been awarded by the Council to J. R. Crisp for his Paper on "Indian Railways." The premium was presented to Mr. Crisp by Sir Alex. Kennedy, on the occasion of the 103rd distribution of certificates of the school on April 19.

Alleged Failure to Supply Electrical Energy.—At North London Police Court on Friday last, Islington Borough Council were summoned by the Consolidated Supply Co., of Canonbury, for failing to supply sufficient electrical energy to drive the motors on the company's premises.

For the Council, Mr. BRAMALL took a preliminary objection. The Council supplied complainants' premises with electric energy. That was sufficient at the time, but complainants had increased the number of their motors, with the result that the present supply was not sufficient. The Council in August last asked complainants what power they required, but it was not until April 2 that a reply was received. Then a new cable was at once laid down, and it only remained to be connected up. Complainants, however, took out these summonses for alleged offences before April 2, and he submitted that before the summonses could succeed an appeal must be made to the inspector appointed by the L.C.C., who would grant a certificate as to the amount of energy passing through the terminals, and that certificate, as in a prosecution under the Food and Drugs Act, must be a precedent to any proceedings.

Mr. LYNCH (for the company) contended that that was an alternative mode of procedure.

Mr. BRAMALL maintained that it was also necessary to give notice of the amount of energy required, and Mr. Lynch agreed.

Mr. LYNCH said the company's requirements had not increased for two years, and all they demanded was the supply contracted for years ago, and which they had never received.

Mr. BRAMALL said that the cable might have been old, and it was the duty of the Council to repair it.

The summonses were adjourned.

Amalgamated Society of Engineers.—The annual report states that the number of members at the end of 1906 was 104,871, the new members numbering 11,782. The moneys to the credit of the society amount to £729,074. 17s. 9d., an increase of £87,615 8s. 7d. The income of the year was £400,699, an increase of £21,344, and the expenditure was £313,084

Aston.—The dispute between the British Electric Traction Co. and the Council respecting the running of through cars between Birmingham and Erdington has been settled, and through cars will be run between Erdington and Aston on Monday.

Australasia.—The "Australian Mining Standard" states that an agreement is being drawn up between the Government and a company who propose to utilise the water power of Barron Falls, situate between 30 and 40 miles from Cairns, Queensland. It is stated that 75,000 H.P. can be developed by this means, and Mr. W. Corin, consulting engineer, has reported that works constructed with the view of ultimately installing four units, each of 3,480 E.H.P., could be run profitably on condition that certain new industries are started in the vicinity to take supply of power, and that power is also taken for operating the Cairns railway.

The offices, car-sheds, and all the rolling stock (including nine motor and eight trailer cars) of the Victoria Government's St. Kilda-Brighton tramway were destroyed by fire on March 7. Fortunately the power house was practically uninjured. The amount

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of the damage (estimated at £15,000) is not covered by insurance. The line has only been open since May 7 last.

The Hon. J. W. Taverner, Agent-General for Victoria, states that Mr. Bent, Premier of Victoria, will arrive in London at the end of this week or the beginning of next, and one of the principal objects of his visit is to make inquiries with regard to the proposed electrification of the Melbourne and suburban railways, including Melbourne to Brighton (9 miles), St. Kilda (3 miles), Port Melbourne (2 miles), Bexhill (8 miles), Caulfield (7 miles), Heidlebergh (8 miles), Collinwood (2 miles), and others, bringing the total to about 50 miles. Mr. Bent is to have the advice of Mr. Thomas Tait, chairman of the Victorian Railway Commissioners.

Belfast.—The special sub-committee appointed to consider the desirability of acquiring the undertaking of the Cavehill & Whitewell Tramway Co. recommend the purchase of the company's lines for £60,000. The Tramways committee approve of the recommendation, which now awaits confirmation by the Council. Some few years ago the Whitewell tramway system was purchased and electrified by the British Electric Traction Co. The line runs from the terminus of the Belfast tramways at Fortwilliam Park to a favourite suburb about 6 miles distant. The company was incorporated in 1881 and its capital is £60,000 in £1 shares, of which £83,205 has been called up. There is also £20,000 in 4½ per cent. mortgage debentures.

Blackburn.—For the first time in their existence the electric tramways show a profit on the past year's working.

Bolivia.—In the town of Oruro electric lighting has recently been introduced, and also tramways; the latter are, however, horse-hauled.

Charing Cross, Euston & Hampstead Railway.—It is expected that this line will be ready for opening in June. The stations are Charing Cross, Leicester-square, Oxford-street, Tottenham Court-road, Euston-road, Euston, Mornington-crescent, Camden Town, Chalk Farm, Belsize Park, Hampstead and Golder's Green, and on the Branch to Highgate from Camden Town, South Kentish Town, Kentish Town, Tufnell Park and Highgate. The fares will range from 1d. to 3d. (the maximum).

Chichester.—Chichester & District Electric Lighting Co. have notified the Council that they propose to carry out the terms of their provisional order, and to establish electricity works in the town.

City & South London Railway.—May 11 has been fixed for the opening of the Angel to Euston extension of this railway by the chairman of the London County Council, Mr H. Percy Harris.

Denmark.—Our Danish correspondent informs us that the Corporation of Odense have decided to establish electricity works at a cost of 1,050,000 kr. (about £27,900).

Copenhagen municipal electricity works are to be extended at a cost of 2,450,000 kr. (£66,354). The extensions will include building work, four boilers, economiser and two steam turbine-generators, mains extension, &c. 15,000 kr. (£406) are to be expended upon plans for a new station.

Devonport.—The Electricity committee has entered into an agreement with the Admiralty for the supply of electric current to the R.M.L.I. Infirmary at Stonehouse.

Dublin.—The question of the acceptance of a tender for turbo-alternators (referred to on pages 32 and 34 of our last issue) was again discussed at a special meeting of the Corporation on Tuesday, when the Town Clerk reported that a letter had been received from Messrs. Dick, Kerr & Co. complaining of alleged misstatements made at the last Council meeting regarding their turbo-alternator.

The Town Clerk also read a letter from Messrs. Willans & Robinson making a similar complaint regarding their tender, and a letter from Messrs. Casey & Clay (solicitors for Messrs. Willans & Robinson) asking the Council not to seal any contract at present, but to afford an opportunity to their clients of placing before the Lighting committee all the circumstances of the case. A letter was also read from Mr. Mark Ruddle, city electrical engineer, declining to accept any responsibility in connection with the acceptance of a tender which he had formally reported to be not in accordance with the specification drawn up by him.

Ald. Irwin moved that the communications be referred to the committee for report, but after an amendment that the letters be marked "read" had been rejected, the Council was counted out, and the matter dropped.

Ealing.—The Council have rejected the amended offer of the Metropolitan Electric Supply Co. for supply of energy in bulk.

The borough electrical engineer (Mr. J. D. Knight) reported that the offer was not sufficiently advantageous to justify the abandonment by the Council of their own generating plant.

In reply to a question the chairman of the Electric Light committee (Ald. Peel) said it was not practicable to adopt a supplementary supply, and it would be unsatisfactory to have two different systems.

Electric Traction in Austria.—It is reported that the Ministry of Railways is considering plans for the introduction of electric traction on all the State railways in the western part of Austria, embracing the lines between Vienna and Bregenz and Salzburg and Trieste. It is proposed to use water power available in the districts for the generation of electrical energy, and an engineering commission has been engaged for some months in investigating the amount of power available.

Electricity in Spinning Mills.—Kearsley Spinning Co, Farnworth, near Bolton, has paid a dividend of 10 per cent. on the half-year's turnover. This mill is driven by electricity generated on the premises and is claimed to be the first spinning mill in the country to be driven by energy so generated.

Erith.—An inquiry was held last week into the application of the Council for permission to borrow £30,000 for the extension of the electricity undertaking.

Felixstowe.—The Council have decided to borrow £13,610 at 3⅞ per cent. to clear off the temporary bank loan for the electricity works.

Fulham (London).—The borough electrical engineer (Mr. A. J. Fuller) has been instructed to test (during the summer months) the value of the destructor for steam raising.

The question of obtaining two additional underfeed stokers for the boiler house is under consideration.

Halifax-Huddersfield Tramways.—The National Electric Construction Co. have intimated to Elland Council that they are prepared to carry this scheme through, having already spent about £10,000 upon it.

Hanley.—The Electric Lighting committee reported to the Council on Tuesday that they had considered the accounts of the electricity department for last year, together with the annual report of the borough electrical engineer (Mr. C. H. Yeaman), and they recommended that out of the surplus of £2,157 a sum equal to a 1d. rate be allocated to the general district fund, and that the balance be transferred to the depreciation and contingency fund.

Mr. Walton Stanley moved as an amendment that the whole of the surplus be devoted to the necessary repairs, alterations and extensions of the generating plant, &c.

After discussion only two voted for the amendment, and the recommendation of the committee was confirmed.

Italy.—Rome Municipality are considering a scheme for the establishment of a municipal electricity supply undertaking, for which it is proposed to raise a loan of 3,605,000 lire (about £144,200). It is stated that tenders are to be invited for supply of plant, cables, &c.

L.C.C. Electricity Supply Bill.—It is stated that the report of the Highways and Parliamentary committees, to be presented to the London County Council on Tuesday next, will recommend the introduction of numerous amendments in this bill. The following are stated to be the main points of the new scheme which has been drawn up:—

Second reading of the bill to be proceeded with, but certain clauses to be deleted.

A new clause to be inserted when the bill reaches Committee stage, giving the Council powers to purchase, within a certain period, existing undertakings in the event of the Council failing to arrive at an agreement with the companies for the future working of their undertakings on lines to be approved by the Council.

Proposed coalescence of existing undertakings for the purpose of uniform working throughout London.

The companies to provide four generating stations to serve the Metropolis—one in the east, one in the west, one in the south and one in the north.

Maximum of 1d. a unit to be charged by the companies.

The consideration to the companies to be an extension of the time within which their undertakings cannot be acquired except by expropriation.

The clause in the bill conferring powers to work the undertaking is to be struck out. It is also intended to limit the period within which the purchase of the undertaking can be made, in the event of no agreement being come to with the companies for coalescence and uniformity, to two years.

London County Council.—At Tuesday's sitting the Finance committee recommended that a loan of £49,136 be granted to Marylebone for electric lighting, but added that in view of the large sum which the borough council had expended upon their undertaking they had informed them that, while appreciating its statutory obligations with regard to the supply of electricity, they would feel great difficulty in recommending the Council to sanction any further loans therefor, and that only loans for such additional expenditure as is absolutely necessary would be considered.—Carried.

Construction of Electric Cars by Direct Labour.—The report of the Highways committee, adjourned from March 12, recommending that 50 bodies of electric cars be constructed by the Tramways department at an estimated cost of £23,150 was again adjourned.

Strand Subway.—The adjourned report of the Highways committee recommending that the resolution with reference to the acquisition of property for the construction of a subway station at the Strand was brought up for further consideration and agreed to.

Westminster Technical Institute.—An expenditure of £1,510 in respect of the installation of arc and incandescent electric lighting, bells, telephones and lightning conductors at this institute was agreed to.

Greenwich Generating Station.—The Highways committee recommended that the erection of the superstructure of the second portion of the Greenwich generating station be carried out by the Works department at an estimated cost of £47,940.—Agreed.

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Woolwich Tramways.—It was agreed that the roadwork and plate-laying in connection with the construction of tramways for Woolwich and Plumstead be carried out by the Works department on a schedule of prices based on those for which the department have undertaken the construction of the new tramways from Lewisham to Lee Green.

L.C.C. Tramways.—May 4 has been fixed for the official inspection of the new line from Lewisham to Lee Green.

Manchester.—The manager of Manchester Corporation tramways (Mr. J. M. McElroy) and the manager of the Salford Corporation tramways (Mr. G. W. Holford) have drawn up a report recommending the principle of through tramcars, and the Corporation are asked to sanction through cars for some months over one important route with a view to a practical demonstration of the utility of the scheme before it is more widely adopted. Tickets issued by each Corporation would be sold by the conductors in the administration area of the issuing Corporation only.

The Tramways committee have decided to contribute £55,000 out of profits to relief of rates.

Municipal Accounts.—At the annual meeting of the Association of Municipal Corporations last week, the chairman (Mr. J. S. Harwood Banner, M.P.) referred to the question of municipal accounts and expressed regret that no action was taken by the late, or had as yet been taken by the present, Government to deal with the recommendation of the Joint Committee of Lords and Commons in reference to municipal auditing. The principal point of that recommendation was that professional auditors should be appointed in place of the present elective auditors, and certainly in priority to L.G. Board auditors.

Municipal Telephony.—The balance sheet of the Hull municipal telephone department was presented at the meeting of the Telephone committee on Monday.

The Chairman (Ald. J. BROWN) complimented the committee and the manager upon the year's working. The year's revenue amounted to £8,989 and out of that they had spent on repairs £1,200. 6s. 2d.; wages, £1,959; rent, £636. 13s. 10d.; P.O. royalties, £909. 14s. 1d.; and other expenses, £136. 9s. 9d. The balance was £4,146. 15s. 9d. out of which they had paid interest £1,527. 1s. 6d., and repayment of loan £1,231. 1s. 8d., which left a balance profit of £1,388. 12s. 7d. to be placed to reserve. The position of the concern was that, having paid interest and all other charges and written off capital £2,340. 5s. 1d., they had a reserve of £1,791. 15s. 4d. That was after only two years' working.

Mr. GRINDELL urged that they should write off 10 per cent. for depreciation of the instruments.

The CHAIRMAN said the capital outlay was £52,000. They had written off £2,340. 5s. 1d. and had a reserve of £1,790.

Municipal Works Department.—Some time ago Manchester Corporation appointed a sub-committee of three (Ald. Jennison and Councillors Johnston and Smethurst) to consider and report upon the advisability of creating a works department. The members visited the London County Council and Battersea works departments, and on Wednesday three reports were issued by the sub-committee, one being signed by all three representatives, the second by Ald. Jennison and Councillor Smethurst, and the third by Councillor Johnston.

The second report is adverse to the establishment of a works department, and summarises some of the objections as follows:—

1. The legitimate functions and duties of our municipalities are already large enough, if not, indeed, more than enough, to tax all their energies and fill up all their time.
2. It will involve an immense increase in municipal debt.
3. It will more and more involve municipalities in labour disputes.
4. As there will not be the same stimulus to economy and attention there will be a great probability, not to say certainty, that the service will cost more than it ought to do.
5. It will be a serious check to progress and discovery. The proposal to centralise the workshops of the gas, electricity, tramways and water-works departments would cause much confusion, irritation and loss. The inquiries made from London County Council, Battersea and elsewhere satisfied them that Manchester Corporation would not gain either in efficiency or economy by the establishment of a works department.

On the other hand, Councillor Johnston takes the view that his inspection of the work done by the London County Council through their works department confirmed his anticipation that work produced under such conditions would be of the best, generally superior to the ordinary contractor's work. In addition, the cost had been less than similar work executed by contractors, but if that result had not been obtained the lessened cost of maintenance due to good work would compensate a public body even if a higher first cost had been incurred. There could be no fear of the failure of a works department if care was taken to appoint capable and efficient officials and foremen to supervise the work and the workmen.

A deputation from the Manchester, Salford and District Property-owners' Association waited on the Lord Mayor yesterday (Thursday) to protest against the formation of a works department.

New Talc Mines in Styria.—In the district of Floing, Styria (Austria), which is about 4,300 ft. above the level of the sea, various talc mines have been explored, and the reports of mining experts testify to the richness of the mines and the extremely pure white and slippery quality of the talc. All the mines have now been acquired by Mr. Edward Elbogen, of Vienna 3/2, who is proprietor of nearly all the large talc mines in Austria. Mr. Elbogen has, in consequence, been compelled to make considerable additions to and extensions of his refinery works.

Personal.—Mr. Percy Rosling, M.I.E.E., for a number of years manager of the Leeds Office of the British Thomson-Houston Co. and recently on the staff at head office, Rugby, is leaving shortly for Australia to accept a very responsible position. On his departure from Rugby he was presented on behalf of his friends on the staff of the B.T.-H. Co., with a silver rose bowl.

Poplar (London).—Last week the Council considered a report from the borough electrical engineer (Mr. J. H. Bowden).

The report stated that certain extensions of the plant and mains were necessary, including an additional 500 kw. motor converter at the southern sub-station, and that an additional e.h.t. feeder, capable of carrying 500 kw., was necessary and a low-tension feeder. The estimated capital outlay was £9,000—*i.e.*, boiler £2,800, economiser £1,000, chimney £800, converter £1,550, e.h.t. feeder £1,880, h.t. feeder £1,000, contingencies £50.

The Electricity committee stated that they had considered the possibility of meeting the difficulty either by (1) accumulators, (2) bulk supply from another undertaking, (3) discontinuing public electric lighting, wholly or partially, (4) arranging with consumers not to take current on the peak of the load. With regard to these alternative suggestions Mr. Bowden had reported that the estimated cost of accumulators was £6,750, in addition to cost of extension of buildings. There was no probability of obtaining bulk supply for a peak load only, and the best terms yet suggested for a bulk supply (viz., in the projected L.C.C. Electric Supply Bill) would involve a rental of £3. 15s. per kilowatt for 500 kw., equal to £1,875 per annum, and a further charge of 0·22d. per unit for current supplied, in addition to an expenditure of about £2,500 for transformers and mains. The only present available bulk supply was that of the Charing Cross Co., who quoted £4 per annum for each kilowatt of maximum demand, and 0·5d. per unit for all energy delivered untransformed, which was the price the Council now charged for transformed current. The discontinuance of the public lighting would not materially influence the present capital requirements. As to asking consumers not to take current on the peak, Mr. Bowden advised that it was most undesirable, as any uncertainty as to the ability of the Council to meet all demands would considerably retard the progress of the undertaking and be prejudicial to its financial success.

In view of these representations, the committee thought the suggested extensions were necessary and inevitable. They did not propose to proceed with the low-tension feeder, and the economiser would be dispensed with, while the provision of a chimney would be included in the boiler contract. The revised figures amounted to £5,950, and the committee recommended the acceptance of the tenders set out in our last issue (p. 34).

Consideration of the report was adjourned.

Preston.—The Fire, Lighting and Tramways sub-committee recommend that the central area of the town be lighted by 64 6 amp. arc lamps, to be supplied with current by the National Electric Supply Co.

Provisional Order Revocation.—The Board of Trade have revoked the Egremont Electric Lighting Order, 1900, as from April 8.

Southport.—At a special meeting of the Council on Tuesday Ald. Unwin announced that the electricity department had contributed £2,750 to relief of rates.

Southwark (London).—The firm of accountants called in to report upon the financial position of the electricity undertaking state that, so far as they have been able to ascertain, the only fund for renewals is the reserve.

The instalments paid off capital were not a satisfactory method of providing for renewals, as the L.C.C. would not permit the renewing of any portion of the loan until it had been paid off in its entirety, and, therefore, with the exception of £2,925, which should be repaid by 1912, there would be no further sum available at the present rate of repayment of the loan until 1942. It would, therefore, seem that not only should a charge for repayment of capital be made (as at present), but also a further charge in respect of renewals. It was impossible to say what this further charge would be without engineering advice, but, calculated on the basis adopted by the L.C.C, the provision should be as follows:—Buildings, 2 per cent. per annum; mains, 3½ per cent.; plant, 5 per cent.; house connections, 8½ per cent.; meters, 10 per cent. In the case of the Southwark undertaking there would require to be set aside, on the foregoing basis, for 1905-6 about £4,000, equivalent to between 4½ and 5 per cent. on total capital expenditure. With the exception of Islington, the cost per unit was higher in Southwark than in any of the other metropolitan boroughs whose results are published. This might be partly owing to the Southwark undertaking being the smallest of the 12. Southwark had a higher cost of coal consumption (0·73d. per unit sold), while Bermondsey (next in point of size) spent 0·38d. per unit. Wages cost in Southwark was the largest (0·28d. per unit), Shoreditch coming next with 0·27d. per unit, Under repairs and maintenance Islington spent most, with 0·44d., Shoreditch 0·42d., Southwark 0·34d.

The Electric Lighting committee point out that, worked on this basis, the depreciation to date would amount to £18,071, whereas repayments of loans to date only amount to £8,190, which added to the reserve (£773)

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makes £9,963. If, however, the rates recommended by the borough electrical engineer (Mr. D. M. Kinghorn) be taken, the undertaking has a depreciation to date of £16,142, against £9,142 provided for, but if a fair sum is placed to reserve the £6,900 deficiency is likely to be met before any serious charge for renewals is necessary. In future the reserve is to be called the "Renewal Reserve," and no items or ordinary repairs or small renewals will be charged to it, and the amount placed to renewal reserve will be decided independently of the profits and be in no case less than the actual profits earned until the reserve fund represents the difference between the actual value of the plant (after depreciation has been deducted) and the net sum represented by plant as an asset in the balance-sheet.

Stepney (London).—London County Council have intimated that their Finance committee purpose to vary the maximum period which will in future be sanctioned for repayment of electricity loans. The existing periods (in parentheses) and the proposed new conditions are as follows: Freehold land (60 years) 60, buildings (42) 50, mains (42) 30, plant (42) 20, house services (42) 12, meters (10) 10.

In a lengthy report by the consulting and borough electrical engineers (Mr. A. Wright and Mr. W. C. P. Tapper) the proposals of the L.C.C. are criticised, particularly those relating to mains, plant and house services, and the conclusion which the engineers arrived at is that, if the L.C.C. carry them into effect, the reductions in the periods would operate prejudicially to a successful financial working of electricity undertakings established by the London borough councils. The Electric Lighting committee endorse this view, and recommend that London County Council be asked to reconsider their decision.

Sweden.—The consumption of electrical energy in Stockholm during 1906 was 11,560,000 units, compared with 8,540,000 in 1905.

The Postmaster-General and Tramway Undertakings.—On Monday a deputation from the Municipal Tramways Association waited on the Postmaster-General to make representations against the proposal of the Post Office authorities to insert a new clause in the bills promoted by London County Council and the Corporations of Glasgow, Huddersfield, Leeds, Manchester, Rawtenstall, Sheffield and West Ham, which will enable the Post Office to attach telegraph wires to posts or standards erected in the public roads in connection with the tramways authorised by those bills.

Bailie M'Farlane (Glasgow) introduced the deputation, which included representatives from the London County Council and the Corporations of Glasgow, Liverpool, Sheffield, Manchester, Salford, Leeds, Reading, Sunderland and West Ham. Mr. J. M. M'Elroy, tramways manager at Manchester, acted as spokesman for the deputation, who considered that such far-reaching proposals as were being made should not have been presented so late in the session, but should have been submitted direct to the municipalities before going to Parliament. They admitted there was something to be said in favour of minimising the number of posts and standards erected in public thoroughfares, but urged that care be taken that the public interest does not suffer. The Board of Trade had made regulations for guarding against accidents by compelling the erection of guard wires over the trolley lines where there was danger of telegraph and telephone wires falling or being blown over a trolley line. Tramway authorities were generally of opinion that these guard wires added to the public danger rather than diminished it, and they thought the time had arrived when the question should be considered whether the public was amply protected from accident, and whether it was just that tramway authorities should be compelled to pay the whole cost of providing that protection. It was not the cost of putting in fuses and heat coils to protect the property of the Postmaster-General which they were fighting against. They wished to come to some arrangement whereby the public might be protected against accident. They suggested, however, that any legislation dealing with the subject ought to be by way of public bill, general in its character, rather than by private bill dealing with localities in detail.

The POSTMASTER-GENERAL, in reply, promised to arrange for a further conference with a view to coming to an amicable arrangement with the representatives of the municipalities.

Tramway Bye-Laws.—East Ham Tramways committee have decided to adopt the standardised bye-laws drawn up by the conference of tramway managers in the eastern Metropolitan area, to be applicable to all cars running within the area of the various authorities.

The electrical engineer and manager (Mr. W. C. Ullmann) is preparing plans and estimates for additional cooling plant.

Underground Telegraph Cables.—A second underground telegraph cable between London and Birmingham is being put down. The first cable comprises 70 lines and the new one will contain 200. Only the portion of the new cable from Birmingham to Olton has been laid up to the present.

Wandsworth (London).—The County of London Electric Supply Co have intimated the L.C.C. that, without prejudice to any appeal to the Board of Trade which it may decide to make at any future time, it is willing to establish as a beginning seven testing stations in the district. The Highways committee of the L.C.C. have informed the Borough Council that additional testing stations should be provided, but that these seven stations may be accepted as a commencement. The company has, therefore, been called upon to provide these stations.

Watford.—The adjourned L.G. Board inquiry into the application of the Council for permission to borrow £8,979. 3s. 7d. for electric lighting extensions was resumed last week.

Originally sanction was asked to borrow £13,500, but this figure has been amended and certain items excluded. After hearing evidence, the inspector (Mr. H. Ross Hooper) adjourned the inquiry until to-day (Friday).

West Africa.—In an interesting report on the trade of French West Africa for 1905-6, Capt. Cromie, British Consul-General at Dakar, states that the trans-Saharan telegraph to join up the French Algerian and West African systems has been jointly studied by the administration of these two French colonies, and that a definite scheme has now been drawn up. The line is to strike the river Niger at Burrem, which is not at present connected with the French West African system. For this purpose a new line is to be constructed from Timbuktu to Burrem, thence to Niamey and Zinder. This will allow the utilisation of the trans-Saharan line when it is made, and will immediately place the Zinder-Lake Chad region in telegraphic communication. The total length of the line will be 1,075 miles, and the estimated cost is £80,000.

West Ham.—In a communication from the L.G. Board as to the Council's application for sanction to loans for the electricity department (£4,308 and £13,326 to defray excess expenditure in respect of the Abbey Mills and Canning Town stations, £17,505 for additional plant, £17,212 for the extension to Silvertown and £23,300 to meet prospective expenditure on cables, meters and transformers) it is stated that the Board found that the excess expenditure arose almost entirely, not from the insufficiency of the original estimate, but from the failure of the Council to provide out of revenue £18,229, which, when sanctioning the loans amounting to £218,460 in 1903, the Board deducted as representing the debt outstanding on the Abbey Mills station, which was to be superseded. After going into figures the Board stated that, on receipt of information showing how the Council proposed to find £14,161, the amount for which the Board were not prepared to sanction loans, they would give their sanction to the borrowing of £992, £2,680, £17,076 and £23,300.

The borough treasurer reported fully on the matter and recommends that the L.G. Board be asked to further consider their decision. In the meantime, the Finance committee would have an opportunity of considering the best means of providing the sums not sanctioned. This course was adopted.

The Electricity committee have authorised the borough electrical engineer and manager (Mr. A. Hugh Seabrook) to undertake small motor wiring orders for execution by the men fixing the motors where the estimated cost of such works does not exceed £5.

Will.—The will of the late Mr. John Willey, managing director of the London Electric Wire Co., has been proved, the value of the estate being £65,791.

Jubilee Dinner.—There was a representative gathering of railway, colliery and electrical men at the Hotel Great Central, London, on Wednesday evening to celebrate the jubilee of the business of J. B. Saunders & Co, electrical engineers, Cardiff and London. For 50 years this firm has carried out the installation of light and power plants and signalling, also bell and telephone equipments for railways and collieries. Mr. W. H. R. Saunders, son of the founder, in acknowledging the toast of "The Firm," proposed by Sir J. Szlumper, said he was one of the few men who could boast the possession of a double-needle telegraph instrument. Mr. C. Lundie, a veteran railway engineer of 92, supported the toast, and recalled the foundation of the firm in 1857. The company included many engineers from the South Wales district. Messrs. J. H. P. Berthon and S. G. Leech took the vice-chairs at the dinner table.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Blackpool.—In a preliminary report of the borough electrical engineer (Mr. Chas. Furness) it is stated that the output of the electricity department for the year ended March 31 was 3,404,311 units (1,429,256 for private lighting, 282,251 for public lighting, 1,261,946 for Corporation tramways, 122,075 for Lytham and St. Annes, and 308,783 units used on works, motors and works lighting, &c.), compared with 3,154,325 units in 1905-6.

Mr. Furness states that the coal consumption, nothwitstanding the increased output, shows a further reduction—viz., 8,582 tons at £4,150, compared with 9,987 tons at £4,517. There has been a steady increase in the number of customers and in the demand from private electric light consumers since the reduction in the lighting charge in 1905. There were 66 new consumers in 1906 and 58 in 1907. Mr. Furness estimates that the increase in revenue from private lighting will exceed £17,749, the figure reached in 1905 when the charges were 7d. and 2d., and should this prove the case the department will have recovered in two years the sacrificed revenue of approximately £1,800 represented by the reduction to 6d. per unit. When the official figures are available the result of the past year's working will show an available surplus exceeding

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£8,000 (against £6,120 in 1906 and £5,900 in 1905), after meeting all expenditure on revenue account and providing for interest and sinking fund charges.

The profit on the electric tramways for the past year amount to about £10,000, of which it is reported that one-half will go to relief of rates.

Bolton.—The income of the electric tramways for the year to March 31 was £111,294 and the expenses £61,563. Out of the net profit £9,079 is to go in relief of rates. The number of fares collected during the year was 23,410,690, over 2,000,000 more than in the preceding year.

Huddersfield.—The profit on the working of the tramways for the past year (about £5,000) will be transferred to the district rate fund.

Rochdale.—The sum of £2,500 has been transferred from the profits on the past year's working of the electricity department to relief of rates.

There is also a profit of £2,893. 4s 7d. on the electric tramways, but after paying the loss on the steam tramways during the process of reconstruction (£4,637. 4s. 2d.) there is a deficit of £1,743. 19s. 7d.

Rotherham.—During the year 1906 7 the electricity department sold 1,388,999 units of electrical energy, which realised £11,127.1s 1d. (or 1·923d. per unit), compared with £10,524 5s 11d. (2·030d. per unit) in 1905-6.

Generating expenses, at 0·468d. per unit, show a reduction, as also do the other expenses, except rates and taxes. Gross profit was £6,315, compared with £5,823. 16s., and, after paying loan charges, the net balance is £2,332. 6s. 1d., out of which £1,924. 11s. has been transferred to depreciation and renewals, leaving £407. 15s. 1d., which, added to previous year's surplus, gives an available balance of £562. 13s. 6d.

The traffic receipts of the tramways department were £26,916. 14s. 5d., representing a car mileage of 618,211 (10·45d. per car-mile), an increase of 0·65d. per mile. After debiting working expenses and repairs, the balance is £8,712. 13s. 10d., and after paying loan charges the net balance is £4,201. 3s. 6d., which has been transferred to renewals and depreciation fund. During the past year £6,616 was expended on capital account, and £5,000 borrowed on mortgage.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

London County Council invite tenders for the manufacture, delivery and erection of (*a*) six fuel economisers at its tramway electricity generating station, East Greenwich, (*b*) h. and l.t. switchgear for five tramways sub-stations (with basements), and (*c*) h. and l.t. switchgear for three tramways sub-stations (with galleries). Tenders to the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring Gardens, S.W., by 10 a.m. May 7 for economisers and 11th June for switchgear See also an advertisement.

London County Council want tenders by 10 a.m. May 7 for supply of about 100,000 tons of coal (North Country washed nuts) to East Greenwich generating station.

London County Council also want tenders by 10 a.m. April 30 from specialists for manufacture and erection of two electric lifts at the Central School of Arts and Crafts and the London Day Training College. Forms from the Chief Engineer, Spring-gardens, S.W.

Bristol Electrical committee invite tenders for a.c and d.c. flame arc lamps, to be supplied and delivered within the city. Specifications, &c., from the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol, to whom tenders by 10 a.m. of May 20. See also an advertisement.

Barnes District Council invite tenders for supply, delivery and erection of a section of steam exhaust and other piping. Tenders to the Clerk, Council House, High-street, Mortlake, by noon of Tuesday, May 14. See also an advertisement.

Pembroke (Co. Dublin) Council invite tenders for supply and erection of a high-speed reciprocating engine, direct-current dynamos, switchboard and instruments, accumulators, tubular boiler, arc lamps and gear and arc lamp-posts Tenders to the clerk (Mr. J. C. Manly), before noon May 4.

Malvern Gas and Electricity committee invite tenders for supply of stores for the electricity department for the ensuing 12 months, including bitumen, joint and junction boxes, oils, waste and cleaning materials, house fuse boxes and electricity meters. Tenders to the town clerk (Mr. H. L. Whatley) by 29th inst.

Islington (London) Lighting committee invite tenders for supply and erection of a fan (12 ft. diam.) and a single-phase alternating-current motor. Tenders to the town clerk (Mr. W. F. Dewey), Town Hall, Upper-street, N., by noon May 8.

Wolverhampton Electricity committee invite tenders for boilers, economiser, feed pumps, steel chimney and feed-water tank, and also for turbo-alternator generating sets and condensing plant. Tenders to Chairman by noon May 2.

Luton Corporation want tenders by noon May 3 for a boiler, stokers, 500 kw. steam generator, condensing plant, feed pump, pipework, coal bunkers, elevators and conveyors, &c. Specifications from the Borough Electrical Engineer.

St. Pancras (London) Council invite tenders for supply of arc lamp carbons for 12 months. Tenders to town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras-road, N.W., by noon May 13.

Huddersfield Corporation want tenders by 10 a.m. May 8 for locomotive electric crane, grab and traverser. Forms from Borough Engineer and Surveyor.

Walthamstow Council want tenders by 5 p.m. May 3 for supply of stores for the electricity and tramways departments, including cables, carbons, electrical fittings, car accessories, &c.

Moss, Rimmington & Co., *Selby*, invite tenders for the equipment of their works for electric, steam or gas driving (200 to 300 H.P.).

Great Yarmouth Corporation invite tenders by noon May 2 for supply of 6,500 tons of Scotch anthracite peas coal.

Aston Manor Corporation want tenders by May 11 for h. and l.t. three-phase cables for Erdington lighting extension.

Croydon Corporation require tenders by 11 a.m. May 6 for boiler feed pipe-work and new flue and economiser set.

The Deputy Postmaster-General, *Hobart*, Tasmania, wants tenders by noon, June 17, for supply of common battery telephone material. Forms obtainable and schedule to be seen at the General Post Offices, Hobart, Sydney, Melbourne, Brisbane, Adelaide and Perth.

Antwerp Municipal authorities invite tenders for supply of electric lift and crane appliances. Specification from the Hotel de Ville. Tenders (in sealed registered envelopes) to M. le Bourgmestre de la Ville, Hotel de Ville, Antwerp, by May 6. A deposit of 3,000 fr. (about £120) is required to qualify any tender. A copy of the specification may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

Copenhagen (Denmark) Corporation want tenders by noon May 21 for four water-tube boilers, with superheaters and mechanical stokers. Specifications from Elektrisk Station, Gothersgade 30, Copenhagen, K., on deposit of Kr.30 (about 16s. 6d).

TENDERS RECEIVED AND ACCEPTED.

West Suffolk Standing Joint committee have accepted the tender of Faraday & Son for supply of electric light fittings for the Shire Hall at £100, and that of Higgins & Griffiths for electric cover plates at £13. 13s.

Paddington (London) Council have accepted the tender of C. Mickleburgh to maintain the electric light installation at £37. 10s. and to maintain the electric fans in the Council chamber at £3 per annum.

The tender of T. Larmuth & Co. has been accepted by London County Council for supply of eight overhead travelling hand cranes at £1,427. There were 16 tenders and the accepted one was the lowest except one which did not accord with the specification.

Two tenders were received by London County Council for special trackwork at the Elephant and Castle, the Lorain Steel Co., of America, at £2,650, and Hadfield's Steel Foundry Co., £2,875. That of the latter company was recommended for acceptance.

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A Babcock & Wilcox boiler has been ordered by the Eastern Bengal State Railway administration for the Chitpore electrical installation at R.23,500 (about £1,567).

Eccles Corporation have accepted the tender of the Tudor Accumulator Co. for the supply of a storage battery and automatic reversible booster at £1,419.

Feltham (London) Council have accepted the tender of Kaye & Sons to supply during the year 2,000 tons of Belwoth Peas at 8s. 5d. per ton delivered alongside Council's wharf.

Preston Tramways committee have accepted the tender of the United Electric Car Co. for 10 top-deck covers at £120 each.

Battersea (London) Council have accepted the tender of Callender's Co. for the purchase of scrap copper at £103 per ton.

Veritys Limited inform us that Bristol Corporation have placed a contract with them for motors and starters.

West Ham Council have accepted the tender of the British Thomson-Houston Co for a Tirrill regulator at £82.

Bruce Peebles & Co., Edinburgh and London, have received an order from Cardiff Corporation for a 250 kw. Peebles motor converter.

BUSINESS NOTICES.

Messrs. Mountain & Gibson (Ltd.), electrical tramway and railway engineers, Elton Fold Works, Bury, Lancs., have removed their London offices to Albert-buildings, 49, Queen Victoria-street, E C. Telephone, 2023 Bank; telegraphic address, "Girders London."

The care of the London sales department will be in the hands of Mr. F. W. Newman (director), as heretofore, but owing to the increased volume of business, he will be joined by Mr. N. McL. Lawrance, director (from the works), who will attend more particularly to the engineering and technical work. The business of the firm has very largely developed recently. Some extensive additions have been made to the works at Bury; the plant has been reorganised and added to, and the works are very fully employed. The orders which the firm have in hand include complete tramcars (including trucks) for Llandudno, Delhi, Coventry, Portsdown and Horndean; and trucks for Nottingham, Leyton, West Ham, Wemyss, Pontypridd, Birkenhead, Stalybridge, Dublin, Bury, Derby, &c., and for Calcutta and Montreal. In addition, the firm have recently secured the contract from London County Council for supply of 300 pairs of maximum traction trucks, similar to 350 pairs previously supplied. This recent order represents the fifth consecutive order which the Council have placed for Mountain & Gibson's improved type of centre-bearing swing-bolster maximum traction trucks, making a total of 650 cars which will be mounted upon this special design. Other orders include a large number of patent radial trucks, which type of truck is being very favourably considered by tramway engineers. The firm have added many important improvements, and have modified the designs of their various classes of trucks to meet the requirements of up-to-date tramway practice. Many of these are shown in an instructive pamphlet recently issued describing their manufactures.

Mr. Walter R. Rothenberg, late of the Electromotor & Dynamo Co., has joined E. P. Allam & Co., of 11, Red Lion-street, Clerkenwell-road, E.C., who have also appointed Mr. C. B. Converse to represent them in the London district, vice Mr. Walter Baker, resigned.

Mr. Chas. Pullan, of Bradford, Swinton, Otley and Shipley, has opened a branch at 19, Duke street, Cardiff, to deal with the South Wales business, and Mr. Brinley Rees has been appointed his representative in that district.

Chas. John Utley and Tom Standley (trading as C. J. Utley & Co.), electrical and general engineers, Overton-road and Quenby-road, Leicester, have dissolved partnership. Debts by Mr. Standley.

The Adams Mfg. Co. (Ltd.), have removed from 147, Queen Victoria-street, to 106, New Bond-street, W.

BANKRUPTCIES, LIQUIDATIONS, &c.

The abstract of the accounts of the receiver and liquidator (Mr. Wm. Rowe) of Headley Limited, Truro, shows a balance in hand of £14. 2s. 5d., but it is anticipated that this sum will be absorbed by out-of-pocket expenses and remuneration of liquidator. Creditors will therefore get nothing. Receipts amounted to £1,593. 15s. 9d., and included £59. 18s. 6d. trade debts received prior to appointment of receiver and £1,559. 14s. 1d. from sale of stock, book debts, &c., but all moneys collected had to be paid into Court to meet the debenture holders' claims.

Mr. J. W. Close, East Parade, Leeds, has been appointed (with a committee of inspection) as liquidator of McPhail & Simpson's Dry Steam Patents Co. (Ltd.)

At the Liverpool Bankruptcy Court last week, Judge Shand granted an application for confirming a composition of 7s. 6d. in the £ to the creditors in the failure of Thomas E. R. Phillips, electrical engineer, 15, Nicander-road, Liverpool. Unsecured liabilities £304, assets 16s.

A supplemental dividend of 10¾d. is payable at the O.R.'s, Byrom-street, Manchester, in the bankruptcy of Walter Morton and Walter T. Sampson, electrical and mechanical engineers, Trinity-buildings, Warrington.

Claims against the British Uralite Co. (Ltd.) to the liquidator (Mr. R. L. McLaren), 16, St. Helen's-place, E.C., by May 31.

A meeting will be held on May 27 at 9 and 10, Fenchurch-street, London, E.C., to receive an account of the winding up of the Raymond Phillips Electric Railway & Tramway Equipment Co. (Ltd.)

A meeting will be held at 35, New Broad-street, London, E.C., on May 22, to receive an account of the winding up of the Pioneer Electric Light & Power Co. of India (Ltd.)

A meeting to receive an account of the winding up of the Northern Engineering Co. (Ltd) will be held at Somerset House, Halifax, on May 27.

Deed of Assignment.—A deed of assignment has been executed by Albert Rutherford, electrical engineer, 2, Station-road, Church-end, Finchley. Claims by May 15 to Mr. E. H. Stringer, 110, Cannon-street, London, E.C.

Sales by Auction.—Messrs. Wheatley Kirk, Price & Co. have been instructed by the receiver of Lionel Robinson & Co. (Ltd), (Mr. Herbert J. Page, F.C.A.), to sell by public auction, piecemeal, at an early date, the entire contents of the Ferry Electrical Works, Thames Ditton, Surrey. Catalogues are in course of preparation and will include 15 H.P. Crossley gas engine and producer plant, 15 lathes, including sliding, capstan, screw cutting, plain and other lathes, milling machines, electric lighting and testing installations, complete sets of testing instruments, shafting, loose tools and utensils for a hundred hands, office furniture, &c. Catalogues (gratis) shortly from the auctioneers, 14, Watling-street, London, E.C., and Albert-square, Manchester. See also an advertisement.

Messrs. Fuller, Horsey, Sons & Cassell have been instructed by the Lords Commissioners of the Admiralty to sell by auction at H.M. Dockyard, Sheerness, on May 14 and following days, at 11:15 a.m. each day, old and surplus stores, including old leather and india-rubber, 300 tons of old iron, 15 tons of foundry ashes, 31 tons zinc ashes and bottoms, a quantity of electric cable, cells and electrical gear (various), 50 tons scrap brass and copper, 107 tons old brass, obsolete machine tools, including lathes, planing and slotting machines, &c. May be viewed three working days prior to and on morning of sale. Catalogues (6d. each) at the Dockyard, and of Messrs. Fuller, Horsey, Sons & Cassell, 11, Billiter-square, London, E.C. See also an advertisement.

Messrs. Fuller, Horsey, Sons & Cassell have also been instructed to include in the sale at Sheerness Dockyard a quantity of old and surplus stores lying at H.M. Dockyard, Devonport. May be viewed at Devonport Dockyard, but will be sold at Sheerness Dockyard as above. Catalogues (6d. each) at either yard, or of Messrs. Fuller, Horsey, Sons and Cassell, 11, Billiter-square, London, E.C. See also an advertisement.

Motor Wanted.—Messrs. T.W. Lench (Ltd.), Blackheath, Staffs., require a secondhand a.c. motor (about 10 H.P. to 15 H.P.) with all accessories.

Agency Required.—An advertiser desires an agency for Holland in electric light and gas fittings, &c.

Manufacturers' Representation in Canada.—An electrical engineer, with extensive colonial experience, advertises that he is leaving for Canada on a five months' tour, and is desirous of representing an English engineering firm of good standing, chiefly with a view to introducing motors, generators and switch gear.

Works Driving.—Messrs. Thomas Firth & Sons, of Norfolk Works, Sheffield, have decided to remove the crucible steel department to Tinsley, where it is proposed to put down a thoroughly up-to-date crucible steel plant, with the most modern rolling mills. These will be driven electrically. The new building will be about 600 ft. long and will be in four spans, each 60 ft. wide. Two 1,000 kw. turbo-generators have been ordered from C. A. Parsons, and steam will be supplied by Babcock & Wilcox water-tube boilers. The roofing and ironwork has been entrusted to Sir Wm. Arroll & Co.

Messrs. Urquhart, Lindsay & Co., of Dundee, have recently made considerable extensions to their works, and the whole of the new tools and machinery are driven electrically, current being taken from Dundee Corporation's mains.

Ozonising Patents.—Mr. L. Melville Clark, solicitor, 53, Chancery-lane, London, W.C., writes us that his clients, Ozonair Limited, have had their attention called to a prospectus in circulation of the Craig Ozonising & Ventilating Co. (Ltd.), and Mr. Clark controverts, on behalf of his clients, a number of the statements alleged to be made in the prospectus, claiming for Ozonair Limited the use of wire gauze sheets in the construction of electrodes in ozonising apparatus.

Electric Locomotives.—The Siemens-Schuckert Werke G.m.b.H. forward a neatly-bound and well-illustrated booklet giving particulars of their electric locomotives. Up to date the company have supplied 328 locomotives of 16,684 H.P. Among the illustrations is one of the electric train built by Siemens & Halske, and exhibited by them at the Berliner Gewerbeaustellung in 1879. The booklet is published by Julius Springer, of Berlin.

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CATALOGUES, &c.

Electric Cranes.—The electric crane catalogue of Applebys Limited, just to hand, is distinguished by its convenient size and the concise arrangement of the matter and illustrations. The idea has evidently been to produce something more useful than ornate. Consequently we do not find that the artistic has been unduly considered in the get up of this list. The cranes illustrated have capacities varying from 1 to 100 tons, and are designed for every conceivable class of crane work.

Stationary Motors.—Messrs. Dick, Kerr & Co. spare no expense in the production of their standard publications, and the latest production, dealing with direct-current stationary motors, is no exception to the general rule. The half-tone illustrations are exceptionally well reproduced.

Portable Light Lamps and Accumulators.—The latest leaflets of D. Santoni & Co. (Z and Z – 1) are devoted respectively to portable accumulators for carriage lighting, ignition, &c., and a new type of portable electric safety lamp.

French Brackets.—Leaflets F1,169 from the General Electric Co. contain a number of pleasing de igns of French brackets in the Louis XV. and Louis XVI. styles.

Electrical Plant.—A number of useful leaflets put up in a convenient file is to hand from Kolben & Co., Budge-row, Cannon-street, London, E.C. The leaflets contain illustrations and brief descriptions of the manufactures of the firm in the way of dynamo-electric machinery and motors for a.c and d.c. circuits.

Dynamos, Motors, &c.—The loose leaflet and file are much favoured by electrical manufacturers just now. Newtons Limited, of Taunton, are the latest to send us their sheet file, which contains numerous illustrations of dynamos and motors made under the "Zone" patents. The file is made to take a large number of leaflets.

Artistic Fittings.—The publications of C. J. Thursfield & Co are generally distinguishable both by the handsome character of the designs of electric light fittings and also by the admirable manner in which these are presented. The latest fittings catalogue is undoubtedly a work of art, and we regret that space does not permit us to publish a selection of the fittings shown.

A Useful Gift.—The Phœnix Dynamo Mfg. Co., of Bradford, are sending to their customers and friends a handsome copper tray embossed with their now well-known initials. This will serve as a pleasing reminder to many of the firm and its dynamo-electric products.

General Accessories.—The advance catalogues 1 and 2 issued by Eckstein, Heap & Co. are replete with illustrations and particulars of the very wide range of accessories handled by the firm. A speciality amongst these is made of main switches and fuses and watertight fittings. This range includes a special double-pole iron-clad switch, with laminated brush contacts and carbon break. This switch is put up also in a special water and gas-tight form.

Telephone Supplies.—The National Telephone Co. send us three more of their catalogue sections, Nos. III., IV. and IX., dealing respectively with switchboards, bells and indicators, and tools and sundries.

Lampholder Fans.—E. Figueras & Cie, 4, Rue Pajol, Paris, send two neat leaflets which describe their latest pattern of lampholder fan, and their special designs of ceiling and pedestal fans.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from April 17 to 23 with the ports of destination:—

Africa—Alexandria, £215; Cape Town, £91 (including £20 telegraph material); Delagoa Bay, £490; Durban, £2,670 (including £1,785 telegraph material); East London, £24; Port Elizabeth, £885; Port Said, £60 (telegraph material); Suakim 208 loads creosoted telegraph poles; Tripoli, £19 (telegraph material). *Argentina*—Buenos Ayres, £302. *Australasia*—Adelaide, £102 (including £92 telegraph material); Auckland, £551 (including £84 telegraph material); Fremantle, £385; Melbourne, £2,385; Otago, £79; Perth, £35; Sydney, £1,231 (including £70 telegraph material); Wellington, £67. *Belgium*—Antwerp, £34; Ghent, £99; Ostend, £20. *Brazil*—Bahia, £39 (telegraph material); Santos, £31. *Burma*—Rangoon, £54. *Canada*—Montreal, £46; St. John (N.B.), £23; Toronto, £2,648. *Ceylon*—Colombo, £222. *Chili*—Antofagasta, £19; Valparaiso, £17. *China*—Shanghai, £358 (telegraph material). *Germany*—Bremen, £5; Hamburg, £131. *Gibraltar*, £565. *Holland*—Amsterdam, £385 (including £360 telegraph material); Flushing, £10; Rotterdam, £57. *Hong Kong*, £194. *India*—Bombay, £3,403; Calcutta, £3,393 (including £365 telegraph material); Madras, £732. *Italy*—Genoa, £180. *Japan*—Kobe, £202; Moji, £3,254; Tokyo, £31; Yokohama, £165. *Malta*, £104. *Norway*—Christiania, £20. *Portugal*—Oporto, £15. *Russia*—Riga, £62 (telegraph material). *Straits Settlements*—Penang, £62; Singapore, £338 (including £64 telegraph material), *Sweden*—Stockholm, £136 (including £111 telegraph material). *U.S.A.*—Boston, £12. *Zanzibar*, £110. Total, £26,807, against £23,353 for 12 days last year (April 13 to 24).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

February 15, 1907.

3,783 LEVY. Transmitting systems for wireless telegraphy.*
3,786 CARTWRIGHT. Batteries.
3,790 LOEBL & BRITISH EVER-READY ELECTRICAL CO. Destination indicators for motor cars.
3,803 FÉRY & LANGLET. Electric resistance furnaces. (Date applied for, 17/2/06.)*†
3,809 FELTEN & GUILLEAUME-LAHMEYERWERKE A.-G. Regulating arrangements for electric hoisting or winding engine installations. (Date applied for, 15/2/06.)*†
3,834 JUNGNER. Production of electrodes of magnetic metals by electrolytic oxidation. (Date applied for, 16/2/06.)*†

February 16, 1907.

3,850 BIRKBY & BIRKBY. Trolley wheels.
3,880 HEWITT. Electrical distribution. (Date applied for, 14/3/06.)*†
3,881 TORDA. Variable speed electric motors or variable voltage generators.
3,904 LATOUR. Dynamo-electric machines. (Date applied for, 16/2/06.)*†
3,908 SUNDERLAND FORGE & ENGINEERING CO. & BLAIR. Electric cranes and winches.
3,914 REYNOLDS. Electric furnaces.
3,915 REYNOLDS. Electrical heating apparatus.
3,923 LAWS, PETRIE & MIDDLETON. Incandescent lamps.
3,927 COUADE. Electric servo-motors. (Date applied for, 13/8/06.)*†
3,933 EISENSTEIN. Electric wave meters.*
3,935 GRAHAM. Telephonic apparatus.
3,938 CONSORTIUM FÜR ELEKTROCHEMISCHE INDUSTRIE G.M.B.H. Incandescent lamps with wolfram incandescent bodies. (Date applied for, 21/2/06.)*†

February 18, 1907.

3,945 SMITH & MACONOCHIE. Steam turbines.
3,949 MUDIE. Automatic time contact for electrical appliances.
3,962 RICHMOND. Batteries.
3,974 STEVENS. Governor for engines of petrol electric cars.
3,982 COWPER-COLES. Vessels for containing fused salts during electrolysis.
3,992 MULLAN. Vacuum pumps.*
3,996, 3,997 & 4,081 ELECTRIC IGNITION CO. & HALL. Electric ignition apparatus.
4,000 JACKSON. Switches. (Date applied for, 3/3/06.)
4,026 VOSMAER. Rheostats.*
4,028 VICKERY. Telephone mouthpieces or receivers.
4,031 FYNN. Alternate-current motors.
4,045 FELTEN & GUILLEAUME-LAHMEYERWERKE A.G. Compensating or commutation poles of dynamo-electric machines. (Date applied for, 17/2/06.)*
4,046 FELTEN & GUILLEAUME-LAHMEYERWERKE A.G. Electrical switching and controlling installations. (Date applied for 17/2/06.)*
4,055 MEYER. Safety plugs for electric conduits.

February 19, 1907.

4,071 WIGLEY. Carbon brushes for dynamo electric machines.
4,078 MCLELLAN. Metallic conduits or fittings.
4,085 COLEMAN. Electric alarm apparatus.
4,089 FAIRBROTHER. Arc lamps.
4,104 CROWLEY & SOMERS. Wireless telegraphy.
4,120 BROCKIE. Apparatus for suspending lamps and electroliers.
4,123 STONE. Space telegraphy. (Date applied for, 27/2/06.)*†
4,132 PECK. Electrical distribution.
4,133 WESTINGHOUSE. Electrical distribution.
4,151 MORDEY. Dynamos.
4,172 WUILLOT & FERON. Automatic electro-chemical differential pressure regulators *
4,175 MERSHON. Producing a desired distribution of magnetic flux in electrical apparatus.*

February 20, 1907.

4,180 ALLGEMEINE ELEKTRICITÄTS-GES. Centrifugal pumps or compressors. (Date applied for, 20/2/06.)*
4,181 B.T.-H. Co. (G.E. Co., U.S.) Preventing electrolysis.
4,182 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric circuits.
4,183 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric apparatus.
4,185 ROBINSON. Reversible steam turbine.
4,211 CROMPTON & Co., MACFARLANE & BURGE. Electric motor generators.
4,227 JOHANNESEN. Transformers. (Date applied for, 3/3/06.)*†
4,240 SIEMENS-SCHUCKERT WERKE, G.M.B.H. Commutators for electric machines. (Date applied for .21/2/06.)*†
4,263 ALLGEMEINE ELEKTRICITÄTS GES. Current collectors for electric vehicles. (Date applied for, 23/2/06.)*†

February 21, 1907.

2,417A CHAMBERS & BENNETT. Switches. (Date applied for, 31/1/07.)
4,274 EDMONDS & MCKENZIE & HOLLAND. Interlocking apparatus for railways and tramways.

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4,287 HANN & INGLE. Earth return couplings for electric conductor tubes.
4,288 WHITTAKER & STANDRING. Electric light fittings.
4,292 ELECTRIC & ORDNANCE ACCESSORIES CO., HALL & GARNER. Switches.*
4,333 WEBB. Selective continuous electric wave telegraphy.
4,338 AUSTIN. Electric receiving apparatus.*
4,352 BOULT. (Lessing, Germany.) Carbon electrodes.
4,359 MEYER. Transmission of electric power for driving ships.
4,363 B.T.-H. Co. (G.E. Co., U.S.) Insulating conductors.
4,364 B.T.-H. Co. (G.E. Co., U.S.) Incandescing bodies for electric lamps.

February 22, 1907.

4,397 ECKSTEIN. Automatic electric circuit breakers.
4,419 EPPS. Holders for incandescent lamps.
4,425 SCOTT. Time limit electric circuit breakers.*
4,429 COUADE. Electric servo-motors. (Date applied for, 19/9/06.)
4,445 LJUNGSTRÖM. Gas turbines. (Date applied for, 28/2/06.)*
4,446 LJUNGSTRÖM. Vane sets for gas turbines. (Date applied for, 28/2/06.)*†

February 23, 1907.

4,455 HARTNELL. Electric gear for motor cars.
4,462 BODDAM. Hydraulic cranes electrically operated.
4,470 LAUTENBACH. Electric power-generating plants.*
4,476 NORRIS. Trolley arms.
4,484 CUNNINGHAM. Jointing devices for electrical fittings.
4,499 DUSSEK & DUSSEK. Conduit for underground conductors.
4,512 GRESLEY. Railway or tramway vehicles.*
4,515 SPENCER. Apparatus for suspending arc lamps.*
4,517 SCOTT. Accelerating the motion of magneto-armatures.
4,518 KNEEN & KING. Tramway conduit points.

SPECIFICATIONS PUBLISHED.

1905 SPECIFICATIONS.

26,094 ALLGEMEINE ELEKTRICITÄTS-GES. Alternating current dynamo. (Date applied for, 15/12/04.)

1906 SPECIFICATIONS.

3 119 GUÉNÉE. Electric stamp hammers.
3,213, 3,684 & 4,081 JUST, HANAMAN, LANDESBERGER, SALZMANN & VEREINIGTE ELECTRICITÄTS A.-G. Incandescing bodies for electric lamps.
3,583 MOSCICKI. Producing nitric oxide by electricity.
3,604 DAVIS. Dynamo-electric generators.
3,781 B.T.-H. Co. (G.E. Co., U.S.) Electromagnetic switches.
3,904 B.T.H.-Co. & HOLDEN. Electric measuring apparatus.
4,102 MECKE. Measuring, indicating and registering speed by a dynamo in combination with a solenoid provided with a core whereby indicator is actuated.
4,677 BLONDEL. Electric arc lamps.
4,700 LAKE. (Rhode Island Electromobile Co.) Secondary batteries.
4,702 FIEDLER. Charging and discharging secondary batteries.
4,849A RAVENSHAW, MIDDLETON & TOWNSEND. Magnetic clutches. (Date applied for, 27/2/06.)
4,925 B.T.H.-Co. (G.E. Co., U.S.) Insulation of metal for electrical apparatus.
4,926 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.
5,170 PEARD. Electric fusible cut-outs.
5,171 PEARD. Electric fusible cut-outs.
5,465 VICKERS SONS & MAXIM & LINDLEY. Brush-holders.
5,892 B.T.-H. Co. (G.E. Co., U.S.) Electrically operated power transmission mechanism.
6,193 B.T.-H. Co. (G.E. Co., U.S.) Electrical resistance units.
6,933 HARDINGHAM. (Hartmann & Braun Akt.-Ges.) Reed combs for indicating the frequency of electrical alternations or mechanical oscillations.
7,725 REES. Dynamo-electric machines.
8,259 LEIGHTON. Magnetic compasses.
8,347 THOMPSON. (Soc. Lyonnaise de Mecanique et d'Électricité.) Electric capstans.
8,902 DAWSON & BUCKHAM. Electrical apparatus for controlling the fire of guns.
9,186. NORTH. Armature mounting for electro-magnetic apparatus. (Date applied for 22/4/05.)
9,410 KNIGHT. Electric bells and working same.
9,792 GARDNER & GARDNER. Electric ignition devices.
11,279 BOURDOS, ROTHSCHILD & SUTCLIFFE. Filaments of incandescent lamps.
11,859 METHEANY. Electric couplings for portable telephone sets. (Date applied for, 25/5/05.)
12,290 JOHNSON. Turbines.
12,477 FAIRWEATHER. (Electrical Devices Co.) Switches.
12,777 BARKER. Magnetic compasses.
13,212 A.G. BROWN, BOVERI & Co. Steam turbines. (Date applied for, 7/6/05.)
13,312 AITKEN. Telephone exchange apparatus.
13,955 LASKAY. Electrically operated self-levelling marine tables.
14,073 DURKIN. Electric motor-controllers. (Date applied for, 8/1/06.)
14,166 RANSFORD. (Compagnie Parisienne des Voitures Electriques (Procédés Kriéger).) Self-propelled vehicles.
14,433 ILES & ARMISTEAD. Regulation of continuous-current motors.
14,614 HADDAN. (Kutnow Bros.) Electric clocks.
14,696 LATOUR. Single-phase alternating-current series motor. (Date applied for, 28/6/05.)
14,780 LLOYD. Medically administering three-phase sinusoidal currents.
16,269 GRÖNDAL KJELLIN CO. & HÄRDÉN. Electric induction furnaces.
16,410 BROCKIE. Enclosed arc lamps.

COMPANIES' MEETINGS AND REPORTS.

BUENOS AYRES & BELGRANO ELECTRIC TRAMWAYS CO. (LTD.)—Including £5,375 brought forward the available balance is £76,126. The directors recommend a dividend of 3s. per share (tax free) on the ordinary shares. An agreement has been entered into with the Compagnie Generale de Tramways de Buenos Ayres for the sale of the company's undertaking for £1,350,000, £200,000 in cash and the remainder at the option of the purchasers on 12 months' notice within 50 years. Interest on the balance until completion (£60,500 per annum) would be sufficient, after meeting all prior charges, to admit of a dividend of 4 per cent. per annum on the ordinary share capital. When the balance of the purchase money is paid the ordinary shareholders will, it is estimated, receive a return of not less than £4. 5s. per share on liquidation after redemption of the debenture and repayment of the preference shares at par.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The directors recommend that £12,000 be transferred to depreciation, a dividend at the rate of 10½ per cent. for the half-year ended Dec. 31 (making 8½ per cent. for the year), and that £5,286 be carried forward.

COPENHAGEN ELECTRIC TRAMWAY CO.—The profit last year was 2,025,000kr. (about £54,844), compared with 1,869,000kr. in the previous year. After payment of capital charges, and providing for reserve and sinking fund, 600,000kr. (£16,250) remained for dividend, which has been declared at 6 per cent.

COVENTRY ELECTRIC TRAMWAYS CO.—The gross earnings for 1906 were £25,934 (against £20,685 in 1905) and the cost of operation was £16,637 (against £14,087). Net profit, after paying interest, was £7,143. 17s. 7d., added to £64. 8s. 3d. from 1905. The directors recommend a dividend of 3 per cent. In view of increased traffic arrangements have been made with the New General Traction Co. for increased power, new condensing machinery, the sinking of a well for an independent water supply, and six new cars, the total cost being estimated at about £8,650.

GRAVESEND & NORTHFLEET ELECTRIC TRAMWAYS (LTD.)—The total revenue for 1906 was £12,965. 19s. 4d., and after deducting all expenses the profit is £1,994, added to £83 brought forward. The directors recommend that £600 be placed to reserve, that £1,200 be applied to paying preference dividend to Dec. 31, 1905, leaving £276. 15s. 9d. to be carried forward. The result of the year's working is £891 better than 1905, due to an increase of £646 in receipts and a decrease of £245 in expenses. The total capital expenditure at Dec. 31 last was £118,735. 19s. 6d.

HARROW ELECTRIC LIGHT & POWER CO. (LTD.)—The substantial reduction made in the rates for lighting has resulted in current consumption having increased by 40,000 units. Lamp connections also show an increase of 4,013 8 c.p. The additional output of electrical energy has led to further economies in working, with the result that net revenue is but slightly lower than in the previous year. The receipts were £7,938, against £7,789 in 1905; expenditure was £3,285, against £2,947; works costs 1·36d. per unit, against 1·42d., and 1·67d. in 1904; and total working expenses, exclusive of depreciation and capital charges, 2·42d. per unit, against 2·48d. in 1905 and 2·61d. in 1904. The directors recommend a dividend on ordinary shares of 5 per cent. for the year.

KALGOORLIE ELECTRIC TRAMWAYS (LTD.)—Mr. A. H. P. Stoneham stated at the meeting last week that the increase in profit was not quite so large as expected. During the year the cars travelled 673,544 miles and carried 3,220,728 passengers. Kalgoorlie had now settled down into a steady commercial centre. In reply to questions, the chairman said the board had requested Mr. Somerset, engineer of the Perth tramways, to make a special visit to Kalgoorlie to report in what way the working expenses could be reduced. In Kalgoorlie wages were very high and trade unions were very powerful.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—The gross profit for 1906 was £41,714. 12s. 5d., and deducting expenses of administration, &c., the balance is £31,306. 9s. 10d. The directors recommend a dividend of 10 per cent. The progress of the undertakings in which the company is financially interested is satisfactory. At Musselburgh traffic receipts from the tramways were very good, and the lighting undertaking also did well. It is expected that the construction of the extension of the tramways to Port Seton will be commenced this year. Portions of the tramways at Mexborough and Swinton and Torquay have been opened and the traffic receipts have been encouraging. Both undertakings should be wholly completed in the course of the next two months. The progress of the Bo'ness and Carnarvon electric light undertakings has been maintained. The contract for the construction and equipment of tramways in the Rhondda Valley is well in hand. The following tramway concessions have been obtained:—West Yorkshire (connecting Huddersfield with Halifax), Folkestone, Sandgate and Hythe, and City of Oxford.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—At the meeting on Wednesday Sir Auckland Colvin, K.C.S.I., said the main feature of the past year had been the progress with their extensive cable operations. Since the beginning of the present year an improvement had taken place, and there was reason to anticipate that the steady increase in the number of subscribers would now be resumed, as had been the case until the reconstruction operations caused an unavoidable temporary interruption.

PERTH (W.A.) ELECTRIC TRAMWAYS (LTD.)—Gross receipts for 1906 amounted to £78,542. 12s. 1d., compared with £74,484. 18s. 11d. for 1905. Nett profit was £35,260. 16s. 3d., against £32,041. 14s. 1d. After payment of interest and sinking fund for the year, the balance is £17,739. 16s. 3d. A dividend of 5 per cent. is declared on the ordinary shares.

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POTTERIES ELECTRIC TRACTION CO. (LTD.)—Mr. G. F. M. Cornwallis-West at the meeting on Monday stated that during the past year they had carried 1,723,658 more passengers than in 1905. The parcel traffic showed a small decrease compared with 1905; but that item was still a useful and considerable one in the company's profit and loss account. The power and running expenses showed a decrease of £1,158. The increased expenditure on repairs and maintenance was no less than £7,500. If electrical engineers 10 years ago had known as much about electric traction as they do now they would never have suggested the life of a permanent way to be from 17 to 20 years, nor would they have used 85 lb. rails or made a single line with passing places where they might have made a double. However, it was always easy to be wise after the event, and in the meanwhile the directors have had to face the position. They decided to place a sum annually to a new fund to be called a renewals fund. Last year, out of the total of £18,725 spent in repairs and maintenance, only £1,476 was charged to that fund, and £2,500 had been added to it. It was probable that, outside the ordinary expenses of upkeep the company would have to spend some £10,000 or £11,000 in renewing part of the permanent way. It was proposed to lay a much heavier rail than heretofore. Assuming that the same amount was placed to renewals fund every year that outlay would be wiped off in four years. Where it could be proved to be of pecuniary advantage it would be the policy of the board to double the track, provided, of course, the consents of the local authorities could be obtained. Such doubling would be, of course, a capital expenditure as to half the cost. There was an increase of £310 in rates. £12,700 had been spent on capital account in 1906. The company had purchased five large cars, a new car-shed had been built, feeders had been put in which had effected economies in the power stations and facilitated the running of the cars during the rush hours of busy days. The question of finance had caused the board anxiety during the year. They were precluded from issuing shares at a discount—their shares were unfortunately at a discount—and unless the articles of association were altered they could not issue any further debenture stock until more shares were issued. It had therefore been necessary to arrange an overdraft with the bankers. Since the issue of the report they had received from the Board of Trade power to abandon the southern half of the Longton-Blythbridge route and a three years' extension of time for the construction of the remainder.

RIVER PLATE ELECTRICITY CO. (LTD.)—The directors' report for 1906 states that the net balance to credit of profit and loss, after providing interest and writing off depreciations, is £12,018. Adding £4,276. 1s. 7d. from last year, the total available is £16,294. The directors recommend a dividend of 2½ per cent. for the year on the ordinary shares. During the past year there has been a large growth of business at La Plata, and at Tucuman a fair extension of private lighting. Owing to the great increase in the price of fuel, especially at Tucuman, and scarcity of labour, the cost of working has been less favourable than in former years.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

BRITISH ELECTROMOBILE CO. (LTD.) (92,815.)—*Reg.* April 8, capital £25,000 in £1 shares to acquire the business of electrical engineers and motor-carriage makers carried on by the Carl Oppermann Electric Carriage Co. (Ltd.), to acquire from C. T. J. Oppermann and others certain inventions relating to electric appliances and apparatus, and to carry on the business of suppliers of electricity, &c. First directors, R. Miokel, A. Kennedy, D. Watson, C. T. J. Oppermann and C. F. G. R. Schwerdt. Reg. office, 1, Queen Victoria-street, London, E.C.

DUMBARTON BURGH & COUNTY TRAMWAYS CO. (LTD.) (6,482.)—Reg. in Edinburgh on April 13, capital £130,000 in £1 shares, to construct, purchase or otherwise acquire, manage and work any light railways, electric or other tramways, and electric lighting or power undertakings, &c. Reg. office, 15, York-place, Edinburgh.

J. HALDEN & CO. (LTD.) (92,899.)—Reg. April 13, capital £40,000 in £1 shares, to acquire business carried on in Manchester, London, Newcastle-on-Tyne and elsewhere as J. Halden & Co., and to carry on the business of manufacturers and sellers of drawing materials and papers, mathematical instruments and specialities, electric arc lamps, electric photographic copying apparatus, &c. First directors, J. Halden, G. F. Pringle and J. R. Ball (permanent governing directors), W. A. Halden, W. Monkhouse, W. V. Brown, H. R. Watts, H. F. Moir, L. Wordsworth and E. W. M. Taylor. Office, 17, Altrincham-street, Manchester.

SIMMS MAGNETO CO. (LTD.) (92,900.)—Reg. April 19, capital £100 in £1 shares, to carry on the business of manufacturers and proprietors of and dealers in magnetos, magneto parts and accessories, motors, motor and other carriages, electricians, suppliers of electricity, &c.

VICI MOTORS (1907) (LTD.) (92,843.)—Reg. April 9, capital £60,000 in £1 shares (30,000 7 per cent. cumulative preference), to carry on the business of mechanical, electrical and general engineers, manufacturers of steam, electrical, oil, spirit and other motor vehicles, &c. Reg. office, 64, Salusbury-road, London, N.W.

STATUTORY RETURNS.

BATH ELECTRIC TRAMWAYS (LTD.)—In return to March 26 capital is £230,000 in £1 shares (75,000 5 per cent. cumulative preference, 125,000 preferred ordinary and 30,000 deferred ordinary), of which 75,000 preference, 75,606 preferred ordinary and 30,000 deferred ordinary have been taken up. £1 per share has been called up on 75,000 preference and 75,606 preferred ordinary, and £150,606 has been received. 30,000 deferred ordinary are considered as fully paid. Mortgages and charges, £157,900.

BISHOP'S STORTFORD & STANSTED ELECTRIC LIGHTING CO. (LTD.)—The capital in return to Feb. 8 is £1,000 in £1 shares, of which 340 have been taken up and paid for in full. Mortgages and charges nil.

CHATHAM, ROCHESTER & DISTRICT ELECTRIC LIGHTING CO. (LTD.)—In return to Dec. 31 capital is £50,000 in £5 shares, all of which have been taken up. £5 per share has been called up on 6,224 and £31,112 has been received, leaving £8 in arrears. £18,880 is considered as paid on 3,776 shares. Mortgages and charges nil.

DAVIES, KENT & STEWART (LTD.) — Return to April 19 gives capital as £3,500 in 2,500 preference and 1,000 ordinary shares of £1 each, of which 1,974 preference and 1,000 ordinary have been taken up. £2,974 is considered as paid. Mortgages and charges, £1,050 debentures.

HART ACCUMULATOR CO. (LTD.)—According to return to March 20 the capital is £60,000 in £1 shares (20,000 preference), of which 40,000 ordinary and 7,059 preference have been taken up. £1 per share has been called up on 17,500 ordinary and 7,059 preference and £24,559 has been received. 22,500 ordinary are considered as fully paid. Mortgages and charges, nil.

KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)—The capital return to March 14 is £350,000 in £5 shares (50,000 ordinary, 10,000 first preference and 10,000 second preference), of which 21,000 ordinary, 10,000 first preference and 10,000 second preference have been taken up. £5 per share has been called up on 15,968 ordinary, 10,000 first preference and 10,000 second preference, and £179,840 has been received. £25,160 is considered as paid on 5,032 ordinary. Mortgages and charges £90,000. Ditto in respect of debenture stock issued by company in conjunction with Notting Hill Electric Lighting Co., £178,400.

NORTHWICH ELECTRIC SUPPLY CO. (LTD.)—Return to March 12 gives capital as £25,000 in £5 shares, of which 3,629 have been taken up. £5 per share has been called up and £18,145 has been received. Mortgages and charges, £11,000.

NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)—In return to March 12 capital is £200,000 in 16,452 ordinary, 2,998 ordinary preference and 550 founders' shares of £10 each, of which 10,852 ordinary, 2,998 ordinary preference and 550 founders' have been taken up. £10 per share has been called up and £144,000 has been received. Mortgages and charges, £64,000. Ditto guaranteed jointly by company and Kensington & Knightsbridge Electric Lighting Co., and issued under the Kensington & Notting Hill Electric Lighting Companies Act, 1899, £178,400.

WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)—Return to March 13 gives capital as £2,000,000 in £5 shares (200,000 4½ cumulative preference), of which 110,000 ordinary and 81,279 preference have been taken up. £5 per share has been called up and £956,395 has been received. Mortgages and charges, £250,000.

MORTGAGES AND CHARGES.

ROWLAND BARNETT & CO. (LTD.)—Three mortgage debentures, dated April 4, 1907, to secure £450, £217 and £679 respectively, charged on company's undertaking and property, present and future, including uncalled capital, have been registered. Holders (1 and 2), T. D. Byers and (3) Rowland H. Barnett.

CITY NOTES.

MEMORANDA (April 25).—Bank rate 4 per cent. (April 25, 1907). Price of silver 30¼—30 5/16d. per oz. Consols 85 5/16—85 11/16 for money, 85⅝—85¾ for account; 2½ per cent. annuities 84¼—84¾. Consols Pay Day, May 3; Stocks and Shares Continuation Days, May 13 and 28; Ticket Day, May 14; Pay Days, April 26 and May 15; Mining Share Carry-over Day, May 10.

ASCOT DISTRICT GAS & ELECTRICITY CO.—The directors have issued a circular stating that they have obtained tenders for plant to enable the company to supply electricity in the neighbourhood of Sunningdale and Sunninghill, and offering the shareholders £8,000 4 per cent. perpetual debenture stock and 1,000 7 per cent. ordinary shares of £10 each.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—The directors recommend a dividend of 6 per cent. on the ordinary shares for the year to March 31.

MELDRUM BROS. (LTD.)—The directors regret being unable to recommend payment of the cumulative preference dividend for 1906.

MONTREAL LIGHT, HEAT & POWER CO.—A dividend at the rate of 5 per cent. per annum has been declared for the three months ending 30th inst.

RAND CENTRAL ELECTRIC WORKS (LTD.)—At an extraordinary meeting on Tuesday the resolution passed on April 8 for the liquidation of the company was confirmed.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have been asked to grant quotations to a further issue of £83,000 4½ per cent. first mortgage debenture stock of *Edmundson's Electricity Corpn. (Ltd.)* and a further issue of 2,000 £5 fully-paid ordinary shares of the *Hove Electric Lighting Co. (Ltd.)* The Committee have also been asked to grant a quotation to a further issue of 50,000 £5 fully-paid ordinary shares of the *Anglo-Argentine Tramways Co. (Ltd.)* (Renewed application.)

TRAMWAYS & GENERAL WORKS CO. (LTD.)—The directors recommend a dividend of 1s. per share (tax free).

TRAMWAYS & LIGHT RAILWAYS ESTATES CO. (LTD.)—The directors recommend a dividend of 3 per cent. for the year 1906.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	April 17	1,210	– 125	46	63,572	+ 1,833
Airdrie	,, 12	226	– 3	14	3,149	– 4
Anglo-Argentine	,, 22	17,611	+ 2,467	16	261,222	+ 21,533
Ashton-under-Lyne Corp	,, 20	347	– 36	4	1,607	+ 214
Ayr Corporation	,, 21	222	– 97	49	13,872	– 21
Baker St. & Waterloo Ry.	,, 20	2,480	+ 958	6	13,615	+ 4,544
Barnsley	,, 12	138	– 38	14	2,265	– 7
Barrow	,, 19	203	– 107	14	3,146	+ 28
Bath Electric Trams, Ltd.	,, 17	720	– 552	16	10,787	– 146
Birkenhead Corporation	,, 21	930	– 216	...	...	...
Birmingham Corporation	,, 20	5,241	...	3	16,399	...
Birmingham & Mid.	,, 5	1,192	...	13	10,150	...
Blackburn Corporation	...	...	...	...	...	...
Blackpool Corporation	,, 18	452	– 1,820	3	2,232	– 813
Blackpool and Fleetwood	,, 20	298	– 624	3	1,601	– 239
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 21	2,009	– 62	3	6,289	– 847
Bournemouth Corporation	,, 17	1,496	– 1,110	¶2	4 480	– 286
Bradford Corporation	,, 20	4,204	– 1,666	3	13,753	– 418
Brighton Corporation	,, 21	738	– 352	3	2,591	– 420
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 19	4,781	– 1,758	10	47,049	– 498
Buenos Ayres & Belgrano	,, 14	4,033	+ 227	15	56,317	+ 3,865
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 20	1,154	+ 63	3	2,272	– 362
Burton Corporation	,, 21	254	– 86	3	832	– 129
Bury Corporation	,, 14	928	...	2	1,976	...
Calcutta Tramways Co.	,, 20	¤46,726	+ ¤5,545	16	¤818,889	+ ¤106,575
Camborne-Redruth	...	...	...	...	...	...
Cardiff Corporation	,, 20	1,908	– 402	3	6,264	+ 92
Cavehill	,, 12	62	– 32	14	1,013	+ 251
Central London Railway	,, 20	6,236	– 123	16	99,591	– 9,739
Chatham & Dist. Lt. Rys.	,, 18	640	– 247	¶15	10,111	+ 693
City & South London Rly.	,, 21	2,836	+ 110	16	47,417	+ 584
City of Birmingham	,, 12	2,672	...	14	38,483	...
Colchester Corporation	,, 17	178	...	...	...	...
Cork Electric Trams Co.	,, 18	444	– 64	16	6,462	– 196
Croydon Corporation	,, 19	1,289	– 590	‡3	3,918	– 567
Devonport & Dist. Trams	,, 12	420	– 161	14	6,260	+ 192
Dover Corporation	,, 20	189	– 102	3	660	– 109
Dublin & Lucan Railway	,, 19	100	– 66	16	1,525	– 28
Dublin United	,, 19	5,120	– 766	†16	74 023	+ 2,127
Dudley Stourbridge	,, 12	743	– 89	14	11,428	+ 447
Dundee Corporation	,, 17	1,063	+ 21	56	52,585	+ 7,105
East Ham Council	,, 20	811	– 291	3	2,649	– 283
Exeter Corporation	,, 19	283	– 103	‡3	894	+ 9
Falkirk and District	,, 17	271	...	3	922	...
Gateshead & Dist. Trams	,, 12	920	– 109	14	23,967	+ 546
Glasgow Corporation	,, 27	17,056	+ 479	47	781,758	+ 61,600
Glossop	,, 20	130	– 4	16	2,031	+ 46
Gravesend—Northfleet	,, 12	211	– 41	14	3,141	+ 208
Great Northern & City Rly.	,, 20	1,817	+ 58	16	29,518	– 18
Gt. Northern, Piccadilly, &c.	,, 20	4,080	...	16	60,409	...
Greenock & Port Glasgow	,, 12	725	– 51	14	8,689	+ 116
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 12	236	– 86	14	3,595	– 164
Hastings Elec. Trams Co.	,, 18	928	– 309	16	13,011	+ 6,077
Hong Kong	,, 20	$6,650	+ $212	3	$22,785	+ $2,988
Huddersfield	,, 20	1,482	– 471	3	4,860	+ 136
Hull Corporation	,, 20	2,215	– 173	3	6,798	– 125
Ilford District Council	,, 20	438	– 199	3	1,154	– 213
Ilkeston District Council	,, 17	117	– 39	3	439	+ 60
Ipswich Corporation	,, 20	351	– 148	3	1,121	– 148
Isle of Thanet Co.	,, 20	353	– 291	29	8,292	+ 196
Jarrow	,, 12	105	...	14	1,557	...
Keighley Corporation	,, 18	136	– 75	42	6,307	+ 472
Kidderminster & District	,, 12	93	– 16	14	1,378	+ 40
Kilmarnock Corporation	,, 20	139	– 21	49	7,696	+ 142
Lanarkshire Trams Co.	,, 18	1,141	+ 228	16	16,272	+ 3,094
Lancashire United	,, 17	1,078	– 540	$16	17,756	+ 4,725
Leamington	,, 12	159	– 8	14	2,005	+ 32
Leeds Corporation	,, 20	6,011	– 1,398	3	19,008	+ 700
Leicester Corporation	,, 20	2,027	– 607	16	33,426	+ 138
Leith Corporation	,, 20	464	+ 4	†19	24,696	+ 6,282
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 21	1,397	– 76	16	22,258	– 76
Liverpool Corporation	,, 13	10,211	– 758	15	155,497	+ 3,036
*London County Council	,, 13	27,982	+ 2,127	2	57,119	+ 6,383
London United	,, 19	5,599	– 3,624	†16	85,680	+ 2,342
Lowestoft	,, 20	137	– 27	29	4,449	+ 567
Maidstone Corporation	,, 20	97	– 31	3	321	– 27
Manchester Corporation	,, 20	13,345	– 584	3	40,761	+ 2,198
Mersey Railway	,, 20	1,730	– 78	16	29,377	+ 1,189
Merthyr	,, 12	195	– 28	14	2,896	+ 282
Metropolitan Dist. Railway	,, 21	7,945	+ 453	16	125,321	– 2,440
Metropolitan Elec. Trams	,, 12	3,813	– 198	14	56,812	+ 11,405
Middleton	,, 12	292	– 116	14	583	+ 343
Nelson Corporation	...	...	...	...	...	...
Newcastle-on-Tyne Corp.	,, 20	3,741	– 860	3	12,050	– 400
Newport (Mon.)	,, 20	596	– 124	3	1,999	+ 21
Northampton Corporation	,, 19	374	– 209	‡3	1,198	– 81
Oldham, Ashton & Hyde	,, 12	524	– 133	14	8,310	+ 771
Oldham Corporation	,, 21	1,752	– 139	4	7,975	+ 701
Perth (N.B.) Corporation	,, 17	145	– 17	48	7,437	...
Perth (W.A.) Elec. Trams	,, 19	1,423	– 119	16	24,053	– 245
Peterborough	,, 12	109	– 47	14	1,583	+ 110
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 20	1,677	– 761	3	5,663	– 544
Potteries	,, 12	1,650	– 172	14	25,965	+ 367
Preston Corporation	,, 17	651	– 162	3	2,302	+ 81
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 18	511	– 174	‡3	1,532	+ 85
Rothesay	,, 12	196	– 5	14	1,153	+ 280
Salford Corporation	,, 22	4,202	+ 178	3	11,233	– 592
Sheerness	,, 10	51	...	14	801	+ 19
Sheffield Corporation	,, 21	5,174	– 499	4	21,336	+ 441
Singapore Trams	,, 20	$9,837	+ $1,901	3	$30,942	+ $5,486
Southampton	...	...	...	...	...	...
Southend Corporation	,, 17	283	– 269	3	818	– 125

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. ¤ Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southport Tramways	April 12	246	– 75	14	3,375	– 84
South Metropolitan	,, 12	603	...	14	10,002	...
South Staffs	,, 12	821	+ 5	14	22,541	+ 1,268
Stalyb'dge, Hyde, &c., Jt. Bd	,, 29	701	– 105	3	2,313	– 143
Sunderland Corporation	,, 22	1,246	– 246	3	4,010	– 324
Sunderland and District	,, 17	438	– 250	16	6,459	+ 678
Swansea Trams	,, 19	780	– 145	14	11,449	+ 693
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 12	44	...	14	567	– 31
Tynemouth and District	,, 12	172	– 108	14	2,387	– 97
Tyneside Trams Co.	,, 17	396	– 518	16	6,382	+ 490
Victoria, Elec. Supply Co. of	March 17	920	+ 152	...	...	...
Wallasey District Council	April 20	709	– 203	3	2,375	– 2
Walsall Corporation	,, 20	412	– 280	16	7,473	– 390
Warrington Corporation	,, 18	351	– 75	3	1,149	+ 22
West Ham Corporation	,, 18	2,195	– 721	3	7,531	+ 175
Weston-super-Mare	,, 10	65	+ 5	14	596	+ 144
Wolverhampton Co.	,, 12	370	– 21	14	5,984	+ 360
Wolverhampton Corpn.	,, 17	770	– 348	14	11,807	...
*Worcestr	,, 12	245	– 35	14	3,494	+ 45
Wrexham	,, 12	107	– 14	14	1,365	– 23
Yorkshire W.R. Trams	,, 21	1,031	– 169	16	17,018	...
Yorkshire Woollen District	,, 12	879	– 16	14	13,143	+ 1,196

(a) These comparisions are with the corresponding period last year. * Partly electrical. ¶ Plus 3 days.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs	Last Divi-dend	Name.	Price Wed., April 24.	Rate % Yield-ed.	Divi-dend Due.	Business week to April 24. High-est.	Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	†Anglo-Argentine Ord. Shares	7½–7½	5 6 6	Ap, Oct	7⅝	7⅞
5	2/9	Do. 5½ per Cent. Cum Pref.	5⅛–5⅛	4 12 6	..	5⅛	5⅛
St.	6⅞	Do. Permanent 6% Deb. Stock	132 –136	4 9 0	..	..	..
St.	5⅞	Auckland Elec. Trams. 5% Deb. (red.)	104 –107	4 13 6	..	..	..
5	..	Brisbane Electric Trams, Invest. Ord.	2⅞–2⅛	..	..	2⅝	2⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞–5⅛	4 18 9	..	..	..
St	4½%	Do. 4½ per Cent. Db. Prov. Certs.	98 –102	4 8 0	..	..	..
St.	6%	British Columbia El. Ry. Df. Ord.	126 –130	4 12 0	..	129⅛	128
St.	6%	Do. Pref. Ord. Stock	106 –111	4 10 0	..	103½	106½
St.	5%	Do. 5% Cum. Perp. Pref. Stock	102 –1 6	4 14 3	..	..	..
40	4½%	† Do. 4½ per Cent. 1st Mort. Debs.	99 –101⅞	4 9 0	..	..	..
100	4½%	Do. Vancouver Power Debs.	102½–1 4½	4 6 0	..	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	3½–4	3 15 0	..	8⅛	8⅞
5	3/0	Do. 6 per Cent. "A" Cum. Pref	5 –5½	5 9 0	..	..	..
5	3/0	Do. "B"	4⅞–5⅛	5 11 6	..	..	..
St.	5%	Do. 5 per Cent. Debs.	104 –106	4 14 3	..	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	101 –104	4 16 0	..	102	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	98 –101	4 19 0	..	..	..
10	5½	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	100 –104	5 5 9	..	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	100 –105	5 14 0	..	..	..
5	3/6	Calcutta Tramways (1 to 105,000)	8 –4½	4 14 0	..	..	..
5	2/6	Do. Nos. 105,001 to 157,610	7⅜–8⅛	3 0 6	..	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5⅛–5⅜	4 7 0	..	5⅛	..
1	4½	Do. 4½% 1st Deb. Stock (red.)	103 –108	4 3 3	..	..	..
S	..	Cape Electric Tram Shares	⅞–1⅜	..	..	⅞	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db	98 –102	4 18 0	..	..	..
1	6%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 –90⅞	5 11 0	..	..	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 –95	5 5 0	..	..	..
5	6%	Do. 6 per Cent. "B" Ditto	80 – 84	7 2 6	..	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅜–1⅝	3 9 6	..	..	..
100	7/	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	5 1 0	..	..	..
St	5%	Do. 5 per Cent. Reg. Mort. Deb	98 – 1 1	4 19 0	..	101	..
St.	5%	Madras Elec. Trams. 5% Deb Stk.	98 –101	4 19 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 –104	4 6 6	..	..	..
St	4%	Perth E. Trams. 1st Mt. Db. Stock	102 – 106	4 14 3	..	..	..
..	8%	Sao Paulo Tramway, Light & Power Co. $100 Stock	129 – 134	2 19 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	95⅝–97⅞	5 3 0	..	96½	95⅝
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½–5½	5 14 0	..	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 1d.	7½–8½	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	97 –100	4 10 0	..	..	..
5	3/3	Calcutta Elec. Supply Ord.	7½ 8½	4 17 0	..	..	..
5	0/8	Do. £4 paid	6½–7½	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 –51	4 13 0	..	..	..
..	5%	Cordoba Lt. & Power Co. 1st Mort. Stock £100,000 5 per Cent. Bds.	90 – 92	5 9 0	..	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½–2¾	..	..	..	..
St.	5%	Do. 5 per Cent. Deb Stock	88 –92	5 8 6	..	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 – 98	5 2 0	..	97¼	..
St	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 –1 9	5 10 0	..	..	..
1	0 7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	⅞ ⅞	..	..	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½–97½	5 2 6	..	96	..
1	1/6	Rand Electric	1 – 1⅛	..	..	..	..
1		River Plate Electricity Co. Ord.	⅝–¾	..	..	⅝	⅝
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	⅝–1	6 0 0	..	..	..
St	5%	Do. 5 per Cent. Deb. Stock	97 –100	5 0 0	..	..	..
5	3/0	Rosario Elec. Co. 6% Pref (1,20,000)	5 – 5½	5 9 6	..	..	..
100	4/	Royal Elec. Montreal 4% per Cent. 1st Mort. Deb.	95 –99	4 11 0	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	98 – 100⅝	5 0 0	..	99	..

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. ¤ Plus 2 days.

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., April 24.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO APRIL 24. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	†Bournemouth & Poole Elec. Sup. Ord...	9½ – 10⅛	6 16 6	..	10¼	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¼ – 10	4 10 0	..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10½ – 10⅝	5 11 8	..	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock (red.) ..	101 – 104	4 6 6	..	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	..	..	..
St.	4½	Do. Do. 1st Debs.	99 – 101	4 9 0	..	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7½ – 7¾	5 18 0	..	8	7⅛
5	3/6	Do. 7 per Cent. Pref.....	7 – 8	4 7 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co 4½ Guar. Db. Stock	100 – 103	3 17 6	..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4⅜ – 4½	5 13 0	Feb, Aug	5⅞	..
£	2/3	Do 4½ per Cent. Pref.	4 – 4½	5 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 – 99	4 1 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ – 4½	5 9 0	..	..	..
5	2/3	Chelsea Electric Supply Ord.	3½ – 4½	5 6 0	March ..	3⅜	..
St.	4½	* Do. 4½ per Cent. Deb. Stock (red.) ...	104 – 107	4 4 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord..	9⅜ – 10½	5 17 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼ – 11¾	4 18 0	Jan, July	12	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 – 124	4 0 9	June, Dec	..	..
St.	4½	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 – 100	4 10 0	..	99	..
5	5%	County of Durham Elec. P.D. Ord.	4¼ – 4⅜	4 7 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 5	5 4 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	8 – 8½	5 17 6	..	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10½ – 11⅛	5 4 0	Mar, Sept	10⅝	..
St.	4½	Do. 4½% Deb. Stock (all paid) (red.)...	1 6 – 1 9	4 2 6	..	..	..
St.	4½	Do. Second Deb. Stock Prov. Certs....	97 – 100	4 10 0	..	..	..
5	3/6	†Folkestone Electricity Supply Co. Ord	4⅞ – 5⅛	5 2 0	..	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	4 11 0	..	..	..
St	4½	Do. 4½ 1st Deb. Stock (red).....	97 – 100	4 10 0	..	..	..
5	5 0	†Hove Electric Lighting Ord.	7 – 7½	6 0 0	..	7⅞	7½
5	5/0	Kensington & Knightsbridge Ord.....	8½ – 9½	5 5 0	..	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½ – 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 – 100	4 0 0	..	..	..
St.	4%	Kensingtn. & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 1/0	4 0 0	..	..	..
3	2 4½	London Electric Supply Ord.	1⅞ – 2⅛	5 13 0	..	..	..
5	3 0	Do. 6 per Cent. Pref.	4⅝ – 5⅛	5 14 0	..	5	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	95 – 98	4 2 0	Mr, Jn, S, D	..	..
5	4/0	Metropolitan Electric Sup. Ord.	6¼ – 6⅝	5 13 6	April, Oct	6⅞	6⅝
5	2 3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 5 6	Jan, July	5⅛	..
St.	4½	Do. 4½ per Cent. Deb. Stock 1st Mort.	106 – 109	4 2 9	June, Dec	..	..
St.	3½	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	93 – 94	3 14 6	..	..	..
100	4½	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 – 93¾	4 12 0	..	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅝ – 9⅛	5 3 1	Feb, Aug	..	..
100	4½	Do. 4½ per Cent. Deb.	100 – 101	4 9 2	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7¼ – 7⅝	5 8 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛ – 5⅜	4 7 9	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 – 100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 – 1⅛	2 16 6	Mar, Aug	..	..
100	4½	Do. 4½ per Cent. Deb.	100 – 101	4 10 0	Jan, July	..	..
10	9 0	Notting Hill Electric Ord.....	12 – 13	5 15 0	March ..	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	96 – 99	4 1 0	..	..	..
5	4 6	Oxford Electric Ord.	5½ – 6	5 16 9	March ..	..	..
St.	4	Do. 4 per Cent. Deb. Stock	96 – 99	4 1 6	..	..	..
5	5 0	St. James' & Pall Mall Elec. Ord	8 – 8⅝	5 17 6	Feb, Aug	8	..
5	3/6	Do. 7 per Cent. Pref.	6½ – 7½	4 13 0	Feb, Aug	7½	..
St.	3½	Do. 3½ per Cent. Deb. Stock (red.)	93 – 96	3 13 9	..	..	..
5	..	Smithfield Markets Electric Sup. Ord...	1½ – 2½	..	..	1½	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 – 77	5 4 0	..	..	..
5	3 0	South London Electric Supply Ord.....	2½ – 2⅝	6 8 0	..	2½	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝ – ¾	8 6 9	..	..	..
1	0/3⅛	Do. 7 per Cent. Cum. Pref.....	1⅛ – 1⅜	4 15 0	..	..	..
St.	4½	Do. 4½ 1st Db. Stk. Red.....	100 – 103	4 7 6	..	..	..
5	2/6	Urban Electric Supply Ord.	2 – 3	8 6 0	..	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	3 – 4	6 5 0	..	3 5/16	3¾
St.	4½	Do. 4½ per Cent. 1st Mort. Deb.....	95 – 98	4 12 0	..	..	..
5	6 6	Westminster Elec. Sup. Ord.	9¼ – 9⅝	6 3 0	Mar, Sept	9 21/32	9¼
5	2 3	Do. 4½ per Cent. Cum. Pref.	5¼ – 5⅝	3 13 3	..	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 – 95	4 4 0	..	91	..
1	1/0	Bath Elec. Trams Pref. Ord.	3/32 – 3/32	5 8 0	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	¾ – 1	5 0 0	..	..	..
St.	4½	Do. 4½ 1st Mort. Deb. Stock (red.) ...	95 – 100	4 10 0	..	..	..
St.	4½	B'ham & Midland Trams 4½ 1st Db. Stk.	96 – 99	4 11 0	..	96⅜	96
10	9½	Bristol Tramways & Carriage Ord.	14½ – 14⅝	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 – 9½	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 – 102	3 17 6	Feb, Aug	..	..
10	6 0	British Electric Traction Ord.....	2⅞ – 3⅛	9 4 0	..	3⅛	3
10	6/0	Do. 6 per Cent. Cum. Pref.....	6⅞ – 7⅛	8 5 6	Feb, Aug	7 3/32	6⅞
St.	5%	Do. 5 per Cent. Perpetual Debs.	101 – 105	4 15 0	..	104	1 03/4
St.	4½	Do. 4½ per Cent. 2nd Deb. Stock	81 – 84	5 7 0	..	82½	..
St.	4%	Central London Ordinary Stock	75 – 77	5 4 0	June, Dec	78	75⅝
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	..	93¼	..
St.	4%	Do. Deferred Stock	57 – 60	6 13 0	..	60	57
100	4%	Do. 4 per Cent. Debs.	103 – 106	3 15 6	..	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	88 – 96	4 13 0	..	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4⅜ – 5¼	4 15 3	..	4¼	..
100	4%	† Do. 4 per Cent. 1st Mort Debs.....	98 – 101	3 19 0	..	98	..
St.	2%	City & South London Rly. Con. Ord. ..	41 – 43	4 19 0	Feb, Aug	42½	..
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ..	119 – 122½	4 2 0	Feb, Aug	120¼	..
St.	5%	Do. (1896)	115 – 118	4 4 9	..	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	..	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 04 – 107	3 4 9	May, Nov	103	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	14½ – 15½	3 18 6	..	..	..
10	6/0	Do. 6 per Cent. Pref.....	13½ – 14½	4 1 3	..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2½ – 3	..	..	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 – 88	4 11 0	..	..	..
St.	4½	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	93 – 101	4 9 0	..	93¾	..
10	9%	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 – 11½	5 6 6	Mar, Sept	..	..
St.	4½	‡ Do. 4½ per Cent. Pref.	100 – 102	4 8 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref	1 – 2	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	70 – 75	5 6 6	..	..	..
St.	47/6	Lancs. Utd. Trams 5 : Prior Lien Db. St.	95 – 98	..	..	..	..
10	..	Liverpool Overhead Railway Ord.	1⅜ – 1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 – 90	4 9 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	5⅛ – 5⅜	5 14 8	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 89	4 10 0	..	86½	84½
St.	..	Mersey Con. Ord. Stock	6 – 7	..	..	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	7 – 10	..	..	..	..
1	..	Metropolitan Elec. Tramways Def.	1/32 – 3/32	..	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	5/32 – 7/32	5 3 0	..	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0	..	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜ – 1/2	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	4⅜ – 6¼	5 16 0	..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 – 7⅛	6 18 5	Feb, Aug	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	98 – 101½	4 8 6	..	..	..
1	3/56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	1⅛ – 1⅜	5 16 6	..	..	..
St.	36/3½	Do. 4 per Cent. Deb. Stock	84 – 87	..	..	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	86 – 90	5 11 0	..	..	..
..	5%	Underground Elec. Rys. Co. of London ...	76 – 79	6 6 6	..	78½	78
5	..	Yorkshire (W. B.) Elec. Trams. Ord.	1 – 1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3½ – 3⅝	..	..	..	..
St.	4½	Do. 4½ per Cent. 1st Debs.	90 – 93	4 16 9	..	..	..
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	¼ – ⅜	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	1/16 – 1/8	7 7 9	..	..	..
1	1/7½	Babcock & Wilcox Ord.....	3¾ – 4⅛	5 2 6	..	4 1/32	3 15/16
1	0/7½	Do. Pref.....	1 3/16 – 1 5/16	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅛ – 7	7 3 0	July, Feb	6 1/16	..
5	3/0	Do. 6 per Cent. Pref.	5⅝ – 6½	4 16 0	Jan, July	6	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 1 4	4 6 6	..	..	..
St.	4⅛	British Thom'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3	..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	65 – 69	5 16 0	..	..	..
2	1/0	Brush Electrical Engineering	⅜ – ½	..	March ..	..	..
2	2/1⅛	Do. 6 per Cent. Pref. non-Cum.	1⅛ – 1⅜	6 17 0	Mar, Sept	1 3/32	1 1/16
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 92	4 13 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 – 78	5 14 6	Jan, July	..	..
5	5 0	Callender's Cable Con. Ord.....	1⅛ – 11⅛	6 10 0	Jan, July	10⅝	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ – 5⅜	4 7 0	Jan, July	..	..
St	4½%	Do. 4½ per Cent. 1st Mort Debs (red.)	106 – 108	4 8 3	Nov, May	..	..
1	0/8⅜	Castner-Kellner Alkali Co.	1 3/16 – 1 5/16	5 14 0	..	1⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 – 102	4 8 0	..	101⅛	..
1	0/9⅜	Chadburn's (Ship) Telegraph Ord.	1 3/32 – 1 5/32	7 5 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16 – 1 3/16	5 4 0	..	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 51,000).....	1⅝ – 2⅛	3 10 8	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	93⅝ – 99⅝	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1½ – 1⅝	6 13 8	Sept	..	..
5	2/0	Do. 6 per Cent. Cum. Pref.	1 3/32 – 1 5/32	4 17 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	..	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1⅜ – 1⅝	9 8 0	Feb, Aug	1⅝	..
5	4/2	Do. (£5 paid)	2⅛ – 2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	85 – 87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 – 92	5 8 6	..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	1 – 2	10 0 0	H'lf-yearly	1⅜	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2½ – 3½	8 11 6	..	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	89 – 92	4 7 9	..	90	..
2	..	Electric Construction Co.....	3/16 – 7/16	..	July	..	..
2	2/0⅜	Do. 7 per Cent. Cum. Pref.	1½ – 2	7 0 0	July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. (red.)	81 – 84	4 15 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8½ – 9⅜	5 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 95	4 4 0	..	..	..
5	10/0	Henley's Telegraph Works Ord.....	12 – 13	5 14 6	Feb, Aug	12⅛	12⅛
5	2/3	Do. 4½ per Cent. Pref.	5⅛ – 5⅜	3 18 8	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 – 109	4 2 6	..	..	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15½ – 16½	6 2 6	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 – 100	4 0 0	..	..	..
10	5/0	Mather & Platt 5 per Cent. Cum. Pref...	11¼ – 11⅝	4 5 0	Mar, Sept	..	..
1	1/2⅜	Richardsons, Westgarth & Co., Ltd. Ord.	3/32 – 5/32	7 2 0	..	1/8	3/32
1	0/7½	Do. 6 per Cent. Cum. Pref.	3/4 – 1 1/32	5 16 6	..	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 – 100	4 10 0	..	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	2 4/0	Telegraph Construction & Maintenance	3 1/4 – 3 1/2	5 15 0	Mar, July	3 9/16	2 9/16
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100 – 103	3 17 6	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2 7/16 – 2 1/2	5 17 3	..	2½	2 7/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1 1/16 – 1 1/8	4 1 0	..	1 3/32	1 1/16
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 – 117	4 5 6	..	115½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	103 – 105	3 16 0	..	103⅝	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 – 107	4 4 0	..	10 3/4	105
10	6 0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½ – 10	5 0 0	..	..	..
5	..	Willans & Robinson Ord.	1½ – 1⅝	..	Apr, Oct	1⅝	..
5	..	Do. 6 per Cent. Cum. Pref.	3½ – 4½	..	Apr, Oct	..	..
100	4¼	Do. 4 per Cent. 1st Mort. Debs.....	79 – 83	4 16 6	May, Nov	81	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3½	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 – 91	5 10 0	..	..	..
St.	15/0	†Anglo-American	61 – 64	6 1 3	F, My, Ag, N	61½	60
St.	30/0	† Do. Preferred	106½ – 107½	5 11 6	F, My, Ag, N	107	105¼
St.	13%	Do. Deferred	22 – 22½	7 19 0	F, My, Ag, N	22¼	22
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	93 – 95	4 4 0	Jn, Ap, Jy, O	94¼	93½
10	5 0	Cuba Submarine Ord.....	8½ – 8¾	5 14 8	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	16½ – 17½	5 14 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜ – 3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8½ – 9½	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	98⅝ – 101¾	4 9 0	Jan, July	..	..
100	4%	Direct United States Cable	14½ – 15¼	6 3 6	Ja, Ap, Jy, O	15⅛	14⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 – 101	4 9 0	June, Dec	..	..
St	25/0	Eastern Ordinary	139 – 141	4 19 9	Ja, Ap, Jy, O	140⅜	138
St.	17/6	Do. 3½ per Cent. Pref. Stock	87 – 89	3 18 6	Ja, Ap, Jy, O	89	87½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 – 103	3 14 0	May, Nov	106⅛	..
10	2/6	Eastern Extension	13½ – 13⅝	5 2 6	Ja, Ap, Jy, O	13⅞	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock	105 – 107	3 14 9	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 – 101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	101½ – 102⅝	3 18 6	May, Nov	..	..
10	5 0	G.N. (of Copenhagen), with Coupon 69	85 – 87	6 11 0	Jan, July	36⅛	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 – 101	4 9 0	June, Dec	..	..
25	12/6	Indo-European	58½ – 60½	5 7 6	May, Nov	59⅜	..
100	4%	Mackay Companies Common	70⅛ – 72⅛	5 10 0	Jan, July	..	..
100	4%	Do. Preference	71⅛ – 72	5 11 6	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜ – ½	..	..	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99½ – 100½	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10½	3 16 0	..	..	..
2½	..	West Const of America	⅜ – ½	..	..	..	..
100	4%	Do. 4 per Cent. Debs.	99 – 101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1/16 – 1/8	..	May, Nov	3/32	1/16
10	8/0	Do. 6 per Cent. 1st Pref.	7½ – 8	7 10 0	May, Nov	7 1/16	..
10	..	Do. 6 per Cent. 2nd Pref.	6 – 7	..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	99 – 102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅜ – 14	5 0 0	Mr, Jn, O D	14	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	1 1 – 1 04	3 17 0	..	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 – 94	4 5 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 – 101	4 19 0	..	..	..
5	3 0	Chili Telephone	6⅜ – 7¼	5 11 0	August ..	..	..
1	0/7½	Monte Video Telephone Ord.	1/32 – 1/16	4 14 0	..	..	..
1	0/6	Do. 5 per Cent. Pref.	3/32 – 1/16	4 17 0	..	..	..
St.	6%	National Co. Pref. Stock	103 – 110	5 9 0	..	109½	107½
St.	5%	Do. Def. Stock.....	10 – 10⅝	5 3 0	..	10 9/16	10 7/16
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11½ – 13⅝	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛ – 5⅝	4 9 0	Feb, Aug	5⅝	..
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	95 – 98	3 12 3	June, Dec	97½	96⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 0	..	101½	1 0⅛
1	0/7½	Oriental	1⅛ – 1⅜	4 17 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛ – 1⅜	4 16 0	..	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	93 – 94	4 2 0	..	93⅛	95½
St.	4½%	Telephone Co. of Egypt 4½% Deb. Stk. (red.)	99 – 102	4 7 0	..	..	..
5	3 0	United River Plate	6¾ – 7¼	5 9 6	July	6⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	4 15 0	June, Dec	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	10 – 11⅜	4 9 3	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	4 – 5	6 0 0	..	..	..
10	2 0	Globe Telegraph & Trust.....	10⅛ – 10⅜	5 0 6	Ja, Ap, Jy, O	10⅝	10⅜
10	3/0	Do. 6 per Cent. Pref.....	13⅜ – 14½	4 4 0	Ja, Ap, Jy, O	14½	13⅛
10	6%	†Submarine Cables Trust (Cert.).....	125 – 128	4 13 9	April, Oct	125⅛	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Oxford University.

AT last a serious attempt is being made to remove the reproach that Oxford University cares very little for anything but classics and knowledge of that kind. The Chancellor, LORD CURZON, and the Vice-Chancellor, have issued an appeal for financial assistance, and it certainly seems to be badly required; for the appeal shows that the income of the University has for many years been inadequate to meet the demands that are made upon it, even upon the somewhat narrow basis upon which the University has hitherto been run. In 1903 there was a deficit of nearly £6,000, and in 1904 a deficit of nearly £3,000. This situation has been somewhat relieved by raising the fees, with the result that the magnificent balance of £5. 17s. 6d. on the right side was obtained in 1905, and there has been some further improvement since that time, but the increased revenue has already been allocated or pledged. It is difficult to realise that Oxford is almost the only University at which it is impossible to qualify for admission to the Institution of Civil Engineers. It is now proposed that scientific training should be given, suitable for the would-be engineer, that the study of hygiene in its social and industrial bearings should be made more important, and that greater facility should be given for instruction in scientific agriculture. Further, there are pressing needs of the Bodleian Library, which certainly must be regarded as an institution of national importance. A meeting is to be held on the 16th inst. at Burlington Gardens to consider the possibility of raising a sum of £250,000 to enable these objects to be realised. Unfortunately, appeals by Educational Authorities to the generosity of the public have been so frequent in recent years, and generally for large sums, that there may be some little difficulty in raising such an amount as that required.

The Engineering Societies' Building, N.Y.

MEMBERS of the Institution of Electrical Engineers will read with somewhat envious feelings the description given in our present issue of the new building for accommodating the engineering societies at New York. Instead of each of the societies concerned having a home of its own, or perhaps no home at all, the ideal has been realised of housing them in one building, specially designed and built for the purpose, with every facility for experimental demonstrations and accommodation for a joint library. The realisation of the scheme is largely due to the munificence of Mr. CARNEGIE. The financial difficulty of providing the necessary sum for such a purpose is, of course, the most important one to be overcome, but almost equally important is the difficulty of bringing different societies into line in such cases. Every society seems to have the inherent desire to possess a home exclusively its own, and once such a home is obtained there is great difficulty in showing good reason why it should be abandoned. The idea of a combined home naturally appeals most to those societies which do not already possess homes of their own. It is, therefore, not unlikely that the Institution of Electrical Engineers would welcome the idea of erecting a building similar to that which has just been opened in New York, but we doubt if there is the least probability of getting the older societies to co-operate.

Electric Lighting in Marylebone.

Theoretically, when an electrical undertaker changes the pressure of supply from low to high pressure, for the benefit of the undertaker, the wiring and fittings of any consumer are modified free of charge, so as to make them suitable for the higher pressure of supply. As to how far this has actually been the practice is probably somewhat doubtful, as undertakers are not likely to spend money on unremunerative work of this kind if it can be avoided. Some consumers, however, are well alive to the position,

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and try to make the best of the opportunity. Mr. ALBERT BENDON is a consumer of this kind, and when he was sued by the Marylebone Borough Council to recover a sum of over £60 for the supply of electricity he replied to the effect that the necessary alterations to the wiring had not been carried out in accordance with the regulations of the Board of Trade and of the London County Council. The Daily Press give the usual picturesque account of the defects existing in Mr. BENDON'S installation, and these appeared so serious (or possibly so trivial) to the legal advisers of the Borough Council that the case was settled and the necessary alterations are to be carried out. The County Court judge remarked that the jury, as residents in the neighbourhood, would have a particular interest in the case, for, in addition to the Borough Council having paid an enormous sum for the electricity undertaking, it now seemed they would have to re-wire the whole of the district. We think, however, that the sins of the Borough Council have been visited upon them with sufficient penalties without contemplating this further disaster.

"Electrical" Fires.

THERE is a wide-spread belief among consumers of electricity that electric light gives off no heat, and this idea in many instances leads them to run unsuspected risks of fire. This danger was brought prominently forward by the City Coroner last Friday at an inquiry on a fire. In this case a number of lamps were enclosed in an airtight jeweller's case, in which were a number of celluloid articles. Presumably, some of these were placed very near to the lamps, with the result that a fire took place. This view, at all events, was taken by the jury and appears rational. Although in the Wiring Rules of the Institution attention is called to the advisability of keeping inflammable material from coming in contact with glow lamps, it would be well if suppliers of electrical energy were to emphasise this point in some way that would impress the general public. For example, a notice of this kind on the quarterly account might be effective, and might also include a warning that fuses should not be meddled with in an indiscriminate fashion.

Personal.—It is announced that Prof. Sir James Dewar, F.R.S., has been elected an honorary member of the National Academy of Sciences, Washington, U.S.A.

Institution of Electrical Engineers.—Prof. Gisbert Kapp has been nominated as chairman of the Birmingham Local Section for 1907-8. The committee in their report mention that the average attendance at the meetings for the session was 50.

Monument to Finsen.—It is announced that a monument to the late Dr. Finsen, the discoverer of the treatment for lupus which bears his name, will shortly be erected in Copenhagen. Thirty sculptors competed for the work, and the choice fell on Mr. R. Tegner, a celebrated Danish artist.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tarifa—Tangier	Jan. 18, 1904 ..	—
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
New Brunswick—Prince Edward Island.....	Jan. 9, 1907 ..	—
Panama—Buenaventura	Feb. 28, 1907 ..	—
Buenaventura—Santa Elena..	Feb. 28, 1907 ..	—
Tangier—Cadiz	Mar. 20, 1907 ..	April 29, 1907
Cadiz—Teneriffe	April 10, 1907 ..	—
Dakar—Konakry	April 24, 1907 ..	—
Gibraltar—Tangier	April 25, 1907 ..	—

Wireless Telegraphy Notes.—The United States Consul-General at Constantinople reports that the Turkish Government has decided to establish several wireless-telegraph stations in the Empire. At present there are only two, at Kelemish, on the Anatolian coast, and Derna, on the coast of Tripoli, in Africa. The Government will engage two specialists in Europe for training the staffs of the projected stations.

Price of Power in Ontario.—According to the *Western Electrician* the following scale of charges for electric power have lately been formulated in Ontario: 5 H.P., used 10 hours a day, will cost the consumer £6. 6s. 8d. per horse-power per annum; 10 H.P., £6; 50 H.P., £4. 16s.; 100 H.P., £4. 10s.; 200 H.P., £4. 4s. The rates for arc lamps will be for 60 lights all night, every night in the year, £8. 8s. to £9, as against £15 now paid, and for incandescent lighting 2½d. to 3½d. per unit, as against the present rate of 6d. to 7d.

Luxemburg.—The *Elektrotechnische Anzeiger* states that La Société des Forges d'Eich is installing at Dommeldingden a central station, which will be worked by blast-furnace gas. A contract has been made for a term of 15 years with the town of Luxemburg for the supply, for lighting and other industrial purposes, of all the energy over and above that necessary for the society's own needs. The price is fixed at 0·7d. per kilowatt-hour for the first 2,000,000 units and 0·6d. per unit after. The cost of generation is estimated to be 0·25d.

Obituary.—We regret to record that Brigadier-General Eugene Griffin, first vice-president and general sales manager of the General Electric Co., died very suddenly of apoplexy at Schenectady, N.Y., on the evening of April 10th. He was trained as a military engineer at West Point, and after serving for some time in the United States Army he entered the business world as second vice-president of the Thomson-Houston Company. Upon the consolidation of this company with the Edison Electric Co. (forming the General Electric Co.) General Eugene Griffin became the first vice-president of the General Electric Co., holding this office until his death.

Cost of Electric Power in Chicago.—The electric supply companies in Chicago have established the following system of charging for energy consumers: 5d. per kilowatt-hour for that portion of the metered consumption equivalent to the first 30 hours' use per month of the maximum demand. For that portion of the metered consumption in excess of 30 hours' use per month of the maximum demand, and for further use up to 60 hours, 2½d. per kilowatt-hour. For all quantities in excess of a metered consumption equivalent to 60 hours' use per month of the maximum demand 1½d. per kilowatt-hour. There are also discounts for large quantities.

Rail Corrugation.—We have received a letter from "Road Inspector" on this subject, in which the communication by Mr. J. H. Briggs, published in last week's *Electrician*, is criticised. He takes Mr. Briggs to task for stating that there is corrugation on straight rails, and states that if corrugation *is* observed on a rail which appears straight, it will be found on closer examination to be really out of alignment. He also refers to the corrugation on the tube railways in London and on the Overhead Railway in Liverpool, and states that the following points need elucidation: (1) The absence of corrugation on a straight rail; (2) the absence of corrugation on the inner rail of a curve; (3) the absence of corrugation on a rail less than 150 ft. radius. Corrugations will form on any rail that is not absolutely straight, provided it forms the outer or longer rail, no matter how slight the amount of deviation from alignment may be.

Municipal v. Company Charges.—In reference to an article on this subject which appeared in our last issue, our attention has been called to the fact that the particulars given of the County of London Electric Supply Co.'s charges may be somewhat misleading because they were incomplete. The issue was decided solely on the question of price obtained, and not merely on advertised rates. For both lighting and power the company charges specially low rates when these are justified by the character of the demand. There is a ¾d. rate for night power supply, and a special rate for lighting basements. The

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published rates were higher than those of Bermondsey Borough Council, but in respect of the total supply in the St. Olave District the company received only an average rate of 1·97d. per unit, while the average rate obtained by the Council in the Bermondsey area was 2·22d.

Royal Institution.—At the annual meeting of the members of the Royal Institution, held on the 1st inst., the chairman announced that the managers had awarded the Actonian Prize of one hundred guineas to Madame Curie, as the author of the essay "Recherches sur les Substances Radioactives." The following gentlemen were unanimously elected as officers for the ensuing year: President, The Duke of Northumberland; treasurer, Sir James Crichton-Browne; secretary, Sir William Crookes; managers, the Right Hon. Lord Alverstone, the Right Hon. Earl Cathcart, Sir Benjamin Baker, W. A. B. Burdett-Coutts, Dr. Donald W. C. Hood, George Matthey, the Right Hon. Lord Lister, Francis Elgar, Sir Andrew Noble, Bart., Henry F. Makins, Sir William H. Perkin, Thomas Edward Thorpe, Sir William H. White, Alexander Siemens and the Right Hon. Sir James Stirling; visitors, Arthur N. Butt, Dugald Clerk, William A. Frost, Sir John Craggs, George F. Deacon, Robert K. Gray, Edward Dent, Major E. H. Hills, Charles E. Groves, Sir John Jackson, Frederick G. Henriques, Edward Kraftmeier, Francis Lys Smith, James Swinburne and Alfred F. Yarrow.

Annual Dinner of the Institution of Mechanical Engineers.—On Friday last the Institution of Mechanical Engineers held its annual dinner at the Hotel Cecil, Mr. T. Hurry Riches, President, being in the chair. He was supported by the Right Hon. R. B. Haldane, Secretary of State for War; Engineer Vice-Admiral Sir A. J. Durston, Messrs. E. B. Ellington, J. A. F. Aspinall, A. Tannett-Walker, Vice-Presidents of the Institution; Right Hon. J. Lloyd Wharton, Chairman N.E. Railway; Hon. Sir Horace Tozer, Agent-General for Queensland, and Sir Wm. H. M. Christie, F.R.S., Astronomer Royal, Sir Alexander Kennedy, F.R.S., Dr. R. T. Glazebrook, F.R.S., and Prof. J. Perry, F.R.S. There were about 250 guests present, including engineers from all parts of the country. The toast of "Our National Defenders," proposed by Mr. J. A. F. Aspinall, was responded to by Vice-Admiral Sir A. J. Durston and the Right Hon. R. B. Haldane, both of whom referred to the important part played by the mechanical arts in the provision of effective armaments for the naval and military forces. The toast of "The Institution of Mechanical Engineers," proposed by Sir Wm. Christie and responded to by the President, brought the proceedings to a close at a late hour.

Tests on High-tension Insulators.—The *Street Railway Journal* gives an account of some tests made on the Kleinstuber type of Ambroin high-tension insulators made by the Vereinigte Isolatorenwerke Actiengesellschaft, of Berlin-Pankow, Germany. These insulators are not of the multiple-petticoat form commonly used for high-tension work. The ordinary insulator consists of a single bell of Ambroin moulded at the top, in which a metal cap is screwed, but for very high potentials there is also a disc of insulating material to separate the bell from the cap. To compare this construction with porcelain, the company submitted a number of its insulators for tests by the Reichsanstalt. The figures thus secured were then compared with the latest for porcelain insulators made in Germany. The following figures are taken from this comparison:—

Porcelain Insulators.			*Ambroin Insulators.*		
Arcing voltage in dry weather.	Arcing voltage in wet weather.	Weight in grammes.	Arcing voltage in dry weather.	Arcing voltage in wet weather.	Weight in grammes.
60,000	29,000	700	56,000	29,000	610
75,000	37,000	1,460	69,000	46,000	740
91,000	44,000	1,850	77,000	54,000	810
93,000	49,000	2,125	83,000	66,000	1,200

Electrical Development in Canada.—An article in *Cassier's Magazine* describes the extensions which have lately been made by the Shawinigan Water & Power Co. to their station on the St. Maurice river. This station has, up to the present, supplied about 15,000 H.P. to Montreal (over a distance of 80 miles) and to other nearer points, for the operation of railways and electrochemical works. A fourth unit of 10,500 H.P. has just been installed and is now in operation. A second transmission line to Montreal has also been built. Three-phase current is generated at 2,200 volts 30 cycles, and is stepped up to 50,000 volts for transmission. In the Montreal sub-station, the conditions to be met require two sets of 60 cycle 'bus bars and one set of direct-current 'bus bars. The 30 cycle 'bus bar is so arranged that it can be divided into three parts, to feed respectively one or other half of the frequency changers and the rotary converters. The system has been arranged so that all the load can be carried on either of the two transmission lines or on both, or the lines can be separated and a portion of the load carried on each line, which lines can be fed from different generators. In connection with the addition to the Montreal sub-stations the 4,000 kw. motor-generator is of interest. It consists of a 60 cycle three-phase 2,300 volt generator directly connected to a 30 cycle three-phase 2,400 volt motor. The generator is rated at 4,000 kw. at 75 per cent. power factor—*i.e.*, a builder's rating of 5,300 kw. or 7,100 H.P. The rating of the motor is 8,000 H.P., making it the largest synchronous motor in operation. To bring this set up to synchronous speed an induction motor is used having two poles less than the synchronous motor. This motor is designed to give a large starting torque and under test has developed 1,500 k.v.a. Its speed is controlled by a motor-driven water rheostat. This scheme has worked well in practice, as the set can be brought from rest to synchronous speed, the switches closed, the field put on the generator and the 60 cycle side connected to the 'bus bars in four minutes. The machine runs at 300 revs. per min., which gives a peripheral velocity of over 10,000 ft. per minute.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 3rd (to-day).

North-East Coast Institution of Engineers and Shipbuilders.

7:30 p.m. Meeting in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Paper on "The Application of Electricity to the Driving of Pumping Machinery for Pontoons and Graving Docks," by Mr. W. C. Mountain. (Reply to the discussion.)

MONDAY, May 6th.

Society of Chemical Industry.

8 p.m. Meeting at the Chemical Society's Rooms, Burlington House, Piccadilly. Paper on "The Works Chemist as Engineer," by Mr. O. Guttmann.

WEDNESDAY, May 8th.

Junior Institution of Engineers.

8 p.m. Meeting at the Westminster Palace Hotel. Paper on "The Theory of Steam Turbines," by Messrs. H. M. Martin and R. H. Parsons.

THURSDAY, May 9th.

Birmingham and District Electric Club.

7:30 p.m. Meeting at the Colonnade Hotel, New-street, Birmingham. Paper on "Polyphase Induction Motors," by Mr. R. D. Archibald.

Institution of Electrical Engineers.

8 p.m. Meeting at the Society of Arts, John-street, Adelphi. Papers on "The Use of Wooden Poles for Overhead Power Transmission," by Mr. C. Wade (adjourned discussion, if not concluded at the previous meeting), and on "Telephonic Transmission Measurements," by Messrs. B. S. Cohen and G. M. Shepherd (if time permits).

FRIDAY, May 10th.

Association of Engineers-in-Charge.

7:30 p.m. Annual General Meeting at St. Bride's Institute, Bride-lane, Fleet-street, E.C.

Physical Society.

8 p.m. Meeting at the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Paper on "Stereoscopy with Long Base-line, illustrated on the Screen," by Dr. T. C. Porter.

Society of Chemical Industry.

8 p.m. Meeting at the Chemical Society's Rooms, Burlington House, Piccadilly. A Critical Statement on "Consideration of the Patents and Designs Bill, 1907," will be communicated by the Chairman. A discussion will follow.

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ELECTRIC FURNACE METHODS OF IRON AND STEEL PRODUCTION.—VI. (*continued*).

BY JOHN B. C. KERSHAW.

Summary.—In these articles, after briefly giving the history of the electric furnace and stating the present position of the industry, the author describes the Héroult, Keller, Kjellin, Stassano, Gin, Conley, Ruthenberg, Rossi, and Willson furnaces, and finally deals with the question of yields and costs.

The Harmet Furnace.—M. Harmet was connected with the Fonderies, Forges et Acieries, St. Etienne, when Héroult was developing his electro-thermic steel refining furnace, and the furnace described below is reported to be due to M. Héroult's attempt to introduce his process of steel refining at St Etienne.

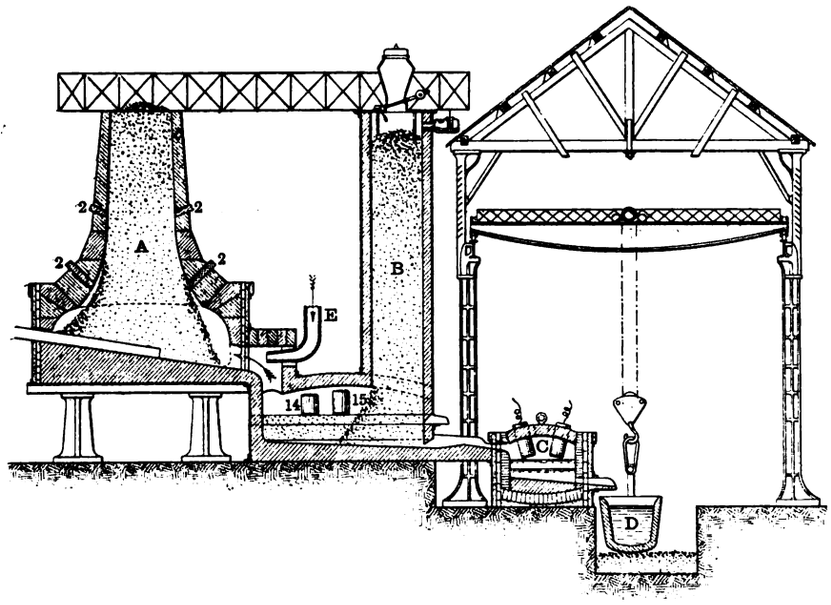

FIG. 18.—THE HARMET FURNACE.

The Harmet furnace is shown in sectional elevation in Fig. 18. The general plan comprises three parts, each corresponding to one phase of the treatment of the ore and molten metal. In the first shaft (A) the ores are fused, in (B) they meet with the pre-heated reducing and slagging materials from this column, and are reduced to the metallic state, while in (C) the final refining operation is carried out. The progress of the ore and metal through (A) and (B) is continuous, while (C) is tapped intermittently. The heating of the ore and other materials in A and B is effected largely by the heated gases escaping from B and C, but resistance heating is also employed, carbon electrodes being placed at suitable points in the walls of A and B (see 2, 2, 2, 2, 6, 6, 14 and 15). The heating of the metal in the refining crucible is carried out by massive carbon electrodes passing through the top of the crucible, and carrying a current of electricity which passes from the one electrode through the slag and metal back to the other electrode. The complete furnace is therefore a combination of the Keller and Héroult furnaces already described, with an attempt to utilise the heat of the waste gases for the preliminary heating of the raw materials—coke, lime and ore.

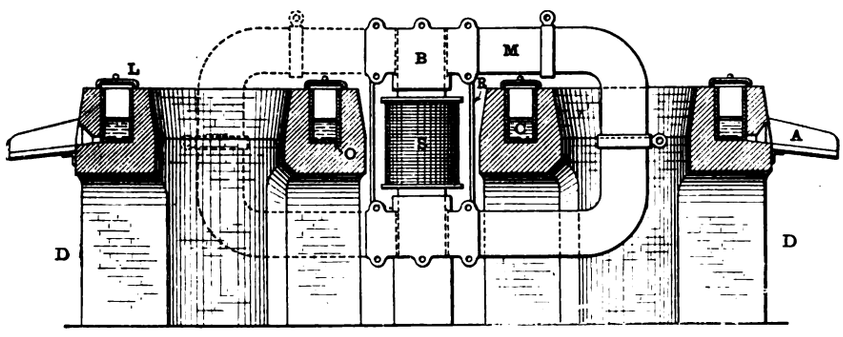

FIG. 19.—THE HIORTH FURNACE.

M. Harmet has calculated that one ton of steel can be made in this furnace with an expenditure of between 2,500 and 3,600 E.H.P.-hours, and has estimated the cost at 29.24fr. per ton for electric power and coke alone. These estimates are based solely upon theoretical calculations, and must be accepted with some reserve.

The writer is not aware that the Harmet process and furnace are now in operation, although it is stated that trials of the furnace were carried out at St. Etienne a few years ago.

The Hiorth Furnace.—This furnace has recently been patented by F. Hiorth, of Christiania, and is somewhat similar in principle and design to the Kjellin furnace described in Article IV. Fig. 19 is a sectional elevation of the new design which provides for two or more furnaces being served by the one transformer coil. The iron core of the transformer is D shaped, and is mounted as shown at B; the primary coil is indicated at S. A current of 90 amperes at 3,000 volts pressure is supplied to this coil, and is said to be transformed into a current of 3,000 amperes at 70 volts in the secondary circuit of the transformer, which in this case is formed by the mass of metal contained in the annular channel C of the furnace. An efficiency of 78 per cent., and a temperature of 2,000°C., are reported to be attained. The furnace is built as a hollow brickwork cylinder, D. The channel which contains the iron is covered by lids, L, to prevent oxidation of the metal during the refining operations. The screen R is provided to protect the coil S from the heat radiated by the walls of the furnace. A is the spout by which the metal is tapped when ready for discharge.

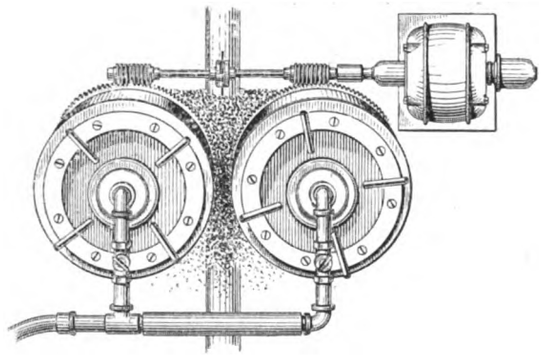

FIG. 20.—THE RUTHENBERG FURNACE.

There is little to distinguish the Hiorth furnace up to this point from the Kjellin type, but the provision made for rotating the electromagnet on its axis, and swinging it round into the position shown by the dotted lines, is a peculiar feature of the Hiorth design, and may be held to substantiate the claim for novelty.

By utilising this plan in the construction of transformer furnaces it is claimed that continuous operation is attained, and that the capital expenditure upon the electrical portion of the plant is reduced. It is not clear, from the drawing, how the furnace design allows for the removal of the coil from the centre by swinging round on its axis without destruction to the furnace walls, and it may be doubted whether this plan in practice would offer the advantages claimed for it by the inventor. The similarity to the Kjellin furnace is also likely to raise questions of patent priority should the Hiorth furnace ever be operated upon an industrial scale; but, so far as the writer is aware, the furnace has not yet been worked on a large scale.

The Ruthenberg Furnace.—The Ruthenberg furnace is shown in Fig. 20, a reproduction of a photograph taken from an

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experimental furnace erected at Lockport, N.J., in 1902, and described by the inventor in the issue of *Electro-chemical Industry* for February, 1903.

The furnace consists of two magnetic rolls carrying an electric current, between which the ore, mixed with a calculated amount of carbon, is fed. The ore is picked over to free it from gangue, and is crushed before use. The poles of the magnet are within the bronze rolls, which are driven by a small motor and worm-gearing at a speed of 4 revs. per min. The rolls carry a current of 700 amperes at 50 volts, and are water cooled. The magnetic action of the rolls holds a bridge of the crushed particles of ore and coke in the narrow gap. The electric current passes from one roll to the other through this crushed ore and coke before the latter is carried downwards by the revolution of the rolls and dropped into the soaking pit below.

The metal produced in this way requires smelting and refining in an open hearth steel furnace before it can be placed upon the market. If successful, therefore, the process is really one of ore agglomeration with partial reduction of the iron oxide to the metallic state.

The inventor in his original specification claimed the further reduction of the agglomerated ore in a special chamber by means of waste furnace gases, but this part of the patent does not appear to have been developed.

As regards cost, Ruthenberg stated that one ton of steel could be produced by his process with an expenditure of only 500 kw. hours, and an experimental plant was erected at the works of the Cowles Electric Smelting Co., at Lockport, N.J., in 1902, to substantiate this claim. The plant attracted much notice, and was visited by a large number of steel makers in January, 1903, but the further development of the process has not realised the inventor's hopes. In July, 1903, this experimental plant at Lockport was visited by three of the Canadian Commissioners, and their report upon it was distinctly unfavourable, as theyfound little reduction or agglomoration of the ore had occurred, either in the gap between the rolls or afterwards in the soaking pit. The company financing the trials has since gone into liquidation, but it is reported that further trials of the process and furnace will shortly be made at Niagara Falls. The writer does not consider that these are likely to result in financial success, but the process is interesting on account of its novel features, and it is, therefore, worthy the study of electro-metallurgists.

(To be concluded.)

WIND POWER FOR THE GENERATION OF ELECTRICITY.

BY W. O. HORSNAILL.

Summary.—The Author considers the possibility of utilising wind power for the electric lighting of country houses. Some account is given of actual installations, and the conclusion is drawn from estimates that a wind-power plant is cheaper in both first cost and in running.

Surprise is frequently expressed that wind is so little used in this country for all kinds of purposes requiring small and moderate motive power. If the velocity of the wind were constant throughout the year, or for a certain number of hours during each day, a large amount of power now provided by oil or gas engines could be much more cheaply obtained by means of windmills. Unfortunately the speed of the wind is continually varying from day to day, and sometimes the velocity will scarcely rise above 10 miles an hour for several days together, the consequence being that windmills can only be utilised (1) for the production of power in such a form as to be capable of storage; (2) for running machinery which can be used intermittently whenever the weather is suitable. The second purpose need not be considered here, as wind power is already in use extensively for driving chaff cutters, circular saws, root cutters and other farm implements. With regard to the storage of energy only two means of doing this are available—the raising of water into a tank and the storage of electricity in a battery of accumulators. The method of raising water to be afterwards used as a source of power by means of a water motor is put out of court by the cost of the storage tank, which must be of enormous dimensions to provide an appreciable amount of power over a calm period of several days. Supposing, for instance, that 1 H.P. be required for four days of 10 hours each, and assuming the fall to be 60 ft., 33,000 ÷ 60 lb. of water will be wanted per minute, or $\frac{33{,}000 \times 60 \text{ minutes} \times 40 \text{ hours}}{60} = 1{,}320{,}000$ lb. of water for the period in question. Dividing by 62½ it is found that 21,000 cubic ft. capacity is necessary, requiring a tank 36 ft. in diameter by 21 ft. deep, and this estimate takes no account of the losses incurred in the water motor. Such figures as these dispose finally of any wind-power scheme based upon the storage of water, our only remaining course being to accumulate energy in an electrical storage battery.

To more clearly illustrate the difficulties to be overcome and the means and cost of meeting them, a proposal to light a private house will be considered, followed by some reference to what has already been done in this direction.

Suppose the house to require 100 lamps of 21 c.p. (assuming tantalum lamps to be used at 100 volts), out of which 50 will be alight at once, on the average, during ordinary evenings when no entertaining is taking place. We may now safely take 1·7 watts per candle power; therefore 50 by 21 by 1·7 equals a total of 1,800 watts, or say 18 amperes at 100 volts.

The next question to consider is the capacity of the storage-battery, and a study of the wind velocity diagrams shown in Fig. 1 will enable this point to be settled. These diagrams represent the daily average speed of the wind at a meteorological station in the eastern counties for the year 1905, and although the varying velocities for night and day respectively are not shown, reference to the actual wind charts discloses the fact that during periods of light winds the highest speeds occur in the daytime. This is an important feature, as it enables the battery to be charged in daylight when no current is required. Turning again to the diagrams the calmest period will be noted extending from July 3rd to 22nd, but at this time of year very little light is required, and if we assume that current be turned on half an hour after sunset and the lights are put out at 11:30 p.m. current is only consumed for three hours each night. Suppose the battery to be fully charged on the second instant, 18 ampere hours must be given out up to the 8th, when charging will again commence and go on during the 9th until the battery is fully charged. Hence we require a storage of 18 amperes by three hours by five days equals 270 ampere-hours. But 18 amperes is not a sufficient allowance; possibly entertaining may take place on two evenings out of the five, and lights will be used during the night, so that an allowance of 25 amperes will be nearer the mark, making a total of 375 ampere-hours. If the actual daily velocity charts be examined, however, it will be found that enough wind for charging occurred for six hours on the 4th, three hours on the 5th, ten hours on the 6th, and seven hours on the 7th, in each case during daylight working hours, when the battery could be charged; assuming always that a wind velocity of 10 miles an hour is sufficient for this purpose. A more serious calm for five days occurs from November 30th to December 4th, when lighting current is required for seven hours a day, making a total of 25 amperes by 7 hours by 5 days equals 875 ampere-hours. Here, again, when the charts are consulted, although the average speed is under 10 miles an hour, the following times occur when the mill will give out full power for charging:—6 a.m. to 4 p.m., November 30th, equals 10 hours; 10:30 to 11:30 a.m., December 1st, equals one hour; 6 to 10:30 a.m. and noon to 4:30 p.m., December 2nd, equals nine hours; 10 a.m. to noon, December 3rd, equals two hours; 10 a.m. to 4:30 p.m., December 4th, equals 6½ hours. Supposing a capacity of 360 ampere-hours be provided, and charging takes place at a rate of 30 amperes, on November 30th the battery will be fully charged and 175 ampere-hours will be taken from it; 30 are put in and another 175 are taken out during the following day; on December 2nd 270 ampere-hours are put in and another 175 taken out, leaving 135, to which are added 60 ampere-hours on December 3rd, making 195 available, whereas only 175 are wanted. On the ensuing day charging can pro-

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ceed for 6½ hours, which finishes the calm period. The proposed battery capacity appears to be cut rather fine, but it must be remembered that ample allowance has been made in estimating the number of lamps in use at one time and to cover special evenings and lighting after 11:30. Moreover, at

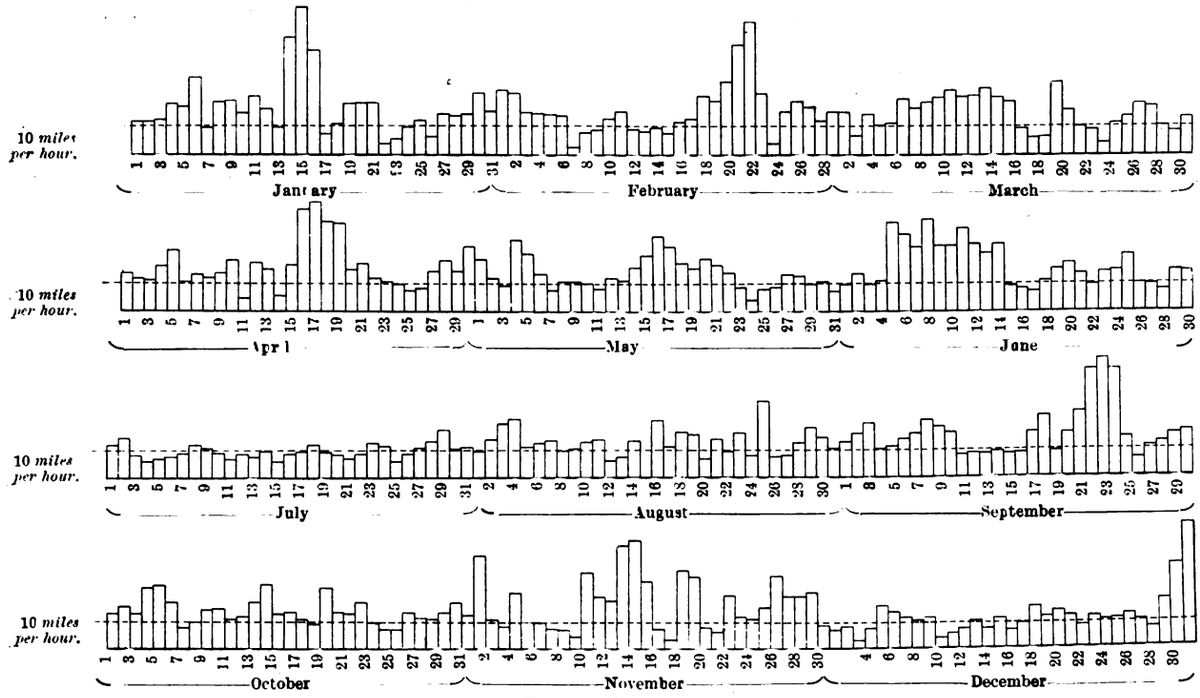

FIG. 1.—WIND CHART.

times, although the wind has not been sufficient to charge at full rate, it has been strong enough to provide a certain amount of charging current, also a comparison to be made later with an existing plant indicates that a battery capable of giving out 360 ampere-hours is large enough for the purpose in view.

The dynamo should be wound in such a manner as to give a gradually increasing voltage over a considerable range of speed. This can be done by winding a few series turns on the field magnets through which a current is passed in an opposite direction to that obtaining in the shunt coils, the result being that as the speed increases and the voltage rises, more current passes round the series turns and weakens the field. If a plain shunt machine be used without this device serious overloads are likely to occur owing to the uncertain speed of the wind, the power from which rises very rapidly with an increase in velocity. If the windmill be large enough to give the full output of the dynamo with a 10 mile-an-hour wind, more than four times the power will be developed when the wind has increased to a speed of 20 miles an hour, and in gusty weather such conditions might frequently occur, in fact very severe overloads have taken place in actual practice where a plain shunt dynamo has been used, resulting in the breakage of the gear. Of course all windmills are fitted with some means for running the wind power to waste when the speed would otherwise increase to a dangerous degree, but these governing arrangements are of a somewhat crude nature and cannot be depended upon to act effectively in such cases as are being considered. The reason for this is mainly because a windmill used for ordinary purposes will only give out its full power with a 15 or 20 mile an hour wind, and the governor, which is dependent upon the wind pressure on the sails, only comes into action beyond this stage. In the case under consideration the full power is developed with a wind velocity of 10 miles an hour, which is too light a breeze to allow of governing by the ordinary methods; therefore, the mill will sometimes attain speeds which would damage the dynamo if the voltage increased in proportion to the number of revolutions per minute as in an ordinary shunt machine. It may be contended that fuses or overload cutouts can be used as an alternative, but if this course be adopted an attendant must always be present when the mill is at work.

Having now settled the size of the battery and the dynamo, the power of the windmill required to drive the latter may be gone into. An average charging current of 30 amperes has already been decided upon, and the mean pressure may be taken at 130 volts, therefore the output of the dynamo will be equal to 3·9 kw. Allowing for an efficiency of 80 per cent., this machine will require about 5 B.H.P. to drive it, involving a mill with sails 24 ft. in diameter, if the disc type be adopted.

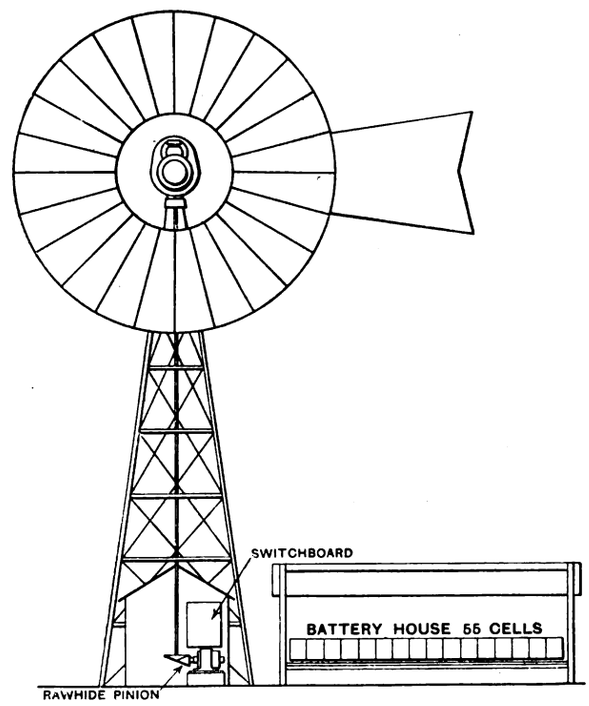

FIG. 2.—GENERAL ARRANGEMENT OF PLANT.

Regarding the latter, careful experiments have demonstrated that the old-fashioned mill with four sails is rather more efficient in a moderate breeze of say 12 to 15 miles an hour, but it is not so easily started in light winds, and the appear-

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ance is less pleasing. However, the four-sailed mill is much the cheaper of the two types, and it will therefore be considered as an alternative in comparing the relative costs of oil and wind power. It is of great importance in dealing with wind power to eliminate friction as far as possible, and for this purpose at least one maker of disc mills employs ball and roller bearings throughout. Some advantage may also be gained by installing the speeding up gear at the top of the mill, in which case a comparatively light vertical shaft is sufficient to transmit the power, as it runs at a considerable speed, and with this construction it is also feasible to drive the dynamo by bevel gear from the vertical shaft as shown in Fig. 2.

The governing of the mill is of some importance, and there are two methods of carrying this into effect. The usual plan is to hinge the vanes and connect them to a series of levers which tend to raise a weight as the wind increases and blows them further open. An alternative design allows the complete disc to turn on its vertical axis partially out of the wind against the pull of a weight; the mill being mounted upon a ball race to make it more sensitive in this respect. One distinct advantage of the latter type is that it cannot become back winded, as when the mill is stopped the tail automatically comes round into the same plane as the disc.

The plant described now consists of the windmill, the connecting gear, the dynamo and the ordinary type of battery switchboard with "cut-in-cut-out" switch, and in comparing the relative cost of driving by an oil engine or a windmill we need not carry the figures beyond this point, as the house wiring and lamps will be the same in either case.

(To be concluded.)

THE DETERMINATION OF THE MEAN HORIZONTAL CANDLE-POWER OF GLOW LAMPS.*

BY F. UPPENBORN.

Summary.—The author describes the four chief methods of obtaining the mean horizontal candle-power of glow lamps. The conditions which must be fulfilled in order that angle-mirror methods may give accurate results are investigated. The method of rotating glow lamps is convenient, but leads to errors owing to the change in shape of the filament and the flickering appearance of the field of view of the photometer. Better results are obtained by rotating the glow lamp in front of an angle mirror. The Reichsanstalt rotating mirror method is also referred to.

The following are the four chief methods of determining the mean horizontal candle-power of glow lamps in use at the present time:—

1. The method of direct measurement.
2. The angle mirror method of the Verband Deutscher Electrotechniker.
3. The angle mirror method of the Siemens and Haeske A.G.
4. The rotation method.

In this article the author contributes a discussion and criticism of these four methods.

1. *The Method of Direct Measurement.*—In this—the original method to which we must always have recourse for purposes of comparison—the lamp is placed in a vertical holder furnished with a horizontal scale of degrees, and the mean horizontal candle-power is calculated from the mean of 36 photometrical readings taken at intervals of 10 deg. This is, at present, the most accurate method, but is very tedious, and must frequently be replaced by others which are more convenient.

2. *The Angle Mirror Method of the Verband Deutscher Elektrotechniker.*—In the so-called "Verbandsmethode," a photometer bar, graduated in candle-power direct in such a way that the division corresponding to 10 c.p. is one meter distant from zero, is employed. Then, if J be the candle-power, and r the corresponding distance from zero in centimetres, we have $\frac{J}{10} = \frac{r^2}{(100)^2}$ or $J = \frac{r^2}{(1{,}000)}$, provided that the illumination of the side of the photometer removed from the lamp under test is kept constant. With this object, the photometer and the "intermediate" or "comparison lamp" are connected rigidly together and are moved together during the measurements. Immediately over the zero of the bar an angle mirror of certain prescribed dimensions is placed, and 9 cm. in front of it stands a standard lamp of known hemispherical candle-power. The photometer is next placed opposite the division of the bar corresponding to this value, and is joined to the comparison lamp by means of a rigid connection about 54–66 cm. long. The P.D. across the comparison lamp is now altered until both sides of the photometer screen are equally illuminated, and this P.D. is maintained constant through the subsequent measurements.

If, now, we replace the standard lamp by the lamp to be tested, adjust the P.D. of the latter to its correct value, and move the photometer and comparison lamp until both sides of the photometer are again equally bright, the reading under the photometer index gives the candle-power of the lamp under test.

This method, therefore, employs a constant and, for photometrical measurements, favourable illumination of about 25–30 lux. This is an advantage because at the same illumination errors of observation are usually the same. On the other hand, the necessity of fixing comparison lamp and photometer rigidly together is a disadvantage, for the increased weight to be moved to and fro becomes wearisome to the observer and slightly influences the accuracy of his setting of the photometer. Liebenthal* has also shown, that in order to obtain accurate results, the standard lamp and the lamp tested should have as nearly as possible the same candle-power and the same polar curve of distribution of light. Therefore it is not advisable to use a 10 c.p. standard lamp when testing 32 c.p. lamps, or a 110 volt standard lamp with a single-looped filament when testing 220 volt lamps with two loops, or to compare lamps with clear bulbs against lamps with frosted bulbs.

The author then proceeds to describe some tests bearing on the accuracy of this method. Eight lamps were first carefully tested by the method of direct measurement and then by the Verbandsmethode, standard lamps with variously shaped filaments being employed. The errors recorded ranged from 0·11 to 3·38 per cent., and it was found that the errors were, in the main, greater or smaller according as the standard lamp and the lamp under test differed to a greater or less degree in candle-power and shape of filament. The author concludes, therefore, that when attention is paid to this point the method gives satisfactory results.

3. *The Angle Mirror Method of the Siemens & Halske A.G.*—In this method angle mirrors are fixed at both ends of the 2 metre photometer bar. The lamps are stationary and the photometer is moveable. The bar is furnished with two scales, one graduated in centimetres, the other in candle-power. The division on the scale at the centre of the bar, and therefore 1 metre distant from zero, corresponds to 10 c.p.

The graduation, therefore, follows the law $J = 10\left(\frac{r}{200-r}\right)^2$, where J = a certain candle-power and r the corresponding distance from zero in centimetres. The illumination of the photometer screen is not constant in this case, being dependent, evidently, on "r."

The method of test is exactly the same as in the case of the "Verbandsmethode," except that photometer and comparison lamp are not bound together and the photometer only is moved. The author describes experiments intended to investigate the accuracy of this method, as in the case of the Verbandsmethode. The experiments again led to the same conclusion—viz., that satisfactory results are obtained, provided the candle-power and form of filament of both standard lamp and lamp under test are very nearly the same.

4. *The Rotation Method.*—According to Talbot's law, "When a portion of the retina is subjected to a regular, periodically varying stimulus, and the duration of the period is sufficiently short, an impression is received which is the same as would ensue if the light received during each period were distributed over the entire duration of that period."

Therefore, if a glow-lamp is rotated about its vertical and photometrical axis so rapidly that a continuous impression of luminosity is produced, one should be able to obtain the mean hemispherical candle-power by means of a single reading.

The author investigates the accuracy of this method by testing the eight lamps before referred to in a rotating ho'der. In all cases the results were too low, the error varying from −3·32 to −9·33 per cent.

One of the chief sources of error connected with this method arises from the fact that, owing to the centrifugal force of rotation, the filaments become distorted in shape and therefore present a considerably smaller vertical projection towards the photometer screen than they do when stationary. This is shown by the fact that the error was most pronounced in the case of those lamps the filaments of which were very long but were, notwithstanding, provided with little or no support.

That better results can be obtained under certain conditions by this method is made evident by the results of experiments on lamps provided with short, well-supported filaments, and, in particular, tantalum lamps, the filaments of which are not easily distorted. Under these conditions the errors were only of the order of 0·35 to 3·67 per cent. An attempt to reduce this error by employing a much lower speed of rotation failed, because a distinct "flicker," making accurate measurements impossible, could then be seen in

* Abstract of an article in the *Electrotech. Zeitschr.*, February 21, 1907.

* "Lichtverteilung und Methoden der Photometrierung von elektrischen Glühlampen," *Zeitschr. f. Instr.*, Bd XIX., 1899, S193 und 225.

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the field of view of the photometer. This flicker is due not only to the variation in light intensity from the lamp in different directions, but also to the fact that many lamps are not fixed straight in their sockets, so that the tips of their bulbs describe small circles during rotation.

As the speed of rotation is increased the *objective* errors arising from the deformation of the filament must increase, but, on the other hand, the *subjective* errors caused by the flicker must decrease. It should, therefore, be possible to find a particular speed for each make of lamp at which the combined effect of these errors is a minimum.

The author investigated this point by careful observation of the errors occurring at speeds up to 460 revs. per min., for different types of lamps. He found, however, that the errors at a particular speed varied very much for individual lamps, even of the same variety. The errors were also almost invariably more pronounced in the case of 220-volt lamps than for 110-volt lamps of the same make.

As regards the most favourable speed, nothing very positive could be said. Errors, however, increased very rapidly for speeds higher than 180 revs. per min.

While the objective errors may be very considerable, the subjective errors are quite inconsiderable at fairly high speeds. The author describes an experiment according to which the subjective errors fall below the limits of observation for speeds above 250 revs. per min.

There is, therefore, no object in increasing the speed past this point, and bearing in mind the increase in objective errors above 180 revs. per min., this latter speed is probably the most satisfactory.

It is to be noted that if the candle-power of a glow lamp is obtained in terms of a standard lamp of exactly the same variety, and both lamps are rotated, very consistent results may be expected. For, in this case, the "deformation coefficient" of both lamps should be the same, and the error cancels out. But even under these conditions it is better to restrict the method of rotation to those types of lamps in the case of which the deformation of the filament is only slight.

The method of rotation may also be combined with an angle-mirror method with the possibility of reducing the errors connected with both. In the first place it is clear that the flickering ffec will be reduced by so doing. For when the lamp is rotated front of the angle mirror the eye receives, at each instant, the um of the light intensities in three different directions and the flicker will be reduced as much as if the lamp had been rotated three times as fast. But a reduction of the errors connected with the angle mirror methods may also be expected, for the exactness of these methods depends upon the distribution of light from the standard lamp and from the lamp under test being the same.

But if the lamp is rotated we utilise the light from, not only three but an infinite series of directions.

In order to test this point four lamps were chosen which were known to undergo only small deformation of the filament when rotated. The actual mean hemispherical candle-power of the lamps was first tested by the method of direct measurement. The lamps were then, in turn, placed in a stationary holder situated 9 cm. in front of the angle mirror and their candle-power again tested. The mirror factor—*i.e.*, the number by which the result of photometering each lamp in front of the angle mirror must be multiplied in order to get the mean hemispherical candle-power—was then obtained, with the results shown below :—

Mirror Factors with Stationary Lampholder.

Lamp No.	Mean horizontal C.P.	C.P. with the mirror.	Mirror factor.	Δ per cent.
1	16·1	43·5	0·370	−1·47
2	19·0	50·9	0·373	−0·67
3	18·8	49·1	0·383	+2·00
4	17·5	46·5	0·376	+0·13
			Mean 0·3755	1·07

The mirror factors are not the same, the greatest deviation △, from the mean, 2 per cent., occurring in the case of lamp No. 3. The four lamps were now again tested in front of the mirror exactly as before, except that the holder was now rotated at 180 revs. per min. The following new set of mirror factors was thus obtained :—

Mirror Factors with Rotating Lamp Holder.

Lamp No.	Mean horizontal c.p.	C.P. with the mirror.	Mirror factor with rotating holder.	Difference between the mirror factors obtained with stationary and rotating holders. Per cent.
1	16·1	43·5	0·370	±0
2	19·0	50·5	0·376	+0·8
3	18·8	50·7	0·371	−3·1
4	17·5	46·6	0·375	−0·3
			Mean 0·373	1·0

It is to be noted that, with the exception of lamp No. 3, the mirror factor is not very appreciably altered. From this the author concludes that the sum of the light intensities in three directions (as obtained by the angle-mirror method with stationary holder) is independent of the position of the plane of the filament of the lamp, and that the mean hemispherical candle-power is obtained with sufficient exactitude.

Finally, the mean hemispherical candle-power was obtained for each lamp with the rotating holder, the angle mirror being removed. The results were as follows :—

Lamp No.	Mean horizontal candle-power.		Deviation from the exact value.
	Exact.	With rotating holder.	Per cent.
1	16·1	15·5	−3·7
2	19·0	18·1	−4·7
3	18·8	18·0	−4·3
4	17·5	16·8	−4·0

The deformation errors are, therefore, considerable, in spite of the careful choice of the lamps tested. The flicker was also very much more pronounced than when the angle mirror was used.

From these experiments the author concludes that by the application of the angle mirror to the method of rotation the flicker is very considerably reduced, and that the mirror-factor is very nearly the same whether the glow lampholder is stationary or is rotated. But it cannot be said with certainty that the variability of the mirror factor for individual lamps is appreciably reduced by rotating the glow lamp.

As regards the constructive details of the rotating holder, it is worthy of note that the use of slip-rings and carbon brushes in order to lead the current into the glow lamp may give rise to a fall of P.D. as great as 4 per cent. Hence it is advisable to bring the voltmeter leads straight to the slip-rings.

Finally, the author refers to the rotating apparatus used at the Reichsanstalt. In this apparatus the glow lamp is stationary and horizontal, with the axis of the bulb coincident with the photometrical axis of the bar. The direct rays from the lamp are obscured by means of a screen, and the mean hemispherical candle-power is obtained by the reflected light from two rotating mirrors inclined to the axis of the glow lamp.

By this means the error caused by the distortion of the filament following the rotation of the glow lamp is avoided.

At present there are no rotation methods applicable to the newer metallic filament lamps, which have very delicate filaments and must always burn in a hanging position.

THE ENGINEERING SOCIETIES BUILDING, NEW YORK.

During the past 20 years the project has been frequently discussed and agitated of bringing together in one building, with proper facilities for offices, library, auditorium, meeting rooms, &c., the various engineering societies that make their headquarters in New York. References to the idea may be found in various transactions and technical journals as far back as the early eighties, but even then the desirability of such accommodation had already become a topic of conversation among engineers. In 1895 an actual plan for such a joint home was submitted to Mr. Andrew Carnegie by Mr. W. D. Weaver, a member of the American Institute of Electrical Engineers, who received a reply of warm approval and commendation. In February, 1903, Mr. Carnegie offered $1,000,000 to erect a suitable building, and this amount he afterwards increased to $1,500,000. The only limitation on the gift was that it should be devoted to the erection of a building, the bodies interested buying the land. Owing to the difficulties involved in the purchase of as much land as would be necessary and in combining under the one roof all the social and technical functions, it was decided to erect two separate buildings, one for the Engineers' Club on Fortieth-street and one for the American Institute of Electrical Engineers, American Society of Mechanical Engineers and the American Institute of Mining Engineers on Thirty-ninth-street, the two buildings to be placed in such relationship that access from one to the other would be easy and the underlying common purpose thus be subserved to the full extent.

The corner stone of the Engineering Societies building was laid by Mrs. Andrew Carnegie on May 8, 1906. The time of completion was fixed for November 15, 1906. Offices were ready for occupancy on December 15, 1906; some were in use before the end of the year, and the entire building, though not quite finished, was ready for use on January 1, 1907.

The electrical current supply for the building is derived from the New York Edison Co. and the United Electric Light and Power

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Co., so that both alternating and direct current are available. Space has been provided, and the steam and electric equipment have been designed, so that an electric generating plant may be installed at any time. The feeders and mains for the lighting system are arranged on the three-wire system, and the two-wire system for power. In all cases, all of the wires of a given circuit are installed in the same conduit, so as to permit alternating current to be used on any circuit in the building. As the building is to be used by different societies, it was essential that the feeder system should be arranged so as to provide means for measuring the current consumption separately in different portions of the building. For this

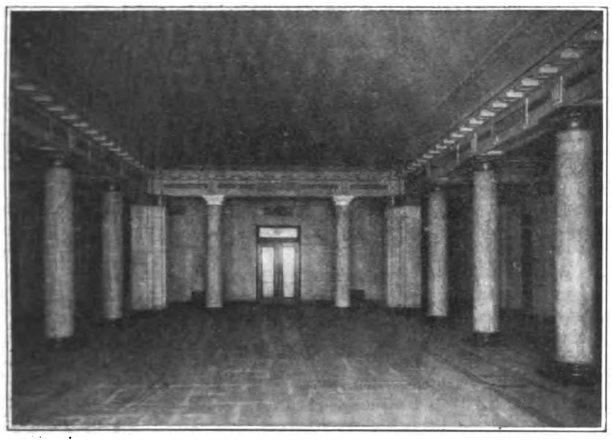

FIG. 1.—THE ENTRANCE HALL.

reason, the feeders were subdivided and the switchboard designed to have meters on each feeder, so as to permit making proper charges for electric current for each floor; separate feeders, of course, being provided for the entrance halls and corridors. Two separate feeders from the New York Edison Co. have been introduced into the building, so as to afford additional security in case of failure of one of the service mains. Two separate feeders are provided for the lighting of the main auditorium connecting at the switchboard with the two independent service street feeders, thereby providing duplicate and independent lighting service for the main auditorium, so as to preclude, as far as possible, the liability of interruption of the lighting service of the auditorium.

The central space in the entrance hall (Fig. 1) is lighted by means of individual lamps, placed in recesses, and concealed by panes of ground glass in the ceiling, at the sides of the rectangle formed by the columns around the large central area. In addition to this, larger crystal balls are provided in the outer corridor beyond the central space and in the elevator hall, entrances, &c. The effect of the individual lights in the recess, screened by glass, is to afford ample illumination without any glare.

Crystal glass balls, holding "metallised filament" lamps of various sizes from 50 to 250 watts, are used on the principal floors. In some cases pagoda reflectors are used inside the balls to increase the effective illumination, and to reduce the current consumption. In other instances, however, in order to sub-divide the number of lights in the hall fixtures, several lamps have been placed inside the crystal balls. In all such instances, the metal plate at the top of the fixture supporting the sockets has been silvered to act as a reflector and to increase the efficiency, as far as possible.

The lighting of the auditorium, which is shown in Fig 2, is the most effective and probably the most interesting feature of illumination in the building. The result was obtained by the complete co-operation of the electrical engineers with the architects. At the engineers' suggestion, the architects provided a space of about 15 in. between the ceiling of the auditorium and the beams of the floor above. At the suggestion of the engineers, also, a glass septum was substituted in place of the proposed plaster panels in the ceiling. The details were then carefully worked out as to obtaining access to the lamps for renewal, and tests were made by the engineers to find a glass that would reduce the intrinsic brilliancy or glare, and at the same time would not have an amount of absorption prohibitive on the score of economy. The result obtained has been very satisfactory, and it is possible to sit through an entire lecture without being disturbed or distracted by the lighting. The general effect is both soft and pleasing, and resembles or suggests sunlight passing through glass, as at Napoleon's Tomb in the Invalides, in Paris. As a matter of fact, the solid arches of the floor above are within 2 ft. or 3 ft. of the glass through which the light passes. Additional lighting screened by the same kind of glass is provided at the rear and at the sides under the balcony. Dimmers are provided for reducing the amount of illumination in the auditorium to any desired amount, and also for the purpose of gradually increasing the lights to the maximum, after the room has been darkened for a stereopticon, thereby avoiding the unpleasant sensation produced on the retina of the eye, by flooding the room with light immediately following comparative darkness.

The lighting of the assembly and lecture rooms was also designed to prevent the lights from being distracting or unduly noticeable. For this reason the cove method was adopted, with additional outlets in the ceiling for supplemental fixture lighting. The difficulties of the building construction did not admit in all cases of obtaining continuous coves, nor coves of the exact form and dimensions desired. While the cost of lighting by this method is in excess of that using exposed lamps, the fact that the rooms are not in continuous use, but occasionally, for lecture purposes offsets this objection.

The general illumination of the library, a view of which is seen in Fig. 3, is obtained by means of lamps placed above the glass ceiling skylight on a plan similar to that used in the auditorium, the glass in the ceiling skylight being of the same kind as that used in the auditorium ceiling. In addition, ceiling outlets are provided for general illumination, so that the indirect lighting above the glass need be used only at certain times. The light for reading is obtained by means of standard fixtures placed upon the tables. The general effect is charming and agreeable.

There are two Otis passenger elevators: these are of the latest type electric drum machines, being equipped with double screws, compound momentum brakes, automatic stop motion switches mounted on the drum shafts for limiting the car travel at either end, hoistway limit switches, slack cable switches and emergency brakes. The telephone equipment consists of one switchboard for the entire service throughout the building from which all of the trunk lines to the central office of the Telephone Company extend, and in which all the extension telephones in the building terminate. At

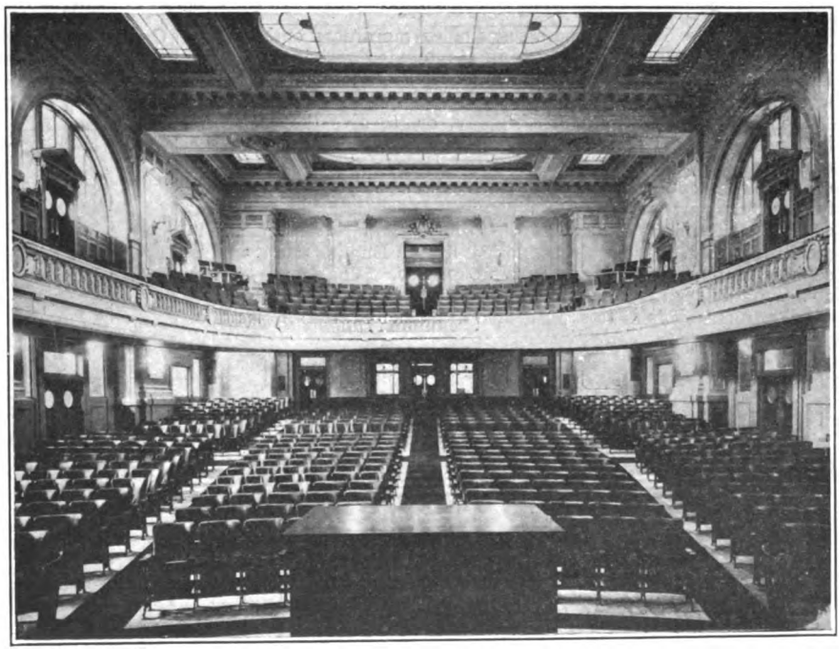

FIG. 2.—VIEW FROM THE PLATFORM OF THE MAIN AUDITORIUM.

the present time the switchboard is connected to the Bryant central office of the Telephone Company by means of seven lines, which may be used for incoming and outgoing traffic; and there are 38 extension telephones connected to this board and located throughout the building. The switchboard has an ultimate capacity of 15 central office lines and 60 extension telephones. This gives the building a flexible telephone service, since from any telephone at any point in the building communication may be had with any other telephone in the building or with any local, suburban or long-

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distance point through the lines of the New York Telephone Co. and its sister telephone companies. It is estimated that about 12,000 messages per year will be originated from the telephones in this building, and the contract to cover this number of messages has been arranged for.

FIG. 3.—ONE END OF THE LIBRARY.

The main auditorium extends up through two floors and with its gallery will seat about 1,000 persons. The requirements of this chamber were unusual and difficult of definition. It had to be arranged primarily for the general meeting of the Societies, at which the speaking is from the floor as well as from the platform, and at which diagrams, illustrations or blackboard drawings are often employed. This is quite the opposite from the ordinary audience hall, where the stage is the starting point both for the seating arrangements and for the acoustic and optical necessities. Hence the platform is notably small for so large a hall, accommodating few persons, while any speaker in the audience is easily within range of observation by everybody. On both the parterre and the gallery floor, at the sides the auditorium is surrounded by corridors, rendering access to every point very easy and permitting ready withdrawal for conversation, committees, &c. The corridors assist also in maintaining quiet within the hall. The platform has ante-rooms and is conveniently close to the freight elevator for delivery of apparatus. There is also a fine stereopticon equipped with connections for moving pictures. The seats are fixed opera chairs in red leather with revolvable tops and the aisles are laid with red carpet. The elevators and stairs open directly upon the two floors of the auditorium, which can thus be emptied very quickly in case of emergency. Practical tests of the chamber have already shown it to be a success in every respect of comfort and convenience.

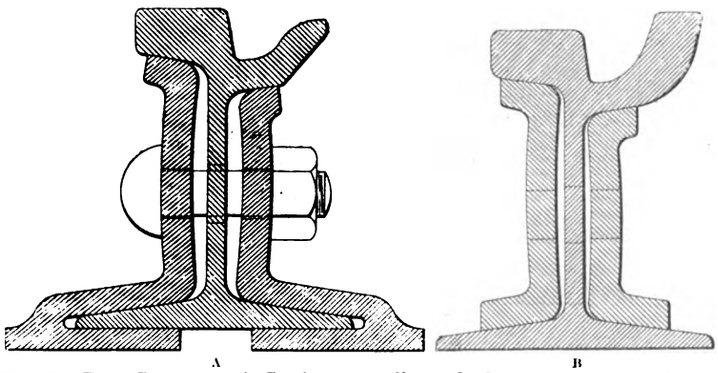
The next two floors above the main auditorium are devoted to lecture rooms, of which there are seven. Two spacious assembly rooms occupy the fifth floor, on which there are also two reception rooms. All these rooms are fitted for demonstrations and experimental purposes. The sixth floor is divided into lecture rooms of somewhat smaller dimensions, so that accommodation is provided for smaller audiences. The seventh and eighth floors provide accommodation for the Associated Societies, amongst which are the Society of Naval Architects and Marine Engineers, the Society of Heating and Ventilating Engineers, the National Electric Light Association, the Society of Chemical Engineers, the American Street and Interurban Railway Association.

Each of the three Founder Societies occupies a floor, the Institute of Mining Engineers the ninth, the Institute of Electrical Engineers the tenth, and the Society of Mechanical Engineers the eleventh floor. The libraries of these three societies are accommodated in the two top floors of the building. It will be seen from this description that the arrangement is an ideal one, which the London engineering societies would do well to bear in mind, though we fear that the homes which have already been created will prevent the realisation of a corresponding scheme.

THE MONTEVIDEO TRAMWAYS.

On November 19th, amidst a scene of extraordinary enthusiasm, the first electrically-operated lines in Montevideo were inaugurated, Dr. Williman, who has since become President of the Republic, switching the current on to the lines.

Montevideo, the capital of Uruguay, or, to give the latter its better known local title, the "Banda Oriental," is situated on the northern shores of the River Plate near its mouth. At the present moment the population of Montevideo exceeds 300,000. The streets for the most part are wide and fairly well paved, and the city being situated on a tongue of land between the bay and the River Plate is pleasantly cool. The water, supplied by an English company, is copious in quantity and excellent in quality. The works at the port, long delayed, are now approaching a state in which they will be of immense benefit to Montevideo in particular and the trade of the country in general. Altogether, if granted a succession of years of peace, Montevideo bids fair to become one of the most important places of the western hemisphere.



A B

FIG. 1.—RAIL SECTIONS. A, Section generally used; B, Section for special work. Scale 1:4.

The first mule tramways in Montevideo were opened in the year 1868, just 39 years ago. This was a short line which has grown with the city until there are now 150 miles of line, either electrified or in course of electrification. Ten years ago the Commercial Company applied for authorisation to the powers that were to reconstruct their lines on more modern principles, but the veto of the president, or rather the opposition of the Municipality, frustrated all their attempts. With the election of the present president, Senor Battle y Ordonnez, a change came over things, and the long wished-for concession was granted, the Government stipulating that all the lines should be extended into more distant suburbs in order to facilitate the solution of the housing question, which in Montevideo, as in Buenos Ayres, had become serious.

FIG. 2.—TRACK IN COURSE OF CONSTRUCTION.

In December, 1904, an agreement was made between the United

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Electric Tramways of Monte Video (Ltd.) and J. G. White & Co. (Ltd) for the complete reconstruction of the existing horse tramways to electric traction and the erection of a power house to supply the required power. The works have been carried out under the general supervision of a committee of the board of the United Electric Tramways of Montevideo (Ltd.), Mr. Frank Bourne acting as engineer to the committee.

The constructional works were started in March, 1905, and the opening ceremony took place on the date stated above. The electrification of these lines (practically 51 miles single track) and the erection of the power station has therefore taken some 20 months, which, considering the many attendant difficulties, is exceptionally quick work.

Track Work.

All the lines are laid to a gauge of 4 ft. 8½ in., and the new rails, manufactured by the United States Steel Products Export Co., are

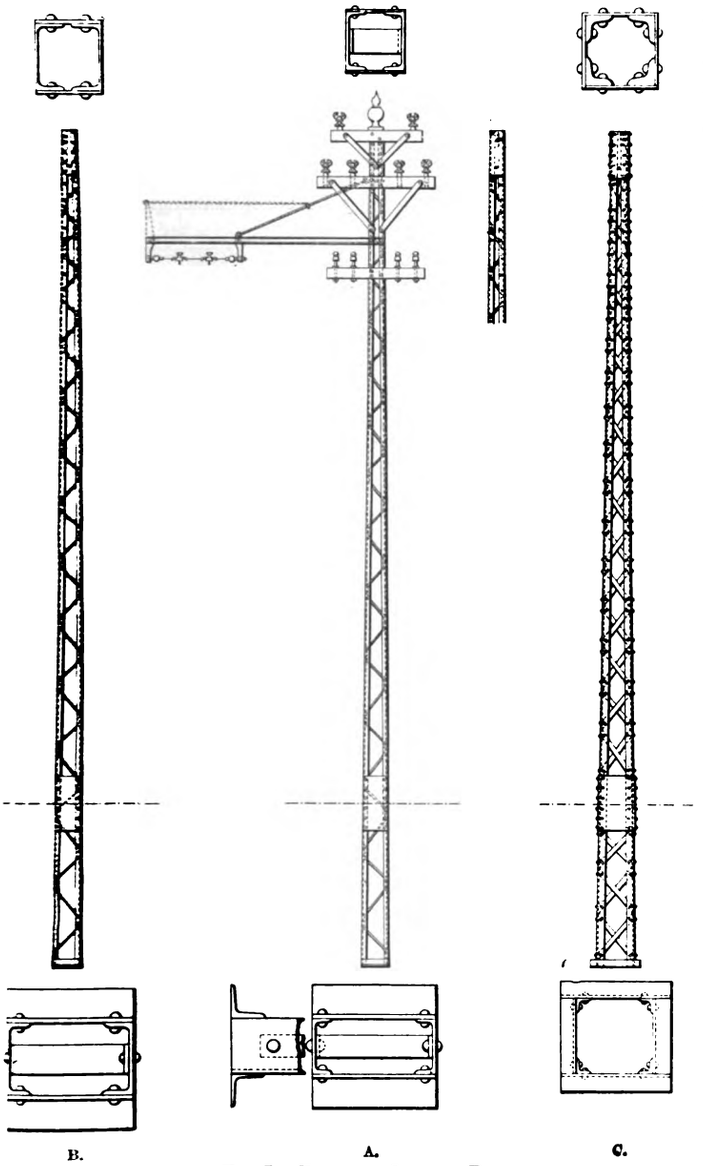

Fig. 3.—Types of Lattice Poles.
Scale: 1:80.

45 ft. in length and weigh 87 lb. per yard on the straight and 100 lb. per yard on curves. They have the following specified chemical composition:—

Carbon	0·55 per cent.
Manganese	1·00 ,,
Silicon	0·10 ,,
Phosphorus	0·10 ,,
Sulphur	0·10 ,,

The specified tensile strength was 40 tons per square inch with an elongation of 12 per cent.

As seen from the drawing (Fig. 1) the section is different from that of the British standard, the design having been worked out specially to suit the conditions in South American cities. The rails are laid on concrete stringers. The depth of the stringer is 6 in. and the width 15¼ in.

The distance between centres of tracks is 9 ft. 10 in. Minimum distance of outside running rail from pavement 8½ ft. The paving was executed in three grades, first with dressed setts, second with cobbles and third with macadam The depth of the trench for the

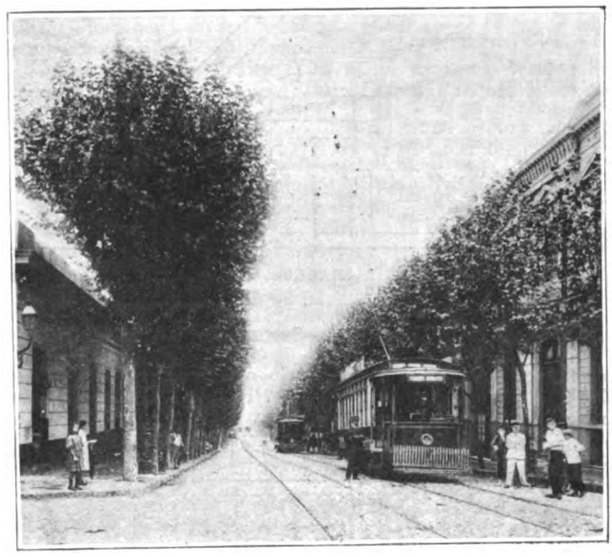

Fig. 5.—View of Part of the Track

stringers is, on an average, 13 in. to 14 in. The Continuous Rail Joint Co.'s rail joints were used, 24 in. long and weighing 88 lb. the pair. A length of track under course of construction is seen in Fig. 2.

All special work for the track except the points was manufactured by the Lorain Steel Co. All points are automatic, made of best toughened cast steel 10 ft. 6 in. long, 100 ft. radius, and are manufactured by Messrs. Hadfields. All frogs were manufactured by the

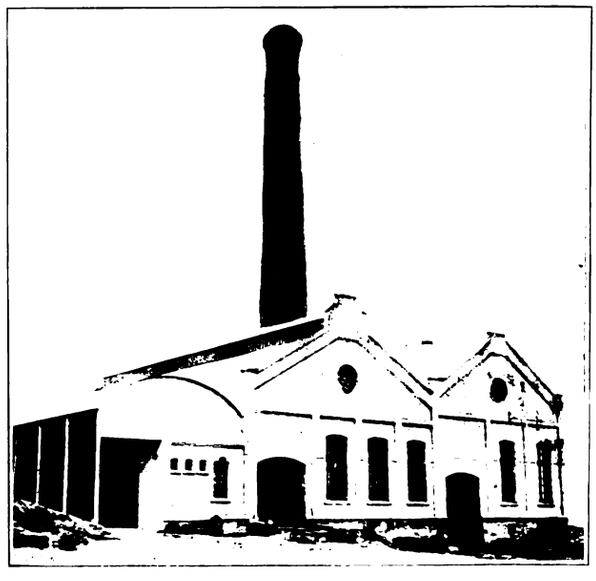

Fig. 6.—Power House.

United States Steel Products Export Co. The rails are bonded by two concealed bonds of 4/0 B. & S. gauge.

Overhead Equipment.

The whole of the overhead equipment is of side pole and stee span wire construction.

The poles supporting the overhead trolley wires are of two designs, tubular and lattice. Both the tubular and lattice poles are of three sizes. The tubular poles, of which there are 457, are used only in the plazas and a few of the main streets. The lattice poles number 2,765, and the types are shown in Fig. 3.

All the poles are planted 6 ft. deep in concrete and also have 6 in. of concrete beneath their bases. The section of the "A" size

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tubular pole is as follows: 30 ft. long, bottom section 7⅞ in., middle section 6⅝ in, top section 5 9/16 in. external diameter.

The trolley wire is of No. 00 B. & S. grooved copper wire, total length being 70 miles divided into ½ mile sections. The wire was supplied by Edward Le Bas & Co. and the National Conduit & Cable Co. The span wire is of No. 7/12 S.W.G. galvanised steel, having a breaking load of 4,500 lb.

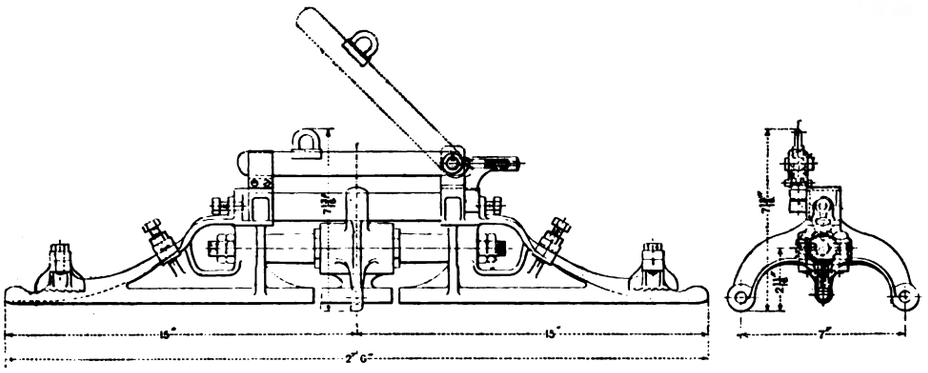

FIG. 4.—SECTION INSULATOR WITH KNIFE-SWITCH.

long bamboo pole, which is usally hung on a pole and secured by a padlock. A hook on the end of a pole fits into the hole in the blade of the switch at the back of which is a spring. This spring, pressing down the blade, assists in making a quick contact.

Cables.—The total cable laid was approximately 28 miles, 15 aerial and 13 miles underground, as follows:—

Diameter and description of cable.	Yards.
61/0·101 in. insulated, steel taped armoured	13,400
61/0·101 in. insulated, steel taped armoured	250
61/0·092 in. insulated, steel taped armoured	2,230
500,000 cir. mil. aerial cable	9,650
600,000 „ „ „	17,300
Five-core test and telephone cable, armoured, approximately	7,200

The insulated cables are of the single conductor type armoured and laid directly in the ground. The lead covering is 1/10 in. thick. The cable was tested at the makers' works with a flash test of 2,500 volts alternating for 15 minutes. The total weight of copper used was approximately 150 tons.

The conductors in the case of the aerial cables are of hard-drawn copper having a conduc ivity of 98 per cent. of Matthiessen's standard. The cable is twice braided, each braiding being separately served with weather-resisting preservative compound.

The cables were supplied by the Lahmeyer Electrical Co. and Johnson & Phillips.

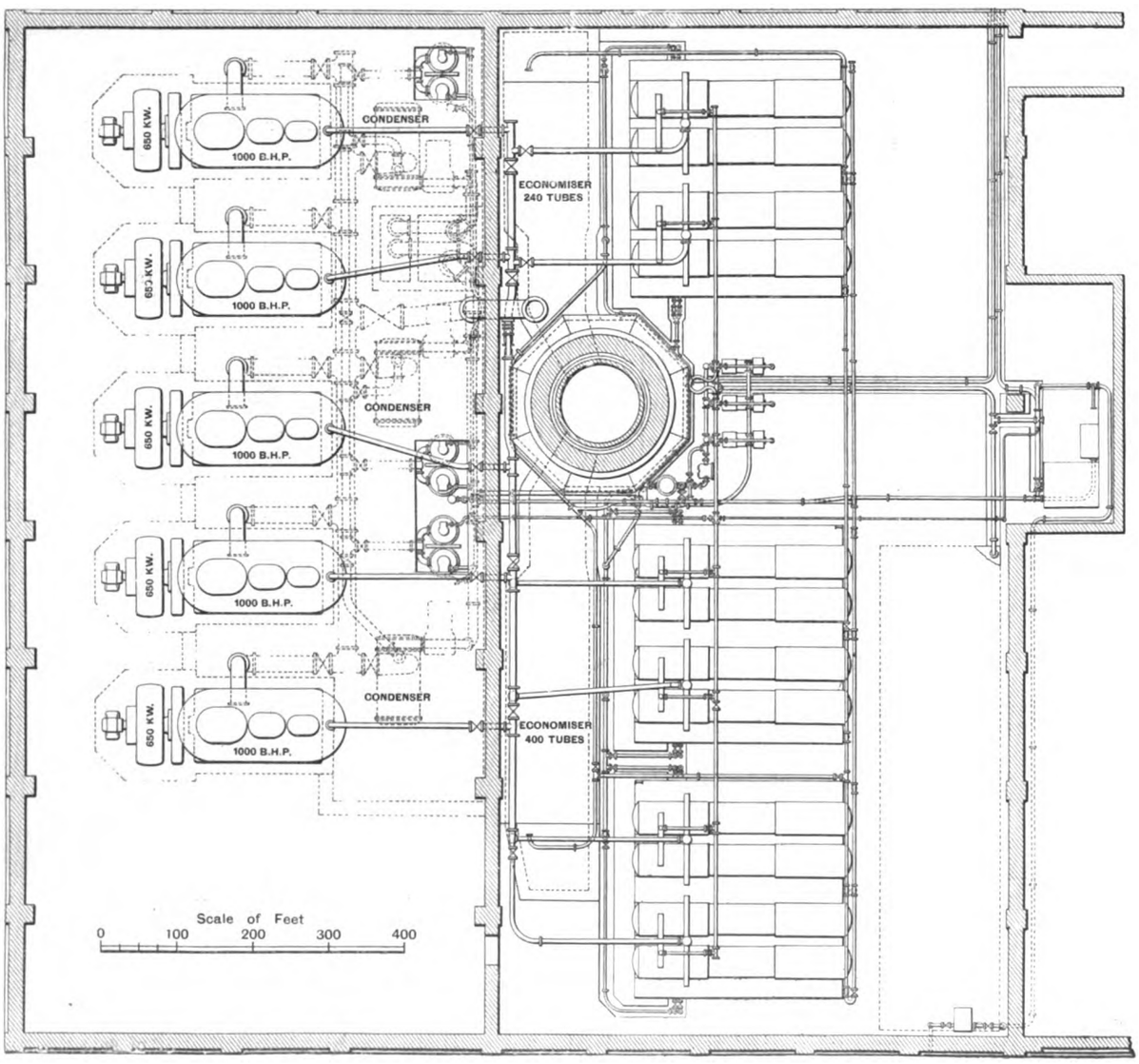

FIG. 7.—PLAN OF GENERATING STATION SHOWING GENERAL ARRANGEMENT OF PLANT.

The section insulators of special make were manufactured by the Electric Tramway Equipment Co. This insulator, which is shown in Fig. 4, consists of an ordinary double-break section insulator with the addition of a knife switch. The switch is closed by means of a

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Carsheds and Depots.

There are three depots for the cars which have been provisionally reconstructed—viz, at Pocitos, Reducto and Del Este. The Del Este car-shed is the largest, having accommodation for 40 cars.

The car-shed workshops have been fitted up with the most modern tools and appliances, and are well lighted throughout with Drake & Gorham's arcs and incandescent lamps. The power for driving the mechanics' shops is supplied by two Lancashire Dynamo & Motor Co.'s motors, one being a 15 B.H.P. 550 volt direct-current running at 650 revs. per min., the other one being a 10 B.H.P. 550 volt direct-current running at 860 revs. per min.

The company has bought land on which it will build one large car-shed and shops for the entire system.

Cars.

The number of cars ordered was 70 double-service cars, 20 open cars (all single deckers) and one flat car. The cars were built by the United Electric Car Co., Preston. The double-service cars are designed so as to be available as open or closed cars according to weather conditions.

The car bodies are mounted on 21-E Brill trucks, having 6 ft. 6 in. wheel base The wheels have steel tyres, with wrought-iron centres, and are 34 in. diameter on tread, and are mounted on forged steel axles 4 in. diameter. The trucks, also, are fitted with Providence lifeguards of the folding type.

The ventilation has received special attention. The inlet for fresh air is provided through the hinged lights over side windows, and also through a perforated louvre on each side of the doors, which admits a large volume of air passing into the car without interfering with the arrangement of coloured signal lenses or allowing the admission of water in wet weather. The outlet for the foul hot air is by way of a recess made in the roof, which is above the hinged windows. On the outside of the roof on each side, and connecting with the recess, are fixed exhaust ventilators; these have a bell mouth, and are constructed in such a way that no air can pass into the car at these points.

The 20 single-deck cross-bench open-type cars, which were also manufactured by the United Electric Car Co., have seating capacity inside for 40 passengers. Each platform is provided with a handle operating the Peacock mechanical brakes.

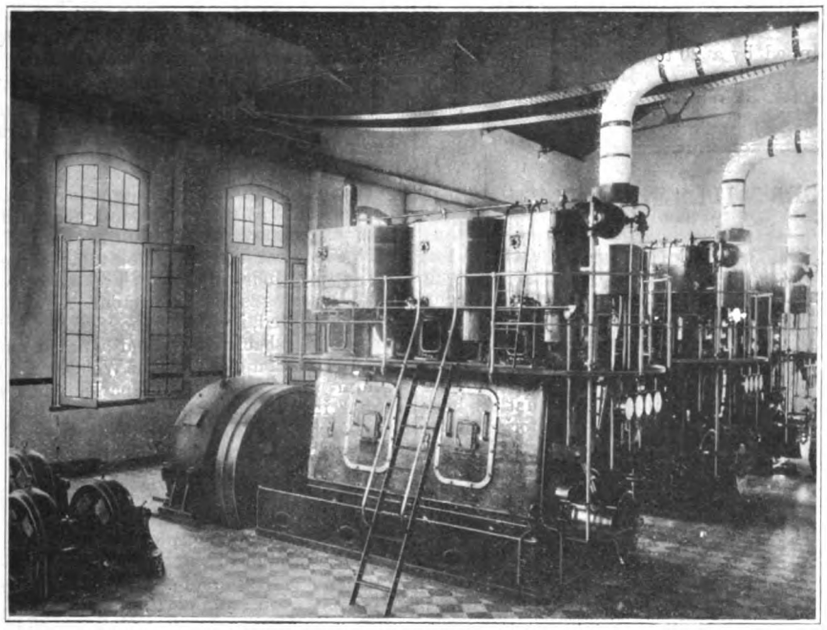

Fig. 8.—Generating Sets.

The electrical equipments of the cars, furnished by Messrs. Dick, Kerr & Co., consist of two motors, type No. 8, form A4, and two series parallel controllers, type D.B.1, form E, and trolley with straight under-running head. The motors are 36 B.H.P. at 500 volts, with a speed of 500 revs. per min. when cold and 440 revs. per min. after one hour's run at full load. Before leaving the works every motor, besides undergoing its specified load run, was tested with an alternating potential of 2,550 volts for five minutes.

The lighting of the cars consists of 15 incandescent lamps of 16 c.p. each, the lights being on three circuits of five lamps each.

Power Station.

The power house (Fig. 6), is situated in the Calle Cebollati, close to the water edge. The framework of the building is made of steel, while the roof is constructed of steel trusses with galvanised iron sheets laid on. The general arrangement is shown in Fig. 7.

The boiler installation comprises four boilers of the Babcock & Wilcox design. Each boiler is capable of evaporating 11,300 lb. of water per hour at natural draught, and at a working pressure of 180 lb. per square inch, used in conjunction with a Green's economiser. They are erected in batteries of two. Each boiler has a B. & W. superheater fixed with it, with 572 sq. ft. of heating surface, and capable of superheating 150°F. Each boiler has a heating surface of 3,240 sq. ft. and a grate area of 58 sq. ft.

There are two horizontal steam-driven direct-acting feed pumps manufactured by the Worthington Pumping Engine Co., size 9 in. by 5¼ in. by 10 in Duplex, each capable of delivering 4,500 gallons of water per hour against a boiler pressure of 160 lb. per square inch when using saturated steam at a pressure of 160 lb. per square inch, the pump running at normal speed. The operation of these pumps is as follows: 3,000 gallons per hour to the boilers; piston speed, 30 ft. per minute; steam consumption, 450 lb. per hour; 4,500 gallons per hour to the boilers; piston speed 45 ft. per minute; steam consumption, 650 lb. per hour.

The feed water is drawn from a hot well at a temperature of 80°F., the water level being not more than 8 ft. below the suction inlet of the pump.

Condensing Plant.—The condensing plant consists of two complete surface condensers manufactured by Messrs Cole, Marchent & Morley. Each plant, which consists of a surface condenser, a pair of steam-driven Edwards air pumps and electrically-driven centrifugal circulating pump, will condense 24,400 lb. of exhaust steam per hour, and give a vacuum of 26 in. with the barometer at 30 in. when supplied with condensing water at an initial temperature not exceeding 70°F. All the condensing water is drawn from the sea. The surface condenser is of the horizontal counter-current design with cast-iron cylindrical shell and water heads. Each Edwards air pump is capable of dealing with 17,100 cubic ft. per hour, and has a piston speed of 200 ft. per minute average.

The feed-water heater, which was manufactured by the Wheeler Condenser Co., and which has 150 sq. ft. of heating surface, is capable of dealing with 3,000 gallons per hour of boiler-feed water at 160 lb. per square inch pressure, and about 950 lb. of exhaust steam per hour at a maximum of 5 lb. per square inch pressure.

Engines.—Three Belliss & Morcom's three-crank three-cylinder enclosed triple expansion engines, Fig. 8, with forced lubrication and automatic cut-off are direct-coupled to the generators. They run at 250 revs. per min., and are supplied with steam at the engine valve at a pressure of 160 lb. per square inch superheated 150°F.

The normal full load of each engine is about 1,000 B.H.P., but they are designed for an overload of 25 per cent. and 50 per cent. for short periods.

The guaranteed steam consumption per brake horse power per hour with a steam pressure of 160 lb. per square inch superheated to a total temperature of 520°F., operating condensing with a vacuum of 26 in. at the engine, is as follows: Full load, 12·2 lb.; three-quarter load, 12·3 lb.; half load, 13·1 lb.

Generators.—The dynamos built by Bruce Peebles & Co. are of the multipolar slotted armature type and are direct-coupled to the engines. Each has an output of 650 kw., and is wound for 550 volts direct current. They are guaranteed to withstand an overload of 25 per cent. for two hours after reaching the maximum temperature due to full load, and 50 per cent. overload for 15 minutes under similar conditions. The speed is 250 revs. per min.

The generators are 10 polar, and are fitted with compensating poles, the field pole being of steel, cast solid with the yoke, with a special polar ring secured to the pole face completely surrounding the armature.

The efficiencies of the generator are as follows: Quarter load, 85 per cent.; half load, 91 per cent.; three-quarter load, 93 per cent.; full load, 94·5 per cent.

Boosters.—Two negative booster sets have been supplied, both manufactured by the Electric Construction Co., Wolverhampton. The first set is 22 kw., consisting of a 550 volt motor coupled to a 315 ampere 70 volt generator, with diverting rheostat and combined bedplate. The second set is 25 kw., consisting of a 550 volt motor coupled to a 625 ampere generator at 40 volts, with combined bedplate, &c.

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The combined overall efficiency of the motor booster at full load is 75 per cent. for the 22 kw. and 76 per cent. for the 25 kw. set. Each booster is capable of standing an overload of 25 per cent. of the full load output in amperes and volts for half an hour. The maximum speed of either set does not exceed 1,000 revs. per min.

Switchboard and Gear, &c.—The main switchboard, manufactured by the British Thomson-Houston Co. is made up of slate panels bolted together on iron frames, the slates being 2 in. thick and of the best quality. The board is so arranged that there is a clear passage 4 ft. wide behind and around it. The arrangement of the instruments and fittings is such that each panel is self contained for the generator and booster panel; but the feeder panels control two feeders each.

The total output and testing instruments and station lighting circuits are all arranged on one panel. There is also one panel for controlling the two 18 B.H.P. 550 volt shunt-wound motors for driving the centrifugal circulating water pumps.

The board is made up as follows: Three 650 kw. 550 volt panels; four panels, each arranged for two 300 ampere feeder circuits; two booster panels; one totalising, testing and station lighting panel; one panel for two 18 B.H.P. motors.

Each generator panel has one automatic circuit-breaker; one ammeter, scale 0—1,800 amperes; two single pole lever switches, field rheostats, &c.

Each feeder panel contains two automatic circuit-breakers; two ammeters, scale 0—450 amperes; two S.P. lever break switches, choking coils, &c.

The totalising panel contains one B.T.-H. recording wattmeter; one recording ammeter, scale 0—5,000 amperes; one round type leakage ammeter, double-pole switches, &c.

All voltmeters are of the well-known Weston dead-beat round type pattern.

The engine room is spanned by a 20 ton hand crane, made by Higginbottom & Mannock.

We have to thank Messrs. J. G. White & Co. (Ltd.), for the particulars here given.

INCANDESCENT ILLUMINANTS.

The Friday evening discourse at the Royal Institution on the 26th ult. was given by Mr. James Swinburne, F.R.S., and was attended by a large audience. The subject was "Incandescent Illuminants." The first part of the lecture was devoted to a discussion of the incandescent gas mantle, and the history of its development from the first imperfect mantle invented just over 20 years ago by Auer von Welsbach, was sketched. These early mantles were made of zirconia and yttria, but it was soon found that the best results were obtained with mantles having a basis of thoria. It is exceedingly difficult to obtain pure thoria, and a mantle made from it is of little value as a light emitter. If, however, a small percentage of a coloured and permanent oxide is added, such as ceria, it gives good illumination. Mantles of pure thoria and of pure ceria, made by Mr. Mackean of the English Gas Mantle Co., were exhibited. The ceria glowed with a dull red light, and the thoria, though much brighter, was quite useless as an illuminating agent. The lecturer then dipped a thoria mantle into a solution of cerium nitrate in alcohol of such a strength that after ignition the right proportion of ceria remained. This had the effect of at once increasing the illumination to the usual value.

There has been much discussion about the theory of the incandescent mantle, the rival views as to the pure temperature and emissivity ideas being based on catalytic action and selective radiation. It has been generally assumed that the temperature of the Bunsen flame is too low to account for the brilliancy of the mantle immersed in it. The mantle, apparently, must be hotter than the flame. Therefore it may be supposed that ceria acts as a catalytic agent oscillating between two states of oxidation, and consequently assuming a temperature in excess of that of the source of energy, the bunsen flame.

It is true that ceria does act somewhat in the same catalytic manner as platinum. For instance, if a burner be fitted with a ceria mantle, the gas be lighted, turned out and then turned on again, the mantle will glow and will finally light the gas.

However, this experiment can hardly be quoted by the advocates of the catalytic theory as an explanation of the part played by ceria in increasing the light emission of the thoria ceria mantle, for zirconia will do the same thing, and zirconia in a mantle gives very little light.

According to the simple radiation theory, the light depends solely on the emissivity or blackness of the mantle, and on its temperature. The flame must have a higher temperature than the mantle, as it supplies the heat which the latter radiates, and the lecturer pointed out that the thermo-couple method of estimating flame temperatures gave far too low a reading, as the couple never reaches the true temperature of the flame, and it is exceedingly probable that this is quite high enough to satisfy all that the mantle requires in that direction.

There is, however, the question of the emissivity, and it is on the correct balance between emissivity and possible temperature that the light-emitting qualities of the practical mantle depend In order to raise the mantle to the highest possible temperature its emissivity should be low—that is to say, the mantle should be very white; but in that case, though its temperature is high, the light produced is small. On increasing the emissivity the light at first increases, but as greater emissivity means lower temperatures the effect of raising the emissivity from white to black results in an increased radiation of energy, a greater abstraction of heat from the flame, a cooler mantle and a smaller proportion of light to a larger proportion of heat radiated. The mantle thus gets redder and gives less light. Whether ceria or any other permanent coloured oxide is used the effect is the same. It has been urged that, as pure ceria is white, adding it cannot make the mantle blacker, but ceria is white only when cold. A mantle may look quite white when cold and be much darker when hot.

A striking experimental confirmation of this was devised by Rubens, and at this point in the lecture the effect was shown. A powerful arc light was focussed by means of a condenser on to a mantle placed in position on a burner so as to illuminate very strongly a small spot. By means of a mirror and projecting lens, an image of this spot was thrown on a screen. A blue filter of cupric ammonium hydrate was interposed to absorb yellow light. On lighting the gas, a very noticeable diminution in the brightness of the projected image was observed A mantle of pure ceria was then substituted, and the difference between the brightness of the cold and of the hot mantle was in this case exceedingly striking. Mantles of pure thoria and zirconia, both white oxides, showed very little difference whether hot or cold. This elaborate experiment was arranged by Mr. Claypoole.

Another illustration of the effect of coloured oxide, on the emissivity, temperature and consequent illumination, is afforded by alumina and chromium oxide. The former, which is quite white, when used alone gives little light. Chromium oxide, a dark body, by itself gives merely a dull, red glow. If a little chromium oxide be added to alumina, a red light is first given, because the former is too dark, but as soon as it combines with the alumina to make a light pink mantle a good light is obtained.

The lecturer then referred to a number of recent improvements having for their object the greater convenience and utility of the incandescent gas-mantle system. A number of specimens of burner were exhibited, including the "Howelite" inverted burner, miniatures of Welsbach make, and a novel automatic gas lighter based on an invention of Auer von Welsbach. He found that an alloy of cerium and iron gave off sparks when scraped or filed, and the burner in question is fitted with a little disc of the alloy, which is struck by a small file by the act of turning on the gas.

A small ingot of the alloy was shown, and emitted a stream of sparks on being filed.

Another example of recent devices, due to Bartlett, to achieve distant control of gas burners, in the form of an automatic bye-pass, was shown. Each burner has an attachment which lets the gas straight through to the burner when the pressure is on, but which closes this passage and opens one to the pilot jet when the pressure is reduced. In practice there is a main control tap near the door, fitted with a bye-pass allowing a small amount of gas to flow. This cannot get through the main burners, but is diverted to the pilot jets, which remain alight until the main control tap is opened.

A number of slides were shown to illustrate this part of the lecture, depicting the treated and untreated mantles, both cotton and ramie, and reference was made to the mode of manufacture of mantles, photographs being shown on the screen of a machine capable of turning out under the superintendence of two girls some thousands of mantles per day.

The lecturer then turned to other incandescent illuminants, and pointed out that the Nernst glower was of very similar material to the gas mantle. Its curious faculty of self repair was experimentally shown. A large image of a Nernst glower was projected on a screen and a pair of forceps was seen at work breaking it in two. When the separated ends were brought together and the whole filament heated, the growing current welded the two parts together again and the glower was practically as good as at first. A micro-photograph lantern slide of the section of a Nernst glower showed it to be a hollow cylinder.

Nernst glowers could lend themselves readily to decorative effects if it were not for the usual accessories of holder, magnet and balancing resistance. A glower was shown detached from its supports and connected to fine and almost invisible wires. This being lighted had a starlike effect.

The great drawback to the use of Nernst lamps was the time taken to heat up the filament. Any attempt to make an instantaneous lighting lamp seems doomed to failure. It is, of course, quite possible to coat a glower with, say, platinum chloride and reduce from this a conducting film of spongy platinum, but although

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the glower will light up the first time it will not do so a second time unless heated in the usual way, since the plantinum has been fused into a quantity of discontinuous globules.

The lecturer then spoke of the immense strides made recently in the perfecting of metallic-filament lamps. A short time ago osmium was the only metal available, and its low specific resistance rendered it impossible to construct high-voltage lamps. The metals employed now include tungsten, tantalum and zirconium. The curious behaviour of the tantalum filament when run on alternating-current circuits was illustrated by a number of very striking slides prepared from microphotographs made by Mr. Swinburne.

The two main methods of preparing metallic filaments were referred to—namely, drawing and squirting. The success of this latter seems to depend almost entirely on the fineness of the metallic particles. As illustrations of methods of preparing finely divided metals, two experiments were made and projected on the screen. In the first, an arc was formed between gold electrodes in distilled water. The volatilised gold was condensed by contact with the cold water, and appeared as a smoke cloud. In the second, a current was passed between two fine copper wires in dilute sulphuric acid. Considered as an electrolytic cell, the current-density was extremely high. The effect was to disintegrate the anode at a rapid rate. The resulting suspension was of metallic copper, and of extreme fineness, exactly resembling smoke.

Some tungsten-filament lamps made by Mr. Story were shown and run up to a high degree of incandescence.

The Zircon lamp was on exhibit and was understood to be made of zirconium and tungsten; probably the filament is a zirconide of tungsten. Lamps of 200 volts have been made, a matter of the greatest importance from a distribution point of view. The 100 volt lamp shown at the lecture had six separate loops of wire mounted in series. A recent improvement is to provide an extremely light spring to keep each filament taut and thus to render the lamps capable of burning in any position. It is probable that tungsten or a compound will provide the high efficiency lamp of the future. An efficiency of one candle per watt is hoped for, but at the same time to provide a filament of 500 ohms fine enough to give 20 candles with 20 watts will require a very great effort of inventive skill.

Towards the end of the lecture the calcium method of producing a vacuum was shown. Near its melting point metallic calcium will combine with oxygen, nitrogen, hydrogen, and water vapour, in fact, with all atmospheric gases except argon and the other monatomic gases.

The lecture concluded with a demonstration of the oxy-acetylene blow-pipe, kindly lent by the British Oxygen Co (Ltd.). The acetylene flame itself, before turning on the oxygen, is large, white and smoky. When the right proportion of oxygen is fed into it the flame is greatly reduced in size and consists of a non-luminous shell containing a very small white core of a highly reducing nature. Practically the whole energy of the combination appears in this small core and the consequent temperature is extremely high. Its illuminating capabilities were shown by playing it on magnesia, and its high temperature was shown by the ease with which iron melted before it.

"FLEXIBLES," WITH NOTES ON THE TESTING OF RUBBER.*

BY PROF. A. SCHWARTZ.

(*Concluded from page 55.*)

Summary.—In this Paper the author first deals with the causes of deterioration in flexible conductors. He then considers the method of insulating them, and describes in detail the properties of rubber. He also deals with the various mechanical and electrical tests to which flexible cables should be subjected, and concludes by describing various systems of surface wiring using flexibles, which have been more particularly adopted on the Continent.

XIII.—Attachments for Flexibles.

The attachment to the ceiling rose is, generally speaking, satisfactory in the best forms now on the market. The hole in the cover of the ceiling rose is in many cases too small to admit C.M.A. flexible, which is much to be regretted, as its certainly limits the present use of this excellent material. With regard to lampholders, with twin-twisted flexible the use of the ordinary single-hole cord-grip should be prohibited, and the older form with two slots should be reverted to, so that the conductors may be clamped when separated, and not forced tightly together. In general, the cord grip arrangement is too cramped in design, and a good deal of improvement might be effected without sacrificing the appearance of the fitting. The cord-grips are commonly made in one piece with a central hole; the wireman has to split the grip down the centre, and enlarge the two half-round channels thus formed to the desired size. The remains of the grip after this operation has been performed are usually of the most slender description. With circular flexibles the single-hole cord-grip cannot very well be avoided, but in this case the filling that is put in to make up to the circular form helps largely in preventing injury to the insulation of the conductors through their being forced together. The brading possesses considerable mechanical strength, and this should be taken down into the grip, the ends being whipped or just touched with a trace of Chatterton to prevent fraying.

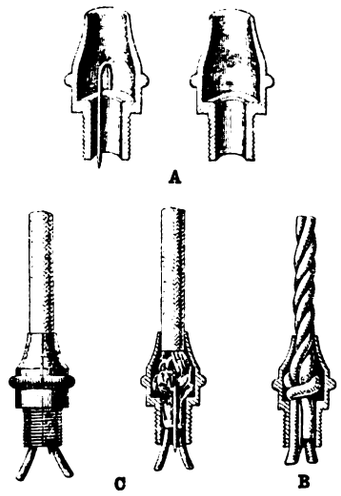

Fig. 10.

An interesting series of cord-grip arrangements has been recently put on the Continental market by Messrs. Hartmann & Braun. The various devices are shown in detail in Fig. 10. It must be borne in mind in connection with these fittings that the regulations of the Verband Deutscher Elektrotechniker call for the inclusion of a suspending cord other than the conductors for counterweight flexibes. The nipple which screws into the top of the lampholder is made in halves; one half is furnished with a hook, Fig. 10 A, which is passed through a knot in the suspending cord, as at B. With flexibles, in which the suspending cord is of stout cotton, the hook shown may be placed behind the knot, as at C in Fig. 10.

A further set of attachments by Hartmann & Braun are shown in Fig. 11.

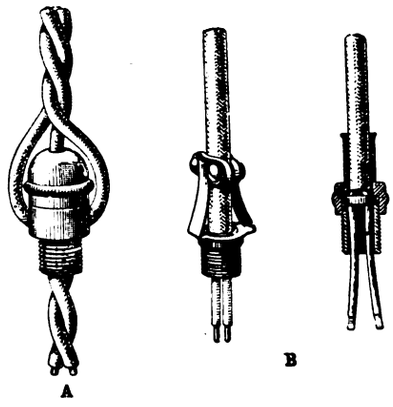

Fig. 11.

In type A the suspending cord is carried into the screw cap and knotted, the conductors entering the nipple at the sides; in type B the suspending cord passes through a hole in the centre of a hard fibre disc and is then knotted while the conductors pass through separate holes at the sides of the disc. Both these types possess the advantage that when in use the flexibles cannot be sharply bent at the lampholder.

XIV.—The Attraction of Dust by Flexibles.

A. A. Campbell Swinton* has shown that the collection of dirt on flexibles is due to electrostatic action, and F. G. Baily has pointed out that the sign of the potential with regard to the earth is without, or almost without, influence on the result. On both two and three-wire systems, so long as the switch is on the live side the deposit of

* Abstract of a Paper read before the Institution of Electrical Engineers, April 18th.

* *The Electrician*, Vol. XLV., 1900, p. 17.

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dirt will be small, but where it is on the earthed side the deposit will be large and may extend several inches from the conductor.

With reference to flexible wiring systems, the discolouration of the adjacent walls may be advanced as an objection, but the author would point out that almost any pipe or conduit crossing a horizontal or vertical surface in a room is liable to cause discolouration, which usually takes the form of a light space in the immediate vicinity of the pipe with a dark area beyond it. This is doubtless due to the action of the air-currents when passing the obstruction.

The Paper concludes with the following appendixes and with detailed particulars of flexibles now on the market :—

APPENDIX A.

American Regulations (National Electrical Code, 1905.)

1. *Installation Rules for Flexible Cord.*

(*a*) Must have an approved insulation and covering.

(*b*) Must not be used where the difference of potential between the two wires is more than 300 volts.

(*c*) Must not be used as a support for clusters.

(*d*) Must not be used except for pendants, wiring of fixtures, portable lamps or motors, and portable heating apparatus.

The practice of making the pendants unnecessarily long and then looping them up with cord adjusters is strongly advised against. It offers a temptation to carry about lamps which are intended to hang freely in the air, and the cord adjusters wear off the insulation very rapidly.

For all portable work, including those pendants which are liable to be moved about sufficiently to come in contact with surrounding objects, flexible wires and cables especially designed to withstand this severe service are on the market, and should be used.

(*e*) Must not be used in show windows.

(*f*) Must be protected by insulated bushings where the cord enters the socket.

(*g*) Must be so suspended that the entire weight of the socket and lamp will be borne by some approved device under the bushing in the socket, and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws.

This is usually accomplished by knots in the cord inside the socket and rosette.

2. *Materials and Construction for Flexible Cord.*

(*a*) Must, except as required for portable heating apparatus, be made of stranded copper conductors, each strand to be not larger than No. 26 (16 mils) or smaller than No. 30 (10 mils) B. & S. gauge, and each stranded conductor must be covered by an approved insulation and protected from mechanical injury by a tough braided outer covering.

(*b*) Each stranded conductor must have a carrying capacity equivalent to not less than a No. 18 (40 mils) B. & S. gauge wire.

(*c*) The covering of each stranded conductor must be made up as follows :—

1. A tight close wind of fine cotton.
2. The insulation proper, which shall be waterproof.
3. An outer cover of silk or cotton.

The wind of copper tends to prevent a broken strand puncturing the insulation and causing a short-circuit. It also keeps the rubber from corroding the copper.

(*d*) The insulation must be solid, at least $\frac{1}{32}$ in. thick, and must show an insulation resistance of 50 megohms per mile throughout two weeks' immersion in water at 70°F., and stand the following tests :—

Each foot of the completed covering must show a dielectric strength sufficient to resist throughout five minutes the application of an E.M.F. proportionate to the thickness of insulation in accordance with the following table—

Thickness in 64ths inches.	*Breakdown Test on 1 ft.*
1	3,000 volts alternating current.
2	6,000 ,, ,, ,,
3	9,000 ,, ,, ,,
4	11,000 ,, ,, ,,

(*e*) The outer protecting braiding should be so put on and sealed in place that when cut it will not fray out, and where cotton is used it should be impregnated with a flame-proof paint, which will not have an injurious effect on the insulation.

(*f*) Flexible cord for use on portable lamps, small motors, or any device which is liable to be carried about must meet all the above requirements as to construction and thickness of insulation, and in addition must have a tough braided cover over the whole. There must also be an extra layer of rubber between the outer cover and the flexible cord, and in moist places the outer cover must be saturated with a moisture-proof compound. In offices, dwellings or in similar places where the appearance is an essential feature, a silk cover may be substituted for the weather-proof braid,

For Portable Heating Apparatus (applies to all smoothing irons, &c., and to any other device requiring more than 250 watts).

(*g*) Must be made up as follows :—

1. Conductors must be of braided copper, each strand not to be larger than No. 30 (10 mils) or smaller than No. 36 (5 mils) B. & S. gauge.

When conductors have a greater carrying capacity than No. 12 (80 mils) B. & S. gauge they may be braided or stranded with each strand as large as No. 28 (12·2 mils) B. & S. gauge. If stranded, there must be a tight, close wind of cotton between the conductor and the insulation.

2. An insulating covering of rubber or other approved material not less than $\frac{1}{64}$ in. in thickness.

3. A braided covering not less than $\frac{1}{32}$ in. thick composed of best quality long fibre asbestos containing not over 5 per cent. of vegetable fibre.

4. The several conductors comprising the cord to be enclosed by an outer reinforcing covering not less than $\frac{1}{64}$ in. thick, especially designed to resist abrasion and so treated as to prevent the covering from fraying.

APPENDIX B.

French Regulations (Syndicat Professionel des Industries Electriques, January, 1906).

1. *Insulation of Flexible Conductors.*

(*a*) *Medium Insulation.*—This should consist of a layer of cotton and a layer of natural rubber or a layer of vulcanised rubber. Mechanical protection to consist of a layer of silk or glazed braid.

(*b*) *High Insulation.*—This should comprise two layers of natural rubber or two layers of vulcanised rubber. Mechanical protection is to be secured by silk braid or glazed braid.

(*c*) *Flexible Conductors for Pendants.*—Flexibles employed for wiring pendants should be insulated by one or two layers of rubber protected by silk braiding and a plaiting treated with paraffin. This applies to installations up to 110 volts, and the insulation resistance should be 600 meghoms per kilometre ($\frac{5}{8}$ mile) after 24 hours' immersion in water at 15°C. For 200 volt circuit the insulation should comprise two vulcanised rubber layers, a silk braiding and a paraffin wrapper giving an insulation resistance of 600 megohms per kilometre. These specifications are given merely as an indication of the practice to be adopted, and there is no obligation to comply with them where the conditions do not admit of doing so.

(*d*) *Nature of Insulation.*—At the time of fixing, the insulation of conductors should satisfy the specification ; the insulating material should not crack, and conductors covered by an insulating material containing sulphur should be tinned.

Rubber used for insulation may be classed :—

1. Para rubber tape made of pure Para rubber.
2. Natural rubber made of indiarubber vulcanised after application.
3. Vulcanised rubber used as a sheath and vulcanised during the process of manufacturing the wire. If there are several layers, these should be perfectly adherent to one another.

(*e*) *Conductors* for flexible wires or cables should be stranded, each strand being not more than 0·25 mm. (10 mils) diameter.

(*f*) *Conditions of Installation.*—Conductors having only a "medium" insulation can only be employed where the pressure is below 150 volts. When the pressure is 150-250 volts between the conductors or 155-500 in relation to earth, the insulation resistance should not be less than 600 megohms, and when the pressure between the conductors is between 250 and 500 volts the insulation resistance should be 1,200 megohms at least. The use of metallic ligatures for multiple conductors is forbidden.

For joining flexible wires to one another and to conductors it is recommended to employ rosettes with screwed contacts.

Flexible conductor branchings must be made from the main circuit by means of a contact plug or some similar apparatus.

Regulations other than the above adopted by the Associations Françaises de Proprietaires d'Appareils à vapeur ayant un service électrique, the Association des Industriels du Nord, and the Association Normande pour prevenir les Accidents. These rules were drawn up in 1900 and revised in 1903-1904, and are chiefly employed in the north and east of France.

2. *Insulation.*

1. Para rubber tape made of pure Para rubber and vulcanised without excess of sulphur. At 15°C. (59°F.) and within 30 seconds it ought to be capable of being stretched to six times its length, 10 times in succession, without cracking or breaking.

(*a*) "*Medium*" *Insulation.*—This should comprise either (*a*) two layers of Para rubber with necessary braided covering, or (*b*) two layers of "natural" rubber with necessary braiding, or (*c*) one layer of vulcanised rubber, without being watertight. In specifications *a* and *b*, the minimum weight in grammes of rubber per metre of single wire is the same as the diameter of the core in millimetres. In specification *c* the thickness of the rubber layer should be at least (0·5 + 0·1 d) mm. (d being the diameter of the core in millimetres). Mechanical protection is to consist of a layer of silk or glazed cotton.

(*b*) "*High*" *Insulation* (300 megohms).—This should comprise two layers of rubber, of which one at least should be vulcanised and completely water-proof, the minimum thickness of which should be (0·7 + 0·1 d) mm.

(*c*) "*Very High*" *Insulation* (600 megohms).—This should comprise two layers of vulcanised rubber, completely water-proof, of the following minimum thickness (0·9 + 10 d) mm.

(*d*) *Flexible Wires for Pendants.*—Flexibles for this purpose corresponding to specifications *a* and *b*, the minimum insulation thickness may be reduced one-third, provided the external protecting layer is of braided silk treated with wax.

Multiple flexible conductors must not be employed in dwellings except in perfectly dry places where explosive mixtures are neither generated nor accumulated, and they should be at least 3 mm. (0·12 in.) from walls and ceilings.

Multiple conductors should be avoided as far as possible for connections with commutators and circuit-breakers. In places where there is inflammable dust or nap which becomes attracted to the wires this method will not be allowed.

When there is risk of movable flexible wires getting soaked with water (as in dye-works, breweries, &c.), they should be inserted in a rubber tube hermetically sealed at its two extremities.

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APPENDIX C.

GERMAN REGULATIONS (ISSUED BY THE VERBAND DEUTSCHER ELECTROTECHNIKER JUNE, 1901; AMENDED JUNE, 1904 and 1905).

1. Flexibles may be employed with two classes of insulation—viz.: (1) Rubber put on spirally in the form of tape, (2) rubber in the form of a continuous sheath. Taped rubber flexibles may only be used in dry living rooms for pressures up to 125 volts. They may not be used under dress material or for portable fittings, and may not be installed in cellars, under floors, in bedrooms or halls. The vulcanised rubber may, however, be used up to 1,000 volts for fixed apparatus and up to 500 volts for portable purposes.

STANDARD REGULATIONS FOR TAPED AND VULCANISED RUBBER FLEXIBLES.

2. (*a*) *Taped Rubber Flexibles.*—This insulation may be applied to conductors of from 1 sq. mm. to 4 sq. mm. (0·0015 sq. in. to 0·0062 sq. in.) in cross-sectional area.

The conductors to consist of stranded tinned copper wires of not more than 0·3 mm. (12 mils) diameter. The conductor is to be spun over with cotton and lapped with unadulterated pure Para strip, which is to be unvulcanised. The overlap of the tapes is to be at least 2 mm. (0·08 in.). The weight of the rubber covering for 100 metres (109·3 yds.) length of single untwisted conductor is not to be less than the following:—

Weight of Insulation on Taped Rubber Flexibles (V.D.E.)

Conductor section.		Weight of rubber covering.	
Sq. mm.	Sq. in.	Grammes per 100 metres.	Lbs. per 100 yds.
1·0	0·00155	130	0·262
1·5	0·00232	155	0·313
2·5	0·00388	190	0·384
4·0	0·00620	230	0·464

Note.—For the purpose of testing for the above the mean of five weighings of 1 metre sample lengths is to be taken. Tolerance for dimensions and weight, 5 per cent.

Over the rubber tape each single conductor must have a cotton covering, and over this a braiding of insulating material such as silk or glacé cotton, which must be non-inflammable.

Each single conductor must be provided over the rubber with a protective sheath, the character of which will depend upon the nature of the work for which it is intended.

(*c*) *Flexibles for Portable Apparatus.*—Conductors for portable apparatus must, in addition to the above, be provided with a suitable covering common to both conductors.

(*d*) *Flexibles for Counterweight Fittings.*—The conductors must have a cross-sectional area of 0·75 sq. mm. (0·0016 sq. in.), made up of stranded tinned copper wires of not more than 0·3 mm. (12 mils) diameter, covered with cotton and with a vulcanised rubber sheath of 0·6 mm. (24 mils) wall. The two conductors are to be made up with a suspending string or cord of suitable material, and are to receive a common braiding of cotton, hemp, silk or similar material. The suspending cord can be double and on both sides of the conductors; if it is metallic it must be itself covered with cotton or braided. In connecting up the leads should be left longer than the suspending cord. The completed flexibles must be so pliable that single conductors can be worked over pulleys of 25 mm. (1 in.) diameter and twin conductors over pulleys of 35 mm. (1·38 in.) diameter without injury. These flexibles in a dry condition must be able to withstand an alternating pressure of 1,000 volts.

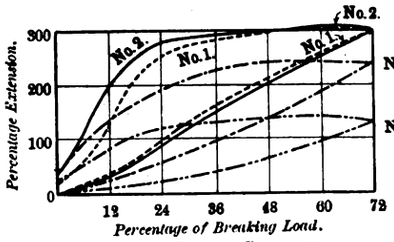

FIG. 12.—JACKET COMPOUND.

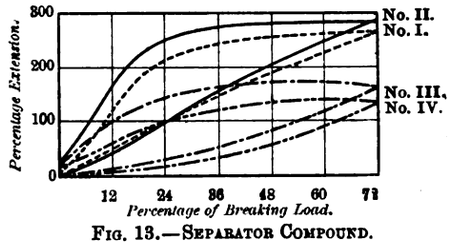

FIG. 13.—SEPARATOR COMPOUND.

A	B	C	D	E	C/D	F	F/D
1	60	304	442	632	0·68	290	0·65
2	53	303	678	967	0·44	270	0·40
3	40	248	613	876	0·40	220	0·35
4	35	144	406	580	0·35	120	0·29

A	B	C	D	E	C/D	F	F/D
I.	55	246	406	580	0·65	260	0·64
II.	48	292	721	1,030	0·40	264	0·28
III.	40	183	514	735	0·35	150	0·29
IV.	85	123	512	775	0·22	108	0·19

A=Number of Sample. B=Percentage of Rubber. C=Extension with 70 per cent. of Breaking Load. D=70 per cent. of Breaking Load. E=Breaking Load in Lbs. per Sq. Inch. C/D=Coefficient of Extension. F=Retraction after Loading to 70 per cent. of Breaking Load. F/D=Coefficient of Retraction. Load added or withdrawn at intervals of half a minute.

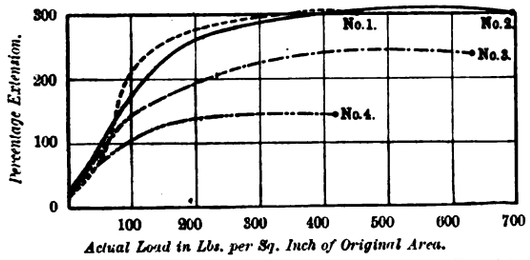

FIG. 14.—RETRACTION CURVES OBTAINED FROM FIG. 12.

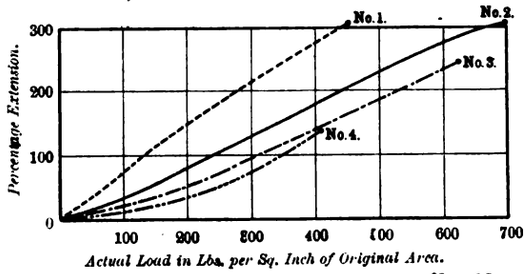

FIG. 15.—EXTENSION CURVES OBTAINED FROM FIG. 12.

Tests on Vulcanised Strip. Jacket Compound. Sample: No. 1, 60 per cent., No. 2, 53 per cent., No. 3, 40 per cent., No. 4, 35 per cent. of Rubber. Plotted on a Base of Actual Load in Lbs. per Sq. Inch of Original Area. Max. Load=70 per cent. of the Breaking Load.

The conductors must, in a dry condition, be capable of satisfactorily withstanding a test pressure of 500 volts alternating for half an hour.

(*b*) *Vulcanised Rubber Flexibles.*—These are permissible in sections of 0·75 sq. mm. to 6 sq. mm. (0·0011 sq. in. to 0·0093 sq. in.).

The conductors to consist of stranded tinned copper wire of not more than 0·3 mm. (11·7 mils) diameter.

The conductors are then to be spun over with cotton and enclosed in a watertight sheath of vulcanised rubber. The quality of the rubber sheath must be such that it will after 24 hours' immersion in water successfully withstand half an hour's application of 2,000 volts alternating between the conductor and the water. The temperature of the water to be not more than 25°C.

The thickness of the rubber covering to be as follows:—

Thickness of Rubber Covering for Vulcanised Flexibles (V.D.E.)

Cross-sectional area of conductor.		Thickness of rubber covering.			
		Maximum.		Minimum.	
sq. mm.	sq. in.	mm.	mils.	mm.	mils.
0·75	0·00116	1·1	43	0·8	31
1·0	0·00155	1·1	43	0·8	31
1·5	0·00232	1·1	43	0·8	31
2·5	0·00388	1·4	55	1·0	39
4·0	0·00620	1·4	55	1·0	39
6·0	0·00930	1·4	55	1·0	39

Note.—Tolerance for dimensions, 5 per cent.

DISCUSSION.

Prof. SCHWARTZ showed some additional diagrams, Figs. 12, 13, 14, 15, 16, 17, not included in the Paper, and said that through the kind co-operation of one of the firms he had been furnished with a series of strips of jacket and separator compound with definite percentages of rubber and vulcanised in the same way. The other ingredients of the compound were varied according to the experience of the manufacturer in order to produce the best results for each per cent. of rubber. The hysteresis loops could be plotted in a number of ways. Figs. 12 and 13 were plotted on a base of per cent. of breaking load; in these cases each sample was stressed up to 72 per cent. of its breaking load. It was seen that the loops plotted in this way did not place the samples in the order of their rubber contents; a reference to the table beneath, however, showed that C/D, the coefficient of extension, and F/D, the coefficient of retraction, placed the samples in their proper order. Figs. 14 and 15 were for the retractions and extensions of the jacket compound; the values were obtained from Fig. 12 and were plotted an a base of actual load. Considering Fig. 15 and assuming the dotted curve No. 1 as representing the standard, there was no difficulty in placing the other samples in their order of merit. Fig. 16 showed the decrease in the extension at rupture, after heating at 150°F. for 10 days; this again placed the samples in the order of their rubber contents, but the breaking load curve Fig. 17 did not do so.

Mr. C. P. SPARKS (chairman of the Wiring Rules committee) said that, on behalf of the Wiring Rules committee, he tendered special thanks to Prof. Schwartz for the mass of detail which he had put at their disposal. Last year, when the question of the revision of the Institution wiring rules was before the committee, they were met with the want of data with regard to the flexibles then in common use, and Prof. Schwartz

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had given them his hearty co-operation in elucidating certain points. Some four or five years ago, when the rules were under revision, no tests as to flexibles were available, and rather than have no test at all they had specified for a 1,000 volt test, but further experiments had shown that this test was not effectual. By the rules now issued they had raised the standard and specified for a 1,500 volt test for a quarter of an hour. That this was not an excessively severe test was shown by the fact that it was less severe than that imposed by the rules in force in other countries. Prof. Schwartz had drawn their attention to the relative merits of vulcanised as against pure rubber flexible, and the results of his investigations were in favour of the pure rubber, the greater durability of such flexible being clearly shown. In the new wiring rules (sec. 44) they drew attention to the desirability of using pure rubber flexible, especially when used in positions where such flexible would be bent a large number of times. The author had said: "For mill and factory lighting it is impossible for economic reasons to employ only 5 ampere circuits where long aisles are to be lit." He thought there was some misunderstanding on this point. There was no difficulty in controlling a 100 or 200-light circuit so long as each section was effectively guarded, so far as fusing was concerned. In revising the rules some five years back they introduced a section (now sec. 21) drawing attention to the necessity for wiring from distributing centres, so that no final circuit carried more than 5 amperes up to 125 volts or more than 3 amperes from 125 to 250 volts, and in his opinion that was one of the soundest rules and one of the most necessary rules that the Institution had ever issued. If that rule was carefully adhered to, the risks usually run would be enormously minimised. If circuits were reasonably fused the safety of the whole system was obtained. In the new wiring rules some definite instructions were given as to the way in which exposed wiring had to be done, and he thought that with the use of the sub-circuit system there was a very great field for exposed work, as it would lead to the use of electricity in many cases where the capital cost of the system must be low. Comparing samples of rubber to-day, one felt that one was dealing with an entirely different article from what was the case in the earlier days. They had before them that evening specimens of pure rubber flexibles, manufactured in England, which had been in use 20 or 25 years, and were little the worse. Whether they could now manufacture such cables he believed was purely a question of raw material. He hoped the cable makers would throw some light on this subject. A reliable but simple test of rubber was wanted to protect both buyer and seller.

This discussion will be concluded in our next issue.

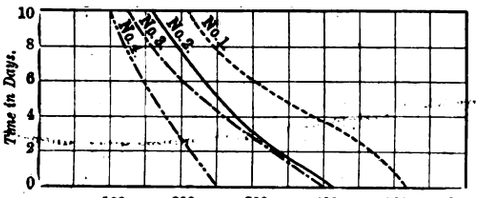

FIG. 16.—EXTENSION CURVE.

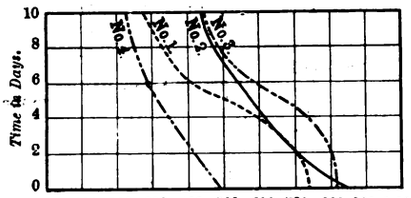

FIG. 17.—BREAKING LOAD CURVE.

Deterioration Curves at 160°F. of Vulcanised Strip. Jacket Compound. Samples: No. 1, 60 per cent., No. 2, 53 per cent., No. 3, 40 per cent., No. 4, 35 per cent. of Rubber.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

On Tuesday, last week, at the conclusion of Sir Oliver Lodge's evidence, Mr. HENRY MUIRHEAD was the next witness, and gave evidence on behalf of his brother, Dr. Alexander Muirhead. This evidence consisted, to a large extent, of a confirmation of Sir Oliver Lodge's statements. Witness said, however, that he wished to correct one or two slight errors in figures given by Sir Oliver. In the case of the Andaman Islands installation the horse-power used was ½ H.P. and the maximum distance over which the station had communicated with that power was 580 miles. This took place some years ago, when the Prince of Wales was in India. The Lodge-Muirhead Wireless Telegraph Synd. was registered on June 29, 1901. The whole of the patents taken out by Dr. Lodge and Dr. Muirhead were owned by the syndicate, the whole of the shares being held by Sir Oliver Lodge and Dr. Muirhead and his brothers. There were no foreigners associated with the Company. Mr. Marconi's patent was published on July 2, 1897. Two months before that date Dr. Lodge applied for his 1897 patent, and Marconi's patent was published in July—it remained in the Patent Office as a sealed document. Therefore, Dr. Lodge could not know what was in Marconi's patent. The most crucial experiment with the Lodge-Muirhead system was that at Hythe, previously referred to. The messages were sent 60 miles using only ⅛ H.P. They had had many communications with the Post Office on the subject of granting to them by the Postmaster-General of licenses for establishing commercial stations, but they had been put off, and had received unsatisfactory answers, and so never got the licences. He thought the Post Office might not have been indisposed to grant them licences at various times, but he rather thought the blocking powers were with the Admiralty. In the view of the Lodge-Muirhead Synd. the Admiralty infringed Dr. Lodge's 1897 patent, but they had been refused permission to test the question in a court of law. The first published patent for tuned wireless telegraphy was Lodge's patent No. 11,575 of 1897. That was the first master patent for tuned wireless telegraphy in this country, and the syndicate also held the master patent for tuned wireless telegraphy in America.

Sir GILBERT PARKER: Have you any litigation pending with the Marconi Co. ?—Yes, we have an action in progress.

Did you register the principle of wireless telegraphy?—We registered the method of carrying out the principle.

The method you patented was the first syntonised method?—Unquestionably.

Is the action that is taking place between you and the Marconi Co. with regard to tuning?—We have spent a great deal of money on adapting our apparatus for the War Office, and the War Office were about to give certain orders, and as the orders did not come to hand we asked them why, and they wrote and stated that they had received a letter from the Marconi Co. claiming that the system the War Office had adopted was an infringement of the Marconi patent. The action now in progress is for threats to our customers.

In answer to a question by Mr. GWYNN, Witness said he thought the Post Office had had a good deal to do with the perfecting of the Marconi apparatus. The magnetic detector was a development of an invention of Prof. Rutherford.

On the Committee resuming its sitting on Thursday last week, Mr. NEVIL MASKELYNE, technical adviser to the Amalgamated Radio-Telegraph Co. (Ltd.), was the first witness to give evidence. He said: I represent the Amalgamated Radio-Telegraph Co., of which Lord Armstrong is chairman. This company was registered on Sept. 15, 1906, and was formed to take over the interests of the De Forest Wireless Telegraph Synd. and to amalgamate therewith other interests more recently acquired. The company has a share capital of £500,000, partly subscribed. No public money is invested in the undertaking. All necessary funds have been and are still being supplied from private and substantial sources, and British capital alone is involved. Regarding the commercial and technical standing of the company, it has already completed contracts with Government Departments in Great Britain, India, Germany and Russia; with the United Shipping Co, for four trans-Atlantic liners; and with Messrs. Blumenfeld Bros. In addition to these installations it owns five stations in this country and three in Denmark. Among the whole of the foregoing, only two stations, those supplied to the General Post Office for Hunstanton and Skegness, have a range nominally less than 100 miles. Fourteen of the stations have a range of 200 miles and upwards, eight have a range of 500 miles, and one has a proved range of over 600 miles.

The CHAIRMAN: Do you anticipate contracts elsewhere in the immediate future?—The company has in course of negotiation contracts with the Governments of Great Britain, India, Cape Colony, West Indies, West Africa, Egypt, Norway, Sweden, Austria, Denmark, Italy, Russia, Turkey, China, Manchuria and Borneo; also with various authorities and private firms for stations in Central America, Faroe Islands, Fiji, Ocean and Pleasant Islands, Christmas Island, &c. There are also numerous ship installations of various kinds, tenders for which are under consideration. In all the number of such contracts will amount to between 60 and 70. In many cases the acceptance of these contracts is held in abeyance pending the ratification of the Berlin Convention. The technical importance of the company's operations has been officially recognised, both at home and abroad. I have been informed that various articles of the Convention were modified especially in view of the company's most recent improvements in radio-telegraphy.

Sir EDWARD SASSOON: In what way has the company been recognised by the Home Government?—The Home Government have been in communication with our company considerably. We have a contract under consideration by the Admiralty. As regards the expert staff of the company, the experts employed are of various nationalities, and include some of the most able men and most distinguished workers in the field of radio-telegraphy. The experts are of various nationalities in order that we may have dealings in all parts of the world. All our operators go through a very strict training in our laboratories here and in Denmark. Regarding the patents controlled by the company, our patents actually in force are 194 in number. Of these, 61 are British and colonial, and 133 are foreign. In addition, there are some 30 patent applications still awaiting acceptance, making 224. These include the most recent advancements and most improved methods connected with radio-telegraphy, and the various patentees, given alphabetically, are: De Forest, Ducretet, Ehret, Gehring, Maskelyne, Pedersen, Poulsen, Rosenthal, Schiller, Seibt, Sharman and Shoemaker. In order that the recent improvements contained in the company's patents may be properly understood, I should like to state very briefly the salient points in which various radio-telegraphic systems mutually differ. The existing systems may differ in four radical particulars. Firstly, in the manner of producing Hertzian waves; secondly, in the characteristics of the waves produced; thirdly, in the method of detecting the transmitted waves; and fourthly, in the perfection of "tuning," or syntony, and consequently the selective capabilities of the system.

1. *Different Methods of Producing Hertzian Waves.*—In practice there are only two essentially different methods of producing Hertzian waves. In the older method the waves are intermittent, their energy being derived

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from successive discharges of electric sparks. In the newer method the waves suffer no interruption. Their supply of energy is derived from a constant electric arc, similar to that of the ordinary arc lamp used for lighting purposes.

2. *Characteristic Differences between Waves respectively produced by these Two Methods.*—The essential differences characterising the two kinds of waves may be readily understood. In the older method, known as "spark telegraphy," each train of waves is derived from the energy contained in an isolated electrical discharge. Therefore that energy is reduced more and more as the successive waves are given off. The first wave is very powerful. The second is weaker, owing to the amount of energy absorbed in the first wave. The third is weaker still and thus the waves die away. In the newer method of "arc-telegraphy" there is no such dying away of the waves. The energy sent out with each wave is immediately replaced by the continuous current supplied to the arc. The basic Poulsen patents controlling this newer system are owned by the Amalgamated Radio-Telegraph Co.

3. *Essentially Different Methods of Detecting Hertzian Waves.*—In practice there are two fundamental methods of receiving telegraphic signals, either wirelessly or by wire. These are respectively, the "direct" method and the "relay" method. In the former the actual energy sent out by the transmitting station operates the recording instrument at the receiving end. In the second method the transmitted energy does not record the signals. It is not powerful enough to do so. It merely controls a local supply of energy at the receiving station. That local energy records the actual signals. This is sometimes called the "trigger" principle. The energy transmitted will not suffice, as it were, to propel the shot from the gun. It is only capable of pulling the trigger. In the older spark-telegraphy, the receiving instruments invariably act upon some form of trigger principle. In the newer arc-telegraphy, the received signals may be recorded, directly, by the actual energy transmitted. This latter fact alone serves to show the superior efficiency of the newer system of radio-telegraphy.

4. *Means employed for "Tuned" or Selective Signalling.*—No matter what system of radio-telegraphy be employed, there is only one method, at present, whereby signals from one station can be transmitted to another station without affecting a third station within range. From its analogy to acoustic principles, this method is described as "tuning." The process has been shrouded in much unwarrantable mystery, but it is perfectly simple, and perfectly understood by all experts throughout the world. It depends, primarily, upon the use of transmitting and receiving electrical circuits which have a similar rate of oscillation. That is to say, in each circuit a current of electricity passing to and fro along the wire contained in that circuit will occupy a certain definite fraction of a second in making each successive journey. Each swing of the transmitter current tends to set up a similar swing in the receiving circuit. If the two circuits are in tune, the transmitted waves will continually assist and amplify the oscillations set up in the receiver. If not, the two circuits soon become at cross purposes, and instead of amplifying the action of the receiver the transmitted waves act in opposition to it. Thus, when two stations are "out of tune," the receiver cannot accumulate energy from the successive waves radiated by the transmitter. The possibilities of tuning are well understood, and its limitations are clearly defined. There is no mystery whatever in such matters. The transmitter must give out a definite number of electrical oscillations per second. Each single oscillation must be too weak to affect any receiving instrument within range. The receiver must include an electrical circuit having a definite range of oscillation. It must not be sensitive enough to respond to a single impulse from any transmitter within range. The transmitter must give out oscillations all of which are as nearly as possible equal in intensity. The receiver must integrate as many impulses as possible before responding to the action of the transmitter. The more sensitive the receiver, and the weaker the individual waves radiated by the transmitter, the more perfect will be the selective action of the system employed. The selectivity and secrecy derivable from tuning, however, must necessarily be subject to certain definite limitations. When stations are so near together that one single impulse from the transmitter at either station will affect the receiver at the other station, tuning is incapable of providing selectivity or of preventing interference, and, however accurate may be the means of tuning, there is no possibilty of preventing the reception, by any station within range, of messages transmitted by the apparatus employed in any system whatever.

The superiority of the continuous-wave or arc-telegraphy system is due to the facts already indicated. In the first place, the waves are of equal intensity, and thus we avoid the defects due to the necessity of building up an increasing store of received energy by means of constantly falling waves. Secondly, each individual wave is too weak to affect a receiving station even at a short distance, and thus there is great freedom from interference. At the same time the tuning is very accurate, because only by means of sharp tuning can a sufficient amount of energy be accumulated at the receiving station. Thirdly, the receiving apparatus may be very insensitive, because the continuous nature of the waves will allow ample energy to be accumulated for overcoming that insensitiveness. All these facts tend to produce great efficiency and selectivity. In actual practice a difference of 1 per cent. in wave-length will suffice to prevent interference between two lines of communication working within range of each other.

From what I have said it will be evident that our latest apparatus is capable of working within a comparatively short distance of other installations without suffering disturbance. In fact, when using the continuous-wave system in ordinary practice we are never aware of the existence of waves transmitted by other stations. And, according to my experience, other stations are equally undisturbed by our signals. Therefore we claim, and reasonably so I think, that we should be allowed to erect and operate continuous-wave stations, for our own special purposes, wherever we may wish to do so. Naturally, we should not wish to build stations where they would be likely to interfere with others, because in so doing others would probably interfere with our working. Under the Convention we should be entitled to put up stations for our own special purposes, but in existing circumstances licences have to be refused us because such licences would permit us to use the means commonly employed in wireless telegraphy; or, at any rate, there would be nothing to prevent vessels from signalling to us by the ordinary means, and thus interfering with neighbouring stations. The result is that, at present, we are debarred from obtaining communication in various important localities—notably on the south coast of England. We may not erect stations of our own, and the existing stations will not accept messages from vessels using our apparatus. Even the stations controlled by Lloyds are debarred from communicating with us. This we consider to be not only a very great hardship, but also an injustice. Our more perfect system is hampered by restrictions imposed upon us by those who employ an older and extremely primitive system. The present lack of general organisation undoubtedly results in the loss of a vast amount of business which would otherwise be done. In very many instances vessels cannot be fitted with our apparatus, because in the localities where communication is most needed we have no shore stations to take the messages. The existing stations will not communicate, and we are not allowed to erect stations of our own. To obtain the required communication, those vessels must be fitted with the type of apparatus used at the existing shore stations. The owners of those vessels refuse to adopt that type of apparatus, and therefore there arises a total loss of much valuable business and there is great hindrance to progress.

The CHAIRMAN: You consider there is necessity for ratification of the Convention?—If the Convention be ratified the detrimental circumstances I have mentioned must automatically cease to exist. Not only would this benefit radio-telegraphic companies in general, but also the particular company which at present refuses to intercommunicate with other systems. If the principle of general intercommunication were adopted, my company, for example, could immediately undertake the equipment of numerous vessels which at present it would be useless to equip. Therein we should benefit. The existing stations would accept messages from those vessels, and would be paid for doing so. They would obtain much traffic, which now they do not get. Further, we should have no justification for our present desire to erect stations which would enter into competition with those that already exist. Such being the case, I venture to say that intercommunication would benefit the owners of existing stations at least as much as it would benefit the company I represent. Concerning the Convention as a whole, there is in my mind no shadow of doubt as to the desirability of having it ratified by the British Government. Broadly speaking, I have two main reasons for adopting that view. Firstly, the present state of chaos is intolerable and utterly opposed to rational progress; while, if the Convention were ratified, that chaos would be converted into order. Secondly, the British delegates who attended the Berlin Conference practically dictated the final wording of the Convention. In all matters affecting the interests of this country they carried their points. They express themselves satisfied with the result of their efforts. If I had no other reason for supporting the Convention, these considerations would compel me to do so. I have reason to appreciate the ability of those gentlemen who represented Great Britain at the Conference, and it seems to me that this country should unhesitatingly abide by their decision.

Asked by the Chairman if he wished to allude to any point raised by Mr. Cuthbert Hall in his evidence, Mr. Maskelyne said he felt it his duty to do so, as representing the Amalgamated Radio-Telegraph Co. Mr. Hall had said the particular feature of the Marconi apparatus was the aerial and earth connections, but he would point out that these were used by Dolbear in 1886 and by Edison in 1891. He could not see, therefore, how these connections could be a particular feature of the Marconi system, seeing that Mr. Marconi's patent was taken out in 1896. In regard to Mr. Hall's statement that there were no stations carrying on a public wireless telegraph service by other systems, he would say that the Amalgamated Radio-Telegraph Co. and also the American De Forest Co. carried on a public service. The official list prepared by Mr. Gavey would show that there were many other stations which undertook commercial work. On behalf of his own company he would say that their efforts in this direction were seriously hampered under existing circumstances. Mr. Hall had said that the policy of non-intercommunication had been justified to a certain extent. He felt that the only justification for any policy consisted in its result, and so far the principal result produced by the policy of the Marconi Co. had been the hastening of the establishment of an International Convention, to which that policy was entirely opposed. As regarded interference, Mr. Hall had stated that they had had that difficulty, but had eliminated competition between operators by the introduction of a bonus system, under which operators received a certain bonus on every message, provided that every rule and regulation had been observed. If this were the only possible solution of the difficulty, he would suggest that under the Convention it would be quite as efficient as in the present circumstances. The necessity for introducing the bonus system showed that private organisation was not able to prevent interference. The only remedy had been to bribe the operators not to interfere.

Questioned as to whether he regarded the Poulsen system as being superior to all others, Witness said he did. He looked for the time when the arc telegraph, or, at any rate, some form of continuous-wave telegraphy, would be universal. Any stations having already the sparking system could adopt the Poulsen system as well. The statement that communication between Denmark and the Danish West Indies by the Poulsen system had been established was inaccurate, inasmuch as they had no station in the Danish West Indies.

(PARLIAMENTARY INTELLIGENCE *continued on page 106.*)

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There are few subjects on the financial side of electrical engineering that have given rise to more discussion than that of depreciation; but the results of discussions so far have been decidedly meagre, and consequently there are no very well recognised rules to be followed. We are, therefore, glad that Mr. HAMMOND has brought the subject before the Institution of Electrical Engineers, and we hope that greater uniformity in ideas will be the result, though time alone can really show the correctness or otherwise of the necessary assumptions.

Depreciation is often surrounded by an air of mystery, which arises no doubt from the fact that when people discuss the subject they do not all necessarily mean exactly the same thing, some including considerably more than others in this term through lack of definition. But we think it will be generally admitted, assuming the plant to be properly maintained, that depreciation is merely another word for decrease in the value of plant up to the end of its useful

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life. If this view is accepted then it is a simple matter to determine the amount of the depreciation if the life can be arrived at.

Something, of course, depends upon what is regarded as proper maintenance. By this term we mean that certain parts which are subject to wear should be renewed from time to time and repaired as found necessary. Even when this is done, there comes a time when the cost of repairs becomes excessive, when breakdowns become frequent, and when, therefore, the useful life of the plant must be considered to be at an end. In the discussion upon Mr. HAMMOND'S Paper, Mr. MATHESON put forward the view that if plant is properly maintained, its value remains constant, or even increases. With this view we cannot agree, for a time must inevitably come when plant must be scrapped, unless the meaning of the term "maintenance" is so enlarged that it includes the complete replacement of plant. Nor can we allow that the writing off of 3 per cent. of the value of the plant standing in the books each year is sufficient (unless new additions have been made to the plant). If the capital sum remains constant, then the actual sum written off under these conditions becomes less and less as the value of the plant on the books becomes decreased, so that eventually the curve showing the value of the plant as affected by the writing off of this 3 per cent. would become more or less flat, whereas the amount expended in repairs and maintenance would certainly increase. Consequently the value of the plant, according to Mr. MATHESON'S method of regarding it, would become greater and greater as time went on.

With regard to the vexed question of the difference between companies and local authorities, we agree with Mr. HAMMOND that there should be no difference as regards depreciation. There are, of course, differences in detail. In the one case dividends are paid, and in the other case loans are paid off and a certain rate of interest is paid on these loans, but there is no reason why this should affect the ordinary question of depreciation. So long as loans are repaid, and so long as a local authority is in a position to repay at the termination of the life of the plant, then all is well. Nevertheless, a sound financial position is sometimes difficult, owing to the way in which loans are granted. But there is no difficulty in providing for short-lived assets, which become of no value before the loan relating to them has been completely paid off, if suitable provision is made for them, as suggested by Mr. HAMMOND and as is already being done at Bristol.

In making any provision, however, it is tacitly assumed that the life of any particular plant will be actually as long as it is estimated to be. Unfortunately this is not necessarily the case. The plant may still be in good condition, but it may be unsuitable for the work that is required of it. In other words, it is very possible that the plant may for some reason have become antiquated. We notice that Mr. HAMMOND does not treat antiquation as a serious matter, but one which should be provided for only in times of prosperity. We think, however, that it should receive rather more consideration than that, and that the value of plant should be considered from the antiquation point of view regularly from time to time. The question is of some importance to companies, but it is of even greater importance to local authorities on account of the attitude adopted by the Local Government Board. It often becomes desirable that plant should be replaced; for example, by larger plant, or by plant which is for some reason or other more suited to the work, the character of which may have changed considerably through developments since the original plant was put in. In such cases, however, the Local Government Board make a point of deducting that part of the loan which has not yet been paid off from the new loan required for putting in the new plant. In many cases this leads to considerable difficulties with no adequate gain. So much indeed is this the case that we think the Council of the Institution would do well to bring pressure to bear upon the Local Government Board to deal with such cases more from the common sense point of view than by a fixed rule as at present.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Elementary Experimental Magnetism and Electricity. By WILLIAM ALLANACH. (London: Longmans, Green & Co.) 3s. 6d.

We have to congratulate the author on having succeeded where so many others have failed; he has produced a useful and intelligible elementary text book. Not the least useful sections of the book are the appendixes, of which the first deals with dynamics, the second with chemistry, while the third is a table of four-figure tangents. Mr. Allanach evidently appreciates the difficulty that is met with when students, and particularly the evening class type, commence the study of electricity and magnetism. He knows that, as a general rule, it is hopeless to expect from them a sufficient knowledge of kindred branches of science, and that these branches have to be mastered as the student progresses. All the matter is of an extremely elementary nature, but it is well and clearly arranged.

Einfuhrung in Die Electrotechnick. By Prof. ANTON ZEEMANN. (Leipzig: A. Hartleben.)

It is by no means a light task to endeavour to cover the whole ground of electrotechnics in seven semi-popular experimental lectures, which are here compressed into a book of 167 pages, but it must be owned that the author has succeeded in the attempt further than one would have supposed possible. The lectures were delivered before the Vienna Urania, and start at once with the production of the current electromagnetically, a description of Faraday's experiments being given, leading up by clear and easy stages to the practical construction of armatures and complete dynamo machines. Descriptions of modern types of direct-current and alternate-current generators and motors are given, with simple explanations of the principal distinctive features of their construction and behaviour, and of electrical measurements, with the necessary instruments. A chapter is devoted to electric traction, which is of some interest, as it deals with the subject from the Continental point of view, and shows some forms of construction which differ materially from those in use here. Considerable attention is given to the three-phase high-voltage systems and the high-speed railway experiments. The fifth chapter is devoted to electric lighting, and is naturally, in view of recent developments, the most interesting. It starts with a very clear exposition of the problem of efficient light production, and shows how thoroughly the scientific nature of the problem has been before those who have been devising the metallic filament and other lamps. A description of these lamps and their properties follows, and this chapter may be commended to those interested in the subject. The remainder of the book is devoted to the subjects of wireless telephony, high-frequency alternating-current work, wireless telegraphy and radio-activity. The illustrations are good and the language simple and well chosen.

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THE USE OF WOODEN POLES FOR OVERHEAD POWER TRANSMISSION.*

BY C. WADE.

Summary.—In this Paper the author discusses the use of wooden poles for the support of overhead mains, and gives the results of a series of tests, the first set of which showed that the compound pole of A type was very much stronger than a single pole of equal area. He also describes the different methods of fastenings used for compound poles of the A type.

The employment of overhead high-tension, and extra high-tension transmission of electricity has only come into vogue in this country within the last two or three years. For overhead structural work there was an old Board of Trade regulation in force that "The factor of safety for wires should be 6, and for all other parts of the structures at least 12, taking the maximum possible wind pressure at 50 lb. per square foot." This has now been reduced from 12 to 10 for the factor of safety on the structure, and from 50 lb. to 30 lb. for the wind pressure.

So strong was the feeling against overhead wires that the earlier power companies did not even seek to obtain powers for their use. In consequence, some hundreds of thousands of pounds have been sunk in the earth which might have been spent with far better results, both financially and from an engineering standpoint, on more comprehensive systems of overhead distribution.

The power companies have necessarily been the missionaries of overhead transmission in this country. They soon found that, in many cases, the cost of underground mains made it unremunerative for them to connect on customers whom they needed and who needed them. The Lancashire Electric Power Co. was the first in England to bring the point to an issue. They approached the Board of Trade and were met by the authorities in a most friendly spirit. Plans were submitted and approved, way-leaves were arranged, and to-day the company has about 4½ miles of overhead mains, transmitting power at 10,000 volts pressure to a variety of industries. The lead of the Lancashire Power Company was quickly followed by the South Wales, the North Wales, the Clyde Valley, the Cleveland & Durham and other companies, and there are now some 55 miles of extra high-tension overhead transmission lines at work in Great Britain.

To those who have studied the subject—especially abroad—it seems strange that this country can only boast, in 1907, of having 55 miles of overhead mains at work. In the districts round Grenoble, Lyons and St. Etienne, to give only one example, there are some 700 miles of overhead power mains at work carrying energy at pressures varying from 200 to 26,500 volts. These mains are for the most part carried on ordinary telegraph poles along the sides of the main roads. One overhead line near St. Etienne, 11 miles in length, carrying energy at 5,500 volts pressure, was erected for £160 per mile, and this sum included wayleaves, special precautions when crossing roads and railways, and the purchase of trees that were in the way of the line.

The author, in August and November, 1906, acting on the suggestion of Mr. A. P. Trotter, of the Board of Trade, carried out an exhaustive series of tests on wooden poles of varying form, lengths and diameter. During these tests the author had the advantage of the advice and help of Prof. Goodman, of Leeds, and the tables printed with the paper were prepared by him.

The first set of tests carried out clearly proved: first, the very marked superiority of an "A" over a single pole, the "A" pole being shown to be at least three times as strong as a single pole, while later and more accurate tests have shown that the "A" is at least four and a half times as strong as a single pole; second, the great flexibility and recuperative power of wooden poles. Some single poles that were tested projected free for 35 ft. from their housing and deflected 13, 14 and 15 ft. before breaking; and those that were released before the breaking point was reached showed a very small permanent set. It was soon seen that "A" poles were preferable to single poles both as regards economy and strength.

In testing the poles it was desired to hold the butt of the pole firmly to a height of 5 ft., whilst the rest of it was allowed to swing free, so two heavy timbers were driven into the ground, one for holding the foot of the pole and the other for taking the stress 5 ft. up. The top end of the pole was supported on a specially constructed trolley, which ran on a platform under this end of the pole. It was first attempted to load the pole by weights placed on a wooden platform, suspended from the end of a wire rope attached to the pole, and carried by a series of pulleys to the top of a substantial frame about 12 ft. high. The platform when heavily loaded sank into a pit dug below the frame. This method was quickly abandoned on account of the friction of the pulleys and the time occupied in loading by this crude means. In subsequent tests the load was obtained by a gang of men with pulley-blocks, and a dynamometer was inserted in the loading chains.

A similar method of holding was adopted in testing "A" poles on the flat—*i.e.*, along the line of the wires—and was satisfactory. This acted admirably for single poles, but when "A" poles were tested across the line of the wires in precisely the same manner, it was found that, owing to their taper construction, there was so much end slip in the housing that accurate results were impossible. When it was found that the strength of "A" poles was the really important point to determine, the author, acting on Prof. Goodman's suggestions, redesigned and reconstructed the testing apparatus and the methods of housing the poles, and carried out a new series of tests.

In this series of tests—confined almost entirely to "A" poles—a different method of holding was adopted to prevent the poles from slipping in their housing, as shown in Fig. 1. All the poles were about 7½ in. to 8 in. diameter at 5 ft. from the butt. The double pole being placed in position, as shown, two heavy blocks, EF, were bolted to it, one below and one above the pair of poles about 2 ft. 6 in. from the butt, and, in addition, a heavy iron ring, G, was bolted to the tension leg of the pole, below the blocks, to prevent them slipping down when under load. The foot of the pole was embedded against a massive timber, RS, supported on the poles BD. A block, H, was inserted, as shown, to give additional stability.

By this means, when the load was applied in the direction of the pile W, the leg that was under tension was unable to move away from the baulk A and its supports on account of the oak cross timbers, whilst the leg that was in compression was also unable to move, as its foot was pressing against the timber RS. The pole was therefore very rigidly held in place, in fact, far more so than would occur in actual practice.

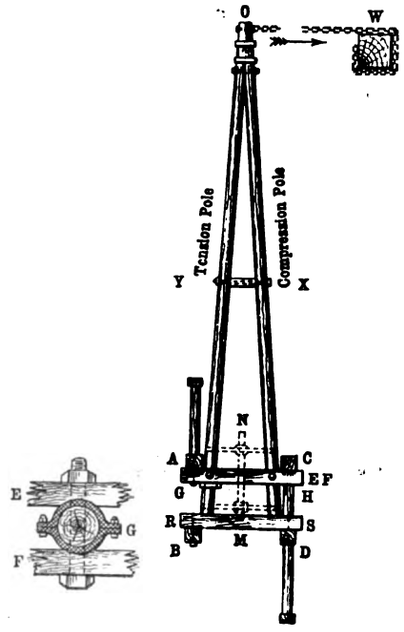

FIG. 1.

Prof. Goodman suggested and provided a telescope, which was attached to the butt of the pole at MN (Fig. 1), and by this means it was possible to sight a plumb-bob, suspended at O, so that accurate readings could be obtained and any slip of the pole in its housing could be detected and allowed for. The use of a telescope in tests of this kind is a very necessary refinement that is too often overlooked, and one was used by the author in all tests made. The housing requires to be of great strength. The author believes that the results of these tests given in the tables are accurate, as very great care was taken to make them so. In all probability if a load equal to the test load were applied to a pole carrying wires the whole structure would be pulled out of the ground.

In these tests it was found that whereas a single pole would often deflect to a very large extent before breaking, an "A" pole, so long as it held together at the top, would only deflect a few inches. The "A" pole, however, would sustain in a direction across its two members—*i.e.*, at right angles to the lines—a load four or five times as great at that of a single pole of the same diameter as one of the two members of the "A" pole. Also experiments show that an "A" pole (as would be expected) is at least twice as strong as a single one of equal section, in the direction of the line, and would only deflect half as much.

The "A" poles failed in nearly every instance through the buckling downwards of the member in compression. This was due to the initial sag of this member, caused by its own weight, which it was impossible to allow for. This sag undoubtedly made the poles fail sooner than they would have done had they been in a vertical position, and the results, therefore, are less favourable than they would be in actual practice. But it should be noted that at this

* Abstract of a Paper read before the Institution of Electrical Engineers.

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point of failure the poles were not actually broken in any way, and if it had not been for the sag out of the line of pull they would undoubtedly have sustained far greater loads. The buckled pole in all cases straightened itself immediately the load was released. In every case the load was applied approximately 2 ft. from the top of the pole, this being about the point where the stress would occur in actual work.

In 1885 Mr. (now Sir William) Preece, chief engineer to the Post Office, carried out a series of tests as to the strength of single poles. Many different kinds of poles were tested that had been seasoned for different lengths of time, and tests were made on creosoted and plain poles of different lengths and diameters. These tests, however, did not deal with the flexibility of the poles, nor with their strength, as compared with composite poles, but they are still the only data that we have on the strength of ordinary poles.

From the tests carried out by the author, it appears that many of the poles in use in this country are misproportioned, and this applies particularly to "A" poles. Some are ridiculously too large, while others are dangerously too small. The few that are correct in length and size have been selected more by luck than judgment. The tests showed that the usual breaking-point of a single pole, when tested to destruction, is about 5 ft. above ground level, or about 10 ft. from the butt. The diameter of a pole at this point is, therefore, the most important dimension to consider in choosing one suitable for certain loads. The top diameter of a poleis also of some litt'e importance, but this is a dimension which Nature settles, and there is no object in altering the natural taper.

The weakest point of an "A" pole is the top, where the stress due to windage and weight takes place. The two members of the pole—owing to their shape—have a tendency to slide and slip on each other when subjected to a load at the top. One member being in compression and the other under tension, that which is under tension elongates and forces itself away from the member in compression.

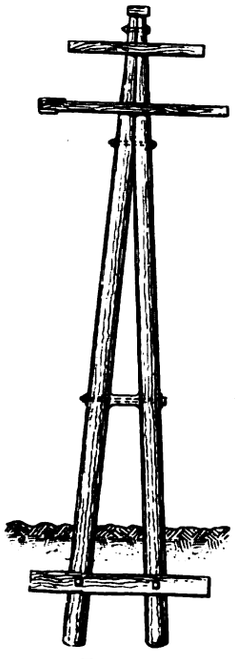


FIG. 2.

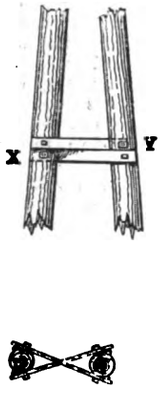


FIG. 3.

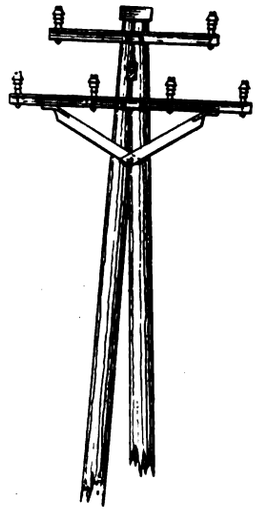


FIG. 4.

The important thing about an "A" pole is its construction and the method adopted to hold its two members at the top. The author's method of securing them is shown in Fig. 2. The two members are scarfed to such an extent as to reduce them to about two thirds of their original diameter. The length of the scarf depends, of course, on the angle at which the members are set. They are held together by two ¾ in. bolts, one about 12 in. and the other about 48 in. from the top of the poles At the foot the two members are tied together by a wooden block about 6 ft. in length and 4 in. by 8 in. in section, which is let into and bolted to each about 2 ft. from the butt. It will be noticed that the arrangement is similar to that adopted in the tests, which were designed to follow as closely as possible, the conditions occurring in actual practice.

A centre tie bolt and tubular distance piece are also used between the two members about 10 ft. above the ground level. Instead of this tie bolt flat iron plates, fixed diagonally across the poles and bolted to the pole at each end, can also be used with advantage (Fig 3), by which means, undoubtedly, the pole is materially strengthened, and is prevented from twisting. Angles or channels bolted to each side of the pole, across the two members, serve the same purpose. It is also desirable to insert an oak block in the scarf. This block should be 6 in. deep, and should be let into each member to a depth of about 1 in., depending on the size of the pole used (Fig. 4). The tests showed that if the blocks are less in depth or if they are nearly square they tend to twist and bed their corners into the poles and thus force the members apart. One deep block in the scarf appears to be better than several of less depth, inasmuch as the insertion of several blocks weakens the timber, and if they are fixed high up they will—when under stress—squeeze the top part of the member on which they bear clean out of the end of the pole. The oak arms let into the poles to carry the insulators materially strengthen the structure and prevent shearing. For the construction of "A" poles the author recommends this method, which is the one usually adopted, but other methods are sometimes employed.

The lower insulator arms are sometimes tied to the centre of the pole by flat ties or iron plates, which help to prevent the twisting of the arms and the parting of the two members. The tying together of the ends of the lower and upper arms also helps to strengthen the structure. It is, of course, most important that as little cutting away as possible be done to the poles, especially at the top, as this weakens the timber.

Whether insulator arms should be composed of oak or angle or channel iron seems a very open question, into which the question of insulation and earthing enters very largely. The life and strength of a wooden arm seem to be equal to those of an iron one, if not more, and wooden arms will no doubt outlast the pole and are slightly cheaper than iron.

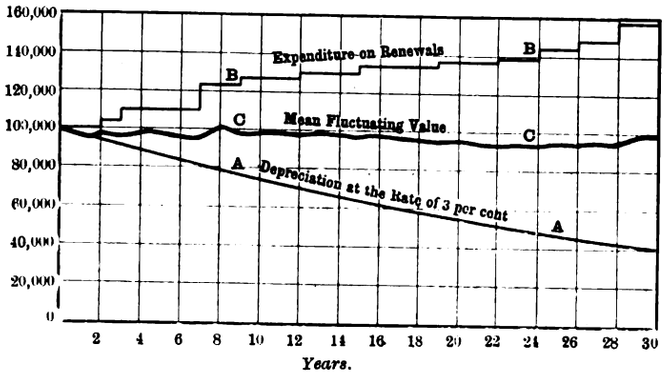
(To be concluded.)

DEPRECIATION.

The following discussion took place on a Paper on "Depreciation" read by Mr. R. Hammond at last week's meeting of the Institution of Electrical Engineers, and of which we gave an abstract in our last issue.

DISCUSSION.

Mr. EWING MATHESON said he did not agree with Mr. Hammond's Paper. There seemed to be some difficulty in deciding what depreciation meant. The author seemed to think that depreciation was some mysterious wearing out, and that antiquation was something else. As a matter of fact, depreciation was merely a convenient word for summing up all the necessary items of savings to provide for the unknown future. Machinery never wore out in any consistent way, and generating plant or



anything else could not be made so that the whole thing and every one of its component parts became worn out at one identical moment. It was well known that spare machinery kept for an emergency became antiquated just as quickly and had to be scrapped practically at the same time as the regularly working machinery. As to the author's estimation of the years of life of machinery, &c., on this he said "that in order to cover depreciation, it was necessary to settle the number of years which would elapse before the various classes of plant and apparatus in use would arrive at the scrapping stage." He disagreed with this, as depreciation was not necessarily a fund for renewing the machinery when worn out. As to the author's suggestion that a sum sufficient to repay the amount of the debt on the expiry of the period fixed should be invested at 3 per cent. for this purpose, this was an unbusinesslike suggestion, as such available capital would be put to better use if kept in the business. He showed a diagram illustrating his view. BB was expenditure, AA a depreciation curve, and CC the curve showing resulting value. BB went on for some years steadily, when something happened leading to a big expenditure. All the values on BB were actual expenditure. All the time depreciation was bringing the line BB down and appreciation was bringing it up, so that at the end of 30 years the assets were worth just as much as at the beginning. With an exact balance the equipment was all in order, and in fact had a bigger earning power and was worth more to the business than at the beginning, although worth no more to the capitalist. Mr. Hammond suggested insurance against antiquation other than regular wearing out, but no insurance could be effected through a society against many of the

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risks for which the depreciation fund was an insurance, and covering work necessary to be done from time to time. As to the depreciation on land and buildings this was not so small a matter as Mr. Hammond seemed to think. If the works for any reason went out of use, to make the land saleable for other purposes large sums had to be expended in pulling down chimneys and buildings and dismantling the place generally. In the case of a power house having big engines with rope gear which had to be replaced by more modern machinery, although not to any degree worn out such engines would not be worth anything like their original cost. Again in some cases boilers had to be pulled out and the cost of such pulling out was considerable, which made the question of depreciation of boilers important. As to mains, they all knew that the earlier rubber-covered mains had to be taken out, in some cases after comparatively short service, and therefore it was a rather daring thing to assume that cables and mains were going to last a certain definite time as there might be a change of system. That was where the question of depreciation came in. He thought most of the systems of the country were based on too liberal a scale, and they should not be in a hurry to reduce their charges or prices or to pay big dividends until they had sufficient funds available for any emergency or requirement.

Mr. A. A. CAMPBELL SWINTON said that while there were a great many points in Mr. Hammond's Paper with which he could agree, there were many more with regard to which he took another view. The author seemed to think that depreciation could be arranged on the same basis for a local authority as for a company. There was, however, a great difference between the two—no one was obliged to become a shareholder in a company, but the ratepayers in respect to a municipal undertaking were compulsory shareholders, having at the same time very little control. Experience in these matters showed that it was advisable to put as much as possible to depreciation. It was proverbial that in the case of a company being bought up by a local authority, that the arbitrator put the then value of the undertaking at a less figure than the value of the undertaking as it stood in the company's books. Companies arranging how much to put to depreciation should carefully consider the effect the amount of their depreciation fund might have upon the amount of money they would get when they were bought out by the local authority. A concern that commenced on a fairly small scale and increased gradually could adopt a system similar to that adopted by the great railway companies—not to have a depreciation fund at all, but to pay all renewals out of revenue; but with a very large system put down all at once, the annual income would not be large enough at any one time to renew the whole system at once. With systems built up gradually it was only a case of small parts wearing out, and these were easily renewed.

Mr. H. SHERLEY-PRICE said they were all agreed that there must be depreciation, whether in municipal, public or private hands, and, whether considered so or not, depreciation was as much a matter of working expenses or establishment charges as amounts paid for rents, rates, taxes, coal or any other similar items of expense. The question which had been raised of including sinking fund with depreciation was, in his estimation, a wrong basis altogether. He did not propose to deal with sinking fund; that was purely a question of accountancy, and, furthermore, had already been fixed by Government and could not, therefore, be changed. It had been suggested that the correct way to arrive at a rate of depreciation was by estimating the life of the plant dealt with, and if this were easily done there would be no further difficulty in the matter, but it was this very fact—namely, the hypothetical life—which he maintained it was impossible to fix with any degree of accuracy. In the Paper a list of estimated years of life, varying from 15 to 60 years, was given, and it was suggested that on this theoretical basis rates could be formed. He ventured to think that the experience of everyone would show that the rates adopted were much too high—probably from 30 to 50 per cent. too high—supposing they were fairly maintained and no case of obsolescence or accident occurred. The best method was that which had been adopted by many of the large engineering firms—namely, to have the same valuer make an annual inspection, which was only a small matter, and this annual inspection could go on for three, five or seven years, and then an entire re-valuation would be made in order to test whether the percentages or allowances made or added had been correctly done.

Mr. W. R. COOPER referred to figures for life given by Sir William Preece in a report to the Bristol Corporation last year, and thought members would do well to compare these with those given by Mr. Hammond. For some items he preferred the longer lives given by Sir William Preece, though in some cases Mr. Hammond's would be preferable. He thought, however, that the figures adopted should depend somewhat on the character of the load, the life being longer, for example, on a lighting than on a traction load. Short-lived assets could be provided for satisfactorily, as suggested by Mr. Hammond, but in the case of local authorities it was often difficult to replace plant which had become unsuitable by new plant, on account of the action of the Local Government Board in deducting any part of the loan referring to such plant, not yet paid off, from the new loan. He thought the Council of the Institution would be well advised to take up this question with the Local Government Board so as to secure more common-sense treatment.

Mr. W. W. COOK said that in fixing an amount for depreciation it was necessary to take into consideration both the engineer and the accountant. The accountant was not concerned with the exact method of depreciation, his business was with the result, but the engineer was concerned with the exact method.

Mr. A. H. DYKES said depreciation undoubtedly caused some controversy with the auditors. Some companies were in the habit of paying a maintenance sum for the upkeep of their batteries to the manufacturers, who kept the batteries in absolutely good repair and working condition, and in a case of this kind he had in mind the question had arisen as to how these payments should be allocated. The auditors said that it should go under either insurance or repairs and maintenance, the result being that the maintenance item for batteries was exceedingly high; but seeing that at the end of a term of years the batteries would be in as good condition as at the start, so far as working capacity was concerned, such payments should have gone to depreciation account, and the company were entitled to debit the depreciation fund to that extent.

Mr. A. WATTS thought the Paper unfortunate, as it conveyed the impression that the question of depreciation and the life of the plant was only a consideration at the profit-earning stage of its life. He thought this was altogether wrong. The life for the various parts of the plant had to be carefully considered, and the amount necessary to be set aside for depreciation should follow as a matter of course. With regard to the treatment of residuals, he did not agree with the way in which the author dealt with that quantity. In arriving at the depreciation item it was necessary to put the residual values into the valuation. For example, mains would represent a considerable percentage of the total expenditure on electricity supply, and in the table given by Mr. Hammond a life of 30 years was given indiscriminately to mains whether laid in ducts or laid solid. This, he thought, would almost invariably lead to a solid cable being put down as it was probably from 10 to 20 per cent. cheaper. A cable laid in ducts cost £1,000, compared with £900 for solid; the amount to be set aside for depreciation based on a 30 years life for both would, therefore, be considerably in favour of the solid system. If, however, the value of the residual was taken into account, which he estimated roughly would be about 25 per cent., the payments for depreciation for the cable laid in ducts would be reduced so far as to show a balance in favour of the dearer cable.

Mr. J. HORACE BOWDEN, in a written communication, said the subject of Mr. Hammond's Paper was one of the utmost importance and demanded the earnest consideration of all managers and engineers of electrical undertakings. He noted in the first proposition in the author's opening remarks that Mr. Hammond estimated a life of 25 years for machinery, apparatus, &c., costing say £100,000, which if invested in the undertaking would necessitate the provision of an annual sum of £4,000 for depreciation, but on the other hand, if invested in securities at 3 per cent. would only require the provision of an annual sum of £2,742. 16s. In the first instance, Mr. Hammond stated that the book value would be reduced to nil at the expiration of 25 years. He thought the author must have overlooked the fact that if invested in the undertaking for machinery and apparatus the book value would still be £100,000. In the second instance he would suggest that the principle was wrong, as at no period until the expiry of the life of 25 years would sufficient provision have been made, which certainly was not sound finance. He presumed that the rate of 3 per cent. was merely figurative, and that in actual practice a company would invest at a smaller rate to the interest paid on their own debentures, which, of course, if adopted, would place both systems on a financial level. He took it that Mr. Hammond's estimate of the various "lives" was merely for the sake of example, but he trusted that, from the discussion which it would undoubtedly incite, the outcome would result in the formation of a fixed standard of depreciation of electrical assets under the auspices of the I.E.E., which would be made compulsory by the Local Government Board and the L.C.C. He was at a loss to understand why Mr. Hammond placed the life of turbines on a lower estimate than reciprocating engines, for, if they believed the statements of the turbine builders, the wear and tear was considerably less than was the case with engines. It would also be interesting to know Mr. Hammond's opinion on the depreciation of spare parts. Should these be included in capital under the allocation of the plant that they are subsidiary to, and thus depreciated in a similar manner? Certainly spare parts should not be provided out of revenue, as at present insisted upon by the sanctioning authorities. He would like to point out that land rarely depreciated, but more often considerably appreciated, and that no provision should be deemed necessary under this heading. Mr. Hammond's list of "lives" was too long, and would involve a tremendous amount of clerical labour to carry out. The system would be equally efficacious if the various items were allocated under a general heading and the "lives" under each heading equated. Insurance should be curtailed as far as possible with safety to the undertaking and the reserve fund built up in such a degree as to include provision against antiquation of the plant, &c. He was certainly in agreement with Mr. Hammond that depreciation, further to the compulsory sinking fund, was necessary in the case of local authorities, more especially those in the Metropolitan area, and he would submit the following suggestion to be followed by such—namely: (1) That a capital limit be fixed for each undertaking, which must not be exceeded unless the sanctioning authorities deemed the demand of the area warranted same; (2) that the normal expenditure on account of capital must not exceed the amount provided for sinking fund; (3) that the sinking fund be composed of redemption, plus an amount necessary to raise same to depreciation basis on the standard life of each class of asset; (4) that the reserve fund should provide against replacement of plant before the expiration of the standard life, the amount required from this fund being the original cost of the asset less the amount provided by sinking fund and the residual value of same; provision against all extraordinary expenditure not covered by insurance; provision for a working revenue balance; (5) that interest on sinking fund investments be carried to revenue account so that in no case would the revenue be charged with more interest than that necessitated by outstanding debt; (6) absolute unanimity on the point that undertakings are only expected to be handed down to posterity at the then value, neither relieved of debt nor, on the other hand, overburdened by obsolete expenditure.

Mr. T. C. PARSONS (communicated) said there was a point which Mr. Hammond mentioned which was frequently lost sight of both by the auditors of municipal accounts and some councillors—namely, that there was a difference between depreciation by a company and by a local authority, in that when the local authority wrote off capital the money

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went out of the business altogether. The proper way of looking at depreciation by a local authority, to his mind, was that such a sum should be added to the renewal fund which, added to the sinking fund and taking into consideration the residual value of the plant, would, at the end of the estimated life of the plant, be equal to the original expenditure on the plant; so that, assuming for the sake of argument all the plant gave out suddenly at the end of the estimated life, the local authority would have no assets and no liabilities. He quite agreed with Mr. Hammond that it was not sound to expect a local authority undertaking, in addition to its sinking fund, to provide out of its revenue, or the rates, a depreciation fund which would enable new plant to be bought at the end of the period of the original loan without raising fresh capital, and he did not know that it would be legal to depreciate in that way out of the rates. This was not done in any other branch of municipal enterprise, and it was difficult to see why it should be done in connection with electrical undertakings. Mr. Hammond's figures for the life were, he thought, well on the safe side. He thought the following figures might be taken as safe for life and residual value:—

	Life.		Residual value.
Machinery	27	....	6 per cent.
Accumulators	15	....	10 ,,
Mains	30	....	15 ,,
Motors	25	....	9 ,,
Meters	12	....	5 ,,
Instruments	12	....	5 ,,

In regard to the question of obsolescence, he did not think that it was such a very vital one with the more modern stations. Assuming that the system of distribution was not changed, they could not expect to get very much more efficient plant than that which was running in many modern stations, and any possible gain in efficiency by using the very latest types of machinery would not be compensated for by the capital value of the existing plant, which would practically have to be scrapped.

Mr. JOHN PLACE (communicated) said that the Paper itself seemed to treat depreciation on far too broad lines, and also seemed to have got into the groove which one might, perhaps, define as the "Accountancy" groove; in other words, the depreciation was supposed to account, not only for a fund to cover the sums borrowed, but also under the same heading to cover the dwindling value of the plant, machinery, &c., involved, and in doing so it practically resolved itself into writing the value of these off according to rates which were to be standardised and used, irrespective of what the plant was and how it was maintained. It was dangerous and imprudent to couple the depreciation as allowed by accountants with that which should be allowed on the plant, machinery, &c., and this latter could not be fixed by any rule, but must be applied on close investigation and examination on the spot, in a manner which many industrial concerns were now adopting.

Mr. ROBERT HAMMOND, in reply, said his idea in preparing the Paper had been principally to endeavour to get the Local Government Board to accept his view on local authority loans. The point raised by Mr. Swinton as to whether companies which were subject to purchase by the local authority should set aside out of their profits a depreciation fund was an important one. Mr. Swinton seemed to think that if they did set aside a depreciation fund the local authority might claim it in 1931. If there were any fear of that, obviously the companies would be most foolish if they did anything of the kind. The words of the act were, however, distinct that the local authority had the power to purchase upon the basis of the then value of the plant, machinery and apparatus, consideration being given to the fact that it was in a position to give supply—that was, that it was bought as a going concern. He could not conceive that anyone would suppose that an arbitrator, having arrived at an estimation of the then value of the plant, would say that the depreciation fund must be handed over as well.

CORRESPONDENCE.

THE ECONOMY OF REVERSIBLE BOOSTERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorry to learn that Mr. Salter considers himself misunderstood, but, after perusing his last letter, I am at a loss to understand what his position really is. To assert that results obtained by the use of a battery and booster, which do not happen to support his previously expressed views, "are of little or no value" because the conditions may have varied during the periods under comparison, may or may not be "unfair criticism," but it is hardly the attitude of the disinterested inquirer which Mr. Salter professes to be.

In my last letter I answered Mr. Salter's inquiries re the quality of coal, and showed from his own Paper that the increased load factor could have only a slight influence on the results. I do not agree that the curve is correct any more than I agree with the opinions expressed in the Paper, but simply used it to answer his contention that the improved load factor and increased output rendered the comparison "nugatory." In his last letter he even improves on his former position and refuses to accept the results because the quality of the stoking or the draught may not have been the same during the two periods and further states "that if there is even a possibility of those conditions varying the comparison is of little or no value."

Most engineers, like myself, would be highly pleased if we could attain the possibility of eliminating all variation in conditions during even short periods, and when the period of comparison extends to nine months, it must be regretfully admitted that conditions will vary. The quality of the stoking may not have suffered much during the period under comparison, as the stokers are of the mechanical type; but the conditions of draught, I am sorry to say, have not been recorded. In spite of these defects, I still think that results obtained in this manner—*i.e.*, comparative fuel tests taken over long periods—are not wholly without value, and may be quite fairly used to prove the economy or otherwise of adopting certain types of plant. I am further inclined to the opinion that the possibility of varying conditions is less in comparisons of this kind than in the tests tabulated in Mr. Salter's Paper, where we find that a period of only 12 hours, with and without a battery, is considered sufficient to prove the case ~~against all boosters and storage batteries.~~ Such a test, to afford a perfect comparison, must ensure that the battery is in exactly the same condition of charge at the commencement and end of the runs. The accuracy of the instruments used for electrical output and steam consumption must be beyond dispute. A short-period test of this nature may, indeed, be utterly worthless for comparison purposes, but Mr. Salter is quite prepared, on the strength of such results, to condemn in the most wholesale fashion the use of batteries under all conditions, refusing at the same time to accept evidence which does not agree with his own conclusions, on the plea that the possibility of the conditions having varied renders the comparison of little or no value.

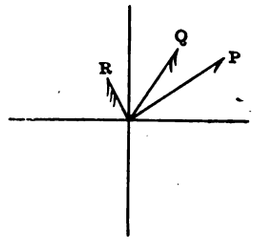
The attempt at sarcasm regarding the cost of building at Greenock may be ignored, but for Mr. Salter's information I may state that the cost of a battery house stated by me (£400) is practically the actual cost of a house built to accommodate a battery of similar capacity. I am not interested in the manufacture of batteries and boosters and cannot afford to be a faddist. I should be pleased to supply Mr. Salter with the particulars which he still desires if he will inform me exactly what he wants. I am afraid, however, that his obvious desire to defend the extreme position taken up in his Paper is hardly conducive to a fair and impartial consideration of the merits of the question.—Yours, &c., J. A. ROBERTSON.

Greenock, April 30.

VECTORS AND WATTFUL CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: *Rotating Vectors.*—A simple method of indicating the direction and speed of a rotating vector is shown in the figure herewith. Vectors P and Q rotate clockwise, but Q twice as fast as P, this being indicated by the double half-arrow-head on Q. R rotates in the opposite direction, and three times as fast as indicated by the three half-arrow-heads. This method is simpler and more easily used than the ordinary one of putting arrows at the head of the vector.



Wattful Current.—Some word appears to be necessary to represent the converse of "wattless." The text books do not appear to agree amongst themselves as to what it should be called, and some of the expressions used, such as "effective" and "useful" current, are not correct, for current used in heating up conductors is frequently the reverse of useful, and also inefficient, from the engineer's point of view.

Analogy with such words as joyful, tactful and similar words would seem to show that the word "wattful" is correct, while it has the advantage of having a distinct meaning of its own which cannot be confused with anything else.

These suggestions may not be original, but I have not seen them in use.—Yours, &c., C. TURNBULL.

Tynemouth, April 27.

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THE ELECTROLYTIC LIGHTNING ARRESTER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest the letter of Mr. Charles C. Garrard in your issue of March 15th, ascribing broadly the invention of the electrolytic lightning arrester to Mr. S. Z. de Ferranti in 1901. Mr. Ferranti was probably the first to use the special type described in his patent, but the idea of using an electrolytic lightning arrester is very much older. Some seven or eight years earlier I designed an arrester consisting of a series of iron plates in alkaline liquid. Its operation was very satisfactory. I made application to the United States Patent Office for a patent on this invention, and was surprised to find that I had been anticipated in a much earlier patent. I regret to say that I can not now recall the name of the original inventor.—Yours, &c., JOHN F. KELLY.

Pittsfield, Mass., U.S.A., April 2.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

(Continued from page 99 of the present issue.)

The POSTMASTER-GENERAL: Wave-lengths of 600 to 1,600 metres have been reserved for naval purposes, and 300 to 600 for ordinary communication. How far would this affect your position?—Our position in connection with the Poulsen system would be that we should have to use rather longer waves. In regard to the De Forest system it depends very largely whether those wave-lengths are to be absolute or capable of being very slightly varied; 1 per cent. would be sufficient margin. Elasticity can be easily given.

I understand you have a considerable number of contracts, &c., in addition to stations already erected. Are these mostly on a commercial basis when carried through?—I cannot say. They will all be open to intercommunication.

Supposing you obtain some of these licences and open commercial stations, shipping and otherwise, how far will they be affected by the Convention?—They will have to communicate, of course. Therefore, the vessels and stations would have to be fitted with both the Poulsen system and the spark system.

Do you consider International Regulations better than a private organisation in preventing confusion and interference?—Undoubtedly. It is better to have uniform regulations and a central authority.

You look upon the danger of wilful confusion, with the Convention ratified by all the countries, as not likely to occur?—Undoubtedly, but in the event of Great Britain standing out of the Convention, there would perhaps be great danger.

In the event of what has been called a wireless war, how far would such a war really cause confusion?—There are two rather important considerations in this connection. On the one hand, all the Powers signing the Convention might adhere rigidly to its terms, and still they would interfere; but, on the other hand, there is the question whether the powers who had ratified would interfere to force Great Britain into ratification, and they might give freedom to their stations to interfere as much as possible with the organisation of Great Britain's stations. Supposing we take the first point, and the legitimate working of vessels in the Channel. Those vessels, not being able to communicate with the Marconi stations on the south coast, would be compelled to communicate with stations on the Continent. In order to do so, being further away from those stations, they would have to use more power, and therefore would undoubtedly interfere with the working of the British stations. Then, again, when outside the 300 km. limit they are not restricted as to the amount of power they use; therefore, vessels would begin to get into touch with France and Germany, and employ sufficient power to do so. This would interfere with all British stations.

Even in a wireless war there would always necessarily be more interference with our stations?—Yes, necessarily.

We have heard a good deal about the organisation of the Marconi Co. Supposing Great Britain stood out, would it be necessary for ships that were not British ships, fitted with Marconi apparatus, to cease to carry Marconi apparatus?—Undoubtedly.

There are something like 43 foreign ships in which the Marconi apparatus is installed, out of 82 which the Marconi Co. claim as having their apparatus on board. I take it that under the Convention those 43 would be prohibited from using Marconi apparatus?—They would be compelled to use intercommunicating apparatus.

There would then only be the 39 English ships in the organisation?—Yes, and those vessels would only be able to communicate with the shores of Great Britain, because the other nations would insist upon all their stations using intercommunicating systems.

Has the Marconi Co. brought an action against your company?—No. There was an action against the De Forest Co. in America, and Mr. Hall says that the Marconi Co. won that action. I should like to point out that the Marconi Co. did not win on the broad claim, but on two restricted claims. The decision was given in De Forest's favour on the broad claim

Sir EDWARD SASSOON: Are you quite satisfied that the Regulations would be effective in preventing interference?—Yes.

Would they be more effective than if the service remains as carried on at present?—Yes.

Continuing, Mr. Maskelyne said that with very small difference in wave-lengths they were able, with the Poulsen apparatus, to send two messages at once and to receive on two different instruments. The distance between exempted stations and other stations depended on the nature of the stations. To put up two spark stations close together would produce interference, but a Poulsen station could come between two spark station without interfering with them. Wherever they had applied for licences they were told their stations would interfere either with the Admiralty or the Marconi working, and they found that although they might put up a station operating on the Poulsen system which would not interfere, there was nothing, in the absence of regulations, to prevent vessels signalling to their stations, and this was the chief source of disturbance always.

Mr. GWYNN: We were given to understand that the Marconi Co. made it a practice to employ their own operators. Would you not consider that the organisation which not only supplied the apparatus wherever in use, but also the operators, represented a more centralised control than can be achieved by an International Convention under which any apparatus can be used, and under which the controlling authority was the unorganised number of Governments?—I take it the controlling authority will not be the Governments concerned, but that all the companies will be simply acting uniformly.

That does not seem to be provided for by the Convention, under which reference must be made ultimately to the Government?—That is so.

In that case, where is the central authority for the control of wireless telegraphy?—I take it the positions would be very similar to that of the cable companies.

You think there is no difference between the case of the cables, which can be absolutely controlled by the companies, and the æther, which can be abstracted by anyone?—The Regulations have been framed accordingly.

At how many stations are you conducting a public commercial service?—We have two stations in England, two in Denmark and one in Belgium, five in all, not taking into account America.

The Marconi Co. have a station at Poldhu and another within 7 miles, and these stations operate simultaneously without confusion?—Yes.

How do you reconcile that with your previous statement?—I do not feel disposed to reconcile it. I do not admit the fact provided Poldhu is working at its ordinary power. If at a reduced power it might happen.

In regard to the wave-lengths imposed by the Convention. Two wave-lengths, 300 and 600, are definitely imposed for general public services—that is to say, ships coming off the British coasts must communicate on either one or other of these wave-lengths. Assuming two ships employing 300 come into operation at the same time there must be confusion?—There is no reason why one should not become 600.

Is it easy to alter the wave-length then?—Certainly.

The possibilities of confusion in the case of three ships could only be avoided by an arrangement for one of the operators to stand by?—Certainly.

Whereas if there were an unlimited choice of wave-lengths the work could go on simultaneously?—Yes, but it is not necessary. The vessels can keep in touch for eight hours, and during that time it would be possible to make all arrangements about signalling.

Assuming Great Britain does not ratify and the other Powers do, and that the other Powers are anxious to interfere with Great Britain's service, is it not a fact that ships or stations working for commercial purposes under the Convention are limited in the power they employ to 1 kw?—Within the 300 km. range, yes.

What power can be generated on a ship's station?—It depends upon the size of the vessel, but well up to 5 kw.

Then you assume that for outside traffic they would be limited to 5 kw., and for inside traffic to 1 kw.?—Yes.

They would also be limited not to interfere with the traffic of Contracting Powers?—Yes.

Do you think then the advantage would rest with the attacking apparatus or with the defending?—Vessels would have to interfere to reach their own stations.

The British stations would be free to employ whatever wave-lengths they like, so that all their communications could go on wave-lengths not employed under the Convention?—Yes.

The employment of 5 kw. within range of British coasts would entirely derange the British stations?—Yes.

The Marconi's Co.'s contention is that they work with 100 kw. at Poldhu and the Lizard simultaneously?—I do not quite understand whether they are sending together or receiving together. That is the great point.

Mr. Maskelyne was invited to give the Committee a practical demonstration of the Poulsen system, in order to show that it did not interfere with other systems, and said that he would be pleased to give this demonstration.

This concluded Mr. Maskelyne's evidence.

Mr. J. HENNIKER HEATON, M.P., was the next witness, and said he was appointed in 1906 by the New Zealand Government to attend the Wireless Conference in Berlin, but owing to the colonies being excluded by a rule framed by the German Government he did not attend. He was convinced that wireless telegraphy would greatly help in cheapening communication to every part of the British Empire, and in his opinion the Marconi system was perfect. He maintained there was no pressing need for the Convention, as England held the field in wireless telegraphy. The British Post Office authorities and the Marconi Co. had not worked harmoniously together. The Post Office was most friendly with Mr. Marconi when he first came here, and Sir William Preece gave him great facilities, ending by making an offer, on behalf of the British Government, for the purchase for the Post Office of the Marconi system. The

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offer was a very low one, and Mr. Marconi received an enormously higher offer from the company, which he accepted. Since that time the Marconi Co. had complained very bitterly of bad treatment and injustice by the Post Office. Pressed by the Postmaster-General to give a specific case, however, Mr. Heaton was unable to do so, but said the Post Office had manifested official stupidity. Asked for his reasons for thinking the Marconi system was the best in existence, he could only say it was through his experience of the system. He had no knowledge of any other system. He held no brief for the Marconi system, however, and any other system which might be invented which would give cheap communication would serve the same purpose. He was not a director of the company. If the Convention were not ratified, any other system would have as much right to erect and equip stations as the Marconi Co. He had the strongest objection to compulsory intercommunication, and thought the Marconi Co. were entitled to refuse intercommunication. He considered it was absolutely unnecessary and unwise to sign the Convention at the present time.

The Committee then adjourned.

When the Committee met on Tuesday this week, Mr. OWEN PHILIPPS, M.P., chairman and managing director of the Royal Mail Steam Packet Co., was called, and said the reason he approved of the proposed ratification of the Convention was that it would enable all his company's steamers, which were fitted with wireless telegraph apparatus, to communicate with all public shore stations. Under present circumstances this was impossible. For instance, in some cases their steamers from the West Indies and New York when approaching England were unable to communicate with any station now open because they were not equipped with Marconi apparatus, and were consequently unable to advise their Southampton office by wireless. If the Marconi Co.'s policy of non-intercommunication prevailed, and the Royal Mail Co. fitted their Australian steamers with the Marconi apparatus, they would not be able to communicate with their own stations in the West Indies and the United States. He considered it would be greatly in the interests of mercantile shipping for the Government to ratify the Convention in its present form.

Mr. GWYNN: Assuming that Great Britain does not ratify the Convention, but licenses other stations than the Marconi stations on the British coast, I presume your objection would be largely removed?—No, because we should then still be unable to communicate with a large number of stations.

Sir EDWARD SASSOON: Those who desire the ratification postponed give as their reason that it would disorganise the present service. Do you think it would have any such effect?—We have found no difficulty on the American coast, where communication is free. I went to the West Indies, Central America and New York in February, 1905, and arranged to have all the boats fitted, but we found it was useless to carry our operators over here, and we only pick them up when we get back. The type of apparatus we use at present is the De Forest.

Mr. LEE: Are you under any contract only to use the De Forest apparatus on your steamers?—No. We adopted that system because it would intercommunicate.

Mr. LAMBERT: Do you advocate the acceptance of the Convention as amended by the British delegates?—Yes, in the interest of the British mercantile marine.

The POSTMASTER-GENERAL: Unless you have a compulsory system of intercommunication a British ship cannot communicate in every part of the globe, whether it has Marconi or other apparatus?—That is so. For instance, the Marconi Co. were recently pressing me to fit up our River Plate steamers with their apparatus, but if I fit the Marconi apparatus on our Brazil and River Plate steamers they would, when put occasionally on a different route, be unable to communicate with the American stations, and that is delaying our fitting wireless telegraph apparatus on our other steamers. I think a ship fitted with any apparatus ought to be able to communicate with any station in any part of the globe.

Sir GILBERT PARKER: In the Brazil and River Plate district are there more Marconi stations than others?—I do not think there are any stations, and as we are the leading line on the route the Marconi Co. are anxious to have our steamers fitted.

If the Marconi Co. permitted intercommunication you would probably make an arrangement with them?—Yes, that is so.

Mr. G. MARCONI was then called and said he desired to give evidence on three aspects of the question, on the technical and scientific aspect principally, on certain commercial aspects, and also dealing with certain points that had been raised by other witnesses. He was at present chief technical adviser to the Marconi Co., and he had designed nearly all their stations in different parts of the world. He had been connected with the company for nearly ten years. He had also been connected with the Italian Government as adviser just ten years. He had advised the Italian Government with regard to the stations they had erected and with regard to the use of wireless telegraphy for military and warship purposes. Sometimes this advice related to communication between ship and shore and sometimes between shore and shore. He carried out his early experiments in Italy, on estates belonging to his father, towards the end of 1895 and in 1896, using his knowledge of the properties of Hertzian waves which had been discovered some years before, and which were electrical oscillations of high frequency. By means of a certain device which he used in his experiments in Italy in 1895 and 1896 he was able to communicate over a distance of two miles. His patent, dated June 2, 1896, was, he believed, the first wireless telegraph patent. Having relations in England he came over to England partly to hear what they said about this invention of his, and in England he carried out some further tests. Shortly after his arrival he was introduced to Sir William Preece, then engineer-in-chief to the Post Office, and Sir William took considerable interest in what he (Mr. Marconi) told him, and asked him to carry out some experiments at the Post Office in London and at Salisbury. The first experiments at the Post Office were in July and August, 1896, and were between different parts of the Post Office buildings. In September, 1896, further experiments were carried out at Salisbury Plain, and the distance covered was 1¾ miles. During the early part of 1897 he carried out further demonstrations and tests at the Post Office, and in March of the same year further tests on his own account at Salisbury, when the distance was increased to between 6 and 7 miles. At these tests he thought there were some representatives of the navy present, particularly Captain (now Admiral) Jackson. In May, 1897, he carried out, at the request of the Post Office, more extensive trials in South Wales, at which communication was realised over a distance of 9 miles. The results of the tests which he carried out in England were clearly described in a lecture before the Royal Institution by Sir Wm. Preece in 1897. He wished to correct an impression which seemed to prevail with regard to his relations with the Post Office. While he was grateful for the interest the Post Office took in his system during those early trials, he wished to contradict the statement that he had obtained financial assistance from them. He did not require it at that time. He only thought it necessary to interest them in what he was doing. It had been stated by a witness at that inquiry (in answer to question 4,265 he believed) that the Post Office had spent thousands of pounds of public money upon his system, and he thought he should state that this was not the case. He thought it was Dr. Muirhead who made that statement. The apparatus used was his own, and was constructed at his own expense. The Post Office did, however, allow him to use some sounders and induction coils and some tall telegraph poles. In most cases he paid for the carriage of the apparatus, and in all cases his own travelling and hotel expenses. He should, however, mention that at the time his experiments were being carried out in South Wales other tests were going on with another method of wireless telegraphy which had been referred to by Mr. Gavey in his evidence as the induction method. It might be that the Post Office spent a certain sum of money on that method at the same time that it was experimenting with his method. He thought Mr. Gavey, who was present at his tests, would say that no real contribution was made to his system by the Post Office at that time. However, they were very friendly, and did all they could to facilitate the demonstrations and experiments.

The CHAIRMAN: Do you consider that the inductive method is inferior to yours?—It has not been used, so far as I am aware, and I do not think it has been considered by the Conference in drawing up the Convention. I have reason to believe that the Post Office at the time of my demonstrations considered that my invention was new, and that I was not trying something that had been discovered by English inventors, because in Sir William Preece's lecture delivered at the Royal Institution on June 4, 1897, and published in the *Proceedings* of the Institution (Vol. XV., p. 467) it was stated that "in July last Mr. Marconi brought to England a new plan. Mr. Marconi utilises electric or Hertzian waves of very high frequency." I believe Hertzian waves had not been used for wireless telegraphy before—not for actual telegraphy. My first patent was applied for on June 2, 1896, and Dr. Muirhead, in speaking of this patent, mentioned that some other patent of Lodge's was applied for shortly afterwards. I will give the dates so far as I have been able to find them in the Patent Office records: The first Marconi patent was applied for on June 2, 1896, and was accepted on July 2, 1897. The first patent applied for by Lodge was applied for on May 10, 1897, and was accepted on Aug. 10, 1898.

Would you kindly explain to us about the beginning of wireless telegraphy in Germany?—The German Government had heard of some of the tests I was making here, and there was a great deal in the newspapers about it. Prof. Slaby was sent over here to witness the tests the Post Office were about to carry out in South Wales with our system. He was introduced to me by Sir William Preece, and I consented to his being present at the tests. He was impressed with what he saw, was on very friendly terms with me, and went back to Germany and delivered a lecture and wrote a book in which he referred to the novelty of my work. Then he wrote to me stating that it would be very much in my interest if arrangements could be made with a certain firm in Germany to manufacture and sell my apparatus. At about that time the Marconi Co. was formed, and I naturally asked the German firm to negotiate the matter with the company. These negotiations did not come to anything, because the consideration for the purchase of my rights in Germany offered by the German company was not considered sufficient by the Marconi Co. After that Prof. Slaby associated himself with a German firm for the manufacture and sale of apparatus, which I believe was a modified form of my apparatus. Later on they made an amalgamation with Braun, another inventor interested in the subject, and the system was called the Slaby-Arco-Braun, and afterwards they amalgamated the whole thing as the Telefunken system. That system, as my company are advised, is an infringement of my patents in Germany and other countries.

Has it involved you in any litigation yet?—No.

Mr. LEE: Why? Is it difficult to take patent actions in Germany?—I should say it was, rather. But the Slaby-Arco system has not reached that stage of practical application in which it can do much damage to my company; therefore, it has not been thought necessary up to the present to take action against the Telefunken Co. in Germany.

The CHAIRMAN: What are the technical objections to the Convention in its present form, in your opinion?—I am afraid—in fact, I feel certain—that if the Convention is ratified it will wrap up a new science in iron swaddling clothes, and will tend to seriously impede scientific progress. The provision in the Convention whereby it is not necessary for technical details of improvements in wireless telegraph apparatus to be divulged to other parties to the Convention is of little value, for, if the Regulations attached to the Convention are strictly adhered to, it will not be possible for anyone to introduce important improvements in the apparatus without at the same time putting them at the disposal of other pos

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sible competitive users. It will be attempted to work the Convention on certain technical assumptions with which I cannot agree. The Convention, as drawn up, I think erroneously assumes the possibility of intercommunication between various wireless telegraph apparatus, and it is entirely based on the question of wave-lengths being similar. Mr. Babington Smith said, in answer to question 143, if two stations in the same neighbourhood are using the same wave-length they would obviously and necessarily interfere with each other, and, further, in answer to question 159, there is no physical difficulty in intercommunication between different systems. I must say I differ from this view. It is not all a question of wave-length. It is also a question of the size of the waves. For instance, I cannot transmit from Poldhu to Poole with waves 1,000 metres long over a certain given amplitude with a certainty of their being received.

Mr. LAMBERT: Will you please explain the meaning of the term "amplitude"?—It is the potential which our wave peaks reach at each oscillation—the extent of the rise and fall. You can have a pendulum which you swing to a certain period. The pendulum has the same rate of oscillation whether it makes a large or small swing, and waves of large amplitude may be compared to a pendulum making a large swing and then coming to rest, all the energy of radiation being included in that big swing. Continuous and small amplitude waves may be compared to a pendulum making a very small swing but with the same period. In that case, in order to get a lot of energy into the system, it is necessary to make a great number of small swings to enable them to become equal to one larger swing—that is, you have more energy in a smaller compass. The large waves give a great deal of energy at one oscillation, but the small amplitude waves require a great number of oscillations in order to give much energy. Time does not come into the question. From Poldhu to Poole I can, with waves of a certain length and a certain amplitude, affect a certain receiver, whilst that receiver would not be affected by waves of the same length but of different amplitude. Therefore, I think it is not enough to conform to a certain prescribed wave-length; it is necessary, before communication can be effective, to agree that the waves are to be of a certain amplitude. The effect of waves of different amplitude and the reception of messages depends almost entirely on the nature of the receiver, so that technical instructions on this subject are of the greatest importance. But no provision for this contingency has, so far as I am aware, been made in the Convention, which has been formed, I should say, with all due deference, on the hypothesis that all systems of wireless telegraphy, present and future, will be easy to graft one into another. The factor of amplitude is only beginning to be recognised at present. As to wave-lengths, these are a question of periodicity—it takes a certain time to go a certain distance, say 1,000 ft., but it takes that time, whether the wave is large or small.

Is this leading up to the point that you have objections to the wave-lengths laid down by the Convention?—I take objection to the fact that no instruction has been given on this question of amplitude. If the Convention were in force it would be difficult to enforce it technically, and a great number of systems in course of development would not be able to communicate.

Mr. GWYNN: The Convention imposes an arbitrary limit in respect of one of two factors and leaves the other factor out?—Yes.

The POSTMASTER-GENERAL: The Convention leaves each system to deal with amplitude as it thinks best?—Yes.

The CHAIRMAN: The Convention limits the amount of energy used so that interference shall not be caused?—That is so, but my objection to the Convention is that it, erroneously in my opinion, seems to consider the question of intercommunication or non-intercommunication to be based on wave-lengths. It is not based on wave-lengths alone, but also on other considerations, which the Convention has not considered.

Mr. LEE. The effect of the Convention permitting the use of different amplitudes may cause interference?—Yes; and the impossibility of carrying out the Convention. Suppose I have a system which uses continuous waves of small amplitude and I think it desirable to adopt it on certain ships which are under my control, those ships are not able to communicate with the ordinary wave-lengths. I foresee some trouble under the article dealing with this matter. Systems that cannot intercommunicate may be adopted.

Mr. GWYNN: The normal wave-length for a mercantile ship is 300 metres, and a ship using that wave-length, and conforming to the Convention in that respect, may, by using the amplitude most convenient for its own purpose, be unable to intercommunicate?—Yes, and even when this is provided for I think it will be difficult to put it into effect. What I contend is that if the science advances in the way in which I believe it will systems which cannot intercommunicate, instead of being the exception, will be the rule.

The POSTMASTER-GENERAL: The spark system can intercommunicate, and will not interfere with the continuous systems?—Yes, that is so.

And if they become the predominant system they will be able to carry out intercommunication the same as the others?—Yes, but I go further than that; there are other systems which are being experimented with now which do not depend for carrying out communication on either of the principles known as the continuous or the non-continuous. Their signals may be produced by the combination of two waves.

The CHAIRMAN: Are those considered by the Convention?—No. I refer to a system of my own which is being tested, and which I think will be in use shortly. Patents have been applied for.

Mr. ADKIN: If you have a system which refuses intercommunication, and that system became world-wide, would not that discourage the progress of science and the development of other systems, because of the authoritative position it would have?—I think all systems should have a chance.

Sir GILBERT PARKER: You are opposed to the Convention more upon scientific than upon commercial grounds?—Well, there is a commercial ground, but I feel that the scientific grounds are very important and will render the application of the Convention difficult if not impossible.

Mr. GWYNN: You would prefer to see neither the wave-length nor the amplitude specified?—Yes.

The POSTMASTER-GENERAL: It is to the advantage of the various systems and to their improvement that the question of amplitude should be left open?—It certainly should be left open. I consider it detrimental to the progress of science that there should be any international regulation. We have not reached finality, either in the application or our knowledge of the subject.

Sir EDWARD SASSOON: What would be the objection to the Fessenden apparatus using the same amplitude as the Marconi apparatus?—I think the present is too soon to provide for that.

Sir GILBERT PARKER: Was the factor of amplitude discovered by yourself?—I discovered that different effects could be obtained by different amplitudes. The knowledge of what different amplitudes would or would not do was probably known to scientific men before, but they did not work it out and apply it to wireless telegraphy.

I understand a large number of small waves would shape themselves into harmony more readily than a large wave?—Yes. A great number of small waves will give very material syntonic effects. In order to be effective at all they have to influence a receiver which acts through the cumulative effect of a number of impulses, whilst the two or three waves of large amplitude act more by the shock they give and are responded to whether in tune or not.

Mr. LAMBERT: Would the reservation of wave-lengths between 600 and 1,600 metres for the Admiralty's use be likely to retard progress?—I think it unwise that they should be fixed by the Convention at present, as it may be found that they are inappropriate.

The CHAIRMAN: Have you anything to say with regard to the method of direction. The Convention makes no reference to the directive method by which messages can be sent in a certain direction. It has been stated in some of the evidence that directive methods have been only partly successful?—I should say that is not correct according to my own experience.

Why then do you not adopt the method of directional signalling as a regular practice?—Only because it has not, up to the present, suited my company's purpose to make use of it.

What have you to say with regard to the limitation of power used for transmitting signals?—The limitation of the power to 1 k.w. for ships is unnecessary. I do not know why vessels should not be competent to use sufficient power to transmit messages over the same distance as they receive. The Regulations place difficulties in the way of carrying out experiments on ships, and if they are put into force it will be impossible to realise the benefits which might have been derived from researches that have been made. I understand from the Convention that there is no provision for experimental licences for ships. Most ships may be carrying on commercial work and experiments as well, and there might be an advantage in the Government licensing them for apparatus for carrying out experiments.

Are there any conditions under which you think a Convention might be practicable?—If all so-called systems were more on an equal basis so far as efficiency and merits are concerned, if the art was in a more complete state or appeared to have reached or approached finality, and could be worked by definite rules, it might be advisable to have a Convention, after patent litigation had cleared the air and established the relative positions of inventors. There exist several organised systems doing a large commercial business. England by standing out of the Convention would, in my opinion, have everything to gain and practically nothing to lose.

The POSTMASTER-GENERAL: England or the Marconi Co.?—I am speaking of England. Then, taking the matter of wave-lengths. If England does not ratify the Convention and other nations do, the latter would be compelled to conform to certain restricted wave-lengths. If, however, we ratify the Convention and modification as regards wave-lengths is found necessary, we could not secure such a modification without the unanimous consent of all the parties to the Convention. If France, for instance, adheres and England does not, then all the stations of the French coast would have to use wave-lengths of 300 to 600 metres, and if such wave-lengths interfered with stations in England, England could use any wave-length she thought fit.

Mr. LEE: You are apprehensive that the provsions of the Convention will be difficult to give effect to?—My chief feeling is that commercially the Convention is not fair to the patentees, and I see technical difficulties that will militate against the practical application of the Convention. Our lawyers say if we intercommunicate we shall prejudice our patent rights.

The CHAIRMAN: One of the main reasons for your objection to the Convention is the prejudice to your patent rights?—It is one of the main reasons.

The POSTMASTER-GENERAL: If England does not adhere to the Convention will not the foreign Governments who do adhere be forced to have stations of some other system, which has accepted the principle of intercommunication?—I think it likely that other countries might not be willing to enter into a Convention which cannot be made effective without England joining, as we own more than half the shipping of the world.

You think the only way in which an efficient service can be carried out is by the organisation of the system of one company?—I say it is impracticable at present to carry on an organisation by the co-operation of users, and that it would be detrimental to the development of the art.

Suppose a company which own the stations in the best positions should refuse to intercommunicate, what would happen?—That is the advantage gained by free competition. When the Marconi Co. put up their stations anyone else could have done the same, and I think the company should be entitled to the advantages they got by having put them up first.

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But is not that a disadvantage from the public point of view?—I think the other workers should have opportunities to develop their systems and to put up their stations, provided they do not interfere with those already established.

Mr. GWYNN: I understand you consider it would be difficult to work the Convention without divulging the details of new inventions, which is not obligatory under the Convention?—Yes. It would be difficult for one party concerned in the Convention to introduce improvements without divulging the details of improvements it has made. It would be impossible to co-operate and work a joint system if improvement or modifications which are made in one station are not communicated to the other users.

Sir EDWARD SASSOON: What is the longest distance over which messages have been transmitted?—The longest distance over which we have sent a message is 3,000 miles.

How far have other organisations sent messages?—I have no record I can turn to of any authentic message being sent over that distance.

You were not able to maintain that achievement?—No.

Was that due to interference?—No. It was due to the power not being sufficient.

On the conclusion of Mr. Marconi's examination the Committee adjourned.

L.C.C. TRAMWAYS AND IMPROVEMENTS BILL.

A Select Committee of the House of Commons has had under consideration this bill, which provides for the construction of several lengths of tramway, &c. After hearing evidence in regard to tramway No. 3, which was a proposed deviation from the existing route along Pancras-road to King's Cross between the Midland and Great Northern termini, the Committee found the preamble (so far as this line was concerned) not proved. The scheme for the electrification of the tramways between Vauxhall Bridge, Camberwell and Norwood, with short spur connections and street widenings, was authorised.

Opposition was made to clause 37 for amending the London County Tramways (Electrical Power) Act, 1900, by declaring that: "The Council shall not be compelled to remove from any street in which any tramway of the Council is situate any accumulations of matter removed from the conduit or grooves of the rails of such tramway, but the Council shall deposit such accumulations of matter in any receptacle for street refuse provided by the road authority in such street, or (where no such receptacle is provided) at the side of the carriage way of the street, and such accumulations shall be removed by the road authority in like manner as other street refuse is removable by them."

The Committee amended the clause by omitting the words "in like manner as other street refuse is removable by them," and adding "provided that the reasonable cost of such removal by the road authority shall be repaid by the Council to the road authority. The amount of the cost in case of dispute shall be determined by a referee, to be appointed under sec. 33 of the Tramways Act, 1870."

The remainder of the bill was approved and the clauses were adjusted.

KING'S NORTON GENERAL POWERS BILL.

Last week the General Powers Bill of King's Norton District Council came before the Police and Sanitary Committee of the House of Commons. Among other powers sought was authority to supply electrical energy in bulk outside the district if thought desirable. The Shropshire, Worcestershire and Staffordshire Electric Power Co. opposed this clause, and the Committee decided that there was no objection to King's Norton having power to deal with Birmingham for the supply of electrical energy to a section of the Birmingham tramways, and they proposed to limit the power of King's Norton to this supply.

MISCELLANEOUS BILLS.

The Folkestone, Sandgate and Hythe Tramways Bill has been passed by the House of Commons Committee on unopposed bills.

The Electric Supply Corporation Bill has been read a second time in the House of Lords.

The North-east London Railway, the Rawtenstall Coporation and the West Riding Tramways Bills have been read a third time in the House of Commons.

Telegrams.—In the House of Commons last week the Postmaster-General, in answer to an inquiry, said the question of typewriting all telegrams was under the consideration of the department.

In reply to a further question, the Postmaster-General said it was not the intention of the department to adopt different coloured envelopes for different classes of telegrams, as such a practice would tend to delay and possible error in the handling of telegrams.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Glues and Gelatine." By R. L. Fernbach. (London: Archibald Constable & Co.) 10s. 6d. net.

"Fuel, Water and Gas Analysis for Steam Users." By J. B. C. Kershaw. (London: Archibald Constable & Co.) 8s. net.

"The Testing of Alternating-current Machines in Laboratories and Test-rooms." By Charles Kinzbrunner. Vol. I. of "General Tests: Transformers; Alternators." (London: Harper & Bros.) 4s. 6d. net.

LEGAL INTELLIGENCE.

Agincourt Steamship Co. (Ltd.) v. Eastern Extension Australasia & China Telegraph Co. (Ltd) and Great Northern Telegraph Co. (Ltd.)

This case came before the Court of Appeal (the Master of the Rolls and Lords Justices Buckley and Kennedy) on Saturday, as an appeal from the decision of Mr. Justice Bray on points of law raised prior to the trial of the questions of fact in a claim made by plaintiffs for damage against defendants. The decision of Mr. Justice Bray was set out in *The Electrician* for March 1.

Plaintiffs are the owners of the steamship "Agincourt," and defendants are owners of telegraph cables lying across the bed of the Yang-tsze-Kiang river, near Woosung, in China. The "Agincourt" on Aug. 31, 1905, when on a voyage from Shanghai to San Francisco, via Japan, in charge of a licensed pilot, anchored in the river, and next morning weighed anchor and the vessel proceeded up the river to safer anchorage. The starboard and port anchors were dropped. Two days afterwards the port anchor was weighed, but was found to be foul of a telegraph cable. It was let go and the starboard anchor hove up, and this was also found to be foul of a telegraph cable. Plaintiffs alleged that the cables were the property of defendants, jointly or separately. With a view to the preservation of defendants' cables in the event of their being fouled by the anchors of vessels, defendants issued a notice agreeing to compensate owners of vessels (excepting house-boats, launches and similar small craft) for loss of anchors, chains, &c., in the terms of the Submarine Telegraph Act, 1885, schedule article VII., according to which owners of vessels who can prove that they have sacrificed an anchor, &c., in order to avoid injuring a submarine cable shall receive compensation from the owner of the cable. It appeared from a statement of the captain of the "Agincourt" that when he found that the port anchor was foul of a telegraph cable he would have cut it, but the pilot on board said he must slip the anchor and chain, and they would be fully reimbursed for any loss or delay caused through slipping their anchors and chains to save damage to the cables. The anchors were accordingly slipped. It was taken for the purpose of the discussion that one of the anchors had fouled an abandoned cable belonging to the first defendants. In consequence of the loss of the anchors it was alleged that the "Agincourt" was delayed eight days at Shanghai, for which damages were claimed, also for cost of extra coal and other expenses incurred to save cancelling date at Portland under a charter party, &c. The total claim was for £2,034. It was contended for plaintiffs that the notice issued by the companies was a joint offer to pay for all loss occasioned by the sacrifice of an anchor which had fouled a telegraph cable, and was not limited to the actual cost of the anchor.

For the Eastern Extension Telegraph Co. it was submitted that there was no contract, as the offer which the captain accepted was that made by the pilot, which was not the offer made by defendants. In any event, there could be no liability on defendants in respect of an abandoned telegraph cable. The notice must be construed as referring only to a live cable. Further the liability, if any, was only for loss of materials and not for consequential damages. Mr. Justice Bray had held there was a contract by each of the defendant companies that if an anchor fouled a cable of either company that particular company would pay compensation for the loss of the anchor, and that the companies would pay compensation for the damage sustained. He had further held that plaintiffs could recover from the owner, even of an abandoned cable, the damage which naturally flowed from the loss of the anchor which had fouled the cable.

Mr. J. A. Hamilton, K.C., Mr. Bailhache, and Mr. Wolfe Barry appeared for the appellants (the Eastern Extension Australasia & China Telegraph Co.), and Mr. J. R. Atkin, K.C., and Mr. W. N. Raeburn were for plaintiffs.

At the conclusion of the arguments the MASTER OF THE ROLLS, in giving judgment, said that the appeal no doubt raised an important question. Mr. Justice Bray had held that the liability of the company under the terms of the notice was not only for the value of the anchor or chain sacrificed, but also for the damage resulting from such sacrifice. The appellants were not satisfied with this, but asked by their notice of appeal for a declaration that their liability was limited to the replacement of the said anchor or chain or payment of their value. With great respect to the learned judge he thought the language of his declaration was dangerously wide, and that the language of the appellants' notice of appeal was too limited. In the circumstances of the case, was payment for the value of the anchor (another having been provided) the full measure of the compensation which the company had agreed to pay? He thought it was not, or at any rate it was not necessarily so in a case like the present, where there was no suggestion that putting back to Shanghai was at all unreasonable. On the other hand, the claims made by plaintiffs were very wide, and opened a field which might involve the company in serious liability. In all the circumstances he thought the proper course was to alter the learned judge's order and declare that the liability of the company under the terms of the notice was to make compensation for the sacrifice of the anchor or chain sacrificed, but not further to pay damages resulting from such sacrifice.

The LORDS JUSTICES concurred, and the order of Mr. Justice Bray was varied accordingly.

British Westinghouse Electric & Mfg. Co. v. Mersey Railway Co.

This case came before the Court of Appeal (Lords Justices Moulton and Buckley) on Tuesday on the appeal of defendants from an order of Mr. Justice Sutton, reversing the order of the Master which directed that further proceedings under the writ should go to arbitration.

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Mr. ASTBURY, K.C., said that in July, 1901, defendant company agreed to electrify their undertaking, and entered into a contract with plaintiffs by which plaintiffs were to electrify the railway for £600,000 odd. In the contract there were a great many details as to debenture issues and matters of that kind. The contract provided that the contractors should execute all the works in accordance with the specification, and provide [all necessary] things for equipping [and completing the railway, so as to enable the traffic to be worked by electric power. Another condition was that the contractors should (if required to do so by the defendants) provide £240,000 cash in order to enable the defendant company to redeem its debentures so as to prevent any interference during the construction. Provision was made as to payment and everything was paid by defendants, except the final payment of £33,600, balance of the contract price. The contract also contained an arbitration clause. In 1904, plaintiffs claimed that the works were completed, that the trains were running and that the power station was in working order, but defendants had three large engines to generate power and defendants said these were too light, and that they were unsatisfactory. Plaintiffs said defendants ought to pay the balance of the contract price, but defendants said they ought to have the power station put right first. An arbitration took place before Lord Dunedin and two arbitrators. The arbitrators examined the whole system and in the middle of the arbitration the third engine in the power station came to grief. Plaintiffs saw they could not keep it up any longer, and it was arranged that the parties should meet and try to come to an agreement. In July, 1904, they did come to an agreement and amongst the terms was one that the £33,600 should be paid by defendants to plaintiffs, half after the expiration of three months after the works were fully completed and the rest nine months after that. The defendant company had to issue to plaintiffs debentures to pay this and all proceedings in the arbitration were to be stayed with liberty to apply. Fifteen other differences and disputes were referred to the same Court. Lord Dunedin believed that as he had taken the matter up he ought to finish it, and he agreed to finish the arbitration, which was now going on before him, on the counterclaim by defendants. In that state of things on the Feb. 8 last plaintiffs issued the writ in the present action when the fresh hearing of the arbitration was then in contemplation. Plaintiffs claimed the money under the agreement before stated, and the declaration that they were entitled to the £33,600. They claimed further that the contract work was completed within the meaning of the agreement. Defendants then moved to stay the action, and an order to stay was made by the Master on March 9, and the learned Judge reversed that order, and that was the order appealed from.

Mr. DISTURNAL supported the order of the learned judge on behalf of the plaintiffs.

Lord Justice MOULTON, in giving judgment, said the appeal must be allowed. Looking at the writ he was satisfied and convinced that the disputes in question were disputes which at the date of the writ were old standing. He thought the action should be stayed, and the matter in dispute go to arbitration. The costs in that Court and in the Court below would be the costs of the defendants in any event.

Lord Justice BUCKLEY concurred.

Demerara Electric Co. v. F. White and Others.

On April 26 the Judicial Committee of the Privy Council (the Lord Chancellor, Lord Macnaghten and Sir Arthur Wilson) gave judgment in the appeal of the company from a judgment of the Supreme Court of British Guiana in an action brought by the owners and occupiers of certain houses near the appellants' power station at Georgetown. Plaintiffs sought damages and an injunction, their complaint being that they were disturbed in their quiet enjoyment of their houses by the noise and vibration caused by engines and machinery at the appellants' works. The company was incorporated in 1899 with the object (inter alia) of acquiring and constructing electric tramways, power houses, &c., in the colony and obtaining orders or licenses under the Electric Lighting Ordinance, 1890, or any other ordinance for such purpose. By the Georgetown Electric Lighting Order, 1899, the undertakers for the purposes of that order acquired "the exclusive right for 30 years and any extension thereof . . . to supply energy for all public and private purposes." That order also included provisions compelling appellants to supply electric energy under penalties for non-compliance, and Sec. 66 contained this proviso: "Nothing in this order shall exonerate the undertakers from any indictment, action or other proceeding for nuisance in the event of any nuisance being caused by them."

The defence was (1) that there was no nuisance and (2) that they were protected by statutory authority in doing what they did. They also pleaded that if there was a nuisance and if they were not protected by their statutory powers, the matter complained of was not of such a character as to entitle defendants to an injunction. Damages, they urged, would be the more appropriate remedy. On each of these three points the Supreme Court decided against appellants and granted the injunction with small damages and costs.

APPELLANTS now asked that the judgment of the Colonial Court might be set aside.

Lord MACNAGHTEN, in delivering the judgment of the Council, said that as to the existence of the nuisance complained of and its serious character, their lordships agreed with the judges of the Supreme Court. As to the defence set up on the ground of statutory authority no doubt they were directed to do and execute all works necessary for the effective construction, equipment and operation of the tramways. The learned judges of the Supreme Court treated the authority to generate and distribute electric energy contained in the tramway licence as superseding the authority to generate and distribute electrical energy as a motive power contained in the Demerara Electric Ordinance, 1899. So treating it, on a careful review of the authorities bearing on the subject (including Metropolitan Asylum District *v.* Hill, and L.B. & S.C. Railway Co. *v.* Truman), and on consideration of the provisions of the tramways' licence and all the circumstances of the case, the learned judges came to the conclusion that appellants were not authorised by the Tramway Licence of 1899 to cause a nuisance. Their lordships agreed in that conclusion, and therefore would advise His Majesty that the appeal should be dismissed.

Lynch v. Macartney, McElroy & Co. (Ltd).

Last week Mr. Justice Bigham and a common jury heard an action brought by Mr. J. J. Lynch, mechanical and electrical engineer, for damages for alleged libel, defendants being Macartney, McElroy & Co. (Ltd.), who denied that the words complained of were capable of the construction put upon them, and also pleaded privilege.

Mr. McCALL, K.C. (with Mr. Compton) stated that in 1903 plaintiff entered defendants' employ in connection with a tramway which they were laying at Delagoa Bay, and in 1905 he was appointed as their engineer-in-charge of tramways they were constructing in Malta. Plaintiff was to be the senior to everyone connected with the company at Malta except a Mr. MacIntyre, the acting secretary. Plaintiff alleged that there was considerable disorganisation in defendants' business, and also certain irregularities. He applied himself to putting the business in order, and for some time succeeded, in defendants' opinion. About Jan. 8, 1906, the post of general manager in Malta became vacant, and plaintiff applied for the post. Immediately afterwards defendants issued a notice in the Malta papers stating that they would not be responsible for any order given or for any debts incurred unless the orders were given on an official form, and were signed by a director or by the secretary of the company. Mr. Macartney shortly afterwards arrived at Malta, and informed plaintiff that he had some permanent position in view for him, but on March 5 plaintiff was informed that a Mr. Treherne was appointed as general superintendent. On March 12 Mr. Macartney offered plaintiff the post of secretary to the company in Malta, but plaintiff, thinking that that kind of employment was not one that he ought to be called upon to undertake, on March 13 wrote tendering his resignation as resident engineer, and stating that he would be pleased to know when it would be convenient for defendants to relieve him of his duties. His resignation was accepted the same day with an expression of regret, and that day defendants wrote requesting plaintiff to return to London and resume his position in the London office. Plaintiff returned to London, and on March 16 defendants published in the "Malta Daily Chronicle" the following notice: "Malta Tramways. Messrs. Alexander MacIntyre and J. J. Lynch, occupying the positions of acting secretary and engineer respectively, have been relieved of their duties. The Malta Tramways, Macartney, McElroy & Co. (Ltd.), are not, and will not, be responsible for any contracts, orders, debts, &c., unless they are authorised in writing by the company's managing-director or general manager.—Macartney, McElroy & Co. (Ltd.), J. F. Macartney, Managing-Director." Plaintiff complained that this notice was calculated to convey the impression to those who read it that he had been dismissed for some misconduct and that he had been a party to giving irregular orders. He brought the action to clear his character, and if he received an apology and was indemnified against the costs of the action he would gladly accept it.

Mr. LUSH, K.C., said defendants had made no imputation on plaintiff and therefore he could not submit to a judgment indemnifying plaintiff against costs.

His LORDSHIP thought that the advertisement was very unfortunately worded, and that plaintiff had not asked anything unreasonable.

Plaintiff having given evidence, Mr. LUSH, for defendants, said he could not shut his eyes to the possibility that the advertisement might convey an impression exactly the contrary to what was intended. There was no intention to cast any aspersions upon plaintiff.

In the result plaintiff was awarded £250 damages, and judgment was given accordingly.

Marylebone (London) Council v. Bardon.

At the Marylebone County Court, on Friday, plaintiffs sought to recover £61. 5s. 3d. for supply of electricity to defendant, who paid the amount into court and counterclaimed for damages for breach of contract in regard to change of voltage of supply and also for breach of the L.C.C. and Board of Trade regulations in carrying out same by not making the necessary alterations in the wiring. He further alleged that his house had been rendered unsafe and dangerous to life by risk of fire and leakage, and that in order to remedy those defects and render the installation safe a complete alteration in the wiring of the premises was necessary.

Mr. ELLIS GRIFFITH (for defendant) stated that the action, which was an important one to consumers of electricity, had been settled by the Council taking the money out of court and undertaking to re-wire defendant's premises and carry out such alterations as were necessitated by the change of system, and also to properly reinstate all decorations. He asked that judgment be entered accordingly, and submitted that, having regard to the general importance of the case, the costs should be on the higher scale.

His HONOUR (Sir W. L. Selfe) said it was scandalous that an action of such importance should be remitted from the High Court to the County Court. He had no power to grant costs other than on scale C, and having regard to the fact that it was a case of great importance, he directed that they should be taxed on that scale.

Thermite (Ltd.) v. Weldite (Ltd.)—We are compelled, by pressure on our space, to leave over to our next issue Mr. Justice Warrington's full judgment in this case.

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SOME NEW DEVICES IN LOWERING GEAR FOR ARC LAMPS.

The London Electric Firm, of Croydon, are now manufacturing a "canting carrier device" to enable centre-pole lamps to be lowered for trimming. It is claimed that this arrangement, which is shown in Figs. 1 and 2, will greatly cheapen the cost of trimming, and will ensure greater safety from accidents than the cumbersome tower ladder now in use. By the application of this firm's

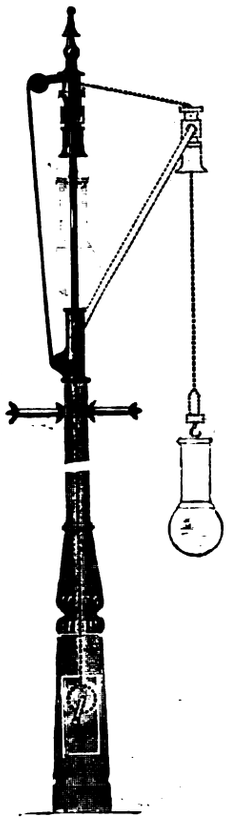

FIG. 1.

FIG. 2.

"one working part" arc lamp lowering gear, lamps on centre-carriers can be lowered with great ease. This gear consists of a canting carrier which allows the lamp to be lowered. The whole operation of unlocking the carrier, lowering the lamp, re-hoisting, re-locking the carrier, and taking the weight of the lamp off, is done by a single winch. Existing centre carriers could in most cases be adapted.

The North Western Electrical Appliances Co., of Cathcart, have lately placed on the market a "cable protector" chain for use in

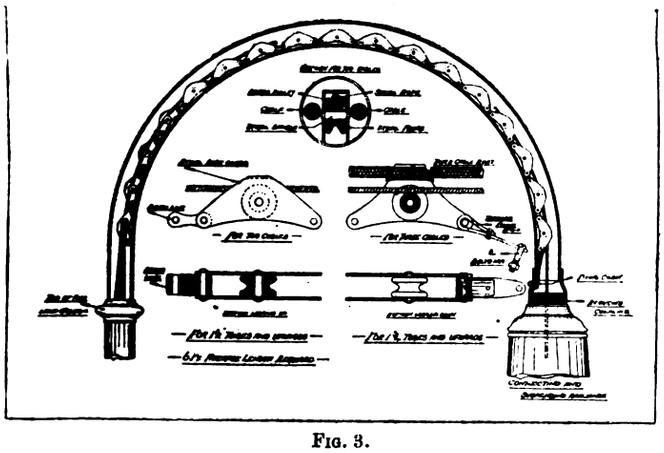

FIG. 3.

"swan-neck" brackets. By this arrangement, which is shown in Fig. 3, it is claimed that the short-circuiting and earthing of the conductors in the arm is avoided. The chain has pulleys, over which the wire travels; this reduces the friction, saves the wire, makes the raising less laborious, prevents the generation of heat and the abrasion of the cable insulation. The suspending wire is placed inside the chain and the cables one on each side (*see* diagram). The sides of the chain render it impossible for the rope to touch the cables and the insulation is thereby preserved. Without this chain the wire rubs on the cables and very rapidly wears the insulation, producing short-circuits and earths, which are the chief objections to the ordinary lowering gear. It also centres the wire at the contact cap and greatly improves the working of the gear. When the wire is drawn through the tube without the chain the tube is liable to be soon cut through.

This firm also manufactures an arc lamp lowering gear with removable handle, which engages with the cam of the winch, and which releases and engages the pawl. The spindle to which the brake wheel is attached engages with and passes into the core of the drum. The handle is made in malleable cast iron, or there is a specially light pattern in aluminium.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Directors of the Savoy Hotel (London) invite applications for the appointment of engineer to the company. The gentleman appointed will be required to take charge of the power plant (aggregating 1,000 kw.), and also of the refrigerating plant; lifts (electric and hydraulic), artesian well pumps, &c. Salary £350, with commission on economies effected, estimated at another £100 per annum. Applications to the Secretary by May 10. See also an advertisement.

Salford Electricity committee invite applications for the position of deputy electrical engineer. Applicants must have had previous experience in the generation and distribution of electrical energy in large undertakings (both a. and d.c.), and be thoroughly conversant with the electrical details of same. Salary £250, rising to £400 per annum. Particulars from the borough electrical engineer (Mr. Victor A. H. McCowen), Electricity Works, Frederick-road, Pendleton, Salford. Applications to town clerk (Mr. L. C. Evans), by mid-day, May 13. See also an advertisement.

The Governing Body of the Battersea Polytechnic (London) invite applications for the position of principal, to date from September next. Commencing salary £800 per annum, increasing to £1,000. Particulars from the Clerk to the Governing Body. Applications by May 25. See an advertisement.

The Governing Body of Battersea Polytechnic also require an assistant lecturer in physics and electrical engineering; full time; teaching experience essential. Commencing salary £180. Particulars from the Secretary. See an advertisement.

A junior assistant is wanted (on the technical side) in large patent agents' office in London. Some electrical training desirable. See an advertisement.

A vacancy occurs at Barnsley electricity works for a pupil. Applications to Mr. E. A. Barker, borough electrical engineer. See an advertisement.

A test-room assistant is wanted for the testing and adjusting of electrical instruments. Workshop experience desirable. See an advertisement.

An electrician, competent to do armature winding and commutator repairs, is wanted in electrically-driven works. See advertisement.

A draughtsman conversant with the design of cable junction boxes is required. See an advertisement.

A vacancy occurs in a company's d.c. central station in the south-western area of London for a pupil, without premium. See an advertisement.

Mr. A. C. Kelly, A.M.Inst.C.E., for several years on the staff of the locomotive department of the G.E.R. Co., has recently been appointed traction engineer to the British Westinghouse Co. at Manchester.

Hampstead (London) Borough Council have appointed Mr. J. C. Barnes junior assistant engineer at the electricity works, in place of Mr. S. D. Barnwell, resigned.

Mr. J. A. Brown has been appointed rental and collecting clerk in the Ealing electricity department, at £100, rising by annual increments of £5 to £140, per annum.

Mr. W. T. Goodman, of Dunedin (N.Z.) electricity works, has been appointed engineer to the Adelaide (S. Australia) Tramway Trust.

Air Gas.—A demonstration of a new gas for lighting, heating and cooking purposes was given by the Non-Explosive Gas Synd. last week. This gas, which consists of a mixture of air and petrol, containing 98 per cent. of air, is made by treating air with petrol in

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a special carburettor at ordinary temperatures. Condensation is completely avoided and the generator requires no attention, automatic regulation being fitted. It is claimed that air gas is safer, more efficient and cheaper than ordinary gas.

Birmingham.—The Washwood Heath tramway route was opened for traffic yesterday.

Bootle.—On the presentation of the minutes of the Electric Power and Lighting committee on Wednesday, Mr. King moved as an amendment that no tender be accepted for the repairs to an engine at the electricity station until the insurance office had submitted a report on the condition of the engine.

After an animated discussion the amendment was lost by a large majority, and it was then resolved to accept a tender for the repair of the engine at £613. 8s. 3d.

Bradford.—The Tramways committee have decided to proceed with the work of constructing the Brownroyd Hill tramway.

Bury (Lancs.)—The Council are recommended to increase the salary of the tramways manager (Mr. W. Clough) from £250 to £300 per year, with two annual increments of £50.

Camberwell (London).—The Borough Council have asked the Board of Trade to give a decision on the dispute between themselves and the County of London Electric Supply Co. in regard to the laying of mains in the district, as the Government do not intend to proceed with their general bill upon the lines of the correspondence with the Council.

The Council insist, when giving permission for laying mains, that such permission "shall not apply to any works, pipes or wires other than such as are to be used exclusively for the company's purposes under their Camberwell electric light orders."

Caution.—A timely warning is given by Messrs. Newtons (Ltd.), of Taunton, as to the practices of a certain Sheffield firm. We are informed that the course of procedure is as follows: Orders for goods are given and when these are delivered they are promptly sent off to another town for disposal. The persons concerned in this transaction appear, however, to have recently left Sheffield and may consequently be expected to continue their operations from some other centre. As might be expected, the principal agent in these doubtful transactions has various aliases, including Tideswell, Sellars and Nance. Manufacturers should, therefore, be on the alert.

Derby.—The Corporation have decided to construct an electric tramway along Nottingham-road at an estimated cost of £17,800. A proposal to construct a line along Burton-road at an estimated expenditure of £5,500 has been postponed

An arrangement has been made between the Highways and Electric Lighting committees for the lighting of Uttoxeter New-road with arc lamps at an annual charge of £196. A reduction is also to be made in the charge for the 76 exisitng all-night arcs of £1 per annum, and flame arcs are to be substituted in some cases without additional cost.

Dundee.—The Tramways committee have decided to provide each tramcar with a jack.

Fatalities.—A blacksmith named Tye was killed at the Aclam Iron Works, Middlesbrough, on Tuesday last. He is reported to have been carrying a number of long rods, one of which came in contact with an overhead electric wire.

An inquest was held at Ebbw Vale on Saturday into the cause of the death of a man named Rhead, who was killed at the Marine Colliery, Cwm, Ebbw Vale, on Thursday last. Deceased was employed as a colliery electric engine driver, and on Thursday was seen to take hold of the lighting wire and instantly fall. The jury found a verdict of accidental death, adding that sufficient care had not been taken by the management in seeing that the wires were properly protected. They condemned the practice of allowing unauthorised persons to repair breakages, and recommended that the mine officials make more frequent reports on the condition of the cable.

Fire Inquest.—Dr. F. J. Waldo, coroner for the City of London and Southwark, held an inquest on Friday last into the cause of a fire which occurred on April 13 at 63, St. Paul's Churchyard, E.C. The fire brigade and police reports stated that the cause was unknown.

The Coroner stated that this was the third fire on the same premises within four years. The first occurred on March 13, 1903, and was reported to be due to a "defective electric circuit." He held a private inquiry, and found the cause to be the ignition of a flexible during a test by an employé of the City of London Electric Lighting Co. The second fire took place on Oct. 19, 1905, and an inquest was held, but there was not sufficient evidence to determine the cause.

The Manager of the premises said that on the occasion of the last fire he heard a report, and the back of the window case flew out. There were some combs in the window, but he did not know whether there were any celluloid combs. The combs were some distance from the electric lights.

A Shop Assistant gave similar evidence, and afterwards police evidence was taken, in the course of which P.C. Page said it seemed to him the flames came at first from the articles in the window.

Mr. C. Harrison, superintendent of the London Salvage Corps, Watling-street, said he thought celluloid was burning in the window. He had seen elsewhere celluloid articles burnt by the heat of an electric lamp. He thought the explosion was due to the expansion of the air in the air-tight window as the result of the heat. His men cut the electric wires.

Engineer Sibley, London Fire Brigade, attributed the fire to a short circuit or the fusion of the wires.

The Coroner: People often attribute fires to electrical causes with very little evidence.

Mr. H. Saqui, proprietor of the shop premises, said there might have been some celluloid combs in the window.

Thos. Davis, electrical engineer, in the employ of Messrs. Duncan Watson & Co., said he fitted the shop for the electric light. The fittings were all high-voltage fittings and the wires were encased in American white wood, which was as satisfactory as metallic tubing, because if water got into the tubes it rotted the wires more readily than was the case where wood casing was used. Flexible pendants were used and, he thought, plain lampholders. With a bare flexible they might get a short, but the danger would end there. With a 200 volt circuit you never got an arc across sufficient to cause a fire. Each lamp would take 40 watts and with that current the amount of arc would be hardly noticeable. A short circuit between the flex. was so small that it would not ignite anything unless there was a drag arc. The work was tested on behalf of the contractors after the installation and also by a representative of the City of London Electric Lighting Co.

Thos. Geo. Watts, the City of London Electric Lighting Co.'s inspector, said he tested the wiring and found it satisfactory. He thought flexibles were safe if properly handled, even though combustible goods were about. He did not think putting flexibles into tubes would tend to greater safety as it would do away with their flexibility, and in shifting them about one got shorts on the tube itself.

Mr. A. A. Voysey, electrical inspector to the City of London Corporation was present, but the jury intimated that they did not require any further evidence.

Some combs were produced and it was admitted that they were celluloid.

The jury found that the burning of the premises originated on the ground floor in the window of the shop, and was caused by the close proximity of celluloid goods to the electric lamps or wires, but there was not sufficient evidence to enable them to say whether it was caused by a short-circuit or arc, or only by the heat from the lamps. There was no evidence of negligence.

German Electro-Medical Apparatus.—The German manufacturers of electro-medical apparatus, X-ray instruments, &c., have decided to advance the price of their goods by 10 per cent.

Lecture.—Mr. Charles Bright, F.R.S.E., lectured last Tuesday on "Submarine Telegraphy," at the Cavendish Laboratory, Cambridge University.

Library Lighting.—Southwark (London) Council, who proposed to use gas for lighting their new library, have abandoned the idea on the advice of their architect, who regarded gas as quite unsuitable as an illuminant for the building from every point of view. The Council have now decided to take electric current for lighting the library from the County of London Co. at 3½d. per unit.

Light Railways.—The Llandudno and Colwyn Bay Light Railway (extension and amendment) Order has been submitted to the Board of Trade for confirmation. Objections by May 18.

The Board of Trade have confirmed the Llandudno and District Light Railways Order, 1907.

London County Council.—At Tuesday's sitting the following matters were dealt with:—

Loans to Local Authorities.—The Finance committee reported that in view of the present condition of the money market, and the consequent necessity of curtailing the amount of loans to be raised, they had considered whether a maximum amount should not be fixed to be lent to other authorities during the current financial year, and they recommended that not more than £1,000,000 be so loaned.

Westminster to Wandsworth Tramways.—On the adjourned report of the Highways committee asking for a supplemental vote of £53,000 for alterations to pipes and mains in connection with the reconstruction of the Westminster to Wandsworth tramways the Finance committee reported that they had informed the Highways committee that, in their opinion, in any future case in which it may appear that the difference between the cost of the overhead and conduit systems would be abnormal owing to the exceptional difficulties to be overcome in removing pipes, &c., every endeavour should be made to avoid the additional expenditure, and that, in the event of the Borough Councils concerned refusing to co-operate to this end, the Highways committee should report the matter fully to the Council, submitting the most accurate estimates available of the total cost involved under each of the two systems. The Council would then be in a position to consider whether it would be justified in agreeing to adopt the conduit system, and, if not, what steps should be taken with a view to its being placed in a position to adopt the other system. Agreed.

Tramways to Woolwich.—The Highways committee recommend that the Council's consent be not given to Erith Council to construct certain tramways in Woolwich, as they were of opinion that London County Council itself should construct the lines and lease them to the District Council. Postponed.

Llansamlet (Glam.)—The Parish Council have under consideration a scheme prepared by Mr. J. W. Johnston, of Swansea, for the electric lighting of the district.

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Maldens and Coombe.—A provisional electric lighting order has been granted to the County of London Electric Supply Co. for this district.

Marylebone (London).—At a meeting of the Council last week the Electricity committee reported that the contract with Messrs. C. A. Parsons & Co. for generating plant provided for a bonus being paid if the turbines came up to a certain standard of steam efficiency.

The consulting engineer (Mr. Arthur Wright) reported that during the last month official steam consumption tests on the turbo-generators had been carried out, the results being as follows: Nos. 1 and 2 machines produced a net kilowatt hour for 21·99 lb. of steam, bonus —; Nos. 3 and 4, 22·08 lb., bonus —; No. 5, 17·17 lb., bonus £2,097; No. 6, 17 88 lb., £1,458; No. 7, 17·2 lb., bonus £2,070; No. 8, 17·1 lb., bonus £2,160. A clause of the specification enabled the Council to reject the smaller turbines should the consumption exceed 22·05 lb. and entitled the manufacturers to a bonus of £900 for every lb. of steam under 19½ lb. on each of the large sets. Nos. 3 and 4 were about ⅛ per cent. higher than the rejection figure, which was so small an amount, and within the limits of the observation error, that he recommended a deduction being made at the bonus rate on account of that slight excess rather than raise the very involved question of the power to now reject these two sets which must arise after such prolonged commercial use. Finally, Mr. Wright submitted a certificate in favour of Messrs. Parsons showing an amount of £7,770 due to them as bonus.

Obituary.—We regret to announce the death (on March 27) of Mr. Pat Doyle, the editor and proprietor of our contemporary, "Indian Engineering."

The death occurred on Monday of Mr. Theodore J. Hare, chairman of the Baker Street & Waterloo Railway Co.

Presentations.—A presentation of an interesting character took place on April 24 at the offices of the Great Northern & City Railway Co. (3, Highbury-place, London, N.), to Mr. R. P. Brousson, chief engineer and traffic manager, on the occasion of his marriage.

The presentation took the form of a pair of antique silver candelabra, and was presented (on behalf of the principal members of the various departments of the railway) by Mr. Crewe, chief traffic inspector, who, in a few well-chosen words, conveyed to Mr. Brousson the good wishes of the staff for his future happiness and welfare. Mr. Brousson heartily thanked the members of the staff for their present and for the good wishes which accompanied it.

The wedding took place at St. John's Church, Wembley, on April 27, and was attended by deputations from the railway and from the East London Engineers, of which corps Mr. Brousson is a captain.

The managers and staff of the Darlington Tramways have presented a marble timepiece to Inspector J. Musgrave, on his marriage.

The staff of Crompton & Co. at Arc Works, Chelmsford, have presented a gold demi-hunter watch to Mr. W. Richardson, who is leaving the employ of the firm.

The Bournemouth tramway staff have presented a marble clock with ornaments, a silver tea tray and tea set and a framed photograph of the inspectors, drivers and conductors to Mr. C. Barber, traffic manager, on his marriage.

The Halifax Electricity staff have presented a roll top desk to Mr. P. Priestley, deputy electrical engineer, who is leaving to become chief engineer and manager of the Mexborough & Swinton Tramways Co.

The staff of Morecambe Corporation electricity department have presented a timepiece to Mr. A. Kirkham, who is leaving to become electrical engineer to the Burnley Co-operative Society.

Provisional Order Revocation.—The Otley Electric Lighting Order, 1902, has been revoked as from April 12.

Pudsey.—Leeds Corporation have agreed to construct an electric tramway from Stanningley into Pudsey.

Rochdale.—The Board of Trade have sanctioned the borrowing of £35,923 for the electric tramways department, viz., £27,681 for electrical equipment and £8,242 for tramcars.

Shipley.—For the year ended March 31 there was a deficit of £703 on the electricity undertaking. A flat rate of 4½d. per unit has been fixed for electricity for lighting, the maximum demand system of charging for both light and power having been abolished.

Stoke-on-Trent.—The salary of the borough electrical engineer (Mr. P. J. S. Tiddeman) has been increased from £300 to £350 per annum.

Stratford-on-Avon.—The public supply of electricity was inaugurated on the 27th ult. The works are owned by the Stratford-on Avon Electric Supply Co.

Walsall-Wednesbury Tramways.—An agreement has been entered into between Walsall Corporation and the British Electric Traction Co. for through communication between Walsall and Wednesbury and Darlaston. This through service was inaugurated on Wednesday.

Walthamstow.—On the recommendation of the Light Railways committee it has been decided to fix the charge for current supplied by the electricity department at 1¾d. per unit for the year ended March, but for the current year the charge will be 1¾d. per unit, subject to revision at the end of the financial year.

Wimbledon—The Council decided on Wednesday to apply £1,330 out of the profits of the electricity undertaking to relief of the rates.

The electrical engineer (Mr. H. Tomlinson Lee) reported that he had tested samples of the 8, 16 and 32 c.p. incandescent lamps supply by the firm whose tender for the annual supply of those lamps had been accepted and he found them to be unsuitable. Instructions were given to Mr. Lee to test the lamps supplied by the next lowest tenderers, and to report.

The Council have asked that their district should be excluded from the area of supply scheduled in the L.C.C. (Electricity Supply) Bill, 1907.

The tramway owned by the London United Tramways (1901) (Ltd.) from New Malden to Raynes Park was opened on Saturday last and the Wimbledon to Merton line commenced working yesterday. The Council have also permitted the Company to open the tramways for traffic in Worple-road, Hill-road, Francis-grove, &c.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Lanark County Council require tenders from manufacturers of electrical generating machinery and from manufacturers of secondary batteries, for the construction and erection of one 70 kw. motor-generator, alternating and direct-current switchgear, one battery charging booster, and one battery of 282 cells. Specifications, &c., from the county clerk (Mr. Thos. Munro), County Offices, Hamilton, N.B., to whom tenders by May 22. See also an advertisement.

The Metropolitan Asylums Board require tenders for supply of builders', engineers', smiths', plumbers' and gasfitters' ironmongery, miscellaneous engineering stores and electrical accessories Official forms of tender at the offices of the Board, Embankment, London, E.C., where tenders are to be sent by 10 a.m. May 15. An advertisement contains further particulars.

Goole District Council is prepared to receive competitive schemes for the erection of electricity supply plant and the necessary distributing mains to supply electricity within the compulsory area of supply. Particulars from the clerk to the Council (Mr. James Wm. Johnson), Council Offices, Goole. Schemes to be in by Friday, May 31. See also an advertisement.

London County Council invite tenders for the manufacture, delivery and erection of (*a*) six fuel economisers at its tramway electricity generating station, East Greenwich, (*b*) h. and l.t. switchgear for five tramways sub-stations (with basements), and (*c*) h. and l.t. switchgear for three tramways sub-stations (with galleries). Tenders to the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring Gardens, S.W., by 10 a.m. May 7 for economisers and 11th June for switchgear.

London County Council want tenders by 10 a.m. May 7 for supply of about 100,000 tons of coal (North Country washed nuts) to East Greenwich generating station.

Pembroke (Co. Dublin) Council invite tenders for supply and erection of a high-speed reciprocating engine, direct-current dynamos, switchboard and instruments, accumulators, tubular boiler, arc lamps and gear and arc lamp-posts Tenders to the clerk (Mr. J. C. Manly), before noon May 4.

Islington (London) Lighting committee invite tenders for supply and erection of a fan (12 ft. diam.) and a single-phase alternating-current motor. Tenders to the town clerk (Mr. W. F. Dewey), Town Hall, Upper-street, N., by noon May 8.

Bristol Electrical committee invite tenders for a.c. and d.c. flame arc lamps, to be supplied and delivered within the city. Tenders to the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol, by 10 a.m. May 20.

Barnes District Council invite tenders for supply, delivery and erection of a section of steam exhaust and other piping. Tenders to the Clerk, Council House, High-street, Mortlake, by noon May 14.

Stretford Electricity committee want tenders by May 10 for supply of condensing plant, switchboard, instruments, and electrical connections for 500 kw. generator. Forms of tender from Mr. T. L. Miller, 19, Brazennose-street, Manchester.

Hull Corporation want tenders by May 11 for supply of two electric water-level indicators and recorders. Specifications from Mr. F. J. Bancroft, Alfred Gelder-street, Hull.

Gravesend Electricity committee want tenders by May 10 for cables, storage battery, balancer and boosters and switchboard. Specification from the electrical engineer.

Warrington Electricity and Tramways committee want tenders (by noon May 7) for six tramcar covers. Specifications from the borough electrical engineer.

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Manchester Tramways committee want tenders (by 10 a.m. May 7) for supply of timber. Specification from Mr. J. M. McElroy, 55, Piccadilly, Manchester.

Colne Electrical committee invite tenders for a 360 kw. d.c dynamo coupled to Belliss engine and a Lancashire boiler with superheater. Tenders to Chairman by 10 a.m. May 13.

Tenders will be opened on May 8 simultaneously at the Palacio Municipal, Pontevedra, and the Direccion General de Administracion Local, Madrid, for the public lighting of *Pontevedra* by means of electricity for 15 years. Conditions are set out in the "Madrid Gazette" for April 4, which can be seen at the Board of Trade, Basinghall street, London, E.C. 500 16 c.p. lamps and 12 9 ampere arcs will be required. The annual rental payable by the Municipality is 20,000 pestas (about £714). A deposit of 1,000 pesetas (about £36) is required to qualify any tender, and local representation is necessary.

Antwerp Municipal Council invite tenders for the supply of 70,000 pairs of carbons for the new arc lamps on the Cockerill and Sud Quays. Specifications from the Hotel de Ville, and tenders to the Bourgmestre by May 14. Deposit of 1,000 fr. (£40) required. Copy of specification may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

The *Bulgarian* Direction of Posts and Telegraphs require tenders by May 10 for supply of 150,500 kilogs. of wire to the estimated value of 300,000 fr. (£12,000). Specification (in French) may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Marylebone Borough Council have accepted the following tenders for annual supplies for the electricity undertaking:—

Siemens Bros. & Co., rubber cables (3/22 15s. per 110 yds., coil ditto 3/20 18s. 11d., ditto 7/22 £1. 10s., ditto 7/20 £1. 9s., ditto 7/18 £2. 1s. 5d., ditto 7/16 £3. 4s. 3d., ditto 7/14 £4. 17s. 6d., ditto 19/20 £3. 2s. 10d., ditto 19/18 £4. 18s. 5d., ditto 19/16 £7. 10s. 11d., ditto 19/14 £11. 1s. 3d.; Vigers, Sons & Co., meter boards (18 in. by 15 in. 18s. per dozen, ditto 11 in. by 15 in. 12s. per dozen, banjo boards 21s. per dozen, batons 11 in. by 3 in. by 1 in. 6d. per dozen); Edison & Swan Co. (switch-holders 12s. 6d. per dozen, tumbler switches 10 amperes 16s. 6d. per dozen, ditto 5 amperes 8s. per dozen, switch blocks 6½ in. by 3½ in. 2s. 4½d. per dozen, 3½ in. 10d. per dozen, wall plugs 16 amperes 16s. per dozen, ditto 5 amperes 8s. 7½d. per dozen, distribution boards 1s. 6d. per dozen, cut-outs 10 amperes 4s. 2d. per dozen, ditto 5 amperes 2s. 9d. per dozen); Rashleigh Phipps & Co. (incandescent lamps, 8 c.p. £4. 7s. per gross, 16 c.p. £4. 7d. per gross, 32 c.p. 10s. per gross, 50 c.p. £1. 1s. per gross, extra for frosting 6d. per dozen lamps); New Brotherton Tube Co. (tubing); Sloan Electrical Co. (arc lamp carbons, cored 12 in. by 18 mm. 12s. 4d. per 250 ft., solid 12 in. by 12 mm. 5s. 10½d. per 250 ft., solid 12 in. by 11 mm. 5s. 4d. per 250 ft., solid 12 in. by 9 mm. 4s. 2½d. per 250 ft.); British Electric Calibrated Fuse Co. (fuses 500 amperes £5. 14s. per dozen, ditto 250 amperes 16s. 6d. per dozen, ditto 100 amperes 8s. 6d. per dozen, ditto 75 amperes 8s. per dozen, ditto 50 amperes 8s. per dozen, ditto 25 amperes 4s. 6d. per dozen); St. Helens Cable Co. (tinned copper fuse wires, No. 26 2s. per lb., No. 30 1s. 6½d. per lb., No. 26 1s. 6d. per lb., No. 24 1s. 5½d. per lb., No. 22 1s. 5d. per lb., No. 20 1s. 4½d. per lb., No. 18 1s. 4½d. per lb., No. 16 1s. 4d. per lb., No. 14 1s. 4d. per lb., binding wire No. 14, 1s. 4d. per lb., No. 16 1s. 4d. per lb., No. 18 1s. 4½d. per lb., No. 20 1s. 4½d. per lb., No. 22 1s. 5d. per lb., Silesian tape 2s. 6d. per lb., black adhesive tape 1s. per lb.), British Insulated & Helsby Cables (fuse wires No. 36 7s. per lb., No. 30 4s. 6d. per lb., No. 26 3s. 6d. per lb., No. 24 3s. per lb., No. 22 2s. 8d. per lb., No. 20 2s. 7d. per lb., No. 18 2s. 6d. per lb., No. 16 2s. 5d. per lb., No. 14 2s. 3d. per lb.); W. T. Henley's Telegraph Works Co. (flexible wire 35/40 silk £1s. 17s. 6d. per gross yds., ditto 70/40 silk £2. 17s. 6d., ditto 35/40 glazed cotton £1. 12s. 6d. per gross yds., ditto 70/40 £2. 10s.); Baxter & Caunter (baton holders 3s. 9d. per dozen, cord grip holders 3s. 9d. per dozen, screw holders 3s. 9d. per dozen, porcelain fuses 2s. 3d. per dozen, ceiling roses 2s. 6d. per dozen; H. P. Mayer & Co. (carbon brushes 1⅝ in. by ⅝ in. by ½ in. 4s. per dozen, ditto 1⅝ in. by 1 in. by ⅝ in. 3s. 9d. per dozen, ditto 1⅝ in. by 1½ in. by ⅝ in. 6s. per dozen, ditto 2 in. by 1½ in. by 3½ in. 3s. per dozen, ditto 2 in. by 1 $\frac{5}{16}$ in. by ⅝ in. 4s. per dozen, ditto 2½ in. by 1 $\frac{7}{16}$ in. by ⅝ in. 3s. 6d. per dozen, ditto 3 in. by 1 $\frac{9}{16}$ in. by 1 $\frac{9}{16}$ in. 4s. per dozen, ditto 7 in. by 2 in. by ⅝ in. 7s. 6d. per dozen, ditto 1½ in. by ½ in. by ⅝ in., 5s. per dozen, ditto 1¼ in. by 1 $\frac{1}{16}$ in. by 1in. 2s. per dozen, ditto 1¾ in. by 1¾ in. by ½ in. 5s. 6d. per dozen, ditto, 1¼ in. by 1 $\frac{3}{16}$ in. by $\frac{5}{16}$ in. 5s. per dozen, ditto 1 in. by $\frac{3}{32}$ in. by $\frac{1}{16}$ in. 2s. per dozen, ditto 2½ in. by 1¼ in. by 1 in. 6s. 7d. per dozen, ditto 2½ in. by 1½ in. by ⅝ in. brass capped 6s. per dozen, ditto $\frac{7}{8}$ in. by 1½ in. by ⅝ in. 2s. per dozen, ditto ⅝ in. by ⅝ in. by $\frac{3}{32}$ in. 2s. per dozen, ditto 1⅝ in. by 1¼ in. by ⅝ in. 5s. 6d. per dozen, ditto 1 in. by $\frac{7}{8}$ in. by ⅝ in. 1s. 6d. per dozen); W. Patterson (dynamo brushes, 10½ in. by 1 $\frac{1}{16}$ in. by ½ in., weight 2 lb. 3 oz. £30 per gross).

For engineer's stores, oils, &c., the following tenders were accepted: India Rubber Company, W. H. Willcox & Co., G. Hatch, Witty & Wyatt, Vincent's Stores, Pryke & Palmer, Croager Bros., F. Bird & Co., C. King & Co., Broad & Co., Towers & Williamson, Glenboig Fire Clay Co., T. & W. Farmiloe, Tully & Straker, C. Jenkins & Co. and Anti-Attrition Metal Co.

For meters: House meters (up to 500), Reason Mfg. Co., 5 and 10 amperes, 240 volts and 480 volts, £1. 5s. each; 25 amperes, 240 volts and 480 volts, £1. 15s. each; 50 amperes, 240 volts and 480 volts, £2 each; dials, units 250. Prepayment meters, Chamberlain & Hookham (up to 200), 3 and 5 amperes, £3 each; 10 amperes, £3. 7s. 6d. each; maintenance 5 per cent.

Woolwich Borough Council have received letters from the following electrical contractors offering to enter into arrangements for the execution of installation work on behalf of the Council: Electrical Contracts Co, Rashleigh Phipps & Co., Fred d'Alquen & Co., Ward & Newman, Whistler & Worge.

The Electricity committee were of opinion, having regard to the status of Messrs. Whistler & Worge as local builders and electrical engineers, and to the fact that their premises were situated in the most favourable position for show rooms, and that they were in close touch with all the leading residents in Eltham, that it would be in the best interests of the undertaking to accept that firm's offer to operate in the parish of Eltham only, especially as they were prepared to canvass the district and to become members of the National Electrical Contractors' Association as a guarantee of good faith. With regard to the remainder of the borough (parishes of Woolwich and Plumstead) the committee thought it advisable to invite applications by advertisement, and this was agreed to.

For wiring for electric lighting, bells, telephones, &c., at the London Day Training College, Holborn, London County Council received the following tenders;—

S. G. Cozens (*accepted*) ..	£1,154	Cowtan & Sons	£1,597
Foote & Milne.....	2,285	Smeeton & Page.....	1,555
Barlow Bros. & Co.	2,027	Vaughan & Cook	1,500
Weston & Sons	1,981	Seth Bros.	1,462
F. A. Glover & Co.....	1,950	A. W. Penrose & Co.....	1,440
Jackson Bros.....	1,920	T. Potter & Sons	1,432
L. Sunderland & Co.....	1,910	Higgins & Griffiths	1,419
R. Brightwell	1,834	W. J. Fryer & Co.....	1,397
J. S. Cunnington & Co.....	1,811	W. Barton & Sons.....	1,375
Ekins & Co.....	1,800	Aberdeen Elec. Eng. Co. ..	1,358
Lund Bros. & Co.	1,780	Lea & Warren.....	1,328
Sweet Bros.....	1,680	Reliance Electrical Co.	1,168
Wippell Bros. & Row.....	1,670		

The following tenders have been received for track rails and slot rails by London County Council:—

Track Rails, &c.

Bolckow, Vaughan & Co. £16,173 17 6		Walter Scott (Ltd.) ..£16,570 0 0	
Barrow Hæmatite Steel Co.	16,731 17 6	Lorain Steel Co.	17,056 10 0
		P. & W. MacLellan..	18,140 18 9
		Steel, Peech & Tozer.	18,213 6

Slot and Conductor Rails.

P. & W. MacLellan ..£5,367 10 0		Walter Scott (Ltd.) ..£6,237 10 0	
Frodingham Iron & Steel Co.....	5,804 10 0	Bolckow, Vaughan & Co.	6,972 10 0
		Steel, Peech & Tozer..	6,985 12 6

The Highways committee recommended that the tenders of Bolckow, Vaughan & Co. and of the Frodingham Iron & Steel Co. respectively be accepted, and pointed out that P. & W. MacLellan proposed to sublet to the Société Anonyme des Aciers d'Angleur (Belgium), and if their tender was accepted it would be necessary to incur considerable additional expenditure in inspecting and testing the rails at the works at Belgium.

The matter stood over for a week.

Islington (London) Electric Lighting committee have accepted the following tenders for small bituminous steam coal for the electricity department:—

Phillips & Co., 2,500 tons, Mapperley small nuts, (1) price per ton in Council's waggons 12s. 11d., (2) price per ton in contractors' waggons 13s. 9d., 2,500 tons, Ainsley Hall peas, (1) 11s. 3d., (2) 12s. 1d., 7,500 tons Riddings slack, (1) 11s. 3d., (2) 12s. 1d.; Charrington, Sells, Dale & Co., 6,000 tons bright screened nuts from Mapperley, (1) 12s. 4d., (2) 13s. 1d.

London County Council have accepted the offer of the Post Office to renew (at its own cost) such of the electric bell apparatus in fire stations, fixed before April 1, 1904, as is defective, and to maintain for 10 years from April 1, 1907, all electric bell apparatus in fire stations for 6s. a bell or indicator a year, to include provision and fixing of new bell apparatus in new fire stations and additional bells in existing stations.

A repeat order for a 500 kw. set has been placed with the Lancashire Dynamo & Motor Co., Trafford Park, Manchester, by Stockport Corporation for their tramways department.

Bolton Electricity committee have accepted the tender of J. Musgrave & Son for a 2,000 H.P. vertical steam engine; that of Dick, Kerr & Co., for three-phase alternator; that of the British Insulated & Helsby Cables for cables; and that of R. W. Kenyon for casings.

A repeat order has been placed with the Lancashire Dynamo & Motor Co. for the remainder of the electrical equipment of the North-Western Railway loco shops, Lahore. This order includes two 250 kw. Howden-Lancashire sets and a large number of motors, mostly of the variable-speed type.

London County Council have accepted the offer of the Metropolitan Electric Supply Co. to supply electric current to the Central School of Arts and Crafts and the London Day Training College, at 3½d. per unit for lighting and 1½d. per unit for power.

Bruce Peebles & Co., Edinburgh and London, have secured an order for a further motor converter from the Oxford Electric Co.

Cardiff Electric Light and Tramways committee have accepted the tender of the Electric Construction Co. for a switchboard for

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the docks sub-station at £243, and that of the Lahmeyer Electrical Co. for cables at £668.15s.

A repeat order has been placed by Manchester Corporation with the Lancashire Dynamo & Motor Co. for a 160 kw. feeder booster driven by three-phase 6,000 volt motor.

The Metropolitan Asylums Board have placed an order with Elliott Bros. for a voltameter, and with A. V. Gifkins & Co. for re-wiring for electric bells, &c.

The British Westinghouse Co. have received an order for their new type six-cylinder vertical gas engine for operating the Hollins Hill Co.'s mill at Marple. This will be a duplicate of four now being delivered to the Castner-Kellner Alkali Co. at Runcorn.

Leyton Council have accepted the tender of the Tudor Accumulator Co. for repairs to the lighting battery and for maintenance of the traction battery.

An order has been placed with the Lancashire Dynamo & Motor Co. for a 500 kw. generator for direct coupling to Belliss engine for the Johannesburg tramways.

The tender of Ferranti Limited has been accepted by Islington Electric Lighting committee for supply of transformers to March 31, 1908.

Portsmouth Electric committee have accepted the tender of Sperring & Co. for 150 arc-lamp standards.

Chelmsford Council have accepted the tender of Christy & Co for supply of a pump and electric motor at £78. 8s.

Hanley Council have accepted the tender of the British Westing house Co. for the supply of a 500 kw. generating set.

Lancaster Council have accepted the tender of E. Green & Sons for the renewal of the remaining section of the economiser at £131.

Mechanical Stoker Contracts.—Messrs. Ed. Bennis & Co., of Little Hulton, Bolton, and 28, Victoria-street, London, S.W., send us a long list of the contracts secured by them from Feb. 1 to April 18, 1907, for their patent gold medal machine stokers, self-cleaning compressed air furnaces, new chain grates (Bennis-Miller-Bennett patents), and elevators and conveyors.

From the list it appears that eight chain-grate stokers are for the Electric Supply Co. of Victoria, Melbourne (per British Insulated & Helsby Cables). A second contract for Amsterdam for 16 stokers and self-cleaning c.a. furnaces with one conveyor shows the practical appreciation of Bennis plant on the Continent. The Kidderminster order (placed by James Humphries & Sons) for a conveyor is also interesting, as the conveyor is to be an aerial ropeway (a unique application of conveying) for conveyance of coal to the boilers. The design of this ropeway is very similar to one erected by Messrs, Bennis in Scotland some time since. Two stokers and c.a. furnaces are on order for the Dover mines. Another contract is one placed by Llandudno Council for supply of two stokers and c.a. furnaces to their electricity works (a repeat order). Nestles & Anglo Milk Co. (Aylesbury) have ordered two stokers and c.a.f. A feature of the list is the variety of industries effecting economy in their boiler houses by the installation of Bennis plant and also that over one-third of the contracts are repeat orders.

In addition to the contracts already mentioned is the following list:—Standish & Co. (Worthington), two stokers and c.a.f. (repeat); Spennymoor electricity station (per Richardsons, Westgarth & Co.), four chain-grate stokers; T. Gillibrand & Sons (Darwen), two stokers and c.a.f.; J. Dickinson & Co. (Watford), two stokers and c.a.f. (repeat); Altham Colliery Co. (Great Harwood), two stokers and c.a.f.; General Electric Supply Co., London (per Babcock & Wilcox), six chain-grate stokers; Regent Hotel (Leamington), one stoker and c.a.f.; J. & M. S. Sharp & Co. (Low Moor), two stokers and c.a.f. (repeat); Leigh Co-operative Society, four stokers and c.a.f.; Ainsworth & Co. (Holcombe Brook), two stokers and c.a.f.; Dobson & Barlow (Bolton), two stokers and c.a.f. (repeat); Wm. Murgatroyd & Co. (Yeadon), two stokers and c.a.f. (repeat); Flower & Sons (Stratford), two stokers and c.a.f. (repeat); Stringer & Jagger (Clayton West), two stokers and camel furnaces; Dupetit & Co. (France), two stokers and c.a.f.; White, Tomkins & Courage (Liverpool), two stokers and c.a.f. (repeat); Weaver & Co. (Swansea), two stokers and c.a.f.; Owler Ings Mills (Brighouse), two stokers and camel furnaces; Wath Main Colliery Co., two stokers and c.a.f. (repeat); Oliver & Son (Burslem), two stokers and c.a.f. (repeat); and James Humphries & Sons (Kidderminster), one conveyor (repeat).

The above include brewers, millers, dyers, cotton, carpet and paper manufacturers, and engineers, besides, as will be seen, several electricity generating stations.

BUSINESS NOTICES.

Newtons Limited, of Taunton, have appointed Berry, Skinner & Co., 16, Oozells-street, Birmingham, sole agents in the Midland counties for the sale of their continuous-current dynamos and motors. Messrs. Berry, Skinner & Co. will keep a large stock of Newton motors at Birmingham, wound for various standard voltages, and will answer inquiries and furnish information respecting Newtons' manufactures.

Owing to the increase of their business in the Northern districts the Newcastle office of the Union Electric Co. will be moved on May 4 to 50, Grainger-street.

Messrs. R. J. Nicholson & Co. (of Manchester) have opened offices at 46, King William-street, London, E.C. Messrs. Umney & Beckett will have charge of the business, and will cover not only the London district proper but also the counties of Essex, Hertfordshire, Middlesex, Kent, Surrey, Berkshire and Hampshire. The telephone number of the London office is 9876 Central.

To meet the business demands of Edinburgh and district Messrs. Anderson & Munro are increasing and re-arranging their office staff there, and Mr. Donald Smeaton Munro, A.M.I.E.E., of the Glasgow head office, will take full resident charge of the firm's electrical business in the east.

Messrs. Baxendale & Co., Miller-street, Manchester, announce that, owing to the present high prices of raw materials, they are compelled to advance as from May 1 all the prices contained in their electric bell list (Dec., 1906) by 5 per cent.

The Armorduct Mfg. Co. have now a second telephone number. The company's numbers are 1394 and 5739 Holborn.

BANKRUPTCIES, LIQUIDATIONS, &c.

An application for the discharge of Geo. Collier, electrical engineer, &c., 89, Long-acre, London, W.C., will be heard on May 15 at Bankruptcy-buildings, London, W.C.

A first and final dividend of 3s. 6d. is payable at 23, King Edward-street, Macclesfield, in the bankruptcy of Saml. Hargreaves, electrical engineer, 2, Victoria-arcade (formerly trading at 6, Greek-street), Buxton.

Claims against Thos. E. Raymond Phillips, electrical engineer, 15, Nicander-road, Liverpool, by May 11 to Mr. F. Gittins, 35, Victoria-street, Liverpool.

Claims against Ernest Holt (trading as Holt & Co.), electrical engineer, Queen's-arcade, Rhyl, are to be sent by May 18 to Mr. L. Hugh-Jones, Crypt-chambers, Chester.

The Victoria Arc Lamp Co. (Ltd.) is being wound up voluntarily. Mr. W. C. Penny, 8, Arthur-street West, London, E C., is liquidator, with a committee of inspection.

The Deep Leads Electric Transmission Co. (Ltd.) is being wound up voluntarily, and Mr. E. S. Rawson, 20, Copthall-avenue, London, E.C., has been appointed liquidator.

A meeting will be held on May 29 at 4, Greek-street, Leeds, to receive an account of the winding up of the British Electrical Tool Co., Ltd. (in vol. liq.).

A meeting to receive an account of the winding-up of the Motor & Electrical Engineering Co. (Leeds), Ltd., will be held at Bank-chambers, Infirmary-street, Leeds, on May 24.

The Rand Central Electric Works (Ltd.) is being wound up voluntarily. Claims to the liquidator, Mr. Hy. Rogers, 120, Bishopsgate-street Within, London, E.C., by June 22.

Sale by Auction.—Messrs. Wheatley Kirk, Price & Co. have been instructed by the receiver of Lionel Robinson & Co. (Ltd.), (Mr. Herbert J. Page, F.C.A.) to sell by public auction, on May 16, at 11 a.m. at the works premises, Ferry Works, Thames Ditton, Surrey, in the lots of the catalogue, the whole of the modern plant, machinery, tools, electrical instruments, stock and effects, including 15 H.P. gas engine and producer plant, 15 lathes of sliding, capstan, screw-cutting and other patterns, nine radial and other drilling machines, milling, shaving, grinding, polishing, shearing, stamping, &c., machines, electric lighting and testing installation, testing instruments, loose tools and utensils for a hundred hands, quantities of testing and other instruments, switchboards and fittings, dynamos, motors, accumulators and contents of general stores. Catalogues from Mr. Herbert J. Page, F.C.A. (Messrs. Annan, Dexter & Co.), 21, Ironmonger-lane, London, E.C., or from the auctioneers, 46, Watling-street, London, E.C., and Albert-square, Manchester. See also an advertisement.

Investment in an Electrical Undertaking.—Prof. John Perry, F.R.S., who owns about half the shares in an electricity company, which supplies electricity under a provisional order in a town in Ireland, adverti es that a person is required, with business and engineering experience, who is willing to invest about £8,000 in the undertaking.

Correction.—We regret that in our article "New Electrical Fittings," published last week, the London Electrical Fittings Co. were referred to as the Electrical Fittings Co. As the latter is the name of another firm, we take this opportunity of stating that the two companies are in no way connected, as the error might lead one to suppose. We learn that the London Electrical Fittings Co. has been established since 1894.

Hill-climbing Test.—The British Thomson-Houston Co. have entered their new petrol-electric 'bus for the Frome's Hill climb organised by the Herefordshire Automobile Club for May 3. While it cannot be expected that a heavy commercial vehicle can secure an award in such a competition (primarily open to touring cars), it will be interesting to note that the company's petrol-electric vehicle can successfully negotiate a grade of the magnitude of Frome's Hill, which is 1,289 yds. long and has an average gradient of 1 in 11·22 and a maximum gradient of 1 in 6·37.

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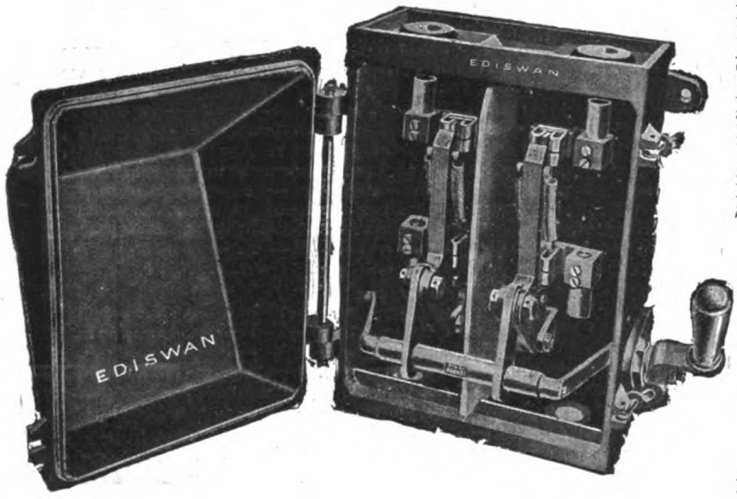
"Ediswan" Ironclad Switches.—A new line of ironclad switches for circuits up to 600 volts is being exploited by the Edison & Swan Co. The accompanying illustration shows the double-pole type with cover open to show the switch. As will be seen, the operating handle is linked up to the switch arms by a double-lever system, which gives a smooth but strong action to the moving parts. The parts are interchangeable, and the knife and clip contacts are



EDISWAN D. P. 150 AMP. IRONCLAD SWITCH.

in phosphor bronze. Asbestos or porcelain-lined cases can be supplied. A gas and watertight pattern is made with sealing chambers for the cables.

CATALOGUES, &c.

Ironclad Switch.—In our last issue we referred to a new ironclad switch being marketed by Eckstein, Heap & Co. We give an illustration of this herewith, from which it will be seen that the switch is made up of brush contact pieces, and the final break is taken on carbon points.

E. H. & Co.'s IRONCLAD SWITCH.

Petrol-Electric Sets.—R. J. Nicholson & Co., Macdonald's-lane, Corporation-street, Manchester, are issuing a publication (No. 69) dealing with their "Ideal" petrol-electric combined sets for country house lighting. These are made in five sizes, ranging from an output of 1 kw. to 6 kw.

Flexibles.—The London Electric Wire Co., Playhouse-yard, Golden-lane, London, E.C., send us their trade list of flexible cords, which are made in five grades of insulation.

Electric Fans.—Julius Sax & Co., 100, Charing Cross-road, London, W.C., are sending out a special publication dealing with their "J S." electric fans. Further details will be found in the current issue of the INDUSTRIAL SUPPLEMENT.

One-phase Motors.—Pamphlet No. 201 of the British Thomson-Houston Co. deals with one-phase induction motors and starting rheostats for same.

Drum Type Controllers.—Complete details and illustrations of B.T.-H. rheostatic controllers and resistances are given in pamphlet 202, also just to hand.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from April 24 to 30, with the ports of destination:—

Aden, £402 (telegraph paper). *Africa*—Alexandria, £500 (including £311 telegraph material); Cape Town, £19; Durban, £834 (including £225 telegraph material); East London, £26; Port Elizabeth, £733 (including £92 telegraph material); Port Said, £608; Sekondi, £16; Suakim, £598. *Argentina*—Buenos Ayres, £4,400. *Australasia*—Adelaide, £47; Auckland, £190; Hobart, £21; Invercargill, £1,044; Melbourne, £410 (including £265 telegraph material); Otago, £188; Sydney, £194 (including £44 telegraph material); Timaru, £283 (including £222 telegraph material); Wellington, £1,919 (including £339 telegraph material); *Belgium*—Brussels, £1,729 (including £258 telegraph material); Ghent, £18; Ostend, £40. *Brazil*—Pernambuco, £60; Rio Janeiro £251 (including £47 telegraph material). *British Guiana*—Demerara, £11. *Burma*—Rangoon, £59. *Canada*—Halifax, £21; Montreal, £20; Toronto, £215. *Canaries*, £7. *Ceylon*—Colombo, £289 (including £9 telegraph material). *China*—Shanghai, £899. *Cochin China*—Saigon, £18. *France*—Boulogne, £20; Paris, £52. *Germany*—Bremen, £224; Cologne, £57; Dusseldorf, £303; Hamburg, £541; Konigsberg, £30. *Gibraltar*, £183 (telegraph paper). *Holland*—Amsterdam, £272 (including £107 telegraph material); Flushing, £100; Terneuzen, £19. *Hong Kong*, £165 (including £25 telegraph material). *India*—Bombay, £1,186 (including £20 telegraph material); Calcutta, £1,111 (including £218 telegraph material); Madras, £31. *Jamaica*—Port Swettenham, £181 (including £124 telegraph material). *Japan*—Nagasaki, £803; Yokohama, £2,798. *Malta*, £56. *Philippines*—Manila, £54. *Portugal*—Lisbon, £68 (including £15 telegraph material). *Russia*—Reval, £11. *Siam*—Bangkok, £20. *Spain*—Santander, £32. *Straits Settlements*—Penang, £36 (telegraph material); Singapore, £222. *Sweden*—Stockholm, £12. *U.S.A.*—Boston, £300 (telegraph material). *West Indies*—Trinidad, £14. Total, £24,962, against £31,270 in the corresponding week last year (April 24 to May 1).

COMPANIES' MEETINGS AND REPORTS.

Indo-European Telegraph Co. (Ltd.)

The fortieth ordinary general meeting of this Company was held on Monday, under the presidency of Mr. J. HERBERT TRITTON.

The SECRETARY (Mr. John I. Bethell) read the notice convening the meeting, and the auditors' certificate.

The CHAIRMAN, in moving the adoption of the report and accounts, said: Since our last annual meeting our esteemed colleague and friend, Mr. W. S. Andrews, has passed to his rest. We feel deeply the debt of gratitude due to him; and, associating with ourselves in that feeling the shareholders present to-day, as I am well assured I am more than justified in doing, we would convey to his widow and family our sincerest sympathy. We are glad to think that our present Managing Director, Mr. T. W. Stratford-Andrews, a worthy son of his father, takes his place, to the entire satisfaction of the Board. The electrical condition of the Company's lines during the year has continued to be satisfactory. That the working of those lines has been well performed is evident from the fact that the daily traffic carried during the year is the largest during the Company's history. This record traffic has been carried with an improvement both as to accuracy and speed over last year, and, it should be noted, without any addition to the number of wires at the Company's disposal. The reduction of rates for Turkish traffic by our route, consequent upon the arrangements to which I referred at the last general meeting, has enabled us to attract a satisfactory traffic. This has involved some rearrangement in our Odessa station, attended with a certain amount of additional expense, but we have no doubt that it will be to the advantage of the Company. The increase in volume of all classes of traffic taken together has, however, not been sufficient to compensate for the loss of revenue resulting from the large reductions of tariff that have been in ful operation during the year. The traffic returns for the first quarter of 1907 are, however, favourable, and if the improvement is maintained, we hope to show better results for the current year. Taking the years 1904, 1905 and 1906 we find the earnings on message account to be respectively £138,284, £129,743 and £124,477, showing a reduction in 1906 of £5,266 as compared with 1905 and of £13,807 as compared with 1904, a serious falling off. Turning to the accounts, the revenue account shows a decrease in receipts of £5,151, and an increase in expenses of £2,851, which is attributable, partly to an increase in salaries and wages, and partly to maintenance charges, which, as I have stated on other occasions, are a fluctuating quantity, and do not call for close analysis. The Directors have considered this a suitable time to bring into profit and loss the sum of £3,838. 5s. 10d. which was kept in last year's accounts as an open balance. The reduction in revenue is unfortunately accompanied by further depreciation in the value of the Company's investments—a depreciation which merely reflects the condition of the money market, and for which the Directors are in no way responsible—with the result that funds which would otherwise have been available for the Retirement Fund and for Equalisation of Dividends Fund have had to be utilised in writing off a depreciation in securities of £16,240 which has accrued during the year. The Directors propose the usual dividend of £14,875 and bonus £17,000, which leaves £8,974. 15s. 5d. to carry forward to the credit of 1907, as against £16,698 for the previous year.

I now come to the question of a special distribution out of interest on unappropriated investments. In considering this question a sharp line should be drawn between this and the dividend and bonus derived from revenue. The shareholders have, after many years of economy and self-denial, accumulated available liquid assets which stand in the balance-sheet at over £500,000. This Company has no risks or liabilities against which to create a larger reserve fund, the only provision necessary to be made in the event of liquidation of the Company being to the extent of the issued capital of £425,000. From this point of view, therefore, any further considerable additions to the reserve and other funds of the Company would be simply to provide a premium over the par value of the shares on the final liquidation of the Company—a provision which is obviously not within the duties of the Directors. It may well

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be that increasing traffics may eventually necessitate a corresponding increase of carrying capacity, and that suitable opportunities may even present themselves for the extension of the system of operations of the Company, but these possibilities hardly seem to justify further large accumulation of funds. The Directors, therefore, recommend the distribution of interest accrued on the investments which are termed in the balance-sheet "unappropriated," amounting to 15s. per share, as on previous occasions. I now move the adoption of the report and accounts.

The Right Hon. Sir FRANCIS MOWATT, G.C.B., seconded the motion, which was carried unanimously.

The retiring directors, Mr. Charles Holland and Mr. John von Berenberg Gossler, were then re-elected, as were the auditors (Messrs. G. F. Kemp, Sons & Co.), and a cordial vote of thanks to the chairman, directors, the principal officers of the Company, and all the staff, concluded the meeting.

Great Northern Telegraph Co. (Ltd.)

At the meeting at Copenhagen on the 27th ulto., the chairman and managing director (Commodore E. Suenson, D.R.N.), in rendering an account of the working during 1906, said that there had been 20 interruptions on 11 of the company's cables in Europe and 12 interruptions on six of the Far East cables, exclusive of the Wladiwostock-Nagasaki cables. The latter was repaired on Jan. 14, 1906, after two years of inactivity, whilst the other was repaired on Oct. 1 last only. Ice, and later on the difficult and dangerous removal of the floating mines laid during the war for the defence of Wladiwostock, prevented an earlier repair of this cable, which consequently remained closed for nearly 32 months. Of their three cable steamers, the "H. C. Örsted" had been actively employed in Europe for 110 days, whilst in the Far East the "Store Nordiske" had been on active service for 112 days (37 of which were for the account of others) and the "Pacific" for 108 days, of which 11 were for the account of others. Although the enforced inactivity of the Wladiwostock route owing to the Russo-Japanese was greatly to be regretted, still it had had the advantage of leading to a material improvement of the Kiachta (Peking-Irkutsk-St. Petersburg) route, which was incontestably the shortest telegraph line between Europe and the Far East, and which ought to be the quickest as well. In fact, owing to the combined efforts of the company and the Imperial Russian and Chinese Telegraph Administrations, the service via Kiachta had been so much improved that a telegram from Peking to England was transmitted twice only—viz., at Irkutsk, where the company's Danish staff since Jan. 1, 1907, had had full charge of the direct service to Peking, and at St. Petersburg, where the company's station was in direct working with Newcastle-upon-Tyne. The service with Germany (Berlin) was just as direct, whilst telegrams to London and Paris were subject to only one re-transmission more. The Japanese traffic would, of course, benefit proportionately by the improved service via Russia, but unfortunately the chauvinistic feelings engendered by the war had to be taken into consideration in estimating the real effect of the improved service on the public. As a matter of fact, the Japanse telegraphing public had, since the beginning of the war and up to the present date, made very little use of the routes via Russia.

The Iceland cable was successfully laid during July and August last year by the c.s. "Cambria," of the Telegraph Construction & Maintenance Co. The southern section (Lerwick-Thorshavn) was opened for traffic on Aug. 1 and the northern section (Thorshavn-Seydisfjord) on Aug. 27. The final completion of Iceland's telegraphic connection with the general system of the world took place on Sept. 29 by the opening for traffic of the overland line between Seydisfjord and Reykjavik. The construction of the line, which was carried out by the Icelandic Government, was exceedingly difficult owing to the hilly country, the severe climate and the absence of carriage roads. The maintenance of those internal lines may, therefore, prove rather difficult, but the Icelandic Government will leave nothing undone to keep them in working order. No interruption of the cable has taken place as yet, although it is much exposed to injury from the numerous fishing vessels in these waters. During the present year (1907) the company's European system will receive another important addition—viz., a new cable between Russia (St. Petersburg-Libau) and Denmark, thus duplicating the old Libau cable. The want of that duplication had been felt since they established their own station at St. Petersburg in 1904; the new cable would, therefore, form a very valuable addition to their system, because it would also create a direct submarine connection with the Russian capital, thus avoiding the disadvantages often resulting from a combination of cables and long landlines. The length of the cable will be about 800 n.m.; it would be composed of exceptionally heavy types in order to withstand the dangers arising from the low depths of water in the Baltic, and particularly in the Gulf of Finland. The contract for the manufacturing and laying of the cable had been given to the Norddeutsche Seekabelwerke at Nordenham, not for want of confidence in their old and proved contractors (the Telegraph Construction and Maintenance Co.), who had, on the contrary, once more proved the excellence of their work by the highly satisfactory way in which they carried out the Iceland contract last year, but solely because the German Works, which enjoy an excellent reputation, twice quoted the lowest price. The cable will be laid as soon as possible after the breaking up of the ice on the Neva and in the Baltic. The extension of the company's Russian concessions till 1926, although on less favourable terms than hitherto, was due partly to their having agreed to establish the above-mentioned new connection, which would cost the company a considerable amount, both in capital outlay and working expenses, and partly to their having undertaken to work the Kiachta line from Irkutsk with an entirely Danish staff. Besides those additional expenses, they should also have to bear a considerable loss through the reduction of the subsidies formerly granted as compensation for our working the cables in Russia. Similar sacrifices were imposed upon them by the Danish and Swedish Governments when their concessions in those two countries were prolonged in 1904 and 1905.

The great historical events of recent years had created great difficulties for them in their efforts to safeguard the company's interests in the Far East, particularly in China and Japan. As the pioneers of the electric telegraph in those countries they had had to bear the initial risk, dangers and losses, but it would be ungrateful on their part not to admit that, particularly during the last ten years, the risks which their shareholders ran in former days have been amply compensated for by the large dividends and the increase of the reserve funds. Thanks, however, to the excellent relations which had hitherto existed between the Japanese and Chinese telegraph administrations and the company, and to the willingness which they had often shown to meet the wishes of their concessionary Governments and to share their privileges with other parties, they hoped that an arrangement might be arrived at which would satisfy the two countries without prejudicing too much the interests of the company's shareholders. The decrease of the traffic made itself seriously felt at the return of more normal conditions in the countries connected by the company's cables. It was the enormous press and Government correspondence in particular which had decreased, without being compensated for by a corresponding increase of the private and commercial traffic; at the same time the two new competing lines in the Far East (the Commercial Pacific and the German-Dutch Cos.) had commenced to take their share of the traffic. Compared with the previous year the revenue account showed a decrease in traffic receipts of £97,342, interest was about £779 less, and sundries higher by about £1,419. Salaries and wages had increased by £5,802. New stations had been established at Thorshavn, Seydisfjord and Irkutsk, and it had become necessary to increase the salaries of the staff in China and Japan, where the increased cost of living (occasioned by the war) seemed to have become permanent.

The meeting approved the adoption of the accounts and balance sheet, together with the propositions as to the distribution of the balance. Proposals emanating from French shareholders that a total dividend and bonus of 24 per cent. or 22 per cent. be distributed were rejected by the meeting.

AUCKLAND ELECTRIC TRAMWAYS CO. (LTD.)—The total revenue for 1906 was £132,364. 17s. 1d., compared with £122,995. 1s. 7d. for 1905. Traffic receipts (£130,336. 19s. 3d.) show an increase of £8,457. 11s. 2d. Deducting expenses (including £14,255 interest) and providing for rental and percentage of profits payable to Auckland Council (£3,246. 6s. 6d.), and after setting aside £10,000 to meet depreciation, there remains (with £3,018. 4s. 11d. brought forward) £36,601. 10s. 9d. The directors recommend a dividend of 7 per cent. (£21,000), that £12,500 be applied to reserve, leaving £3,101. 10s. 9d. to be carried forward. The directors have decided to take in hand the construction of the extension of about 3 miles of tramways in the Mount Eden-road district, and to meet the demand of these extensions and the increased traffic further plant of 600 kw. will be installed during the year.

ASCOT DISTRICT GAS AND ELECTRICITY CO.—At an extraordinary meeting on Wednesday, the directors were authorised to raise additional capital to put into effect powers obtained under their 1906 Act to supply electricity in the company's area of supply. The directors have called in the services of an eminent firm of electrical engineers to advise them generally with regard to an electricity scheme and the firm had given very good reasons why this scheme should be carried out. Since the last meeting of shareholders the directors had obtained tenders for plant and mains and proposed to accept these as soon as the necessary capital was issued, amounting to £14,589. With fees and contingencies, therefore, the capital likely to be required was £16,048. The board did not propose to lay mains in the whole of the compulsory area at first, but to confine operations to Sunninghill and Sunningdale, where there was likely to be an immediate demand.

BABCOCK & WILCOX (LTD.)—At the meeting last week the chairman (Mr. John Dewrance) said the company were further extending their works at Renfrew, and the volume of the business was on the increase. He had been asked to give an opinion as to whether gas-power was going to supersede steam. As to what the future of the two rival powers was to be it was exceedingly difficult to say. It was a very highly technical subject, but there was no question that, for small powers, both gas and electricity had cut into the company's business. They were doing a great deal less at present in small plants than they did in the past, but up to the present, for large powers, they had not felt any considerable diminution in the volume of the demand for their boilers. There was very strong evidence that the difficulties with gas and oil plants were by no means entirely superseded in their application to large powers.

BANBURY & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—Expenditure at the end of 1906 was £19,861. 11s. 8d. The directors recommend a dividend of 2½ per cent. on the amount paid up on the ordinary shares. Installations connected to the mains at Dec. 31 represented the equivalent of 10,281 8 c.p. lamps, an increase of 20 per cent., which have now increased to 12,000 8 c.p. To meet the increasing demand, a contract has been placed for the installation of a 200 kw. generating set and the necessary auxiliary plant.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—During 1906 4,578,38 units of electrical energy were sold, an increase of 29 per cent. over 1905, when 3,548,229 units were sold. The gross revenue (£89,242) is nearly 23 per cent. higher than in 1905, compared with an increase of 21¾ per cent. in 1905 over 1904. Working costs (£39,065) show, however, an increase of 33 per cent., compared with an increase of 23 per cent. last year. Capital expenditure at Dec. 31 last amounted to £544,353, an increase of £46,075 during the year, necessitated by the continued expansion of the company's business. The principal items of expenditure are £5,661 on

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buildings, £19,480 on mains extensions, £12,480 on machinery and £7,255 on meters. There are 3,060 houses connected to the mains (representing 262,893 8 c.p.), compared with 2,451 houses and 215,018 8 c.p. in 1905. Exceptional difficulties have again been experienced with the feeders, and it is evident that a considerable proportion of the underground cables will have to be re-laid. The whole of the repairs and renewals during last year (£8,882) have, in accordance with the Government form of accounts, been charged against revenue instead of coming out of the renewals fund as in former years. The net profits for the year amount to £50,176. 19s. 4d., added to £4,358. 8s. from last year. Deducting the interim dividend and other items there remains £39,486. 2s, 10d. The directors recommend that £12,000 be placed to credit of depreciation and renewals account, and that a final dividend at the rate of 10½ per cent. for the half-year be declared, making 8½ per cent. for the year. The new stations at Howrah and Ultadangha have been completed and are now supplying electricity.

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—Mr. E. Garcke, in moving the adoption of the directors' report at the meeting last week, said that during the past year an important change had taken place in the position so far as the mileage of tramways worked by the company was concerned. Out of the 33 miles which they were working at the beginning of the year, they had parted with 14½ miles. Of those they were working 10½ miles under leases and 4½ miles were owned by the company and had been sold to the local authorities. They were still working about 19 miles, including 6 miles in Aston, 5 miles leased to them by Birmingham Corporation, 3 miles leased by authorities outside Birmingham and 5 miles outside the city which were still owned by the company. The 8 miles leased they held until 1911, and these were very profitable lines to operate. In addition to giving up the leases of the tramways referred to, they had made various sales of properties during the past year. Among the tramways sold were the Balsall Heath, King's Norton and Handsworth lines, the various properties sold realising £74,755. They had about £400,000 available at present for the repayment of debentures and capital. Debentures amounted to £300,000 and carried 4 per cent. interest. The money available and at present invested and to some extent deposited with the trustees for the debenture-holders was not producing as much as they were paying as interest. They were unable to pay off the debentures until 1917 unless the company was wound up. The directors had, therefore, thought it wise to consider whether it was practicable to wind up and make some arrangement for dealing with the leases and the remaining assets of the company. However, he asked the shareholders to leave the matter in abeyance for the present.

CRAIGPARK ELECTRIC CABLE CO. (LTD.)—The net profit for the year ended March 31 was £6,443. 5s. 3d. The directors recommend a dividend of 6 per cent. on the ordinary shares for the year. The cable department shows a satisfactory increase, and, although prices of raw materials continue high, the directors, in view of an increasing volume of trade, look forward with confidence to the future.

EASTERN TELEGRAPH CO. (LTD.)—Subject to final audit, the accounts for the nine months ended Dec. 31, 1906, show that, after making a contribution to general reserve, payment of interest on the 4 per cent. mortgage debenture stock, dividend on the 3½ per cent. preference stock and two interim dividends of £1. 5s. per cent. each on the ordinary stock to Sept. 30, there is a balance available out of which the directors recommend the payment of a final dividend of £1. 5s. per cent. and a bonus of £2 per cent. (both tax free and payable on the 15th inst.), making, with previous payments on account, a total distribution of 5¾ per cent. on the ordinary stock for the nine months ended Dec. 31, 1906. The transfer books of the ordinary stock will be closed from the 6th to the 14th inst. inclusive.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—Subject to confirmation by the shareholders, the directors have declared a dividend for the quarter ended December 31 last of 2s. 6d. per share, together with a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year 1906. The dividend and bonus will be paid on 16th inst., and the share register will be closed from 8th to 15th inst. inclusive.

WM. GRIFFITHS & CO. (LTD.)—At the meeting last week the chairman (Mr. A. Cotterell Tupp) said that the hopeful aspect of their position was that public works could not be postponed indefinitely. Whatever the financial position of the municipalities might be, roads must be repaired and maintained, new communications must be established, tramways and light railways must be constructed as trade and population increased; and when that turn in the affairs of county and borough councils took place he thought they should get their share of the business which would result from it, as they had done in the past. He believed that their worst time was past, and that they were fairly on the way to a more prosperous career.

LYMINGTON ELECTRIC LIGHT & POWER CO. (LTD.)—At the meeting last week the chairman (Mr. Keppel Pulteney) said that only £500 had been expended during 1906 on capital account, against £1,500 in the previous year. The gross receipts had been increased by nearly £300; there had been an increase in the annual expenses, due to considerable cost for maintenance and repairs. There was a large increase in the amount of current sold, but the cost of fuel was less. The net profit was £1,565, and the directors proposed to pay a dividend of 2 per cent. on the ordinary shares.

READING ELECTRIC SUPPLY CO. (LTD.)—At the meeting on Monday the diretors reported that the capital expenditure amounted on Dec. 31, 1906, to £159,109, and the capital was £144,000, all of which is paid up. The total revenue for 1906 was £14,529, and the expenses were £9,401, leaving a profit of £5,127. A dividend of 4 per cent. (tax free) on the ordinary shares for the year was declared. The reduction of the charge for electrical energy, which came into operation at the beginning of 1906, represented a concession to the consumers of over £2,500, and accounted for the decrease in revenue. During the year there was a net increase in lamp connections of the equivalent of 7,687 8 c.p. lamps, bringing the total connections to the equivalent of 99,033 8 c.p. lamps, including 1,299 H.P. in motors.

SWANSEA IMPROVEMENTS & TRAMWAYS CO.—For the half-year ended Dec. 31 the gross receipts of the tramways department were £25,076, increase £1,897; expenses £19,227, increase £798. The expenses include interest and sum payable to Swansea Corporation in respect of the leased tramways and light railways. Net profit is £5,848, added to £2,700 brought forward. A dividend of 2½ per cent. is declared on the ordinary shares. A modification of the agreement with the British Electric Traction Co. with regard to the lease of the Mumbles Railway and Pier undertaking has been arranged.

URBAN ELECTRIC SUPPLY CO. (LTD.)—The profits for 1906 amount to £33,124. 15s. 7d. Deducting London expenses (£1,695. 10s. 9d.) and interest (£9,000), there remains £22,439. 7s. 7d. The 5 per cent. guaranteed dividends require £32,500, and the sum required for this purpose in excess of the balance of profit (£10,060. 12s. 5d.) has been provided by Edmundsons' Electricity Corpn. under their contract. At the end of the year the equivalent of 349,640 8 c.p. was connected to the mains of the 13 electricity undertakings owned by the company, against 395,331 8 c.p. in 1905 and 215,376 in 1904.

NEW COMPANIES.

"CERTUS" GEARLESS CO. (LTD.) (93,097).—Reg. April 25, capital £500 in £1 shares, to adopt an agreement with E. H. J. C. Gillette, to acquire and exploit the invention or inventions referred to therein, and to carry on the business of mechanical, electrical, gas and water engineers, makers of electric tramcars, motor cars, mechanical, electrical and other engines, &c. First directors, C. J. Potter, H. Welsh-Lee and Edward H. J. C. Gillette. Reg. office, Inverness Works, Staines-road, Hounslow.

SHIELDS CONSTRUCTION SYND. (LTD.) (93,132).—Reg. April 26, capital £5,000 in 4,500 ordinary shares of £1 each and 20,000 deferred shares of 6d. each, to undertake construction and equipment of light railway, tube railway or tramway, to acquire any order or Act of Parliament relating to the same, to enter into any agreements for acquisition of concessions or licences for the establishment of railways or tramways, the installation of electric lighting or the accumulation, distribution and supply of motive power, and to carry on business as electricians, engineers, contractors, manufacturers of and dealers in engines, accumulators, dynamos, motors, rolling stock and machinery, suppliers of electricity, &c. First directors, E. Anderson, H. J. Silverlock and Lieut.-Col. Hon. F. L. L. Colborne. Reg. office, 62, London Wall, London, E.C.

W. R. SYKES INTERLOCKING SIGNAL CO. (LTD.) (93,078).—Reg. April 24, capital £50,000 in 10s. shares, to adopt an agreement for the acquisition of the undertaking of a company of the same name (incorporated in 189g), and to carry on the business of signal manufacturers, telephone, telegraph and electrical and mechanical power owners and workers, constructors of cables, mains, lines, stations, exchanges, accumulators, lamps, meters and engines, &c. Reg. office, 26, Voltaire-road, Clapham, London, S.W.

CITY NOTES.

MEMORANDA (May 2).—Bank rate 4 per cent. (since April 25, 1907) Price of silver 30 1/16—30 3/16d. per oz. Consols 84¾—85 for money, 85⅛—85¼ for account; 2½ per cent. annuities 83⅞—84. Consols Pay Day, May 3; Stocks and Shares Continuation Days, May 13 and 28, Ticket Days, May 14 and 29; Pay Days, May 15 and 30; Mining Share Carry-over Day, May 10.

BRITISH ALUMINIUM CO. (LTD.)—Subject to audit, the profit made last year was £155,023, against £93,296 in 1905. The directors recommend a dividend of 7 per cent. on the ordinary shares for the year.

CITY OF BUENOS AYRES TRAMWAYS CO. (1904) (LTD.)—A dividend of 1s. 3d. per share, less tax, has been declared for the quarter ended March 31.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed May 3 a special settling day in, and have granted a quotation to, script (fully and partly paid) for £300,000 4½ per cent. perpetual consolidated debenture stock of the *British Columbia Electric Railway Co. (Ltd.)*. A quotation has also been granted to a further issue of 50,000 £5 fully-paid ordinary shares of the *Anglo-Argentine Tramways Co. (Ltd.)*. The committee have been asked to allow a further issue of £152,237 4½ per cent. first debenture stock of the *Birmingham & Midland Tramways (Ltd.)* to be quoted.

WEST AFRICAN TELEGRAPH CO. (LTD.)—A final dividend of 4s. per share has been declared, making 4 per cent. for the year 1906.

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The directors recommend a dividend of 8s. per share on the first preference shares (being 2s. balance of arrears and 6s. dividend for six months to Dec. 31, 1906).

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (*a*)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (*a*)
		£	£		£	£
Aberdeen Corporation	April 24	1,156	- 82	47	64,728	+ 1,751
Airdrie	,, 19	224	...	15	3,373	- 4
Anglo-Argentine	,, 29	17,008	+ 2,107	17	278,230	+ 23,610
Ashton-under-Lyne Corp	,, 27	349	+ 55	5	1,956	+ 269
Ayr Corporation	,, 27	212	- 63	50	14,085	- 84
Baker St. & Waterloo Ry.	,, 27	2,470	+ 1,066	7	16,085	+ 5,610
Barnsley	,, 19	149	- 82	15	2,414	- 89
Barrow	,, 19	213	- 84	15	3,359	- 28
Bath Electric Trams, Ltd.	,, 24	703	+ 19	17	11,490	- 127
Birkenhead Corporation	,, 28	973	+ 25	...	...	...
Birmingham Corporation	...	...	...	...	...	...
Birmingham & Mid.	,, 12	704	...	14	10,854	...
Blackburn Corporation	,, 24	971	+ 130	‖1	5,162	+ 407
Blackpool Corporation	,, 25	448	- 46	4	2,680	- 916
Blackpool and Fleetwood	,, 27	289	+ 8	4	1,890	- 231
Bolton Corporation	,, 28	2,068	+ 234	4	8,357	- 613
Bournemouth Corporation	,, 24	1,589	+ 25	¶3	6,070	- 260
Bradford Corporation	,, 27	4,310	+ 357	4	18,063	- 91
Brighton Corporation	,, 28	798	+ 7	4	3,389	- 414
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 27	4,682	+ 149	11	51,731	- 349
Buenos Ayres & Belgrano	,, 21	3,911	+ 314	16	56,137	+ 4,091
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 27	1,158	+ 96	4	3,430	- 266
Burton Corporation	,, 28	260	- 13	4	1,091	- 142
Bury Corporation	,, 21	899	...	3	2,875	...
Calcutta Tramways Co.	,, 27	R15,750	+ R3,832	17	R264,639	+ R3,832
Camborne-Redruth	,, 27	106	+ 9	17	1,845	+ 10
Cardiff Corporation	,, 20	1,908	- 402	4	7,992	- 93
	,, 27	1,871	+ 87			
Cavehill	,, 19	65	- 234	15	1,078	+ 17
Central London Railway	,, 27	5,860	- 801	17	105,451	- 10,540
Chatham & Dist. Lt. Rys.	,, 25	638	+ 79	¶16	10,749	+ 773
City & South London Rly.	,, 28	2,825	+ 65	17	50,240	+ 619
City of Birmingham	,, 19	2,541	...	15	41,024	...
Colchester Corporation	,, 21	174	+ 3	...	...	...
Cork Electric Trams Co.	,, 25	462	+ 30	17	6,924	- 166
Croydon Corporation	,, 26	1,309	+ 21	‡4	5,227	- 547
Devonport & Dist. Trams	,, 19	431	- 93	15	6,691	+ 99
Dover Corporation	,, 27	191	+ 4	4	852	- 105
Dublin & Lucan Railway	,, 26	112	+ 7	17	1,637	- 21
Dublin United	,, 26	5,276	+ 458	†17	79,299	+ 2,562
Dudley Stourbridge	,, 19	742	- 638	15	12,170	- 191
Dundee Corporation	,, 24	1,099	+ 55	57	53,615	+ 7,159
East Ham Council	,, 27	817	+ 13	4	3,466	- 270
Exeter Corporation	,, 26	311	+ 68	‡4	1,205	+ 78
Falkirk and District	,, 21	259	...	4	1,180	...
Gateshead & Dist. Trams	,, 19	939	- 132	15	24,906	+ 414
Glasgow Corporation	,, 27	19,081	+ 3,011	47	800,838	+ 64,611
Glossop	,, 27	127	+ 11	17	2,158	+ 57
Gravesend—Northfleet	,, 19	222	- 124	15	3,363	+ 84
Great Northern & City Rly.	,, 27	1,784	+ 1	17	31,302	- 17
Gt. Northern, Piccadilly, &c.	,, 27	3,975	...	17	64,384	...
Greenock & Port Glasgow	,, 19	631	- 26	15	9,320	+ 90
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 19	262	- 96	15	3,857	- 260
Hastings Elec. Trams Co.	,, 25	927	+ 279	17	13,938	...
Hong Kong	,, 27	$6,646	+ $633	4	$29,431	+ $3,621
Huddersfield	,, 27	1,441	+ 128	4	6,302	+ 264
Hull Corporation	,, 27	2,215	+ 179	4	9,013	+ 53
Ilford District Council	,, 27	423	- 2	4	1,830	- 179
Ilkeston District Council	,, 24	117	+ 17	4	557	+ 78
Ipswich Corporation	,, 27	343	+ 15	4	1,464	- 141
Isle of Thanet Co.	,, 27	355	- 24	30	8,647	+ 172
Jarrow	,, 19	114	...	15	1,671	...
Keighley Corporation	,, 25	147	+ 25	43	6,455	+ 497
Kidderminster & District	,, 19	92	- 115	15	1,470	+ 75
Kilmarnock Corporation	,, 27	144	+ 1	50	7,839	+ 113
Lanarkshire Trams Co.	,, 25	1,253	+ 263	17	17,525	+ 3,357
Lancashire United	,, 21	1,979	+ 364	§17	18,835	+ 5,075
Leamington	,, 19	126	- 137	15	2,131	- 105
Leeds Corporation	,, 27	6,089	+ 642	4	25,096	+ 1,514
Leicester Corporation	,, 27	2,023	+ 34	17	35,449	+ 172
Leith Corporation	,, 27	483	+ 26	†50	25,180	+ 6,708
Liverpool Overhead Rly.	,, 28	1,465	+ 92	17	23,728	+ 16
Liverpool Corporation	,, 20	10,256	- 1,109	16	165,753	+ 1,987
*London County Council	,, 20	28,996	- 2	3	86,416	+ 6,282
London United	,, 26	5,476	- 75	†17	91,157	+ 2,206
Lowestoft	,, 27	133	+ 20	30	4,583	+ 587
Maidstone Corporation	,, 27	96	+ 9	4	418	- 19
Manchester Corporation	,, 27	13,665	+ 1,667	4	54,426	+ 3,994
Mersey Railway	...	...	...	...	...	...
Merthyr	,, 19	187	- 97	15	3,083	+ 185
Metropolitan Dist. Railway	,, 28	7,635	- 68	17	132,956	- 2,508
Metropolitan Elec. Trams	,, 19	4,152	- 617	15	60,994	+ 13,788
Middleton	,, 19	300	- 305	15	4,884	+ 38
Nelson Corporation	,, 27	128	+ 6	...	...	...
Newcastle-on-Tyne Corp.	,, 27	3,894	+ 299	4	15,944	- 101
Newport (Mon.)	,, 25	603	+ 78	4	2,602	+ 99
Northampton Corporation	,, 26	378	+ 9	‡4	1,576	- 71
Oldham, Ashton & Hyde	,, 28	553	- 231	15	8,893	+ 540
Oldham Corporation	,, 28	1,803	+ 295	5	9,778	+ 996
Perth (N.B.) Corporation	,, 24	128	- 9	49	7,565	...
Perth (W.A.) Elec. Trams	,, 26	1,388	- 35	17	25,141	- 275
Peterborough	,, 19	102	- 102	15	1,885	+ 8
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 27	1,661	+ 116	4	7,375	- 427
Potteries	,, 19	1,854	- 129	15	27,819	+ 238
Preston Corporation	,, 24	657	+ 19	4	2,959	+ 100
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 25	552	+ 147	‡4	2,084	+ 232
Rothesay	,, 19	127	- 206	15	1,280	+ 74
Salford Corporation	,, 29	4,322	+ 402	4	18,555	- 190
Sheerness	,, 17	52	- 36	15	853	- 17
Sheffield Corporation	,, 28	5,414	+ 717	5	26,780	+ 1,158
Singapore Trams	,, 27	$9,591	+ $2,457	4	$40,533	+ $7,913
Southampton	...	...	...	...	...	...
Southend Corporation	,, 24	269	- 2	4	1,138	- 127
Southport Tramways	,, 19	233	- 290	15	3,608	- 374

(*a*) These comparisons are with the corresponding period last year. * Plus 3 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (*a*)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (*a*)
		£	£		£	£
South Metropolitan	April 19	673	...	15	10,675	...
South Staffs	,, 18	824	- 309	15	23,265	+ 899
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 27	696	+ 100	4	3,010	- 43
Sunderland Corporation	,, 28	1,279	+ 97	4	5,290	- 227
Sunderland and District	,, 24	107	+ 89	17	6,867	+ 767
Swansea Trams	,, 19	795	- 258	15	12,214	+ 335
Swindon Corporation	,, 17	156	- 117	4	698	- 107
	,, 21	142	- 21			
Taunton	,, 19	39	- 17	15	606	- 48
Tynemouth and District	,, 19	161	- 209	15	2,548	- 306
Tyneside Trams Co.	,, 24	406	+ 67	17	6,788	+ 557
Victoria, Elec. Supply Co. of	March 24	890	- 86	...	...	...
Wallasey District Council	April 27	736	+ 17	4	3,112	+ 7
Walsall Corporation	,, 27	418	- 27	17	7,851	- 416
Warrington Corporation	,, 25	365	+ 36	4	1,514	+ 58
West Ham Corporation	,, 25	2,144	+ 190	4	9,657	+ 365
Weston-super-Mare	,, 17	55	- 149	15	651	- 5
Wolverhampton Co.	,, 19	370	- 305	15	6,363	+ 45
Wolverhampton Corpn.	,, 24	774	+ 60	15	12,581	...
*Worcester	,, 19	238	- 150	15	3,732	+ 105
Wrexham	,, 19	112	- 12	15	1,477	- 35
Yorkshire W.R. Trams	,, 26	1,122	+ 403	17	18,140	...
Yorkshire Woollen District	,, 19	877	- 389	15	14,020	+ 807

(*a*) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre	Last Divi-den	Name.	Price Tues., April 30.	Rate % Yield-ed.	Divi-dend Due.	Business 6 Days to April 30. High-est.	Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
£5	4/0	Anglo-Argentine Ord. Shares	7¼—7⅝	5 6 6	Ap, Oct	7⅞	7¼
£5	2/9	Do. 5½ per Cent. Cum Pref.	5¾—6	4 12 0	..	5¹³⁄₁₆	5¾
St.	6¼	Do. Permanent 6% Deb. Stock	132 —135	4 9 0	..	..	..
St.	5	Auckland Elec. Trams. 5% Deb. (red.)	101 —107	4 13 6	..	..	..
£	..	Brisbane Electric Trams, Invest. Ord.	2½—3	..	..	2¹¹⁄₁₆	2⅝
5	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5¼	4 18 9	..	..	..
St	4½%	Do. 4½ per Cent. Db. Prov. Certs.	93 —102	4 8 0	..	..	..
St.	6%	†British Columbia El. Ry. Df. Ord.	123 —127	4 14 3	..	125	..
St.	7%	Do. Pref. Ord. Stock	106 —111	4 10 0	..	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	102 —1 6	4 14 3	..	104½	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs	99 —101½	4 9 0	..	..	..
100	4½%	Do. Vancouver Power Debs.	102½—1 4½	4 6 0	..	..	..
£5	3/0	Buenos Ayres & Belgrano Ord.	3⅝—8⅝	3 17 6	..	8⅝	3⅛
£5	3/0	Do. 6 per Cent. "A" Cum. Pref	5 —5½	5 9 0	..	5³⁄₁₆	5³⁄₁₆
£5	3/0	Do. "B"	4⅝—5⅝	5 11 6	..	..	..
St.	5	Do. 5 per Cent. Debs.	101 —106	4 14 3	..	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	..	..	..
St.	5	Buenos Ayres Elec. Trams. (1901) Ltd.	98 —101	4 19 0	..	..	..
10	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	100 —104	5 5 9	..	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	105 —105	5 14 0	..	..	..
£5	4 6	†Calcutta Tramways (1 to 137,610)	7⅜—8¼	3 0 6	..	7⅞	..
100	2/6	Do. 5 per Cent. Cum. Pref.	6½—5⅞	4 7 0	..	..	..
1	4½	Do. 4½% 1st Deb. Stock (red.)	105 —108	4 3 3	..	..	..
St.	..	Cape Electric Tram Shares	1/16—1/8	..	..	..	..
..	5%	†Colombo Tr. & Ltg. 5% 1st Mt. Db	96 —100	5 0 0	..	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1.000 50 year Coup. Bds.	85 —90%	5 11 0	..	..	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 —95	5 5 0	..	..	..
£5	6%	Do. 6 per Cent. "B" Ditto	80 — 84	7 2 6	..	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 1/16—1 1/8	3 9 6	..	..	..
100	0/7	Do. 6 per Cent. Cum. Pref.	1 1/16—1 1/8	5 1 0	..	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb	98 —101	4 19 0	..	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	98 —101	4 19 0	Ja, Jul	..	..
St	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 —104	4 6 6	..	..	..
St	4	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	..	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	125 —130	3 1 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	95%—97%	5 3 0	..	..	..
		ELECTRICITY SUPPLY.					
£5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½—5½	5 11 0	..	..	..
10	3/1½	Bombay E. S. & T. 6 Cm. Pf. £8 pd.	7⅜—8½	6 0 0	..	8⅛	..
St.	4½	Do. 4½ per Cent. Deb. Stk. (red.)	97 —100	4 10 0	..	97½	..
£5	3/3	Calcutta Elec. Supply Ord.	7¾ 8¼	4 17 0	..	..	..
£5	0/8	Do. £4 paid	6½—7½	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	..	..	..
..	5%	Cordoba Lt. & Power Co. 1st Mort. Stock £100,000 5 per Cent. Bds.	90 92	5 9 0	..	..	..
£5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¾—2¾	..	..	3	..
St.	5	Do. 5 per Cent. Deb Stock	88 —92	5 8 6	..	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	93 — 98	5 2 0	..	..	..
St	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	196 —199	5 10 0	..	..	..
1	0 7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent Cum. Pref.	⅞—⅞	..	..	..	..
St.	5	Madras E. S. Corp 5 per Cent. Consln. Deb. St.	94½—97½	5 2 6	..	..	..
1	1 6	Rand Electric	1 —1⅛	..	..	..	..
1	..	River Plate Electricity Co. Ord.	⅝—¾	..	..	11	..
1	1 2	Do. 6 per Cent. non-Cum. Pref.	⅝ ⅞	6 0 0	..	..	..
St	5%	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	..	..	..
£5	3 0	Rosario Elec. Co. 6 Pref. (£20,000)	5 —5½	5 9 6	..	..	..
100	4½	Royal Elec. Montreal 4½ per Cent. 1st Mort. Deb.	95 —99	4 11 0	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	98 100½	5 0 0	..	..	..

In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Tues., April 30.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS 6 DAYS TO APRIL 30. Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	9⅜ 10⅛	6 16 6	..	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅛ -10	4 10 0	..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1⅛ -10⅜	5 11 8	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	101 -104	4 6 6	..	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ -5½	5 5 0	..	..	..
St.	4½%	† Do. Do. 1st Debs.	97 -99	4 11 0	..	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅜ -7¾	5 14 6	..	..	..
5	3/6	Do. 7 per Cent. Pref.	7 -8	4 7 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co 4% Guar. Db. Stock	100 -103	3 17 6	..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4⅜ - 4¾	5 13 0	Feb, Aug	4⅜	..
5	2/3	Do 4½ per Cent. Pref.	4 -4⅛	5 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 - 99	4 1 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ -4¼	5 9 0	..	..	..
5	2/3	Chelsea Electric Supply Ord.	3⅛ -4¼	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 -107	4 4 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord..	9⅜ -10⅜	5 17 0	Feb, Aug	10⅜	10
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅜ -12¼	4 16 0	Jan, July	12⅜	12
St.	5%	* Do. 5 per Cent. Deb. Stock (red.),.....	121 -124	4 0 9	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 -100	4 10 0	..	..	..
5	5%	County of Durham Elec. P.D. Ord.....	4¼ -4⅜	4 7 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ -5	5 4 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	8 -8⅛	5 17 6	..	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10⅛ -11⅛	5 4 0	Mar, Sept	10⅜	..
St.	4½%	Do. 4½ c Deb. Stock (all paid) (red.)...	1 6 -1 9	4 2 6	..	..	..
St.	4½%	† Do. Second Deb. Stock Prov. Certs....	95 -98	4 12 0	..	..	..
5	3/6	Folkestone Electricity Supply Co. Ord	4⅜ -5⅜	5 2 0	..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 -5¼	4 11 0	..	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).	97 -100	4 10 0	..	..	..
5	5/0	Hove Electric Lighting Ord.	7 -7½	6 0 0	..	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ 9⅛	5 5 0	..	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜ -7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	97 -100	4 0 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	93 -100	4 0 0	..	..	..
3	2 4½	London Electric Supply Ord.	1⅞ -2⅛	5 13 0	..	..	..
5	3 0	Do. 6 per Cent. Pref.	4¾ -5⅛	5 14 9	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	95 - 98	4 2 0	Mr, Jn, S, D	..	..
5	4/0	Metropolitan Electric Sup. Ord.	6¼ 6⅜	5 18 6	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 -5⅛	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 06 -109	4 2 9	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	91 -91	3 14 6	..	89	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 -98⅞	4 12 0	..	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅝ -9⅜	5 8 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	99½ -100⅜	4 10 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7⅜ -7⅝	5 8 1	Feb, Aug	..	..
5	6%	Do. 5 per Cent. non Cum. Pref.	6⅜ -6⅝	4 7 9	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 -100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 -1⅛	2 16 6	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 -101	4 10 0	Jan, July	..	..
10	9/0	Notting Hill Electric Ord.....	12 -13	5 15 0	March ..	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	96 -99	4 1 0	..	..	..
5	4/6	Oxford Electric Ord.	5⅞ -6⅛	5 12 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 - 98	4 1 6	..	..	..
5	5/0	St. James' & Pall Mall Elec. Ord	8 -8⅛	5 17 6	Feb, Aug	8 1/16	7⅞
5	3/6	Do. 7 per Cent. Pref.	6⅞ -7⅛	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	93 -95	3 13 9	..	..	..
5	-	Smithfield Markets Electric Sup. Ord...	1⅛ -2⅛	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 -77	5 4 0	..	..	..
5	3/0	South London Electric Supply Ord.....	2⅛ 2⅜	6 8 0	..	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅞ -1	3 6 9	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1⅛ -1⅜	4 15 0	..	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	101 -103	4 7 6	..	..	..
5	2/6	Urban Electric Supply Ord.	2 -3	3 6 0	..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	3 -4	6 5 0	..	3	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	95 - 98	4 12 0	..	96	95
5	6/6	Westminster Elec. Sup. Ord.	9⅛ 9⅜	6 8 0	Mar, Sept	9 11/16	9 7/16
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛ -5⅜	3 13 3	..	5 5/16	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 -95	4 4 0	..	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	25/32 -27/32	5 8 0	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	¾ 1	5 0 0	..	7/8	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	95 -100	4 10 0	..	97¼	95
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 - 99	4 11 0	..	96¼	..
10	9½%	Bristol Tramways & Carriage Ord.	14¼ -14¾	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 -9¼	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 -102	3 17 6	Feb, Aug	..	..
10	6/0	British Electric Traction Ord.....	2¼ -3	10 0 0	..	3	2⅜
10	6/0	Do. 6 per Cent. Cum. Pref.....	6⅜ 7	8 11 6	Feb, Aug	6⅞	6¾
St.	5%	Do. 5 per Cent. Perpetual Debs.	101 - 105	4 15 0	..	..	..
St.	4½%	† Do. 4½ per Cent. 2nd Deb. Stock	79 -82	5 9 6	..	..	..
St.	4%	Central London Ordinary Stock.....	75 -77	5 4 0	June, Dec	75¼	..
St.	4%	Do. 4 per Cent. Pref. Stock	92 - 94	4 5 0	..	93½	..
St.	4%	Do. Deferred Stock	57 -60	6 13 0	..	..	..
100	4%	Do. 4 per Cent. Debs.	103 -106	3 15 6	..	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db Stk.	82 -86	4 13 0	..	84¾	..
5	2/6	† City of Birmingham Trams. 5% Cm. Pref.	4⅜ 5⅛	4 19 0	..	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 -1 1	3 19 0	..	..	..
St.	2%	City & South London Rly. Cun. Ord. ..	41 -43	4 19 0	Feb, Aug	42⅞	42 7/16
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	119 -123	4 2 0	Feb, Aug	120	..
St.	5%	Do. (1896)	115 -118	4 4 9	..	116	..
St.	5%	Do. (1901)	115 -119	4 4 9	..	..	..
St.	4%	† Do. 4 per Cent. Perpetual Debs.	102 -105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	14½ -15½	8 18 6	..	13½	..
10	6/0	Do. 6 per Cent Pref.....	13¾ -14¾	6 2 9	..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2¾ -3	..	..	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 -7	5 14 0	..	6½	6
St.	4%	Do. 4 per Cent. Deb. Stock	85 -88	4 11 0	..	85½	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	93 -101	4 0 0	..	99½	..
10	9%	‡ Imperial Tramways Ord.....	12 -13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 -11½	5 6 6	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	100 -102	4 8 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 -2	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	70 -75	5 6 6	..	..	..
St.	47/6	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 -98	..	..	..	..
10	..	Liverpool Overhead Railway Ord.	1⅜ -1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 -7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 -90	4 9 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜ -8⅜	5 14 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 -89	4 10 0	..	89 1/16	..
St.	..	Mersey Con. Ord. Stock	3 -5	—	..	..	..
St.	..	Do. 3 per Cent. Perp Pref.	7 -10	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	1/16 -3/16	..	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3/4 -13/16	5 3 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 - 99	4 11 0	..	97½	96½
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜ -1⅝	..	May	..	..
10	8/0	†Potteries Electric Traction Ord.	3⅜ -6¼	6 8 0	..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 -7⅜	6 13 5	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock	96½ -101½	4 8 6	..	..	..
1	3·56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	1 5/16 -1 7/16	5 16 6	..	..	..
St.	36/3½	Do. 4 per Cent. Deb. Stock	84 - 87	..	..	86	..
100	5%	Sunderland Dist. Elec. Trms. 5 & 1st Mt. Db	88 -93	5 11 0	..	..	..
..	5%	Underground Elec. Rys. Co. of London...	76 - 79	6 6 6	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 -1⅜	—	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3¼ -3⅝	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 -95	4 16 9	..	..	..

SHARE	LAST DIVIDEND	NAME.	Price Tues., April 30.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS 6 DAYS TO APRIL 30. Highest.	Lowest.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	½ -¾	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	11/16 -13/16	7 7 9	..	¾	..
1	0/4½	†Babcock & Wilcox Ord .....xd & bonus	3⅝ -3¾	4 17 0	..	4	3 31/32
1	0/7½	† Do. Pref.....	1⅞ -1 15/16	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅞ -7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅞ 6⅛	4 16 0	Jan, July	6⅛	5 15/16
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 -1 5	4 5 9	..	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 - 96	4 11 3	..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 -1½	..	..	1½	1 13/16
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	65 -69	5 15 0	..	65	..
2	1/0	Brush Electrical Engineering	⅝ -¾	—	March ..	..	..
2	2/1½	Do. 6 per Cent. Pref. non-Cum.	1¼ -1⅝	6 17 0	Mar, Sept	1½	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	80 -92	4 13 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 -78	5 14 6	Jan, July	..	..
5	5 0	Callender's Cable Con. Ord.....	1 1/16 -1 1/8	5 10 0	Jan, July	10 1/16	10 1/16
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ - 5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs (red.)	106 -108	4 3 3	Nov, May	..	..
1	0/8½	Castner-Kellner Alkali Co.	1 1/16 -1 1/8	5 14 0	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 -102	4 8 0	..	..	..
1	0/9½	Chadburn's (Ship) Telegraph Ord.	1 3/16 -1 3/16	7 5 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16 -1 3/16	5 4 0	..	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 54,000).....	1⅞ -2⅛	3 10 3	Jan, July	1⅞	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96⅞ -99⅞	5 1 0	Jan, July	97	..
5	2/0	Dick, Kerr & Co. Ord.	1¾ -1¾	6 13 3	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 3/16 -1 7/32	4 17 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 -104	4 6 6	..	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1¾ -1⅞	9 3 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¾ -2⅞	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	85 -87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 -92	5 8 6	..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	1 -2	10 0 0	H'lf-yearly	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	2⅜ -3½	8 11 6	..	3	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	87 -90	5 0 0	..	..	..
2	..	Electric Construction Co.....	13/16 -15/16	..	July	..	..
2	2/9½	Do. 7 per Cent. Cum. Pref.	1⅞ - 2	7 0 0	July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. (red.)	81 -84	4 15 0	Jan, July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref..	8⅞ - 9⅜	5 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 -96	4 4 0	..	..	..
5	10/0	Henley's Telegraph Works Ord.....	12 -13	5 14 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5⅛ -5⅜	3 18 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 -109	4 2 6	..	107½	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15½ -16½	6 2 6	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 -100	4 0 0	..	..	..
10	5/0	Mather & Platt 5 per Cent. Cum. Pref...	11¼ -11⅝	4 5 0	Mar, Sept	..	..
1	1/2½	Richardsons, Westgarth & Co., Ltd. Ord.	⅜ -⅝	7 6 0	..	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	13/16 -1	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 -100	4 10 0	..	97½	97
		Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	3 ½ -31½	5 15 0	Mar, July	31	30
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100 -103	3 17 6	Jan, July	..	—
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅞ -2⅝	5 17 3	..	2½	2 7/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜ -1⅝	4 1 0	..	1 3/32	1 1/16
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 -117	4 5 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	103 -105	3 16 0	..	104½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 -107	4 4 0	..	105¾	..
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½ -10	5 0 0	..	..	..
£	..	Willans & Robinson Ord.	1¼ -1⅝	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅞ -4⅛	..	Apr, Oct	4	..
100	4¼	Do. 4 per Cent. 1st Mort. Debs.....	79 -83	4 16 6	May, Nov	79½	79¼
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 -3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 -91	5 10 0	..	..	..
St.	15/0	Anglo-American	61 -64	6 1 3	F, My, Ag, N	..	..
St.	30/0	Do. Preferred	106⅜ -107½	5 12 0	F, My, Ag, N	107⅛	106½
St.	13½	Do. Deferred	21⅛ -21⅜	8 2 0	F, My, Ag, N	22⅛	21 1/16
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	93 -95	4 4 0	Jn, Ap, Jy, O	94	..
10	5 0	†Cuba Submarine Ord.....	8 -8½	5 13 0	Feb, Aug	..	..
10	10/0	† Do. Preference 10 per Cent.....	16 -17	5 19 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜ -3⅝	5 10 6	April, Oct	..	..
5	5,0	Do. 10 per Cent. Cum. Pref.	8⅞ - 9⅛	5 8 0	April, Oct	..	..
5	4½%	Do. 4½ per Cent. Deb.....	98% -101%	4 9 0	Jan, July	..	..
20	4/0	†Direct United States Cable	15¼ -15½	6 0 0	Ja, Ap, Jy, O	15⅝	15
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 -101	4 9 0	June, Dec	..	..
St	25/0	Eastern Ordinary	139 -141	4 19 9	Ja, Ap, Jy, O	140⅜	138¾
St.	17/6	Do. 3½ per Cent. Pref. Stock	8 -9	3 17 0	Ja, Ap, Jy, O	8 9/16	8 3/16
St.	4%	† Do. 4 per Cent. Mort. Deb. Stk. (red.)	101½ -100⅜	3 15 0	May, Nov	104⅜	..
10	2/6	Eastern Extension	13½ - 13⅝	5 2 6	Ja, Ap, Jy, O	13⅝	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock	105 -107	3 14 9	Feb, Aug	106½	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 -101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	101¾ -102¾	3 18 6	May, Nov	..	..
10	5 0	G.N. (of Copenhagen), with Coupon 69	85 -87	6 11 0	Jan, July	36⅜	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 -101	4 9 0	June, Dec	..	..
25	12/6	Indo-European.....	5⅝ - 6⅛	5 7 6	May, Nov	..	..
100	4%	Mackay Companies Common	70⅞ -72½	5 10 0	Jan, July	..	..
100	4%	Do. Preference	71 1/16 -72	5 11 6	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg Co.	⅞ -1	—	..	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99¼ -100⅜	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 -10½	3 16 0	..	..	..
2½	..	West Coast of America	⅞ -1	..	..	..	..
100	4%	Do. 4 per Cent. Debs.	99 -101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1/16 -1⅛	..	May, Nov	1/16	1/16
10	8/0	Do. 6 per Cent. 1st Pref.	7⅜ -8¼	7 5 6	May, Nov	7⅝	..
10	..	Do. 6 per Cent. 2nd Pref.	6¼ -7¼	..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	103 -103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅜ -14	5 0 0	Mr, Jn, O, D	13 1/16	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 -105	3 16 0	..	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 -94	4 5 0	..	94	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 -101	4 19 0	..	..	..
5	3 0	Chili Telephone	6⅜ -7½	5 11 0	August ..	..	..
1	0/4½	†Monte Video Telephone Ord.	1/16 -1 1/16	4 14 0	..	..	..
1	0/6	† Do. 5 per Cent. Pref.	⅞ -1	5 0 0	..	..	..
St.	6%	National Co. Pref. Stock	108 -110	5 9 0	..	1 9½	108⅜
St.	5½%	Do. Def. Stock.....	101½ -106½	5 3 0	..	1 6⅜	104⅜
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11⅜ -13⅜	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 -12	5 0 0	Feb, Aug	11	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅜ -6⅜	4 9 0	Feb, Aug	6⅛	5⅞
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	96 -98	3 12 0	June, Dec	96½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 - 102	3 18 0	..	..	..
1	0/9⅜	†Oriental	1 5/16 -1 7/16	4 17 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1¼ -1⅜	4 16 0	..	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 -98	4 2 0	..	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 -102	4 7 0	..	..	..
5	3/0	United River Plate.....	6⅜ -7½	5 9 6	July	7	6⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5 -5½	4 15 0	June, Dec	5⅝	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	100 -102	4 9 3	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	4 -5	6 0 0	..	..	..
10	2 0	Globe Telegraph & Trust.....	10½ -10⅝	5 0 6	Ja, Ap, Jy, O	10 1/16	..
10	3/0	Do. 6 per Cent. Pref.....	13⅜ -14½	4 4 0	Ja, Ap, Jy, O	13 1/16	..
10	6%	Submarine Cables Trust (Cert.).....	125 -128	4 13 9	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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Electrician No. 1511. Ind. Suppt. No. 9.] MAY 3, 1907. [Gratis to Subscribers.

Electric Power and Ventilation.

IF air is the life of the body, ventilation is the life of the air. Civilization has herded humanity so closely together, whether in the domain of commerce or the regions of industry, that, without adequate methods of ventilation, languor and depression are set up. London's tube railways have been suggested as avenues by which to convey fresh air from the suburbs to the city, and although nothing has been done directly to accomplish this end the idea is feasible enough and not beyond the bounds of realization on grounds of cost. Much as so vast an area as that of London requires fresh air, so also, but in an intenser degree, do the multitudinous buildings within its borders require adequate ventilation. Both in the office and in the home constant change of the air we breath should be assured either by methods of induced natural draught or by mechanical means where the circumstances require it.

It is in the great field of industrial effort and enterprise that the science of mechanical ventilation has advanced most rapidly. Manufacturers employing hundreds and thousands of hands have found themselves faced with a serious problem in the provision of ventilation for work-rooms and shops. Although they may have erected fine buildings, well lighted and efficiently equipped and driven, questions of ventilation and of equable temperature, both in summer and winter, require satisfactory answer. Again, certain industrial processes give rise to noxious fumes, or the dissemination of minute metal or chemical particles, which, unless at once removed, would primarily affect the employees and subsequently undermine their health and vigour.

There is a humanitarian side to industry which is now finding expression in care and foresight for employees. The conditions under which manufactures of certain kinds are conducted are now above reproach. Many manufacturers have, moreover, set a high standard of comfort to which the particular manufacturer can point in selling his goods. Gradually the heights originally attained have been passed. It has even become a matter of competition and keen rivalry, this "welfare work" as it is termed in the United States. The salesman makes a "point" of the fact that his firm looks after its workmen, and has spared no expense to give them the purest possible atmosphere to work in.

Now this great movement, for it truthfully can be designated as such, affords but another example of the advantages conferred by electric power in the realization of industrial ideals. The electric motor has done wonders for the advance of the science of ventilation. Neither steam, nor gas, nor oil power in their direct application to the solution of the problem of a compact power ventilating unit, could have done a tithe of the work which now stands to the credit of the electric motor. That most desirable of all objects in power ventilation, the direct application of the driving power to the ventilating unit, is only possible of efficient accomplishment with the electric motor. Both for small and large fans it is equally applicable without the need of the belt drive.

Another point: Without the electric motor, makers of ventilating accessories such as air heaters, dryers, humidifiers, &c., would have received no encouragement to proceed with their researches and efforts at the production of improved apparatus. We do not wish to infer that the steam-engine might not have done something towards encouraging the employment of power ventilating apparatus, but it would not have done so much. Its use is hedged round with almost numberless restrictions which only ingenuity and expense can remove. In this issue of the Industrial Supplement we are able to give some details as to the use of the electric motor in this important section of industrial

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VARIABLE SPEED
INDUCTION MOTORS
WITHOUT SLIP-RINGS
THE SANDYCROFT FOUNDRY CO., Ltd.,
CHESTER.

establishments, and the improvements made in the provision for effective heating and cooling of the air of ventilation.

The extension of the application of apparatus exploited originally in industrial centres to State and commercial buildings has followed almost as a matter of course, and here again the electric motor looms largely as the important factor in the case. The use of the electric motor, it may be noted here, is facilitated in both industrial and commercial ventilation. In the first case most manufacturers have an electric power plant and the works distribution circuits answer equally well for the ventilation motor load. In the second case, most large business buildings are connected with the local electric service, either for lighting or power, or for both; and in this case the power needed for ventilation can be readily obtained from the same source. Considered generally from the power standpoint, practical ventilation owes a great deal to the electric motor—more, in fact, than it can ever hope to repay.

The ventilating fan is one of those appliances which the electric motor alone is fitted to drive, efficiently and economically. Steam or gas engines are impossible of application to the same extent as the electric motor. Steam fans, with direct connected engines, are certainly built, but no thinking man would line up his walls with steam pipes and put down a boiler to supply them with power. The water-driven fan is not uncommon in underground lavatories because it can be connected easily and runs from the lavatory supply, but even this is not installed in hotels or business houses, for the electric pattern is obviously more convenient. Again, it must be remembered that there is a large supply of the electric type of fan, which in itself tends to create a demand. When any product is good enough, and sufficiently well appreciated to be made in large quantities its popularity is assured. There are strong indications that this is the case with the electric fan, and a few more hot seasons will establish the hold of the smaller types upon the electricity consumer. The broader matter of ventilation will also be levelled up in favour of electrically driven devices, in both large and small installations. The installation of electric driving in a works, for instance, will be accompanied almost as a matter of course by an electrically-driven ventilating equipment. One will be a complement to the other. This should also be the case with commercial buildings in which electric lifts are now so commonly used.

Cotton Mill Driving.

THERE are two sides to every question, it is generally admitted, and, however enthusiastic the electrical engineer may be on the advantages of electric driving, he must be prepared to hear the views of "the other man." But when those views resolve themselves into misleading statements it is time for the electrical engineer to defend himself. Probably the electric driving of cotton mills is one of the most vexed-of questions to engineers in the textile districts, and it is only natural that attempts should be made to arrest its advance by legitimate means or otherwise. A correspondent of the *Manchester Guardian* recently disputed some figures previously published relating to this particular subject and proceeded to criticise the general efficiency of the electric drive, more particularly from private plants. We give an abstract below of the points he endeavours to make:—

The ordinary manufacturer needs to be reminded that electric driving is, after all, only a method of transmitting energy, and needs in addition to the prime mover a "generator" and a "motor," the two being connected by a wire cable. Taking the efficiency of the electric generator, motor and transmission cable each at 95 per cent., the combined efficiency is about 85 per cent. To this, which represents a loss of 15 per cent., must be added that due to rope, belt or other mechanical connection between the motor and the line shaft or the machine, as well as that between the prime mover (steam or other engine) and the electric generator, unless the latter is mounted on the flywheel shaft (direct coupled). The friction losses of these latter-mentioned transmission gears being roughly proportional to the power transmitted, it will be evident that as much will be lost as in the usual rope, belt or gear drive, and when to this is added the above mentioned 15 per cent. electrical losses, it is further evident that the saving in power will be a minus quantity to the extent of 15 per cent.

Again, it is often asserted as a point in favour of electrical driving that heavy shafts are replaced by small ones; but as light shafting is not generally sufficiently stiff even when large enough in diameter for the power to be transmitted, it is often necessary to increase the diameter, thus making an equal length more wasteful in friction than the usual slow running shaft.

In general there is little or no prospect of reaping any benefit in the direction of a reduction in power by the adoption of the electrical drive; and many advocates therefore show great anxiety to impress upon the reader an asserted advantage in increased output. When, however, it is remembered that the power in the factory is derived from the steam engine it is difficult to see how the electric drive can be steadier than the elastic rope transmission drive would be from the same engine, though the increased output claimed for the electric drive depends on this increased steadiness. There is no doubt that a change of speed in any part of the factory can be most readily effected by a judiciously split-up electrical drive, and any desired part can by its means be easily and gradually accelerated to the utmost speed limit, but as a rule—in cotton factories, for instance, where the speed of the several parts of the plant depends on the feeding ability of each other—there is no advantage in speeding up a part, and all can be easily speeded up at the engine as gradually as with the electrical drive.

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There is undoubtedly an extensive legitimate field for electric transmission of energy, but the great majority of cases in this country can only be properly dealt with by a careful examination and candid weighing of all the circumstances.

Whilst we should discountenance undue haste in the application of electric power to industry, we cannot see that this particular writer has made any case against the electric drive. His figures (which are no figures in reality) omit any reference to the efficiency of the steam and rope drive as compared with the steam-electric combination. The former probably averages about 50 per cent., so that even if the mechanical losses of the individual motors are debited against the electric drive, it still remains the superior of the two transmissions by 5 per cent. The mere statement that the total losses are the same as with rope and shafting transmission fails to carry weight, because it is unsupported by figures. The comparison, moreover, is unfairly made, because it takes no account of all the advantages conferred by electric power as against the disadvantages of steam. Again, to question the regularity and steadiness of the electric drive is to display gross ignorance of the principles of electric power transmission. Such argument as this, carried to its logical conclusion, would throw doubts on hydro-electric overhead transmission of power, and suggest as a substitute the teledynamic plants of decades back.

The writer is evidently unfamiliar with the many industries in which the electric drive has been adopted, not only with complete success, but also with marked economies. Disregarding these, however, and looking beyond the borders of this country to other places in which textile mills are in operation, electric power has been and is being extensively employed, in both new and old mills. Not infrequently British engineers are the technical advisers for these undertakings, and the machinery is supplied from English factories. The same engineers and machinery are identified with English textile schemes. There does not appear to be sufficient difference between British and foreign textile mill practice to warrant the retention of steam driving in the one case and the adoption of electrical operation in the other.

Unfortunately power users wavering between the two methods are deceived by specious arguments of this character, and their doubts of the value of electric power are in certain cases strengthened to the extent of avoiding it altogether.

Special Types of Electric Cranes.

THE purposes served by electric cranes are become so varied that it is difficult to keep pace with the different types employed. At one time overhead travelling, jib and pillar cranes, were the only class in use, but modifications and extensions of these designs have been effected, and many new types have come into vogue. It is significant of the advance of the use of electric power that the bulk of the cranes described in a recent catalogue issued by Appleby's (Ltd.) are fitted with motor equipments. The standard travelling cranes are provided with three motors for travelling, hoisting, and lowering and traverse. A number of special cranes are built by this firm, and some particulars of these will doubtless be of value.

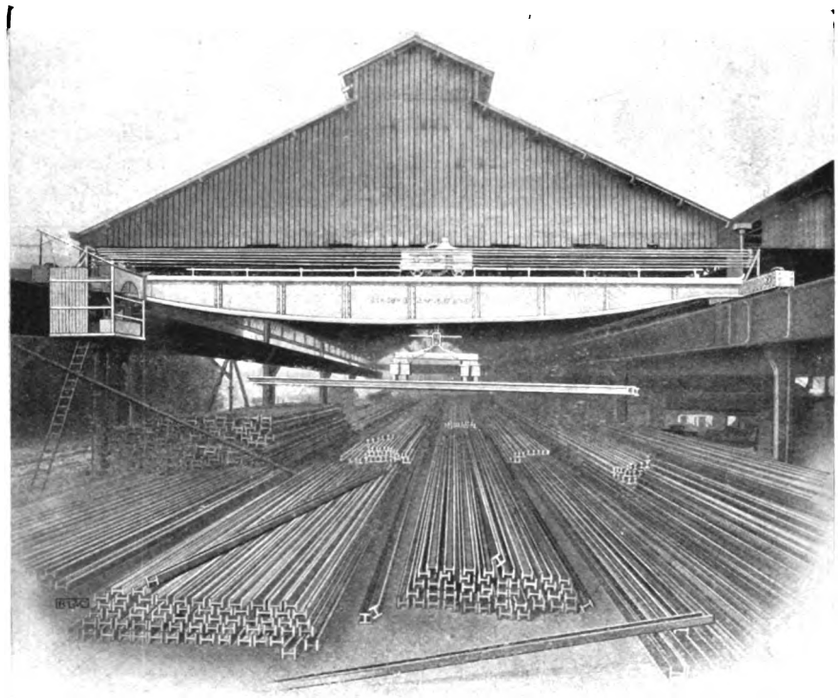

Fig. 2.—Electric Crane with Double Lifting Magnet for Steel Yards, Iron Stock Sheds, &c.

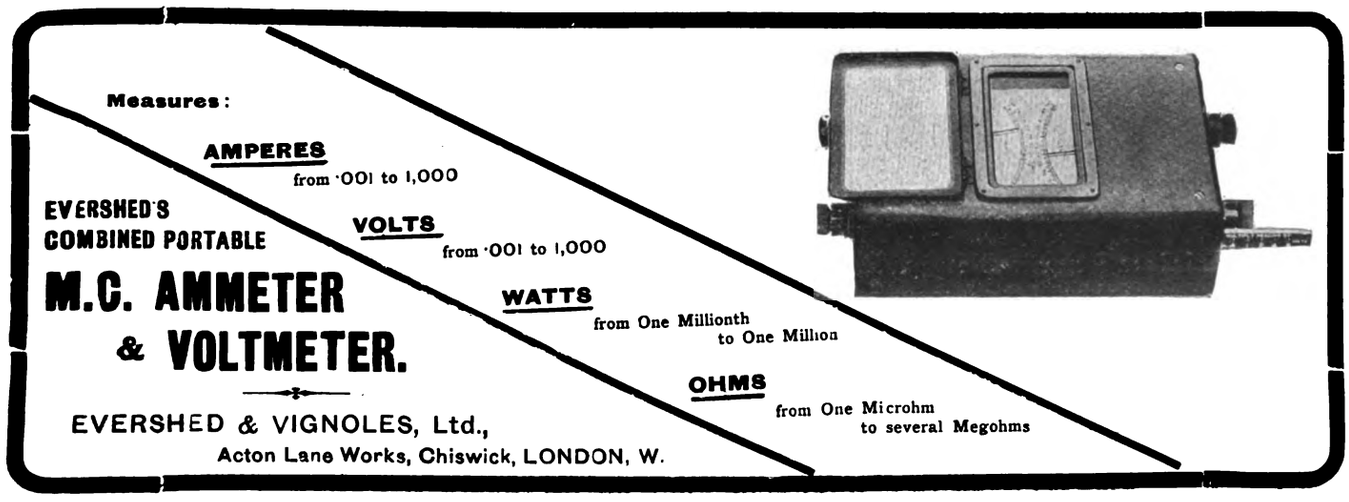

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Fig. 1 depicts a special travelling and revolving jib crane, having a capacity of 2 tons. This is a combination of an ordinary electric jib crane and an overhead traveller. The span is 25 ft. and the four motions of lifting, slewing, travelling and traverse are driven by separate motors. The outputs of these motors are 3, 3, $1\frac{1}{2}$ and $1\frac{1}{2}$ B.H.P. respectively. The speed of the 3 B.H.P. size is 1,080 revs. per min., and of the $1\frac{1}{2}$ B.H.P. 540 revs. per min. Series motors are used controlled from tramway type controllers with magnetic blow-outs. Of the four controllers two are placed inside the operator's cage and two outside, but all are close together under his hand. The range of this type of crane is very wide, as its peculiar construction permits the jib to be run into corners remote from the main bay, to take up or unload. With proper handling it should command every inch of floor space. The brake on this crane consists of a mechanical device actuated by the axial thrust on the worm driver of the lifting motor. It comprises a number of laminated gun-metal discs and steel ratchet wheels fitted with ball thrust bearings. When lifting the worm revolves on the thrust bearings and the ratchet wheels are out of action. When lowering the ratchets are held stationary by the pawls, so that the discs revolve and rub against the ratchet wheels. The device is enclosed in an oil bath. The speeds of the motions are as follows: Lifting, 15 ft. per minute; slewing, 180 ft. per minute; travelling, 150 ft. per minute; and traversing, 60 ft. per minute, with full load in each case. A crane of this pattern would be useful in a narrow workshop having one wide centre bay and two side aisles. The jib can be used to serve the aisles between columns and for transporting material it can be run out into and down the centre bay and into the aisle again. The position of the crane man is rather better from a view point than that usually afforded men in charge of travelling cranes. The fact that all the motions are controlled from the one point is but a further illustration of the flexibility and convenience of electric driving. Cranes of a similar pattern to this, though they were not supplied by Appleby's (Ltd.), were used in the berth over the *Mauritania* with complete success, though the design was somewhat different. The controllers were placed in a cabin at the end of the jib and moved round with it and the load.

We have referred in previous issues to the value and

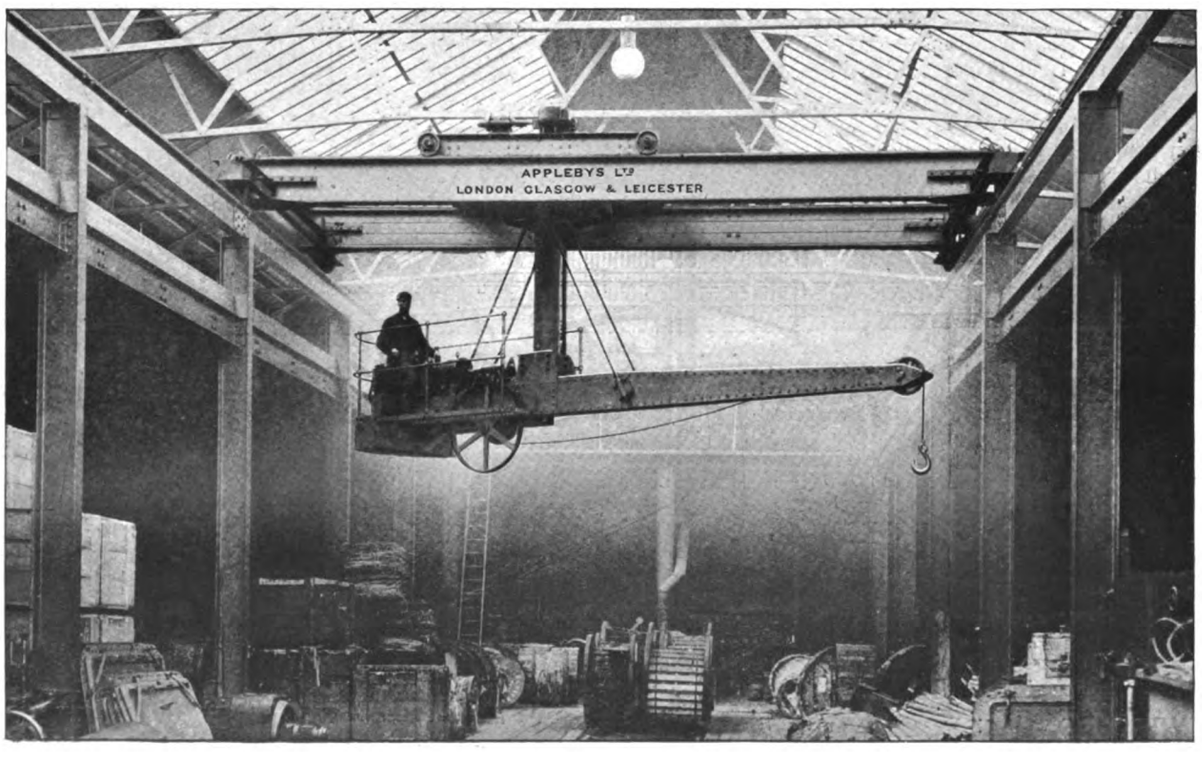

Fig. 1.—Electric Travelling and Revolving Jib Crane.

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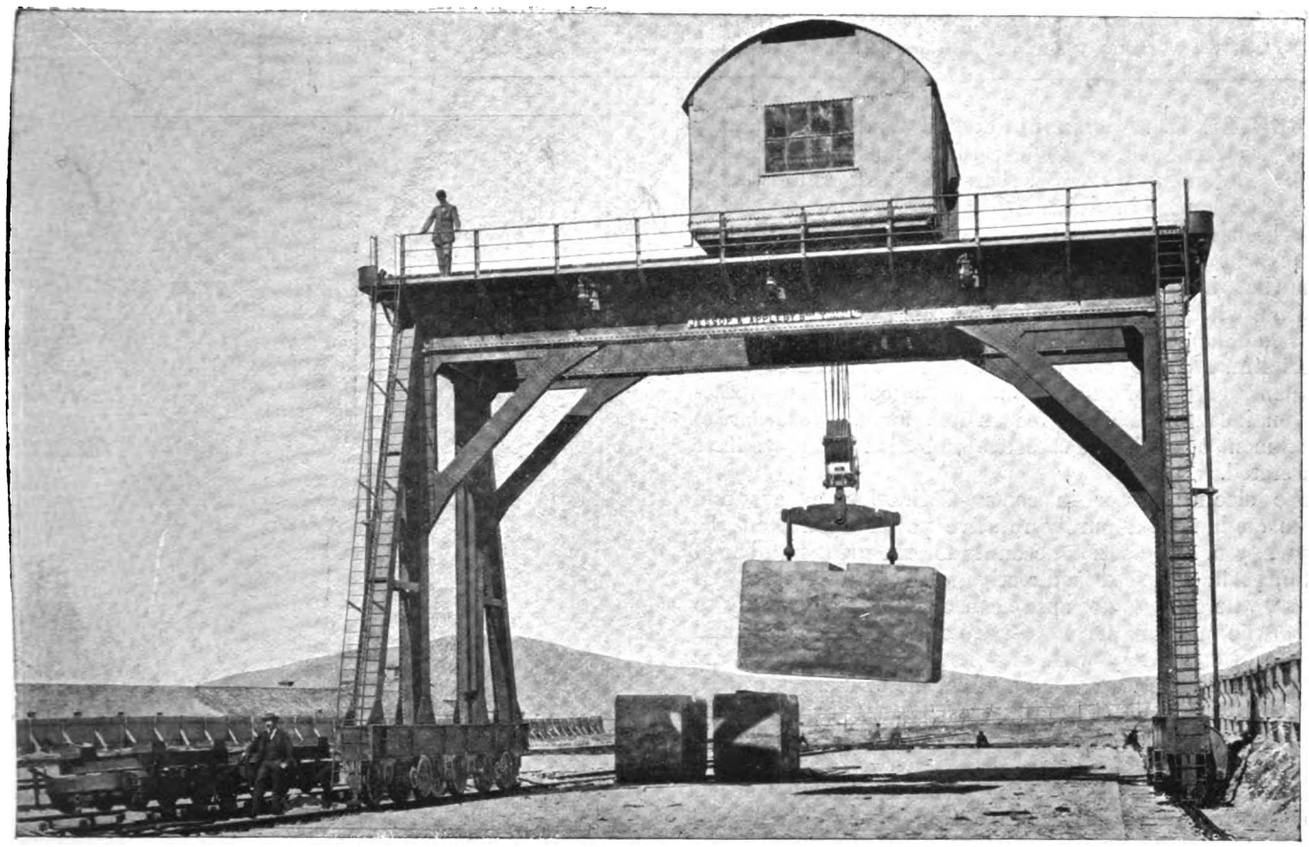

Fig. 3.—40-Ton Electric Goliath Crane.

importance of the lifting magnet for work in steel mills, yards and iron works generally. Fig. 2 shows the application of the lifting magnet to work of this kind. The crane illustrated is in use carrying steel rails, hot or cold, from the "hot bank" through the processes for completion and delivery. The gantry carries two cranes of the type illustrated, each having a capacity of 5 tons. Three separate motors for the motions are used. The magnets have a large overload factor and are controlled from the operating cage. It will be noticed that the rails are picked up clean without lifting tackle and are carried along horizontally. We understand that from 40 to 45 tons of rails or bars can be carried per hour from the store to the railway wagons. Seven of the heaviest rails or their equivalent in other sections can be raised at each lift. The cost of handling is stated as being just under 1d. per ton, and it is estimated that over £1,000 a year is saved by the reduction in the labour needed and the increased duty of the crane.

An electric travelling Goliath crane of 40 tons capacity is illustrated in Fig. 3, this pattern being also built for loads up to 80 tons. The crab motors and controllers are placed in the house surrounding the crab and the different motions are driven by independent motors. The travelling wheels at the base of the legs are driven from a motor in the crab by cross shafts and vertical shafts with bevel gearing. The travelling wheels are double flanged. The crab is provided with double or treble purchase gear, and the gears include cast steel pinions. The lifting rope coils on a drum grooved spirally right and left, to ensure a vertical lift without surge and an equal distribution of the strains on the supporting structure. Special brakes are fitted when desired to the traverse and travelling motions. In addition to an automatic mechanical brake the lifting motion is provided with the usual solenoid brake, which is off when the motor is running, but at once comes on when current is cut off.

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Chain Drive from Electric Motors.

WHILE there is an undoubted tendency to apply electric motors directly to the machines they are intended to drive, there are still innumerable instances in which either belts, gearing, or chains must be used. Probably the belt drive is most in vogue at the present time, although the loss of power due to slip is somewhat high. With prime movers or power agents working with the reciprocating motion, the use of belts is most common, because the uneven turning moment causes intermittent changes of speed which are to some extent compensated for by the slipping of the belt. Reciprocating engines are mainly responsible for the widespread attachment of engineers to belting, for the reasons we have just stated.

The electric motor in contra-distinction to gas and steam engines is a purely rotative power agent and the regularity of this motion accounts for the great number of instances in which it is directly geared to its work. Of course, where the motor speed can be reduced efficiently to that of the machine driven the two are directly coupled and gearing is done away with, but instances of this kind are comparatively few. The high speed motor is largely built, and its application to industrial purposes (at the moment at any rate) is by way of gearing of some description.

The chain giving a positive drive may well be associated with the even turning of the electric motor. With a properly-designed chain there should be no difficulty in effecting this. There are many instances—and the number is on the increase—of the use of chains with electric motors for driving either line shafting or individual machines. Through the courtesy of Messrs. Hans Renold (Ltd.), of Manchester, we were recently afforded a practical illustration of what can be done on a large scale with the chain drive from electric motors. The works of this firm

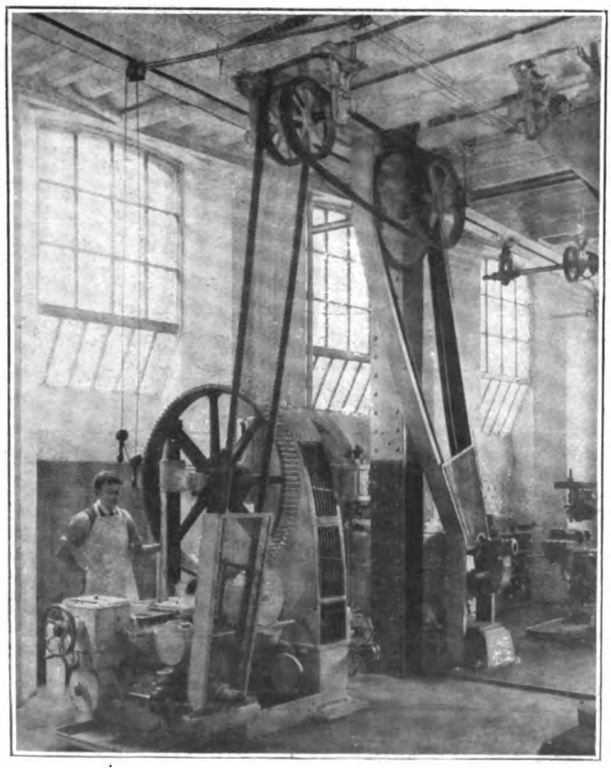

Fig. 1.—Chain Drive from Motor to Line Shaft and Auto Gear Cutter.

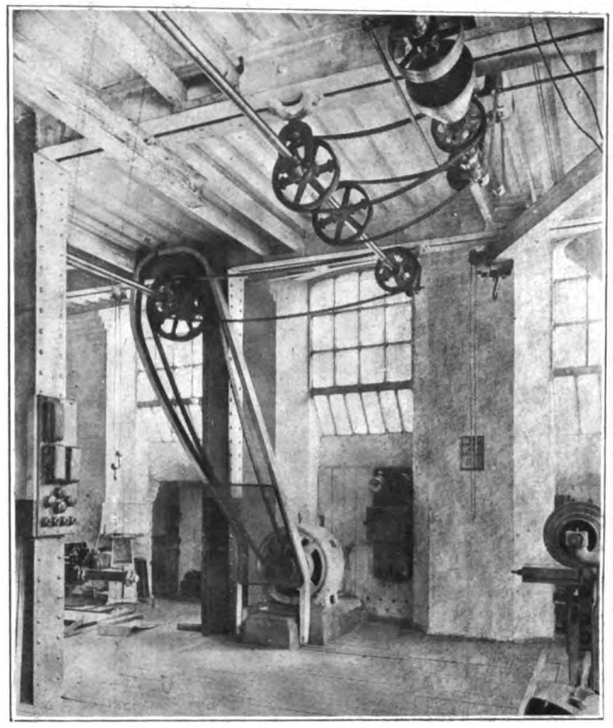

Fig. 2.—Chain Drives from Motor to Line Shafting and Counter Shafting.

are electrically operated throughout, and the special machinery which is constantly making chains of almost every description is driven entirely by this particular form of transmission. We cannot go into details regarding the manufacture of these chains, although the processes are most interesting and attain to a degree of accuracy which is little short of remarkable. The human element has been eliminated wherever possible, and the duty of producing the chain parts is relegated almost entirely to specially-designed machinery.

The power installation is mainly of interest on account of the use of the chain drive. There do not appear to be many machines in the works which have not been adapted for chain driving.

We may remark here that the "Silent" form of chain has been made use of, this pattern being distinct from the more commonly used roller or block forms. It is built up of a number of specially-shaped links, having inwardly projecting teeth, which engage with the pinion and sprocket wheels. Owing to the special link and tooth form the Renold Silent Chain automatically rises up the wheel teeth as wear takes place, thus compensating for the increasing pitch. It therefore gives smooth and silent running, even when the chain is considerably worn, and the efficiency of the drive is maintained throughout its life.

With other chains the action becomes more and more jerky as the chain wears out of pitch with the wheels.

In the drives employed at the Progress Works, there seems to be a limit to centre distances of about 11 ft., a desirable minimum distance being $1\frac{1}{2}$ times the diameter of large wheel. Fig. 1 illustrates a typical drive from a motor to the line shafting, and thence through countershafting to a 60 in. automatic gear cutting machine. The motor is an 18 H.P. machine running at 850 revs. per min., and the pinion has a diameter of $6\frac{1}{2}$ in. The sprocket wheel on the shafting is 35 in. in diameter, and the chain

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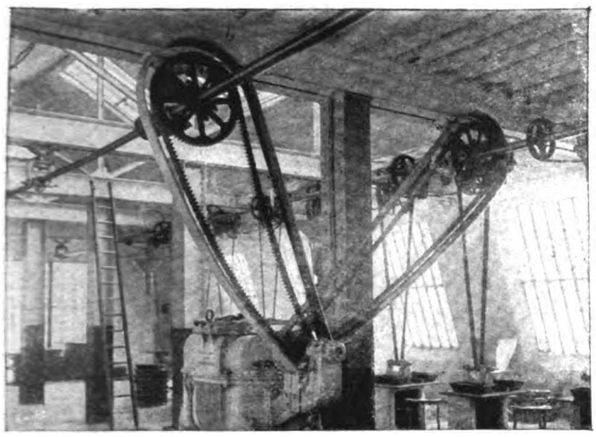

Fig. 3.—Double Chain Drive to Line Shafting from Single Motor.

pitch is 1 in., the width being 2½ in. The distance between the centres is 9 ft. 6 in., and the chain is driven at a speed of 1,345 ft. per minute. In addition to the gear cutting machine shown, the line shaft, which is just over 300 ft. long, drives 38 machine tools. The countershaft was necessary because an almost vertical drive to the gear cutter was required. Previous to the use of the chain the gear was driven by a 6 in. leather belt. The chain shown is 2 in. wide, has a pitch of 1in., and travels at 975 feet per minute. The sprocket wheel on the machine is 9½ in. in diameter, has 30 teeth and revolves at 390 revs. per min.

Fig. 2 is a typical example of the high-speed chain drive from an electro-motor. The motor gives 25 H.P. at 550 revs. per min., the line shaft running at 150 revs. per min. The 27-tooth pinion is 8·6 in. diameter, and the sprocket wheel with 102 teeth is 32·5 in. diameter. The distance

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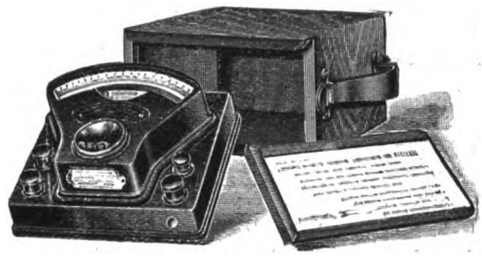

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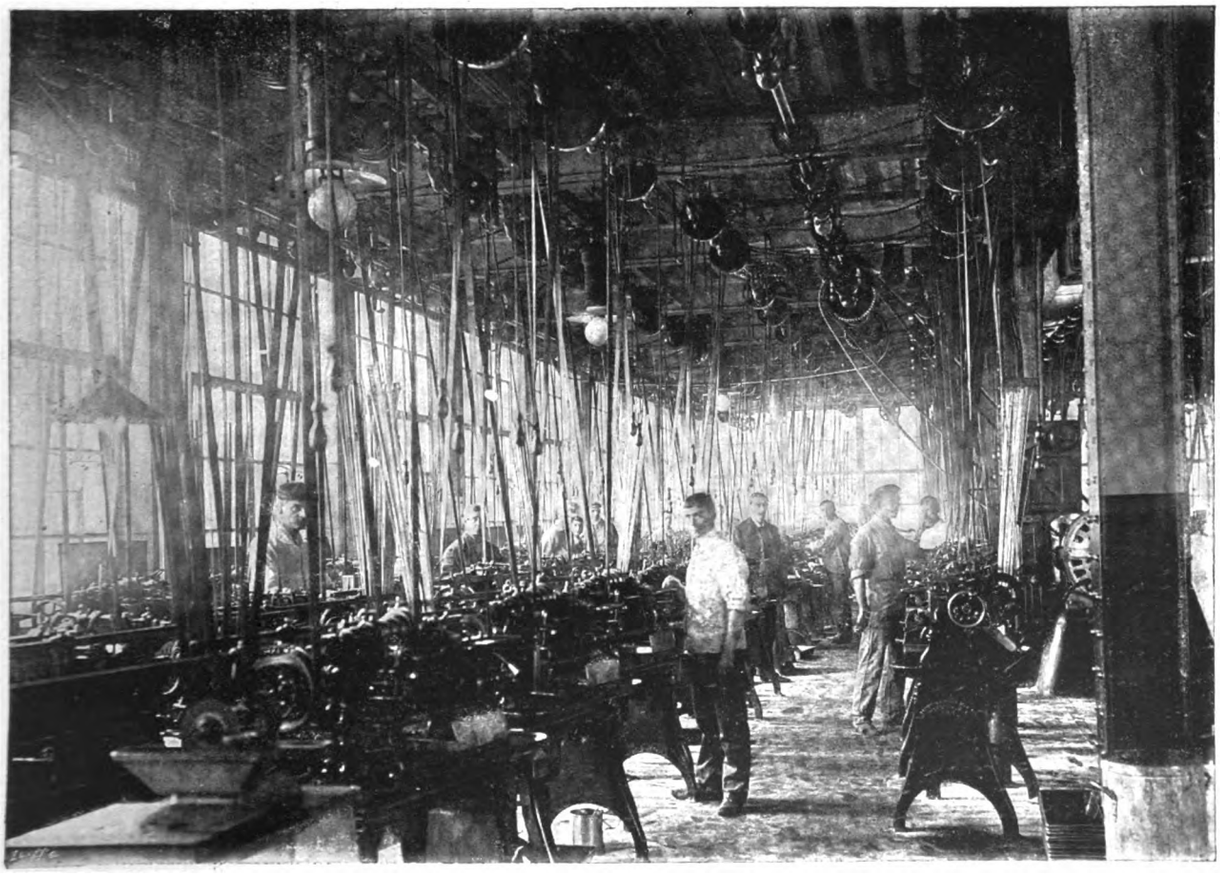

Fig. 4.—Automatic Machine Room driven by Chain from Several Motors. One of these can be seen behind the column on the right.

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between shafts is 11 ft. The chain used is 1·0 in. pitch, and 4 in. wide and runs at 1,238 ft. per minute.

Fig. 3 depicts a special double drive in the polishing and glazing department of the works. The motor is a 15 H.P. machine, running at 400 revs. per min., and the shaft carries two pinions from which two chains of 1 in. pitch and 2_2 in. wide drive on to the line shafting. The centres are 6 ft. and 7 ft. 6 in. respectively.

In the automatic department of the works (*see* Fig. 4) a very extensive application of chain-driving has been made. A number of special machines are here used for the production of very large quantities of chain rollers and pins, all of which are made to gauge to the one-thousandth part of an inch. It was found that with the belt drive drills and tools lost their cutting edges so rapidly that sharpening was necessary several times a day. This was found to be due to the slip of the belts, because when the chain drives were adopted the tools were found to require sharpening only occasionally. The saving in this direction proved to be considerable and there were fewer stoppages of machines. Another important factor of the chain drive was also emphasised in this particular shop. With belts so much tension was required that bearings were found to run hot and also to wear unduly. This fact was speedily noticeable in the accuracy of the parts produced. With the chain drive we are informed that there is no undue pressure on the bearings because the chain always runs slack and there is no tension on the driving pinion, and consequently no pull on the bearing blocks. It was also stated that the output of these particular machines has been increased from 15 to 20 per cent. since the adoption of the chain drive.

The chains are run until they have worn to such an extent that they must be discarded. No repairs are necessary, the only attention required being regular lubrication and periodical cleaning. A heavy mineral oil is used for lubrication, and an application of this is made once a week with a brush to the inner side of the chain while it is moving slowly, only a small quantity being put on.

The motors in the works vary in size from 5 to 30 H.P. and in speeds from 500 to 800 revs. per min. The chains employed are mostly 1·0 in pitch, and vary in width from 2 in. to 5 in., and the speeds at which they are run from 1,000 ft. to 1,250 ft. per min. The makers find that on the line shafting drives in the works the life of a chain as an average is five years, while some chains which have been in use eight years are still running.

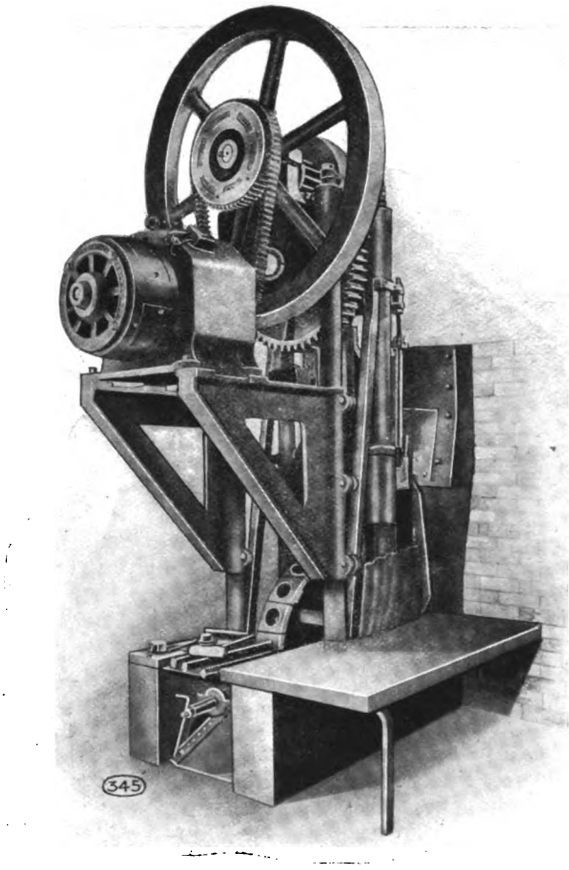

Fig. 6.—Rivet Forging Machine Driven by Chain from Individual Motor.

The electrical energy for the driving of the works is supplied by the Manchester Corporation at 400 volts, and the total horse-power of motors installed aggregates about 500 H.P.

Messrs. Hans Renold, who kindly permitted us recently to look through their works, have supplied the above particulars, and in addition have furnished illustrations of the two typical chain drives which are given herewith.

Fig. 5 shows an air pump fitted with a spring wheel and driven from a 10 H.P. motor running at 620 revs. per min. The chain is $1\frac{1}{4}$ in. pitch and 3 in. wide. This is at the power station of Messrs. the Trafford Power and Light Supply (Ltd.), Manchester.

Fig. 6 shows a rivet forging machine driven by $2\frac{1}{2}$ in. chain from a $6\frac{1}{2}$ H.P. motor running at 700 revs. per min., atthe works of Messrs. McFarlane & Whitfield, Dunston-on-Tyne. This is also a spring wheel drive.

The Renold "Silent" chain has been on the market for some nine years, and, since the applications of electric power to industry have become more numerous, its sphere of utility has been considerably extended. It can be built up in very large sizes and for almost any speed, and for particularly heavy duty it appears to possess numerous advantages of which several are outlined in the foregoing article.

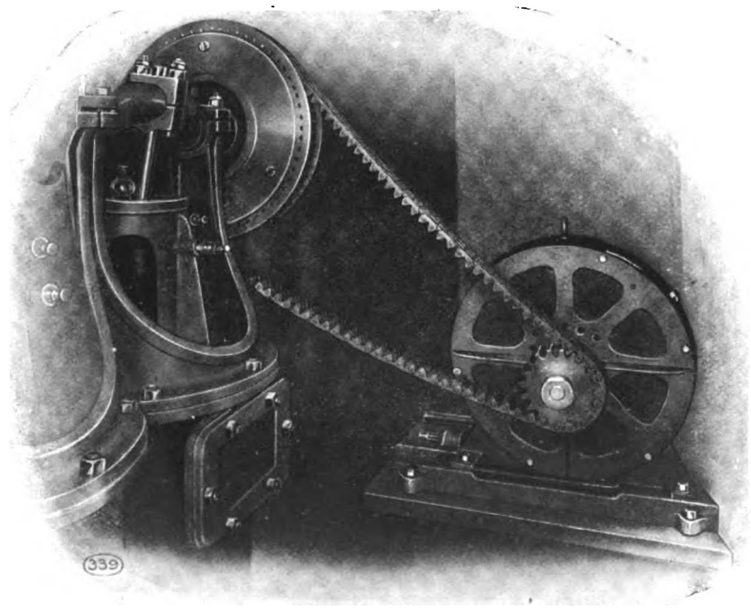

Fig. 5.—Air Pump Chain Driven by Motor.

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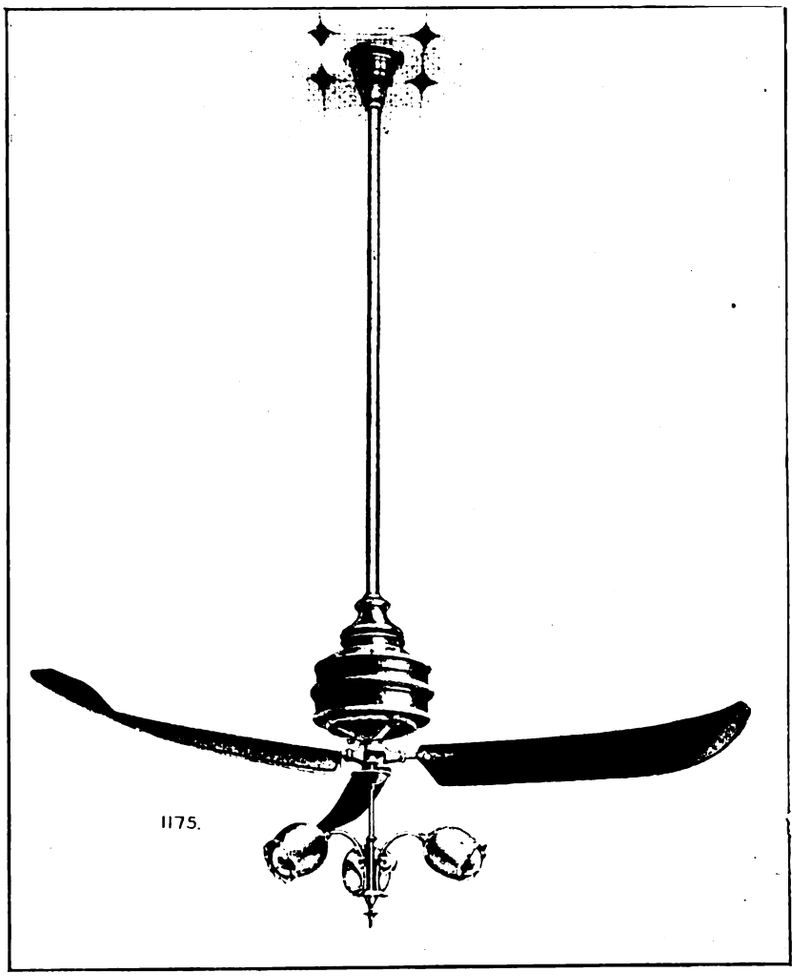

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Industrial and Commercial Ventilation.

THE ventilation of large industrial establishments is now regarded as essential to the welfare of the employés, irrespective of their duties about the works. For several years past the problem has been tackled on quite a large scale, and the experience obtained with the many installations which have been put down has enabled ventilating specialists to establish standard apparatus, which may be applied to almost every branch of the art.

Fan blowers, air heaters, driers and filters are adjuncts to a ventilating installation which make it a complete plant for its purpose. The general efficiency of a combination of these units is mainly dependent upon the type of fan used, as this determines the amount of air moved during a given time. The "Sirocco" centrifugal fan, by reason of its principle of operation, is readily adaptable to direct connection to electric motors for driving purposes. The makers of this fan also claim that the consumption of electrical energy is low for the duties required. The fan wheel is built up of a number of long narrow curved blades supported around the outer diameter of a driving disc. These blades are curved in the direction of rotation to reduce eddies which absorb a considerable amount of power, and this method also is said to increase the velocity at which the air is discharged from the blades of the fan. Messrs. Davidson & Co., Sirocco Engineering Works, Belfast, make this particular type of fan, and have applied it with considerable success to the ventilation of many large industrial and commercial establishments.

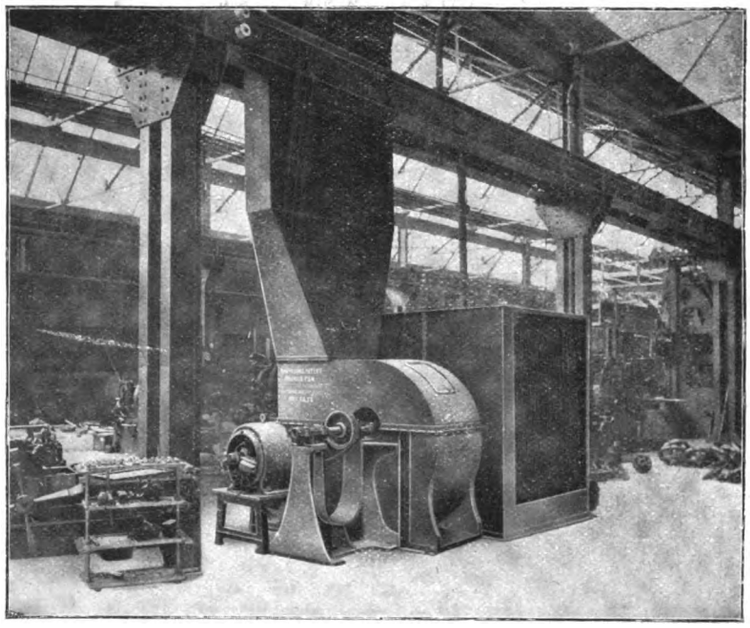

Fig. 2.—Steam Heated Air Warmer with Motor Driven Fan in Large Engineering Workshop.

They have, in addition to the line of special fans referred to, also a complete range of accessories for large heating and ventilating plants. One of these is a rotary drum air filter, arranged for driving by electric power. An illustration of a complete machine with motor is shown in Fig. 1. The apparatus comprises a revolving drum supported on pedestal bearings, and with one end open and the other closed. Around the drum is stretched a web of coarse cocoanut fibre cloth, secured by wooden battens to the drum. Below the drum is a shallow water tank which serves to submerge the lower portions of the drum as they revolve. The air for ventilation is drawn through the moist webbing on to the interior of the drum, from which it is discharged into the air duct. As will be seen, a very large surface is exposed for the filtering of the air, and the moist state of the cloth has a cooling influence on the air, which in the summer has a pleasing effect. Further reduction of the air temperature can be satisfactorily obtained by placing ice in the water tank.

Of course the chief duty of the filter is the cleansing of the air, a function it is stated to perform with very satisfactory results. The motor is geared to revolve the drum at a peripheral speed of about 30 ft. per minute. A filter of this type is also very useful for application to heating systems for workshops and buildings. The satisfactory heating of such premises is not possible with steam or hot-water pipes, and recourse must be had to the heating of air and distributing it through ducts to various points in the works. "Sirocco" air heaters are made for this purpose and are used in conjunction with electric fans. Fig. 2 illustrates a steam-pipe air heater installed in the bay of a large machine shop. This heater is fed with steam at full boiler pressure, and the condensed water is drawn off by suitable steam traps. Similar steam heaters can be arranged to take the exhaust steam from one or more engines for heating the air. The arrangement makes a good air condenser, as the constant passage of cold air over the pipes extracts the heat from the steam within them, leaving only water behind. In all these cases the air is delivered in rectangular iron ducts to the various

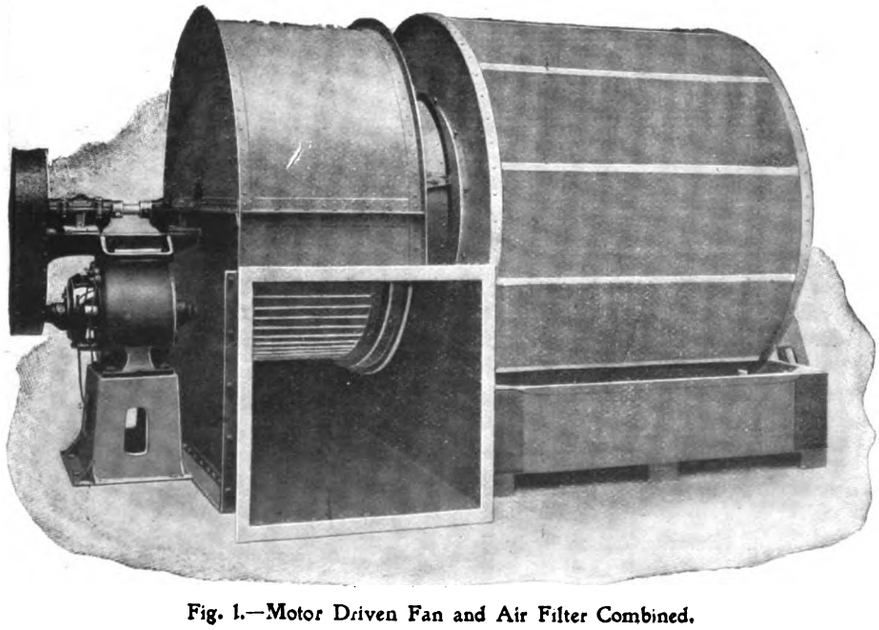

Fig. 1.—Motor Driven Fan and Air Filter Combined.

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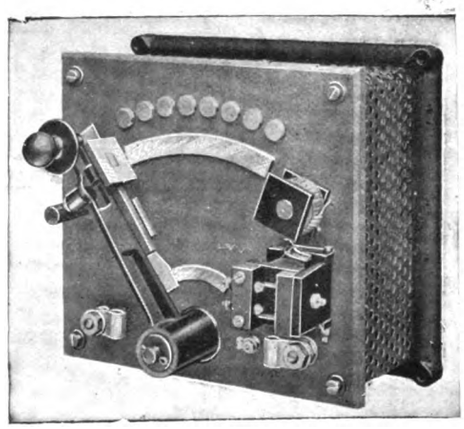

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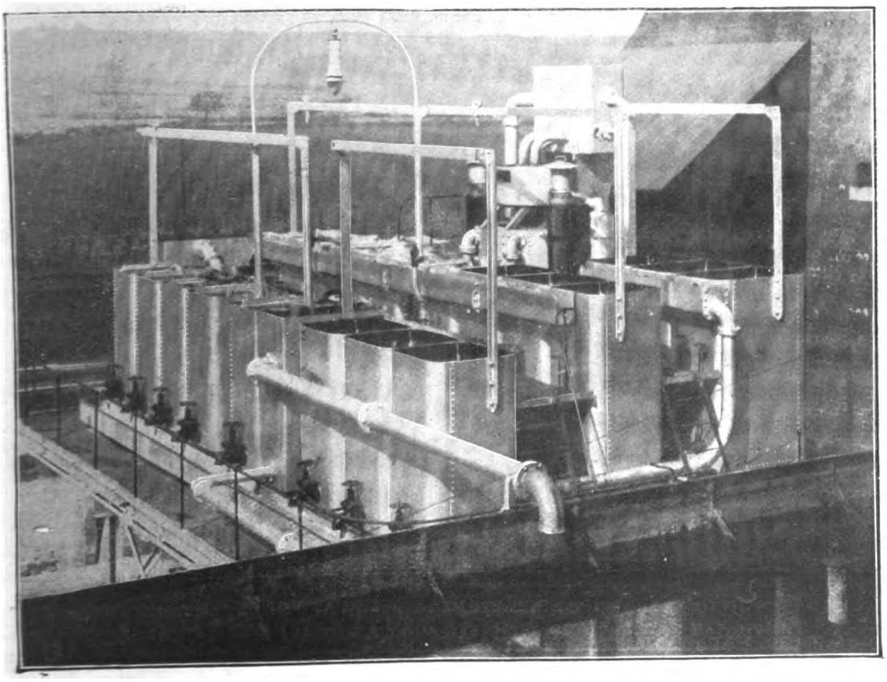

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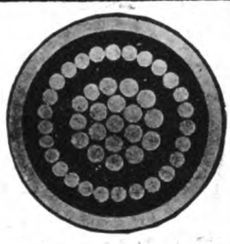

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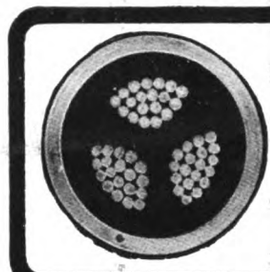

parts of the building. Warehouses are equipped on a somewhat similar plan, but, where the rooms are low, provision must be made not only for the entrance of fresh air, but the foul air must be removed. To accomplish this the delivery fan at the air filter must be supplemented with an exhaust fan connected to a line of ducts provided with openings to extract the air near the floor level. Fig. 3 is a sectional view of a warehouse fitted with an installation of

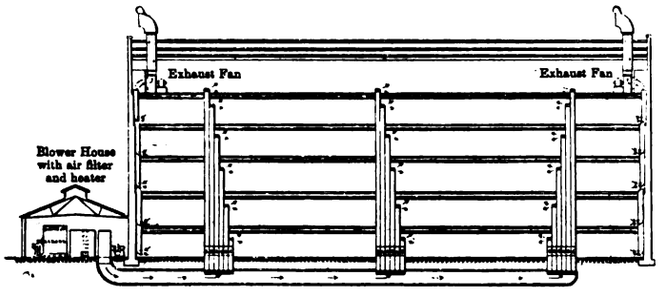

Fig. 3.—Sectional Diagram of Warehouse Ventilating Plant.

this kind. The delivery fan with air filter and steam heater is installed in a low building outside the warehouse, where it does not encroach on the storage space. Similarly, the exhausting fans are situated on the floor of the topmost storey of the building. The convenience of the electric motor drive in an installation of this kind is clearly demonstrated in this particular installation. The delivery fan is driven by belt from a high-speed motor, and the exhaust fans have motors direct coupled to their shafts.

The ventilation of large rooms in hotels, restaurants, business houses, banks, &c., is readily effected by the small direct-connected fan, such as that shown in Fig. 4. This is a "Sirocco" propeller fan, direct-connected to an electro-motor. The fan blades have a special curvature, which enables the fan to be driven in either direction with equal efficiency, according to the makers' claims. This reversible feature, if combined with a reversible motor, admits of the fan being used either to extract air from or to deliver it into a building. In conjunction with this pattern of fan a self-closing shutter, shown in Fig. 5, is employed to close the fan aperture when it has stopped working. The doors of the shutter are hinged in the centre of the opening, and are set slightly out of plumb, so that they always tend to remain closed when there is no air-pressure behind them.

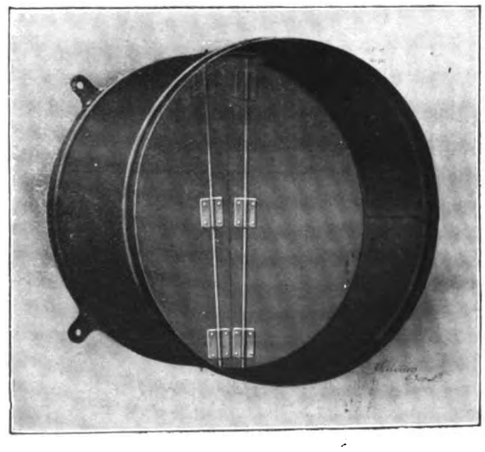

Fig. 5.—Automatic Shutter for Propeller Fan Apertures.

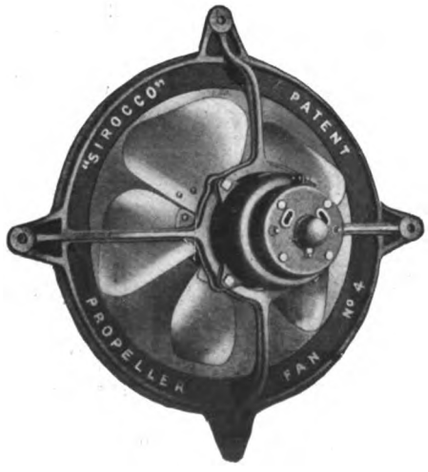

Fig. 4. Propeller Fan driven by Continuous Current Motor.

As soon as the fan is started they immediately open under pressure of the air delivery.

The foregoing will give some idea of the possibilities which now lie before the practical side of ventilation as applied to industrial and commercial purposes. The existence in the field of specialists who can design complete installations and supply them with standard apparatus makes the matter of ventilation less subject to conjecture and more certain of accomplishment. It also reflects the attitude of the captains of industry towards one of the most vital factors in the conduct of manufacture—the care and comfort of the health of employés.

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Sirocco Fans

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Telegraphic Address: "ELECTRICIAN NEWSPAPER LONDON." Telephone No. 949 HOLBORN.

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Copy for text or advertisement pages for next issue should reach the above address not later than the 25th inst.

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms ; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations ; to any firm of Merchants or Agents ; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings ; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Electrical Ventilation.

A considerable portion of the present issue is devoted to the subject of electric fans and ventilation. Of the former we shall have more to say, doubtless, as the warm season advances, and there are prospects of good business being done with these handy breeze makers among electricity consumers generally. The matter of ventilation is not essentially one of climatic changes, or it should not be associated therewith. The conditions governing the conduct of industry and commercial enterprise are such that unless due regard is had for the provision of ventilation a deleterious effect on employees invariably results. We are probably not far wrong when we state that from 50 to 75 per cent. of the great industrial works and business houses suffer from lack of proper ventilation. It seems not to be so much a matter of neglect as of indifference. Neither architects nor business men regard the problem as of sufficient importance. Many captains of industry have despaired of taking any steps in the right direction. Others have, on the contrary, been progressive enough to accept the advice of experts, and adopt their plans for the supply of both warm or cool air, and in both cases of fresh air, to their workshops. This appreciation of the importance of the matter has encouraged ventilation specialists to persevere, and at the present time appearances point to the establishment of standards for many of the necessary pieces of apparatus. This in itself simplifies further progress, because architects and industrial employers can be shown actual installations and well-tried ventilating appliances. A further important detail, and to the electrical engineer the most important, is that the electric motor is practically indispensable to the furtherance of the mechanics of applied ventilation. Its compact design, economy, adaptability and capacity for overload make it the power agent par excellence for the driving of fans, revolving filters, washers, &c. Again, the universality of the electric power service smoothes away any difficulties which would otherwise present themselves in the way of giving the motors the necessary energy for their work.

The question of ventilation is an immensely broad one, and we have chiefly touched in this issue on its industrial and commercial aspects. In colliery work and deep-level mining generally it has figured from the earliest days because of necessity air was an essential to the operation of the workings. And in this province, perhaps, more than in any other, the electric motor has done great things.

Were we able to give space to the subject we could fill many more pages than our normal issue on mine ventilation alone. The extension of the confidence of the colliery manager to the electrically driven fan is one of the highest commentaries upon its importance and value. We hope the heads of industrial establishments and business houses will not be tardy in placing the same degree of confidence in it for efficiently giving their employés an adequate supply of fresh air.

Small Lifting Magnets.

In a previous issue we referred to the possible utility of the electro magnet for attachment to crane hooks in place of the usual rope or chain tackle for lifting purposes. On another page of the present number an illustration and some details will be found of this type of magnet in actual operation. The number of such devices used in practice is, however, ridiculously small in proportion to their utility and economy. As to the latter it is stated that in the example given elsewhere as much as £1,000 per annum is saved by a pair of cranes fitted with lifting magnets. The secret of this lack of practical appreciation is probably, as we have previously intimated, want of confidence. Accidents are feared with heavy loads in case the current fails. Granting this as a legitimate objection the province of the lifting magnet is not necessarily limited to heavy weights. In fact, we think that much greater use might be made of it for small weights in iron and steel works and engineering shops. Such establishments are usually well supplied with electric cranes and often electric runways which give regular and often arduous service. A small capacity lifting magnet on these would save time with certain pieces of work requiring slinging in the ordinary way and by so doing would economise labour. The craneman could, in fact, pick up material, transport it and again drop it at the desired point without needing the services of a slinger. It would appear that this particularly handy device has not yet met with the reception which its merits demand that it should. Perhaps greater experience with magnetic drill pillars and similar devices should stimulate more extended confidence in the lifting magnet. The design and construction of both these devices has been much improved of late years, and they are consequently more economical and reliable. Particularly so have changes been made with lifting magnets, these being now iron cased with protected windings. To increase confidence in these magnets, a safety device might probably be adopted which would take up the weight of the load in case the current was cut off. This mechanical safeguard could be released by hand when the load was being set down in the ordinary way.

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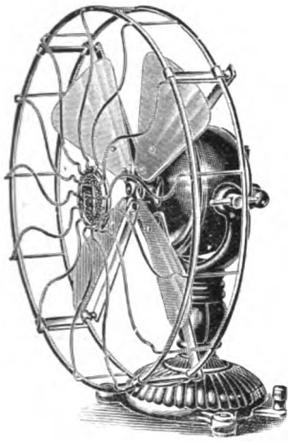
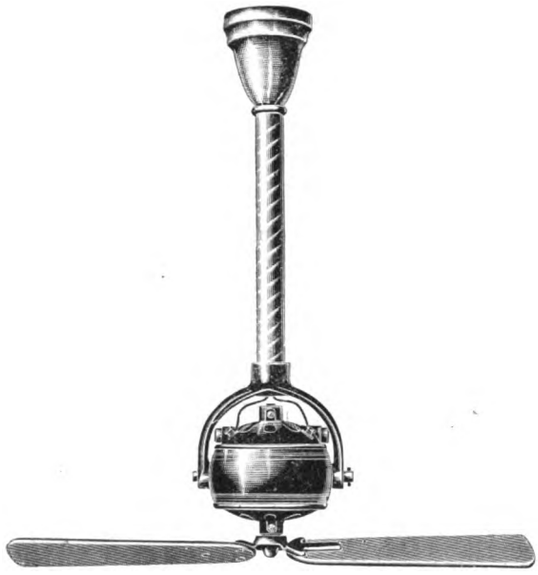


E 2701/7 as a Desk Fan.



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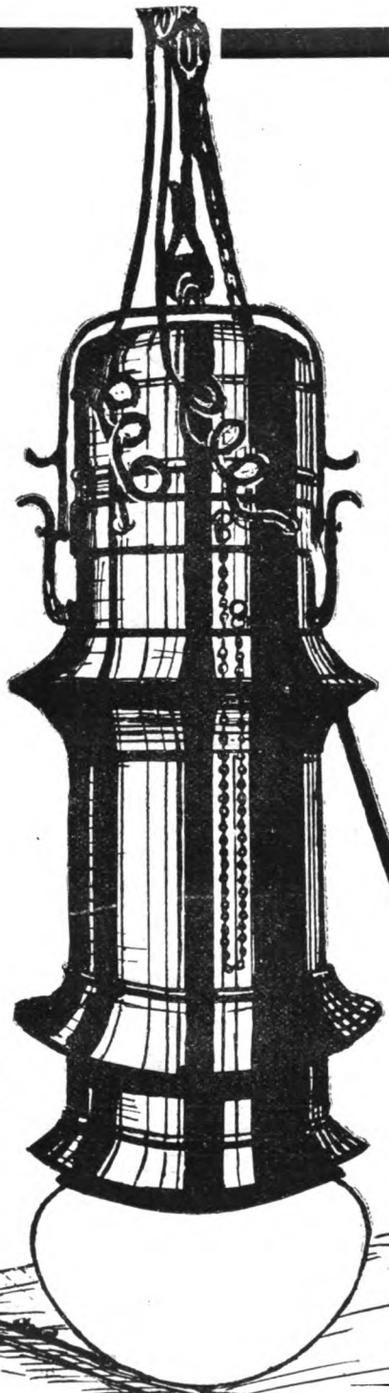

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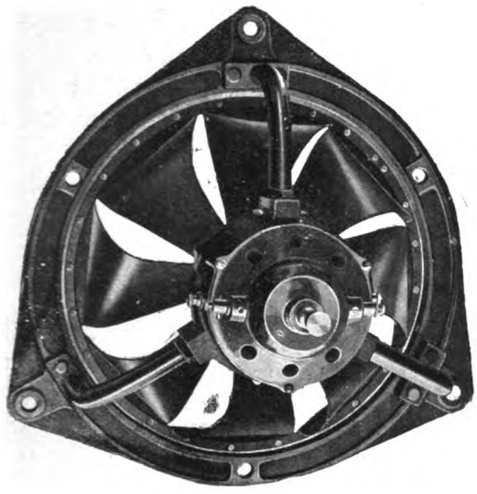

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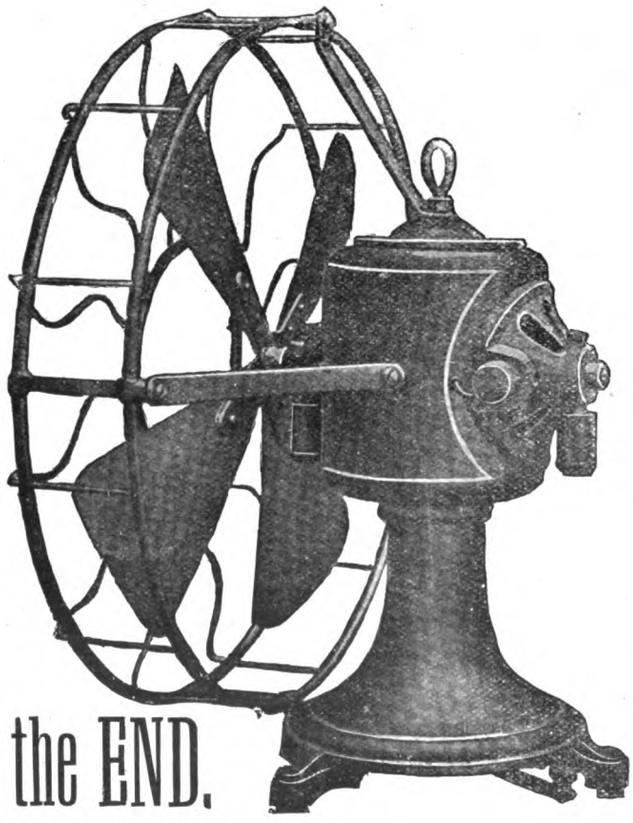

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Suction Gas-Electric Plants.

Given an ample supply of coal and facilities for transporting it and a satisfactory gas producer—with these and a reliable and efficient gas-dynamo, electric power should be generated at figures far below steam-electric and on a level with hydro-electric power in certain districts. On another page we give some figures comparing suction gas with hydro-electric power, culled from American practice. These indicate that under certain conditions the former can be produced more cheaply than the latter, in the case quoted the particular item favourable to the gas plant being its combination with a heating installation. If the latter is domestic the improved working is only effective during the winter months, and this will lower the yearly average saving. But over here the heating comparison cannot be reckoned with, though in contra-distinction we have few hydro-electric installations, and practically none in the coal districts. The figures quoted are, however, of considerable interest, in that they effect a comparison between gas-electric rather than gas and electric power. While admitting the undoubted economy of suction gas plants, we think their use is only commendable for driving dynamos. They are not suited to the driving of machinery. By furnishing power in the shape of electrical energy to the machines to be driven, instead of applying it direct from the gas engine, the power user is securing the advantage both of the economy of the suction gas producer and the efficiency of the electric motor. We have already pointed out that, as a prime mover, the gas engine is quite unsatisfactory for works driving on account of its uneven turning moment. Its direct connection by belt to line shafting is, of course, common enough; but probably the number of belts between the engine and the machines driven serves to smooth out the impulses of the engine. We are not, however, suggesting that gas-electric plants should substitute the electric service. In large towns where a supply is available the small power user should take advantage of it, and the big consumer, before adopting suction gas, should get the best terms from the local authority. Our opinion is that, if electric power is to be generated by suction gas, the power supply undertaking should do it, and, where such undertaking does not exist, gas-electric units fed by suction producers should be installed to supply power to electric motors in preference to plain gas engines put down for the operation of line shafting by belts or ropes The conversion of the energy of coal into mechanical, electrical and mechanical energy, may seem somewhat roundabout, but considered generally it is probably the best for large and medium sized works, unless peculiar conditions favour steam driving or some other method of operation.

Suction-gas engines are now regularly connected direct to dynamos, and standard apparatus is on the market which can be supplied at short notice, and of which spare parts are stocked. The isolated manufacturer need not consequently entertain apprehensions of lengthy stoppage from breakdown through failure of plant. Where the circumstances admit of this method of driving, the choice the particular power user has to make is between gas engines and shafting and gas dynamos and motors. The latter will serve him the better of the two.

Industrial Topics. . .

A MATTER closely associated with problems of industrial ventilation is that of the removal of dust, fumes or metallic particles from workshops and workrooms. The standard type of exhaust fan applied to a roof or at intervals in window frames, while useful enough and efficient for extracting foul air, does not furnish what is specially required in certain processes in which injurious particles or fumes are given off. Certain fumes may be heavier than air, and metallic dust will certainly gravitate speedily or remain suspended at low levels. An exhaust fan in the end wall or windows of a room would in a case like this afford no protection to the employee, who would still breathe polluted air with the fans running their hardest. The existence of a fan may satisfy the employer and inspector, if there be such, but unless it is placed in the right position they will both be deceived, and the workmen will be no better off than if the so-called ventilation, provided for their benefit, did not exist. Air is so mobile a medium that, in many instances, unless something in the nature of a smoke test proved to the contrary, an exhaust fan will disturb the upper strata of air in a shop and leave the air in the lower sections practically stagnant. The points of exhaustion of the foul air and entrance of the fresh may be so located in respect to each other that a constant stream of air will travel across a room and will drive any heavier particles into corners, under ledges, &c. Herein lies a danger which the most elaborate precautions may only tend to aggravate.

Dust Extraction.

There is obviously but one solution of the difficulty At the exact spots at which dust, fumes, metal particles, &c., are given off, suction hoods must be placed to draw in the air so soon as it is polluted. Connected with these hoods must be a duct or ducts leading to the outside air. We have noticed in many processes that this plan has been followed, and it is the only practical method to adopt. To blow dust away from the work and provide an exhausting fan somewhere is worse than useless. To draw in air from the machine to a pipe line connected with a blower, and either collect it or turn it into the air, is to adequately cope with the difficulty. In such an industry as wood working the extraction of sawdust, shavings, &c., can be effectively carried out. The wood chippings can also be recovered and made use of, as there is practically none wasted.

The small electric motor fan is the ideal for this purpose, especially as the exhausting equipment is only needed for one or two departments in a works. When the particular process is out of use for certain times during the day the ventilating motor can be shut down, so that no power is unduly wasted. The power line can be easily tapped for the supply of energy to these diminutive ventilating plants and the entire equipment is simplicity itself to handle. The subject is one needing the attention of manufacturers in whose works this system is applicable. There are still many branches of industry to which these useful electric ventilating equipments could be successfully applied.

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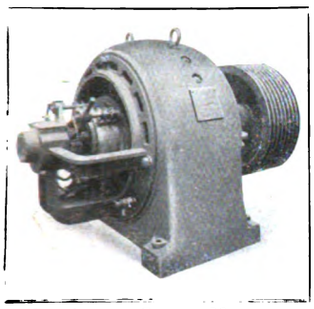

Continuous-Current Motor or Dynamo for Rope Drive.

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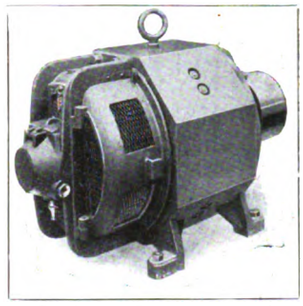
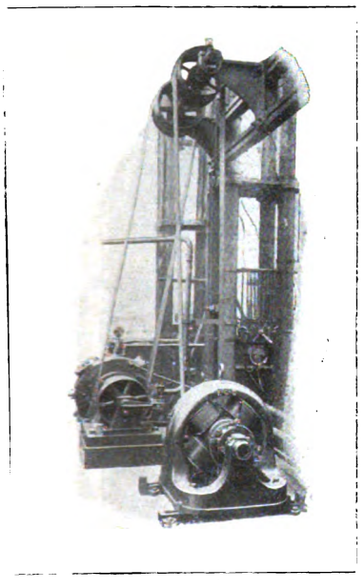
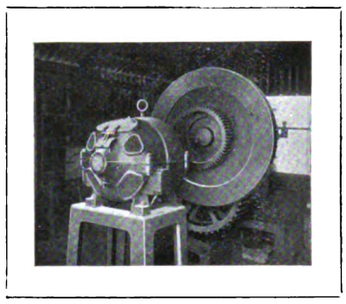


Continuous-Current Enclosed Ventilated Motor.

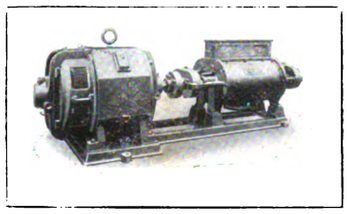


Motor Driving Shafting by Belt.

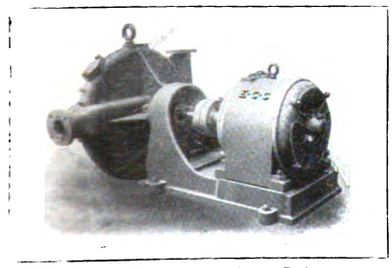
E.C.C.



Motor Driving Cold Shear in Steel Works.



Motor Direct-Coupled to Root's Blower.



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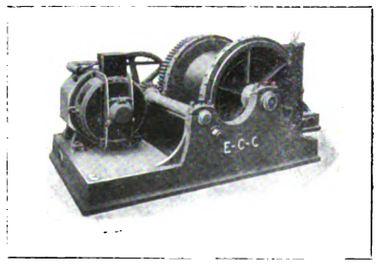

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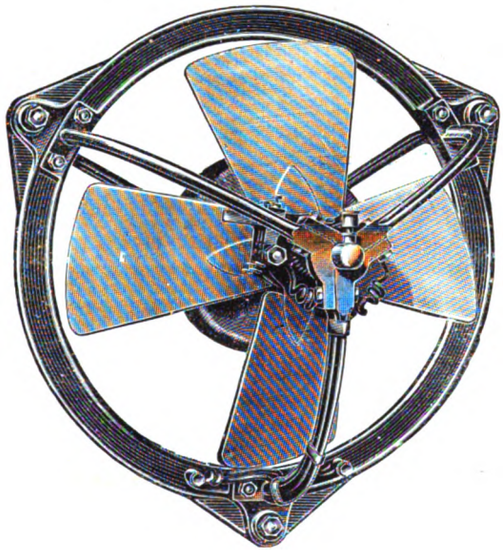
Fans and Fan Motors.

THE design and construction of fan motors are matters requiring as much care and surpervision as larger types of electrical machinery. A small fan will often be kept running under conditions which would not be possible for heavier machines, and this and other circumstances must figure as important factors in fan motor design. The electric fan is probably the most abused piece of electrical apparatus, for it is always hard at work and is never supposed to need attention. This notion is as much encouraged by the maker as by the user. The "Freezor" fans of the General Electric Co., for instance, are described as being equal to almost anything that fans can do.

In the continuous-current type the field cores are cast integral with frame, making an unbroken magnetic circuit, and the armatures are wound with double silk insulated wire. The commutators are built up of hard-drawn copper segments insulated with mica. The brush-holders are of the cartridge pattern, and each brush—which is of square section to insure good contact—may be easily removed by

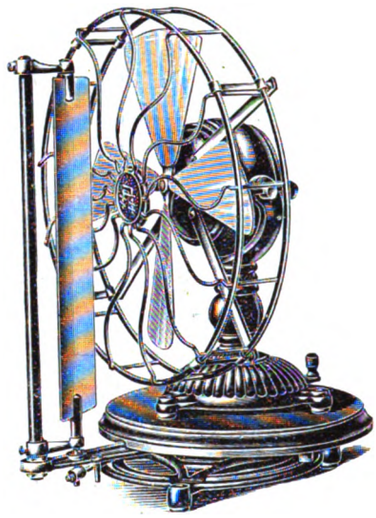


Porthole Fan, driven by Small A.C. Series Motor.

the withdrawal of a pin. The regulators, which give three speeds, are mounted on a fireproof base, and are of mica plates wound with resistance wire of ample capacity to carry the maximum current without undue heating. The plates, made up in separate units, combine to give the requisite resistance for different sizes and voltages of fans. The standard finish is black enamel with polished brass fans, guards and fittings, but these can also be supplied enamelled in white, or any colour, and with nickel or silver-plated fittings.

An alternating current motor is also made for small fan duty, this pattern being of the induction type with two or three speed switch. The makers claim that these machines will run practically without noise.

The mounting of an electric fan is a matter largely dependent upon the demands of fan users. The simple rigid support for desk and table use is widely employed, as is also the trunnion frame, which gives the choice of adjustment of the breeze direction. The same pattern mounted for desk or wall use is also much favoured. A refinement of recent years is an oscillating stand upon which the fan is placed, and by means of which the air is automatically distributed in all directions. Again, the fan guard can be fitted with shutters which give considerable control over the deflection of the air to any desired point. In another pattern the fan is rigid and the shutters move from side to side, causing the breeze to be evenly distributed. Many of these niceties are not usually

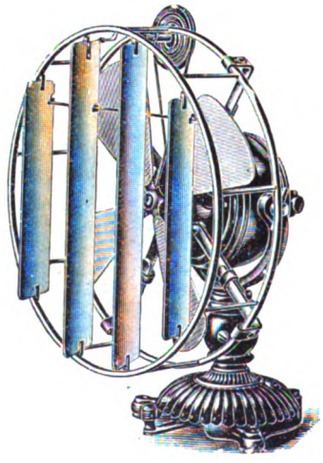


Desk Fan on Oscillating Stand.

The fan moves through a regular angle while running and distributes the air in various directions.

specified, because the fan user is not acquainted with their existence or value.

The ceiling fan, of which there is a line in the "Freezor" series, is another type not favoured so much in this country as it might be, but still enjoying considerable vogue. It is built with two, three or four blades for both alternate and continuous current circuits. The alternate-current type is supplied for high and low periodicities, the former for 80 to 100 cycles and the latter for 40 to 70 cycles. Ball bearings are fitted with these designs, in addition to an oil bath for lubrication. The low periodicity fans can be run at two speeds, 180 and 250 revs. per min. respectively, A "bunch" light placed below the fan body at the



Desk Fan, with Oscillating Shutters.

A small pulley on the motor shaft drives by belt to a wheel geared by a worm to the frame carrying the shutters and causes them to move from side to side, deflecting the air.

centre of the blades makes a neat combination of electrolier and ceiling fans.

Porthole fans for exhausting and ventilating are also among the "Freezor" designs, and the range includes both the smallest and largest sizes. The illustrations given on this page show examples of most of the types referred to.

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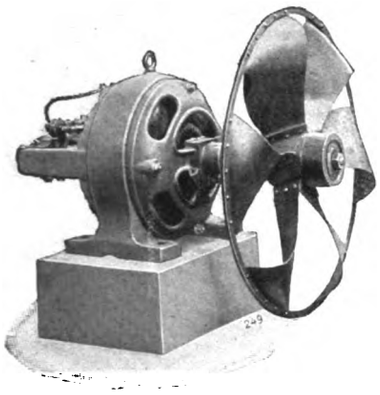

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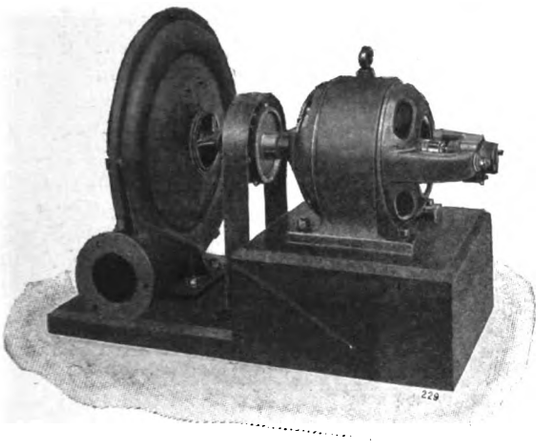

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Notes and Observations.

VII.—A Suction Epidemic.

WE'VE just got rid of the plague in this district. Not a plague of flies or beetles or locusts, but just suction gas plants. The epidemic was bad while it lasted, but a powerful disinfectant composed of insulation mixture in iron cases prevented the spread of the trouble, and ultimately exterminated it. By careful application we managed to fight down the disease.

But one old fogey had it bad, and unless we cured him speedily we feared a fresh break out in a new part of the town, where several factories were being built. Whether the symptoms are productive of infection by auto-suggestion or some other auto, I don't know. At any rate, we felt that unless the violent pulsations, aspirations, and reciprocations of the patient were subdued and finally got under, there might be a danger of relapse.

Mr. Phlegm looked a little more scraggy, and certainly much more snappy when I called in to introduce several matters of importance to himself, but of vastly greater importance to the "cause." Incidentally I had a tale to tell.

"Still buffing merrily?" I asked. He never said "good morning," not even to his dog.

"Why not?"

"You never can tell."

"Tell what?"

"Why, the real worth of suction gas plant."

"Oh!"

"Perkins thought he could, but gave it up."

"Indeed."

"After his bust I kept him going for a fortnight."

"Why?"

"His engine was shut down for a week, and when they started up the piston seized."

"That's nothing."

"So; but you see the fly-wheel went on, and there was the deuce to pay."

"Humph!"

"When I got down there Perkins was slinging hot things around, and consigned me to a warm place when I looked into his office."

"Didn't he hit you?"

"No, but he might have done, because I walked over his papers and took up his telephone."

"What for?"

"To ring up our motor stores for a machine to replace his buckled engine."

"No mains there!"

"None that you know of, but they're there all the same. Perkins will tell you. We were running again inside a couple of hours."

"Liar!"

"Don't mention it, I'm used to that expression; anything stronger if you've got it."

"Perkins always was mad."

"Sane enough now to sell you his repaired engine. It hasn't done any sucking since the night of the beano."

"Really. Good morning."

I didn't despair, however, of wiping out those plague spots, but I did not look for a bit of luck to help me through. I had made it a practice, wherever it could be done without too much expense, to lay mains past the works of likely customers, and to keep a motor handy which could at short notice be run in when the steam or gas engine "croaked." I was well known to the big local manufacturers, and they all had my telephone number writ large on their desks in case of a breakdown.

A call came when I least expected it.

"Ah, Mr. Phlegm, you is it? No anthracite, eh? You're on the wrong number. I don't sell coal in bags. I can give you a supply at the end of a wire. Three weeks famine. Eh? Gee, whizakins! you will feel cold. Good morning."

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I thought I heard him say hard things before the receiver left my ear, and it must have been so, for he fell into my office half-an-hour later positively raging.

"I believe you've done this," he shouted.

"Done what?"

"Worked this anthracite famine. You can't get your motors in by fair means so you are trying foul."

"Really, Mr. Phlegm, you flatter me; but much as I should wish,"—I began, but he fizzed out of the door and was gone.

He'd been shut down two days and the famine continued. I kept clear, though I was always within telephone range.

On the third day he rang up. Only the night before I had opened the ground outside his works and teed on a length of cable which was coiled under some loose flags.

"Good morning," came over the wire.

"Good morning, Mr. Phlegm," I replied, when I had recovered from my astonishment.

"Sorry I spoke so,"—he started.

"Not at all," I interrupted; "fact is I thought it better you let drive. Does a man good sometimes, if the circumstances excuse it."

"Engines are stopped now. They've got furred up. Can't get any more sawdust and brick bats through the producer."

"Aye."

"Your mains, I believe, are somewhere—," he went on jerkily.

"Are you serious?"

"If you can I shall be obliged. I've lost more than I care to reckon through this stop."

"You shall be running inside an hour," I said; "but you might have come before, you know."

"Yes, that's true, but I thought I could hold out. It's a choice between no anthracite for three weeks and the electric at once."

And thus the plague was wiped out. The motors remained and suction ceased troubling. W. E. W.

Commercial Development of Central Stations.

WHAT looks more dismal in a brilliantly-lighted street than an empty shop in absolute darkness? Even during the day the sombre look of the interior is unrelieved by a spot of light or colour, and the place presents as uninviting an appearance as it well can. We know of no better opportunity for the electric sign, one of the simple letter variety, say, than this affords. The shop or estate agent should be encouraged to put some indication in the window at night that the shop is to let, and that it is not half so bad looking empty as it appears at first sight.

Vacant Shops.

In a good thoroughfare there will usually be an electric service laid on, and this will reduce the cost considerably to the station manager. For the connection a two-rate meter might be included, and the installation put on the low rate while the premises remain vacant. Of course, the agent will need persuading. He will not jump at the opportunity at first, but if it is put to him in the proper light he should appreciate the advantage to himself. If he is anyway enterprising he will avail himself of the electric sign, because in a wilderness of space usually noticeable in vacant shops such a device would be given a good show. But the cost should be borne by the station manager, who might make up a talking sign which could be moved from shop to shop as the empty places became let. The agent should pay for the current. This may appear a small matter to bother about, but as an advertisement the "location" could not be beaten, and, incidentally, the electric service might be advertised at the same time. We have never seen this idea tried, but feel sure it would "catch on" as an idea, and, if not directly remunerative, would achieve its purpose in giving publicity to the system.

The Head Office.

For years gas companies have managed to excite interest in the latest appliances for using gas by placing a goodly show of such devices in the counting house where customers naturally resort to pay their bills. Electricity undertakings are somewhat backward in this respect. The customer finds himself more often than not in a narrow office with a high desk in front of him, and not even the meanest suggestion that the uses of electrical energy extend beyond the lighting of the humble incandescent lamp. Now, when a man pays a bill he is not in the best of humour (especially if it is based on maximum demand), so that he wants placating a little. If his eye rests on a few good coloured pictures of radiators, flat irons, arc lamps, intermingled with several of these things actually "in the flesh," his mind is diverted from his bill, which he discharges in an incidental kind of way the while his eye is attracted by the bright goods around. This is a good opportunity lost if the station engineer makes his consumers "pay, pay, pay" in a cubicle akin to a number of horse boxes. He wants to get at his consumers, yet forgets that almost regularly they come to him. We know of no better occasion for publicity than "settling day," and certainly no better place in which to put it into practical effect than the pay desk at head office. But, like everything else, the appeal must be properly made and in season. During the winter months radiators should be aglow in the office, surmounted by neat cards specifying the cost of operating them. Summer pay days should be relieved of their depression by the soft whirr of electric fans. All the year round motors can be on view, and cooking and small heating apparatus.

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Ironclad Switch Fuse Boxes.

WE have pointed out on previous occasions the importance of ironclad switch gear, and its value in the distribution of electrical energy for power purposes. The ironclad switch and fuse is to-day a commercial possibility, because the improvements effected in the manufacture of insulating materials increase the reliability of the medium employed for isolating the current-carrying parts of the apparatus from their support.

When ironclad switches and fuses were first introduced it was a common thing to enclose each individual unit in its own iron box. This method necessitated the use of rubber covered connecting leads between the three units, and although rubber insulation is reliable enough, this arrangement required a considerable amount of space, and, consequently, was more costly to erect than a combined switch and fuse unit would have been. With ironclad switches and fuses the tendency at the present time is to effect this desirable combination of previously independent units. The British Insulated & Helsby Cables (Ltd.), of Prescot, Lancs., have just introduced a switch cutout of this kind, which possesses somewhat novel features. From the illustration (Fig. 1) it will be noticed that the design provides for cable receiver, D.P. fuse and D.P. switch within the compass of a single box. The fittings in the box illustrated are made for ingoing concentric cable and one pair of outgoing cables. The design of switch adopted is both simple and effective. It consists of a single moving part mounted on a spindle,

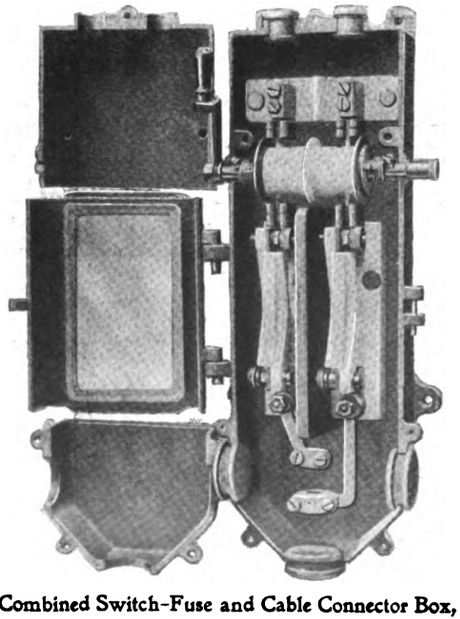

Fig. 1.—Combined Switch-Fuse and Cable Connector Box, Open.

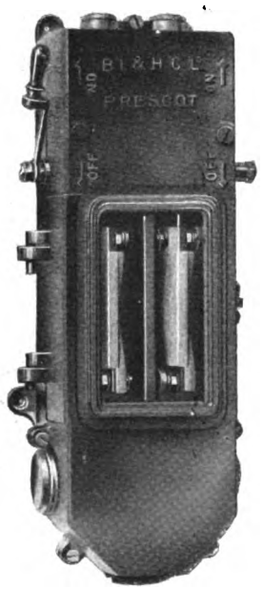

Fig 2.—Switch-Fuse Box, Closed.

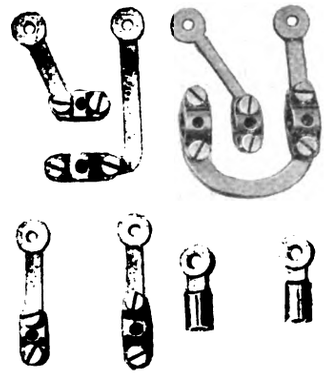

Fig. 3.—Fittings for incoming Cables, showing on the right a Set for Straight-through Connection.

which bears on the sides of the iron box, one end terminating in an operating handle. This handle may also be placed at the opposite side if desired. On the spindle is fixed a porcelain drum with a deep flange in the centre for dividing the two poles of the circuit This drum serves to support the two bridging pieces of the switch, these latter being mounted securely on the porcelain. Springs are provided on the spindle which ensure a quick break motion when the switch is turned off. The cover of the box is in three parts, the centre part being fitted with glass for the inspection of the fuses. The lower cover when closed forms a sealing chamber for the incoming cable. This cable can also be brought in from either side of the box, the only alteration required being in the fittings connecting the conductors with the terminals of the fuses. The holes in the sides of the box also provide for a straight-through connection by which two or more consumers can be conveniently tapped on to the same cable. This provision also is useful where a power and lighting service is to be given to one consumer. A view of the switch box closed is illustrated in Fig. 2.

The British Insulated & Helsby Cables also manufacture a complete line of house fuse boxes for every class of service connection. These are all iron-cased, and they differ mainly in the arrangements made for the introduction of the incoming cables. The fittings illustrated in Fig. 3 include a set intended for straight-through concentric cables. The fuse wire can be asbestos-covered wire, but the fittings are suitable for bridge fuses if these are specified. The products of the company in this direction also include single-pole ironclad fuses which can be mounted on suitable boards for fixing on consumers' premises. Any number of these can be used in combination, and special ceiling chambers can be supplied for the leading-in cables. A large pattern is also made, which has terminals for enclosed fuses of a capacity of 600 amperes.

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Suction Gas v. Hydro-electric Power. . . .

IN Great Britain, where water-power plants are scarce and coal is plentiful, the prevalence of steam- and gas-driven electric power plants is not to be wondered at. But hydro-electric power is commonly regarded as among the cheap forms of energy for industrial purposes, and, compared with even gas power, is assumed to be cheaper under the most unfavourable circumstances. A writer in *Canadian Machinery*, however, effects a comparison between suction gas and hydro-electric power which is not flattering to the latter. We quote his figures in some detail as being of interest. The American notation will not be difficult of conversion :—

Suppose a manufacturer has a factory and that he requires a fairly steady load of 108 H.P. for 10 hours for 300 days per year, and that he has decided to use motors and electric lighting, what will be his best source of energy, and what will it cost?

The manufacturer goes to the city of Toronto and finds that Niagara power will cost as follows for the above-mentioned load :—0·35 cent per H.P. per hour as a meter rate, 0·40 cent per H.P. per hour flat rate whether he uses the power or not; total, 0·75 cent per H.P. hour. His power would therefore cost for 300,000 H.P. hours at 0·75 cent $2,250.

In addition to this there are the fixed charges and maintenance on his motor equipment. This will be the same in either case, and has not therefore been taken into consideration. The power user then goes to the producer gas manufacturer, and finds that a 100 H.P. suction gas engine and produces plant will cost installed $5,700, and an electric generator, &c., $2,300, total $8,000. The fixed charges for this plant will be as follow :—

Interest at 6 per cent.	....	$480
Depreciation, engine, 7 per cent.	.....	294
,, producer, 4 per cent.	.....	54
,, electric generator, 10 per cent.		230
L bour (one man, $50 month)	.....	600
Repairs, &c.	.....	100—$1,758

The fuel and oil charges will be as follow :—A suction gas plant will burn a pound of good pea anthracite per H.P. per hour when running at or near full load; and at half load the consumption will be about 1·5 lb. Pea anthracite costs in Toronto about $4·20 per ton. Fuel used may be calculated as follows :—100 H.P. by 10 hours by 300 days by 1 lb., equal 150 tons per year = 2,000. Allowing 3 lb. for stand-by losses per hour we have 3 by 14 by 300, equal 6 tons per annum = 2,000. Total fuel will then be 156 tons at $4·20 = $655 ; oil and waste, &c., will cost $120 = $775. Total cost for power per annum : Fixed charges on plant, $1,758 ; fuel, oil and waste, &c., $775 = $2,533. Total cost per H.P. per annum, $25·33.

Reducing to same basis as rates for Niagara power we have, for 300,000 H.P. hours : Fixed charges per H.P. hour, 0·586 c. ; fuel, charges per H.P. hour, 0·258 c. ; total, 0·844.

Hence, we find that producer gas power only costs less than one-tenth of 1 c. more per H.P. hour than Niagara power for the same plant capacity. While the cost of power in a 100 H.P. gas plant is very slightly higher than Niagara power in Toronto there are advantages to be gained from the use of producer gas which would more than offset the extra cost.

Niagara power is as yet very much too expensive to use as a source of heat for buildings ; consequently a user of Niagara power has to use coal directly for heating purposes for six months in the year. In a 100 H.P. gas plant there are about 3,500 B.Th.U. available per pound of coal burned, or 350,000 B.Th.U. per hour in the exhaust. By exhausting this heat through the tubes of an ordinary steam boiler it is possible, assuming an efficiency of 60 per cent., to raise 216 lb. of water to steam at 70 lb. boiler pressure per hour. That is, there are available in the exhaust gases from the 100 H.P. gas engine 7 boiler H.P. during the time that the engine is running on 10 hours per day. By arranging this boiler with a grate, steam may be kept up during the night by burning coal in the usual manner. Thus, it is possible to recover 7 per cent. of the capacity of the plant and to save $175 per year, and so reduce the fuel cost of the power to the comparatively small amount of $600. The total cost per horse-power per annum is thus reduced to $23.58.

The writer has charged the whole of the engineer's time to the cost of power. It is quite fair that a portion of this time should be charged to other work, as it has been found that about three hours per day is sufficient to attend to the whole plant in medium-sized installations It can now be easily seen that producer gas can compete with hydro-electric power in all portions of the country, with the exception of the Niagara peninsula and vicinity.

This comparison appears fair enough and contains no extravagant items in support of the suction gas plant. But we notice that no reference is made to the greater convenience of the hydro-electric service. Only those who have discarded isolated plants in favour of a transmitted supply can appreciate the difference between the two on the score of convenience. It seems reasonable enough to suppose that a manufacturer will adopt the cheapest source of power, and will not give a money value to convenience. When he has had his power plant laid by for repairs, and a section of his works shut down, he will add a column to his table of comparative figures headed "convenience." The moral of hydro-electric transmission is the removal of small power units, no matter how efficient they may be. The power user has something else to do than generate electricity. His object in life is to make well and sell well.

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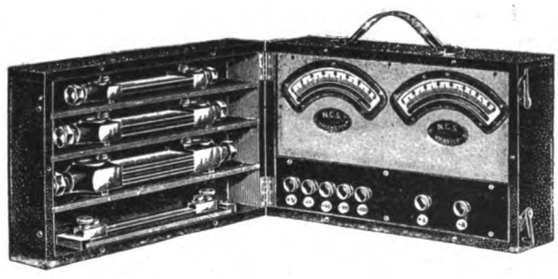
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Henley's Fuse Boxes.

A NEAT design of ironclad fuse box is being marketed by W. T. Henley's Telegraph Works Co., which has several distinctive features. The objects in view have evidently been accessibility, insulation, mechanical strength and simplicity of parts. The device consists of a narrow iron box, into which a shallow and narrow box fitted with a porcelain base with terminals and fuses. The porcelain base is specially shaped to provide a narrow air chamber through which the fuse wire passes, and from which any volatile gases can make their escape. Fig. 1 is a sectional view through this base and the fuse bridge. It will be noticed that the bridge also has a hole leading from the fuse wire chamber to the outside air. When the fuse blows a pressure is createp through this aperture, which causes the air to rush in at the sides of the fuse and put out the arc. In Fig. 2 a general view of the base, terminals and fuse bridge is shown. The terminals are in one piece and the contacts admit of the fuse being replaced at any time.

The fuses are all built up single pole with enclosing iron case, the lower portion of which is modified to suit the type of incoming cable used. For instance, hygroscopic cables require special sealing chambers, which are usually mounted with the fuse on a single board. This board is fixed to the wall on insulators fitted into holes at the four corners. We give illustrations, in Figs. 3, 4 and 5, of various modifications of the mounting of these fuses. The iron cases are finished in stove enamel and have a special fixed sealing pin, which we understand cannot be lost. The standard capacities of the fuses vary from 25 amperes per circuit to 100 amperes. A window is fitted in the hinged cover of the fuse for inspection purposes.

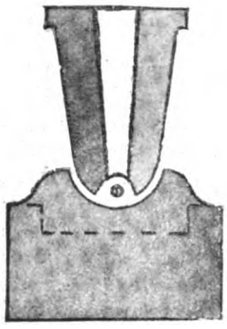


Fig. 1.—Section through Fuse and Block.

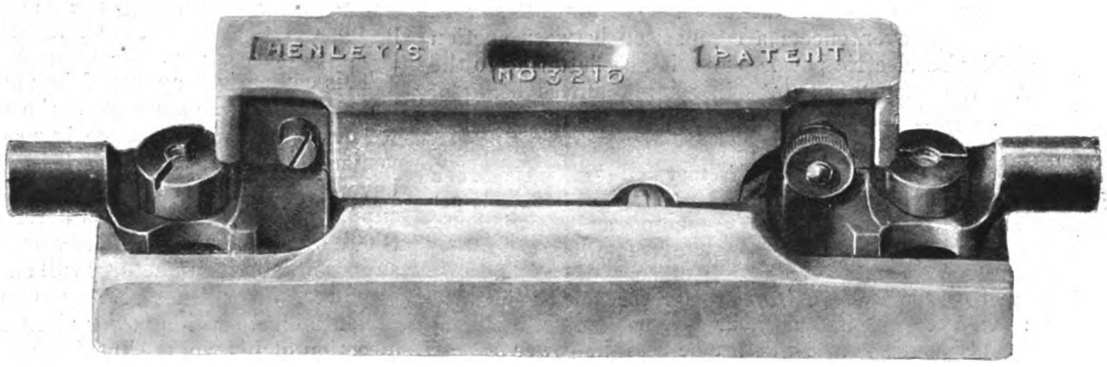
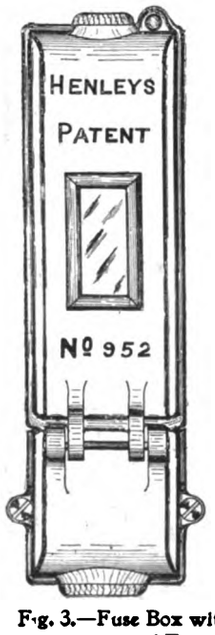


Fig. 2.—General View of Fuse Porcelain Base and Terminals.



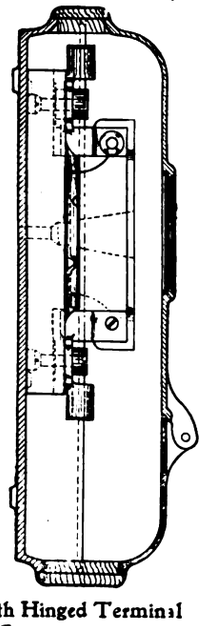


Fig. 3.—Fuse Box with Hinged Terminal and Fuse Cover.

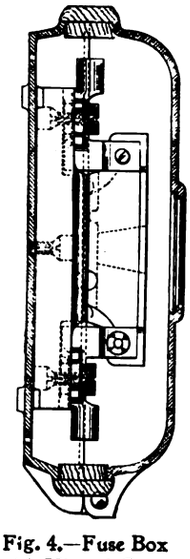


Fig. 4.—Fuse Box with Hinged Cover.

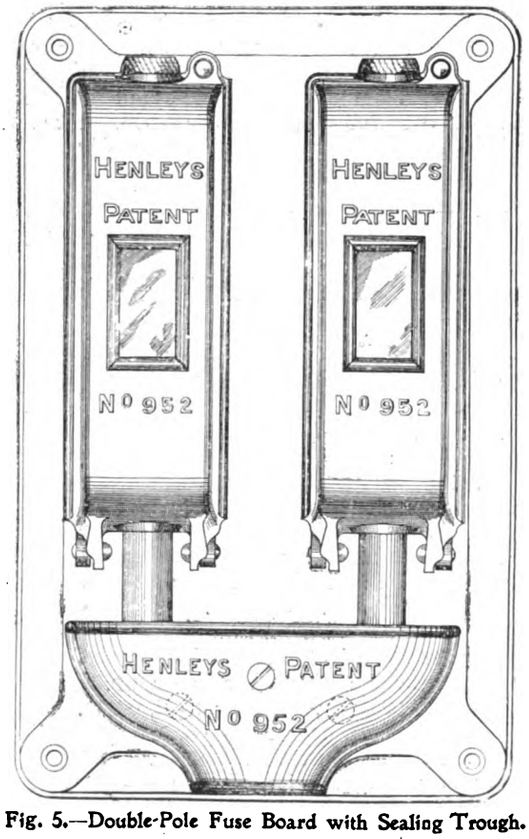


Fig. 5.—Double-Pole Fuse Board with Sealing Trough.

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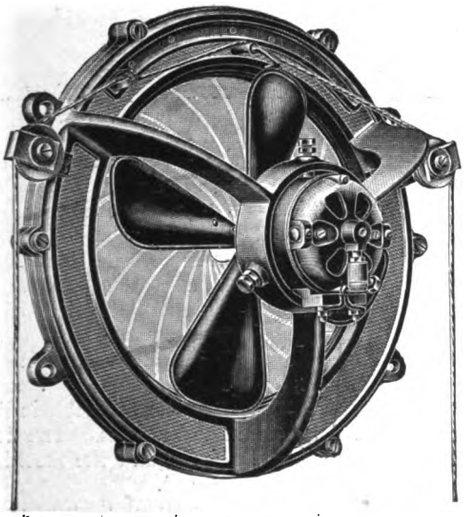
Siemens' Electric Fans.

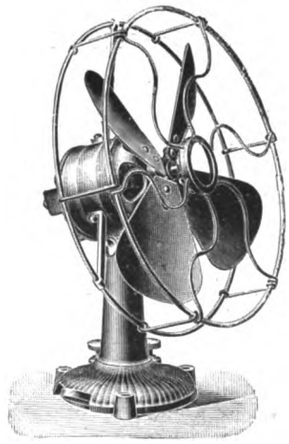
AMONG the products of Siemens Brothers Dynamo Works (Limited) are electric fans of all the usual sizes and types, such as table fans, ceiling fans and porthole fans. In order to meet all possible requirements and conditions, the firm gives customers the choice among the following types of fan motors:—Continuous current motors for any voltage up to 500 volts, and single-phase commutator motors, single phase induction motors and three-phase induction motors for any frequency and for any supply pressure up to 500 volts. The motors are of the protected-ventilated type or of the totally-enclosed type, as may be desired. The brushes are of carbon and are readily accessible for inspection and renewal. As will be gathered from the illustrations, the fans are of neat and strong design.

All the table fans are supplied complete with brass wire guards, and the guards and blades are nickel-plated if required. In all but the smallest sizes the fan may be rotated in a bearing in its base to give the current of air any desired direction. The starting and speed-regulating gear is mounted inside the base of fans of the table patterns, but it is fixed independently of the fans in other patterns. The ceiling fan illustrated is of the "short" type; in the "long" type, the fan is attached to the end of a suspension, the length of which is made to order. Porthole fans may be fixed either vertically or horizontally. The type shown is fitted with Iris shutter, but these fans are also supplied with a Venetian shutter or without shutter at all. The Iris shutter is a convenient adaptation of the well-known diaphragm so commonly used in photography. It is not automatic as the shutter plates are moved by cords depending from the motor support, but it effectively excludes air when the fan is not working.

"Short Pattern" of Electric Ceiling Fan.



Porthole Electric Fan with Iris Shutter in Fan Aperture.



Plain Desk Fan with Fixed Base and Adjustable Motor.

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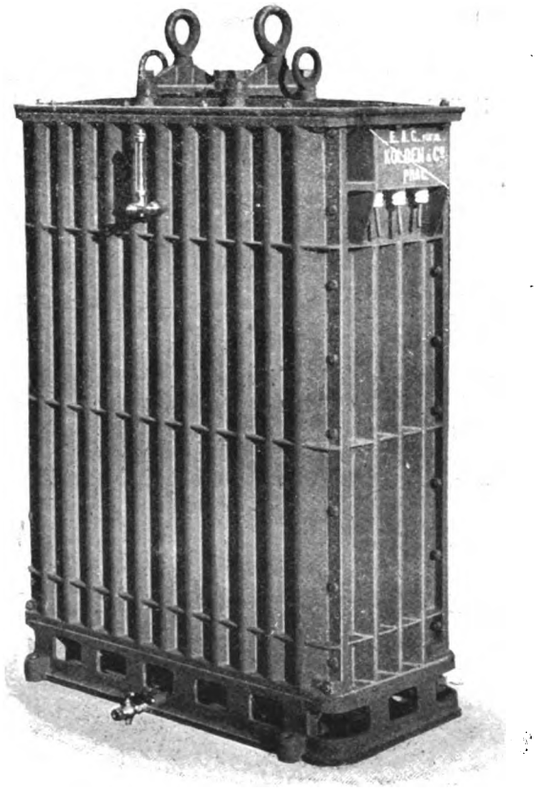
Three-Phase Oil-Cooled Transformers.

THE oil-cooled type of transformer is generally recommended for capacities over 60 K.V.A., and for all transformers where the primary pressure exceeds 5,000 volts. The reasons for this being are that, in the larger sizes, oil-cooled transformers are very much cheaper for the same output, the overload capacity is greater, and for high-tension work there is less liability of break-down, as the windings are entirely isolated from the surrounding atmosphere. The moisture in air, as is well known, is very often the cause of trouble in the air-cooled type.

The transformer shown is a Kolben standard type for outputs from 60 K.V.A. to 400 K.V.A. It consists of three upright and two horizontal cores with butted joints, made up of special transformer sheets 0·45 mm. thick, these sheets being insulated from each other by paper insulation. Special attention is given to the machining of the butted joints of the cores, to keep the no-load losses as small as possible. The stampings of the horizontal cores are built up between strong channel irons which serve as a frame work for the transformer. The vertical cores are placed in position between the horizontal ones, and the latter are then bolted firmly together by long bolts. Numerous ducts are provided in the core allowing the oil to freely circulate. The high tension winding is wound in several sections, these being assembled outside the low tension winding, which therefore comes next to the iron, but is insulated therefrom by a cylinder of specially prepared paper; a similar cylinder also separates the high and low-tension windings. Unless otherwise ordered, the transformers are star connected, the neutral point being brought out to a fourth terminal.



Kolben Oil-Cooled Transformer.

The whole transformer is placed in a corrugated sheet-iron tank, the surface of the tank in contact with the oil being calculated to give a cooling surface of 6¼ sq. in. per watt lost at full load. Throughout the whole construction special attention is not only paid to durability and strength, but also to give a minimum amount of trouble when dismounting for inspection or repairs. Taking as an example a transformer of 200 k.v.a. output the following figures are of interest. The no-load losses due to hysteresis and eddy currents in the cores would not be more than 1·3 per cent. At constant primary pressure the pressure drop from no-load to full load will not exceed 1·1 per cent. for 100 per cent. power factor and 2·2 per cent. for 85 per cent. power factor. The efficiency at full load is 97·7 per cent.

The temperature rise will not exceed 50°C. after a continuous run of 24 hours on full load, the temperatures being taken in the oil at the top of the tank.

Kolben & Co. make all classes and sizes of transformers, including special types for regulating and boosting, and the larger oil transformers over 200 k.v.a. are provided with tubes for water circulation giving a still larger cooling surface. These tubes are arranged in the oil above the transformer, the tanks being specially made higher for this purpose.

Zone Dynamos and Motors.

THE issue of a new file of dynamo and motor leaflets by Newtons Limited, Taunton, recalls the special field windings of their "Zone" machines. The usual method of spacing solid-wound poles in the field casing round the armature is abandoned in favour of a spool which embraces a pair of poles with an air-gap between. The end view of a machine shown in Fig. 1 explains this. The field coils being placed in the neutral zone of the field reduce the magnetic leakage to a negligible quantity and prevent field distortion due to armature reaction. This construction allows the machine to be run with fixed brushes at all loads from no load to 50 per cent. overload. The makers claim increased efficiency for this type of machine, and also a greater cooling effect owing to the peculiar disposition of the field windings. An examination of the diagram will show at once that there is air both inside and outside the coils, and the circulation of this naturally tends to keep the windings cool. Another claim made by the makers is that the special winding dispenses with the need for commutating poles. The design is embodied in both dynamos and motors, and the machines can be wound, shunt, series or compound. The motors can be supplied open, ventilated or enclosed, and they are built in sizes ranging from ¼ H.P. to 500 H.P.

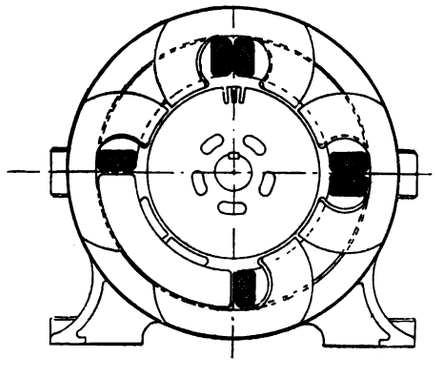


Fig. 1.—End Section of Zone Motor showing special Field Winding.

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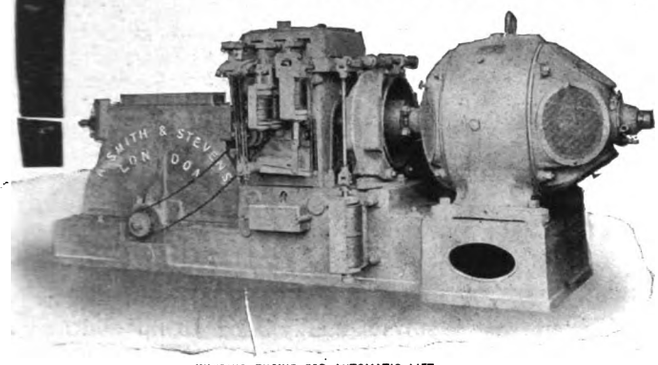
ELECTRIC LIFTS



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A. Smith & Stevens.

Every breakdown of a Lift means delay, loss and annoyance. . . .

Instal ours and you will secure continuous service.

BATTERSEA, LONDON.

Electrical Instruments for the Deaf.

IN this age, when electrical engineers are intent on applying their technical knowledge to the solution of many commercial problems, it is pleasing to note that the lot of those less fortunate than others who are in possession of all their faculties has been considered, and that scientific aids for these have been devised.

It is, indeed, unfortunate, to be deaf and shut off from all enjoyment of general conversation and by-play of life, which form so great a part of it. To these the "Acousticon" and "Massacon" come as a very great boon, and more so to those so afflicted that exchange of ideas by conversation is almost an impossibility.

The "Acousticon" consists of a very sensitive microphone transmitter with a specially designed sound-concentrating case, which is worn on the clothing exposed to the sound; a receiver held to the ear with the hand or by means of a handle or head band; and a small 3 volt dry battery which is carried in the pocket.

Sounds proceeding from any source within the distance of an ordinary room will be received by the diaphragm of the transmitter and sent into the outer ear by the receiver in a magnified form. It is not necessary to raise the voice in speaking to a deaf person using an Acousticon, nor is it necessary to speak directly toward the instrument. The Acousticon has been tried and recommended by many of the leading engineers of the world. It has the approval of Mr. Edison and Prof. Alexander Graham Bell amongst others.

An interesting application of the Acousticon is in connection with what is known as the Dictograph, which connects, says the manager of a large business, with each department as desired, and puts him in immediate communication with any clerk or department manager. The use of earpieces with this instrument is not necessary, and the sound proceeds from it with the same strength as spoken at the other end, nor is it necessary to speak directly or close to the transmitter. It is said to save an hour a day to the busiest man in the office.

Another application of the Acousticon is in the Multiphone, which transmits sermons, speeches, &c., to any distance, and gives them out at natural strength, so that they are perfectly audible to a room full of people. The Acousticon has also been used in connection with the "Telegraphone" to pick up speeches, music, &c., to be recorded on the steel wire of that instrument. It was found after many tests that the Acousticon was the only transmitter that would accomplish this.

The "Massacon" is an electrically-operated sound massage for the cure of catarrhal or middle-ear deafness. It massages the small bones of the middle ear, freeing them from the adhesions produced by catarrh, which bind them together, and restoring them to their normal state.

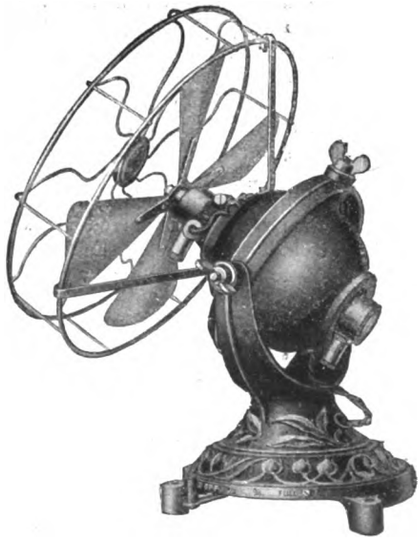
Both Accousticon and Massacon are the inventions of Mr. M. R. Hutchison, of New York, a Member of the American Institute of Electrical Engineers. They are sold by the Acoustic Patents, of 20, Bucklersbury, London, E.C.

"J.S." Electric Fans.

THE electric fans exploited by Julius Sax & Co. have been on the market for some time, and improvements have been made in their construction to ensure their efficient and satisfactory operation under all working conditions. They are British made by skilled labour, and we understand that all fans must pass severe tests, while every possible precaution is taken to maintain their efficiency. They are supplied for continuous-current circuits from 80 to 250 volts.

They are suitable for use on table, floor, desk, wall or ceiling, and by simply loosening the fly nuts the current of air may be delivered in any direction.

The frame consists of a stout pedestal of soft grey cast-iron, with gimbal ring of the same material. The pedestal is provided with rubber feet to absorb vibration, and the field is cast in one piece with motor body, thus forming an unbroken magnetic path. The commutator is of hard-drawn copper, and double silk-covered high-conductivity copper wire is used for the armature coils and field windings. Carbon brushes are self-adjusting, and the armature bearings are of phosphor bronze, fitted with wick-feed lubricators. Starting switch and speed regulator are fitted inside the base, the resistance coils being wound on non-hygroscopic porcelain. Spring catches ensure the switch being left central on the various stops. The standard finish is black enamelled frame and body, polished brass fittings and guard, and frosted aluminium blades.



"J.S." Trunnion Fan.

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J. S.
ELECTRIC FANS

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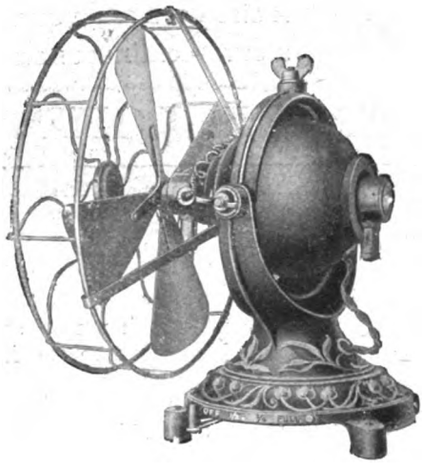

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Japanese Paper Mills.

THERE are evidences that Japan intends to turn her water power resources to good account for electrical and industrial purposes. The actual extent of these resources has not, to our knowledge, yet been ascertained, but the most casual survey of the geography of the island must show considerable amounts of available power.

According to the *Electrical World* representatives of the Oji Paper Co. of Tokio have been for some time inspecting various electrical properties in the United States with a view to installing a modern electrically equipped paper mill in Japan. As a result of their investigations orders have been placed in the United States for complete electrical and mechanical equipment amounting to over a million dollars. At the power station there will be installed four waterwheels driving three phase 3,125 k.v.a. units, generating current at a potential of 3,450 volts, 60 cycles. Exciting current will be furnished by the usual twin exciting units, consisting of two 150 kw. generators, driven respectively by an induction motor and a small waterwheel. Generator regulation will be effected by a Tirrill regulator. Twelve water-cooled step-up transformers will be arranged in sets of three to raise the voltage for a 15 mile transmission. Each transformer will have a capacity of 1,050 kw., and the primary voltages will be arranged with Y connections for either 46,000, 45,000 or 44,000 volts. An eight-panel switchboard will be installed in the main station, and at the sub-station, near the mill, 12 step-down transformers will be employed to reduce the transmitting potential to 2,200 or 1,000 volts. The switchboard will be arranged to distribute power at the desired voltage directly to the motors. In the paper mill five 750 H.P. 2,000 volt induction motors will be used to drive the pulp grinders. The motors will be slip-ring machines with an external resistance in the armature circuit and controllers to vary the speed. Each motor will have an extended shaft and will be so placed between two pulp grinders that both grinders can be driven directly without belting. Four beater machines are to be driven each by a 350 H.P. induction motor, operating at a potential of 2,000 volts. A fifth will be driven by a 200 H.P. induction motor, and all will be operated on the rope-drive system. The Oji paper mill will be situated at Hakaido. From the details given above of the equipment the scheme is one of considerable magnitude.

Marine Electric Stoves.

THE term marine stove naturally brings to lips and nose the taste and smell of oil. That electricity should be used for ship heating, in the more commodious parts of the vessel, seems only natural, particularly as the necessary energy is available from the ship lighting installation. Messrs. O. C. Hawkes (Ltd.), Aldersgate-street, E.C., supply a special stove for use on shipboard, which furnishes heat on their well-

The Lighthouse Marine Electric Stove.

known induced draught principle. This is of neat, compact design and a convenient size for cabin use. The adjoining illustration depicts one of the styles in which the stoves are made. It is dubbed "The Lighthouse," after the design on the front. A small box is furnished with these stoves to store them away when the vessel is passing through more congenial climes.

One-Phase Induction Motors.

THE sphere of utility of the one-phase motor is limited in the majority of industrial operations to comparatively small sizes. The machine, by reason of its simplicity, commends itself to the average power user and in many places where it is used it is highly spoken of. B.T.-H. one-phase motors are built in two forms, (1) the short-circuited rotor and (2) the slip ring. The first is made for sizes up to 5 H.P. and is started by the usual phase-splitting device which limits the starting current to about $1\frac{1}{2}$ times the full load current. A double-width pulley is fitted to enable the belt to be put over to the loose pulley for starting. The slip-ring motor is made for sizes from 5 H.P. upwards. An external resistance is used with this type for starting, and by means of a switch the windings are short-circuited in the rotor itself, the brushes and resistance leads being cut out. Standard types of these motors are built for 100, 200, 400 and 500 volts and a standard frequency of 50 cycles. The covers of the motors are arranged to give an open, semi-enclosed and totally-enclosed machine. The sizes range from $\frac{1}{6}$ H.P. to 20 H.P., the respective weights of these sizes being 46 lb. and 1,115 lb., motor and pulley, without slide rails.

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NOTES.

The Brennan Mono-Railway.

DURING the past few years the mono-rail has been a favourite subject with inventors, but the system so far proposed has generally consisted essentially of a rail raised considerably above the ground level, with the cars so constructed that they practically hang down on either side of the rail, the centre of mass being thus brought below the rail to give the necessary stability. Another method of obtaining the same result is to fix the rails on trestles so high above the ground that the whole carriage can be hung beneath it. But the system devised by Mr. LOUIS BRENNAN is on entirely different principles, depending upon gyroscopic action. The rail is laid on the ground level, or practically so, and the car is fitted with gyroscopes. There is only one line of wheels, which are placed centrally along the length of the truck. Consequently, when the car is out of use some support must be given to it to prevent it falling to one side or the other. In the ordinary course of things this can be easily done by supports projecting downwards on either side to the ground to give the necessary steadying effect, but when the gyroscopes have run up to their normal speed these supports can be withdrawn and the car is then perfectly stable. In the model which was shown at the conversazione of the Royal Society last Wednesday evening, the effectiveness of these gyroscopes was shown in a remarkable way. The model, which was 4 ft. or 5 ft. in length, was equipped with two gyroscopes running at 7,000 revs. per min., and appeared to be equally at home on the tight rope with which it was raised off the platform, or upon the track surrounding the room on which it subsequently ran. The whole model was worked electrically. In actual practice we presume that electrical driving or steam driving would be adopted according to circumstances, the gyroscopes being driven electrically in any case. As to the future of the device, it would appear that there should be a large opening, at least where the difference in cost in laying a single rail and the ordinary track is of importance. This, of course, is essentially the case in War Office transport, and we are therefore not surprised to find that a full-sized vehicle is being built for the War Office to see what its capabilities really are.

The L.C.C. Power Scheme.

MATTERS are moving somewhat slowly in connection with the power scheme of the London County Council, and it is evidently taking a little time for the new Council, with the recent political change in its policy, to know exactly how things stand. The Parliamentary Committee however, has considered the power question in a preliminary sort of way, and has come to the conclusion that none of the private bills at present before Parliament constitute a satisfactory settlement of the question, apart from the Council's Bill, and that consequently the withdrawal of the Council's Bill "would postpone the solution of this most important and pressing question for an indefinite period." The Bill has therefore been submitted for second reading; but no doubt the intention is to transfer the desired powers to some company so as to avoid the financial risks to which the Finance Committee has called attention more than once. Some sort of control is to be retained, though at the present time the Committee is unable to indicate the nature and the extent of the arrangements into which the Council should enter. The Committee is, therefore, content with expressing the strong opinion that a cheap supply of power should be

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provided; this is to be coupled with a sliding scale of prices and dividends, and last, but not least, a satisfactory purchase clause for the Council with regard to the undertaking.

Seamless Copper Tubes.

A NEW method of manufacturing seamless copper tubes by electrolytic deposition is described by KRAUSE in a recent issue of the *Zeitschrift für Angewandte Chemie*. In the Elmore process an agate burnisher is used to give density and smoothness to the copper deposited upon a revolving mandrel, while COWPER-COLES attains the same effect by rapid revolution of the mandrel in the electrolyte, the skin friction of the liquid upon the surface of the deposited copper serving to remove gas-bubbles and small inequalities. The disadvantages of these two methods are the complicated machinery required for the Elmore process, and the comparatively high power required for operating the Cowper-Coles process.

THE new method depends upon the use of some finely divided silicious material such as quartz sand or the infusorial earths as burnishing agents. This material is suspended in the electrolyte, and rubs over the surface of the deposited copper as the mandrel revolves; it thus produces a deposit possessing the density and strength required in the tubes used for marine engineering work. A polished iron cylinder coated with nickel is used as mandrel and the speed of rotation is 20 revs. per min., which is low as compared with the very high speed demanded for the successful operation of the Cowper-Coles process.

THE tubes made by this process at the works of LANGBEIN BROS., in Leipzig, have been tested at Charlottenburg and have given results for strength and tenacity much higher than those demanded by the German Admiralty. Tubes up to 2 metres in length, 20 cm. in diameter, and 5 mm. in thickness, have been made at Messrs. LANGBEIN'S works, using a current density of 2 amperes per square decimeter and an E.M.F. of 2·5 volts. This method of obtaining dense deposits of metals by electro-deposition can be employed with all electrolytes which, under normal conditions, yield porous or spongy deposits at the cathode, and the only precaution necessary is to select a finely-divided material as burnishing agent which will be unacted upon by the electrolyte.

Research on Wooden Poles.

IN the discussion at the Institution of Electrical Engineers on Mr. C. WADE'S Paper on Wooden Poles, Mr. A. P. TROTTER mentioned how the Paper originated. Being in need of some information as to wooden poles, Mr. TROTTER applied to Mr. WADE, who forthwith began to carry out an elaborate series of tests at his own expense in order to secure the necessary information. These tests form the subject matter of Mr. WADE'S interesting communication to the Institution. It is too much to hope that every firm when asked for information should take up a matter of this kind so seriously, but, nevertheless, it would be well if certain firms would follow Mr. WADE'S example, if only to a comparatively small extent.

Imperial College of Science and Technology.—At the annual dinner of the Institution of Mining and Metallurgy last week Mr. M'Kenna stated that he hoped during this week to petition the King for a charter for the new Imperial College of Science and Technology.

King's College, University of London.—We are informed by Mr. P. H. Kirkaldy, honorary secretary of the committee, that the forty-seventh annual dinner of King's College will be held at the Hotel Cecil on Monday, May 27th. The Bishop of St. Albans will be in the chair.

Royal Institution.—At a general monthly meeting held on the 6th inst. Sir James Crichton-Browne, treasurer and vice-president, in the chair, it was announced that His Grace the president had nominated the following vice-presidents for the ensuing year: The Right Hon. Lord Alverstone, G.C.M.G., Sir Benjamin Baker, K.C.B., Dr. Donald W. C. Hood, C.V.O., Sir Andrew Noble, K.C.B., Alexander Siemens, Esq., the Right Hon. Sir James Stirling, Sir James Crichton-Browne (treasurer) and Sir William Crookes (honorary secretary).

Electrical Surveyors' Society.—A meeting of the above newly-formed Society, which consists of the experts attached to the various fire insurance companies, was held on the April 29th. Mr. S. G. Castle Russell presided, and was supported by the hon. secretaries, Mr. Bertram Chatterton and Mr. Arthur C. Cockburn, and by a large attendance of members. A discussion took place upon the question of earthing metallic conduit wiring systems. The opinion of the meeting was taken, and it was unanimously agreed that efficient earthing of metallic conduit systems throughout their entire length was advisable.

Personal.—We learn that Mr. Horace Boot, who has for the past 12 years held the appointment of consulting and resident engineer to Tunbridge Wells Corporation, has resigned this position. It is Mr. Boot's intention to continue to practice as a consulting engineer in London. The Tunbridge Wells Council, at their meeting on May 1st, decided to retain Mr. Boot's services as their consulting engineer.

Oxford University has conferred the honorary degree of D.Sc. on Prof. Alexander Graham Bell.

Sir William Ramsay, F.R.S., has been awarded the Matteucci gold medal by the Società Italiana delle Scienze. He has also been elected an honorary member of the Academy of Sciences of Christiania.

A New Electric Furnace.—A new electric furnace, in which any required temperature may be obtained, is described by Herr A. Schwarz in the *Physikalische Zeitschrift*. The apparatus consists of an iron tube 2·4 in. in diameter and 2 ft. 8 in. long. At two opposite points in the tube are openings covered by a mica screen, through which all actions taking place in the interior can be observed. The whole tube, except the mica screens, is protected with an asbestos covering, on which is wound a nickel heating wire 0·03 in. in diameter. Over this spiral is fitted a cover 1·2 in. thick of some substance, which is a non-conductor of heat. Over all is placed a metal cap, separated from the last-named cover by an air space. There are two openings in the outer cover, corresponding to those in the inner tube. In order to avoid a decrease of temperature at the ends of the furnace the following special arrangement has been devised: Two small auxiliary furnaces provided with nickeline coils are placed at the ends of the main furnace, and the current passing through these coils can be regulated as required. In this way a decrease of temperature at the ends of the furnace can be neutralised, and a very uniform temperature obtained along its whole length.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tarifa—Tangier	Jan. 18, 1904 ..	—
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
New Brunswick—Prince Edward Island.....	Jan. 9, 1907 ..	—
Panama—Buenaventura	Feb. 28, 1907 ..	—
Buenaventura—Santa Elena..	Feb. 28, 1907 ..	—
Cadiz—Teneriffe	April 10, 1907 ..	May 6, 1907
Dakar—Konakry	April 24, 1907 ..	—
Gibraltar—Tangier	April 25, 1907 ..	May 7, 1907

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The Institution of Civil Engineers.—At the annual general meeting of the Institution of Civil Engineers, held on Tuesday evening, April 30th, the result of the ballot for the election of officers was declared as follows: President, Sir William Matthews, K.C.M.G.; vice-presidents, Mr. W. R. Galbraith, Sir E. Leader Williams, Mr. J. C. Inglis and Mr. G. H. Hill; other members of council: Mr. J. A. F. Aspinall, Mr. J. Benton, C.I.E., Mr. B. H. Blyth, Mr. C. A. Brereton, Mr. R. Elliott-Cooper, Col. R. E. B. Crompton, C.B., Mr. J. Davis, Dr. G. F. Deacon, Dr. F. Elgar, Mr. M. Fitzmaurice, C.M.G., Mr. R. A. Hadfield, Dr. C. A. Harrison, Mr. J. Hobson, Mr. W. Hunter, Mr. G. R. Jebb, Mr. J. H. Johns, Sir Wm. Thomas Lewis, Bart., Sir George T. Livesey, Mr. A. G. Lyster, Mr. A. Ross, Mr. J. H. Ryan, Mr. A. Siemens, Mr. J. Strain, Prof. W. C. Unwin, Mr. W. B. Worthington and Mr. A. F. Yarrow. This Council will take office on the first Tuesday in November, 1907. The council have made the following awards for Papers read and discussed before the Institution during the past session:—a Telford gold medal to Mr. Dugald Clerk; a Watt gold medal to Mr. J. T. Milton; a George Stephenson gold medal to Mr. G. A. Hobson; Telford premiums to Messrs. C. F. Jenkin, W. A. P. Tait, A. P. Trotter and M. Kellow.

Telephony in the United States.—The annual report of the American Telephone & Telegraph Co. which has just been issued shows the extraordinary prosperity and development of the telephone industry in the United States during the past year. The gross revenue of the company for the year ended December 31st last amounted to £4,905,340, an increase of £562,653. Owing to substantial increases in operating expenses the net earnings increased only £12,620. After paying dividends there was left a balance of £555,140 of which amount £354,747 was carried to reserve and £200,393 carried to surplus. The development of the system is indicated by the following table:—

	1906.	1905.	1904.	1903.
Telephones, December 31st	7,107,836	5,698,258	4,480,564	3,779,517
Exchanges & branch offices	4,889	4,532	4,080	3,740
Miles aerial wire	2,754,571	2,183,167	1,654,379	1,358,140
Miles wire underground ..	3,241,471	2,585,742	1,888,760	1,618,691
Miles wire marine	11,690	9,373	6,671	6,358
Total miles wire	6,007,732	4,778,282	3,549,810	2,983,189
Number circuits	1,384,175	1,135,449	930,251	798,901
Number employés	90,324	74,718	59,451	53,795
Number stations	2,727,289	2,241,367	1,799,633	1,525,167
Number daily connected ..	16,478,058	13,543,468	11,149,063	9,876,402

The number of conversations was 16,940,000 daily, or 5,455,000,000 per year, being 64 calls annually per capita of the population. On January 1, 1907, there was one Bell telephone subscriber to every 28 of the total population of the United States. The gross income of the Bell telephone system of exchanges for the year was £22,800,000. The total does not include the £13,800,000 earnings from manufactures of the Western Electric Co. (largely owned by the American Telephone & Telegraph Co.) During the year £11,994,219 was added for exchanges, £2,717,132 for toll lines, and £1,162,039 for land and buildings, a total of £15,873,390. In the last seven years this total is no less than £59,782,851. The number of miles of wire per mile of pole line has increased from 5·6 on January 1, 1900 to 9·4 on January 1, 1907. For the year 1906, the increase in miles of pole line was 9,334, while the increase in miles of wire was 195,937, the ratio being more than 20 to 1.

Royal Society.—At the conversazione held on Wednesday last there were a number of interesting exhibits, though from the purely physical point of view there was nothing very novel. Mr. S. G. Brown showed his relay for submarine telegraph cables, which has been the subject of scientific litigation quite recently and has thus become more popular. Commander Chetwynd, R.N., exhibited an improved liquid compass, and Mr. H. Cunynghame, C.B., a detached gravity escapement. Mr. R. H. A. Mallock, F.R.S., showed an instrument for photographically recording rapid changes of pressure in the air, such as are caused by explosions. The action of this apparatus depends on the comparison of the optical lengths of the paths of two beams of light proceeding from a common source, one of which passes through air of constant density, and the other through the air whose density is to be recorded. Prof. W. E. Dalby showed his well-known models illustrating the balancing of engines, and Prof. A. G. Ashcroft exhibited a lecture table testing machine, which was described at the last meeting of the British Association. Col. R. E. Crompton, C.B., showed his measuring machine, designed for measuring slight differences in length to an accuracy greater than 1 in 200,000. The contact is determined electrically. The construction is extremely solid, the screw, with 100 threads per inch, being provided with a nut 4 in. in length. Sir James Dewar, F.R.S., showed that the motion of a Crookes radiometer is arrested if the vacuum is very high, such as that produced by charcoal cooled with liquid hydrogen. Mr. W. Duddell, F.R.S., exhibited an apparatus in action for producing persistent electric oscillations by means of the electric arc, and mentioned the interesting fact that if such a discharge is received on the hand, although it produces no shock, it burns the skin, whereas the usual high frequency oscillatory discharges do not do so owing to the comparatively long intervals between successive trains during which the skin may cool. The action of radium in giving rise to apparent growths in gelatine culture medium was shown by Mr. W. A. Douglas Rudge, and some interesting optical exhibits by Messrs. R. and J. Beck, Mr. A. Kershaw and Mr. Ulrich Behn. Another interesting exhibit was that by Dr. J. T. Bottomley, F.R.S., and Mr. F. A. King, consisting of a "radium clock" and various types of vacuum electroscopes, which deflected when exposed to radiation from sources of heat and light. Mr. C. T. R. Wilson, F.R.S., showed his portable electrometer and Mr. Joseph Goold his beautiful and well-known vibration experiments. Although the exhibits were not so interesting as they sometimes are, it must be admitted that the demonstrations given in the meeting room were of much more than usual interest. Mr. Louis Brennan, C.B., gave an account and demonstration of his Mono-Railway, in which a car provided with a single line of wheels and with the centre of gravity considerably above the level of the rail maintains its running position by means of gyroscopic action. This we refer to elsewhere. Another interesting demonstration was given by Dr. Hele-Shaw, F.R.S., who described the principles on which aerial gliding depends, and gave a brief account of the work of Lilienthal, the Wright Brothers, and other investigators.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 10th (to-day).

ASSOCIATION OF ENGINEERS-IN-CHARGE.

7:30 p.m. Annual General Meeting at St. Bride's Institute, Bride-lane, Fleet-street, E.C.

PHYSICAL SOCIETY.

8 p.m. Meeting at the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Paper on "Stereoscopy with Long Base-line, illustrated on the Screen," by Dr. T. C. Porter.

SOCIETY OF CHEMICAL INDUSTRY.

8 p.m. Meeting at the Chemical Society's Rooms, Burlington House, Piccadilly. A Critical Statement on "Consideration of the Patents and Designs Bill, 1907," will be communicated by the Chairman. A discussion will follow.

MONDAY, May 13th.

GRADUATES' ASSOCIATION OF THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's-gate. Paper on "Petrol Motor Omnibuses," by Mr. C. C. B. Morris.

TUESDAY, May 14th.

GLASGOW SECTION OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Meeting at 207, Bath-street, Glasgow. Annual General Meeting.

THURSDAY, May 16th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Extraordinary General Meeting at the Society of Arts, John-street, Adelphi. Papers on "Telephonic Transmission Measurements," by Messrs. B. S. Cohen and G. M. Shepherd (adjourned discussion, if not concluded at the previous meeting), and on "The Present State of Direct Current Design as Influenced by Interpoles," by Messrs. F. H. Page and F. J. Hiss (if time permits).

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TELEPHONIC TRANSMISSION MEASUREMENTS.*

BY B. S. COHEN AND G. M. SHEPHERD.

The measurement of telephone currents is one of great interest and of considerable difficulty owing to the smallness of the currents and their high frequency. In this Paper Messrs. Cohen and Shepherd give oscillograph records of wave forms produced by sounding various letters into a transmitter, by which the distortion produced by a cable can be conveniently studied. The authors then discuss the measurement of current by the barretter and other instruments, and the measurement of power, in which the accurate measurement of the phase angle is particularly important.

In order to apply in a practical manner the laws which govern the transmission of telephone waves it is necessary to have fairly accurate quantitative information regarding the various factors concerned. The latest formulæ for calculating attenuation take into account practically all these factors, and have been proved to give solutions of most of the transmission problems met with in practice, but unfortunately very little is known as to the value of most of these factors.

The results described in this Paper have been obtained in the investigation laboratory of the National Telephone Co., and embody

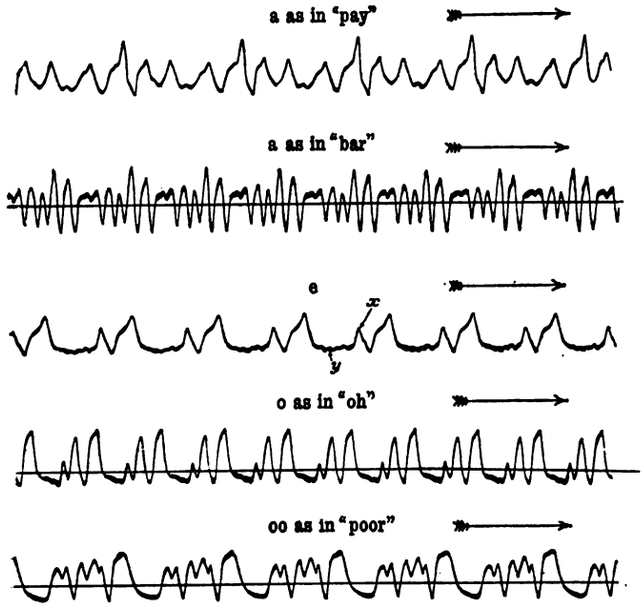

FIG. 1.

methods of measuring frequency, distortion, attenuation, current and power of telephone waves, and also line and instrument impedances.

STUDY OF WAVE FORM AND DISTORTION.

Use of Oscillograph.—The instrument used is the high-frequency pattern of Duddell. This instrument has two separate vibrators, which can be used in a variety of ways. For investigating the attenuation and distortion of waves over telephone lines one can be placed at the beginning and the other at the end of the line. Owing to the small resistance (about 10 ohms) of these vibrators and their negligible inductance, they have no appreciable disturbing effect on the circuit into which they are introduced. Owing to the high frequency and general complexity of many of the telephone waves, it is very necessary that the vibrators should be working at their correct damping temperature in order to obtain reliable records. As mentioned by Duddell and others, the best test for correct damping is a square wave produced by interrupting a direct current.

Oscillograms of Speech Waves.—Fig. 1 shows a number of vowel sounds as interpreted by a common battery solid-back transmitter working at normal load. These were continuously sounded into the transmitter mouthpiece. These vowel sounds are quite characteristic, and can be picked out in many oscillograms of complete words, although they get altered somewhat in shape by different voices. The small ripple on the flat portion of the E wave marked *y*, for example, is considerably amplified in some voices, and the portion *x* very often disappears completely. The main characteristics, however, remain. E appears to be much the simplest of all the vowel sounds.

* Abstract of a Paper read before the Institution of Electrical Engineers.

The falling plate camera does not lend itself so readily to the recording of consonants, but by rapidly repeating the consonant and reducing the speed of the falling plate it is possible to obtain satisfactory records. Fig. 2 shows a number of consonants and words The beginning and end of each word is indicated. These cases ("cur," "pea," and "tea"), which have all explosive consonants, are interesting. It will be seen that the explosive portion is quite separate and distinct from the vowel portion, being, in some cases, separated by an interval of quiescence.

Change in Wave Form in Transmission.—The oscillograph is obviously specially suited to the investigation of the attenuation and distortion of waves over telephone lines, and particularly to the latter.

Fig. 3 shows the attenuation and distortion of a fairly complex sound wave (singing "la") over a 16 mile cable line. The cable in this case was equivalent to one with 17·6 miles of 20 lb. conductors and the transmission over this length of line is very good indeed.

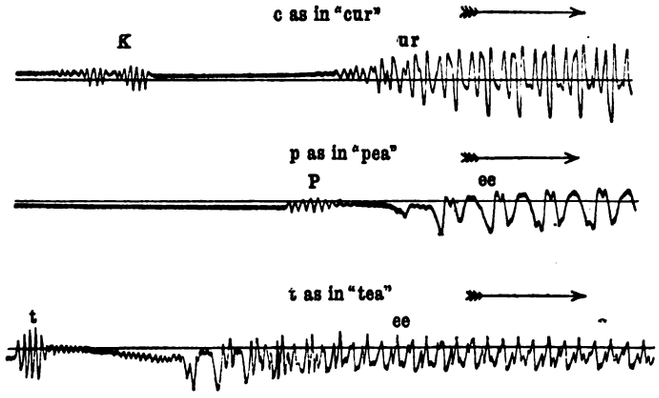

FIG. 2.

On analysing the received wave it is found that everything above the seventh harmonic seems to have practically been wiped out, and this harmonic represents a frequency of 980 ~.

The analysis of the two waves in Fig. 3 brings to light the fact that the attenuation of the current behaves in a curiously fluctuating manner as the frequency increases. The following table gives percentages of received currents for the various harmonics:—

Harmonic.	Percentage received.	Harmonic.	Percentage received.
1 (Fundamental)	81·0	8	30·0
		9	25·0
2	47·0	10	25·0
3	57·0	11	81·0
4	46·0	12	13·0
5	41·5	13	2·5
6	28·0	14	15·5
7	25·0	15	4·0

The big rise at the eleventh harmonic is very noticeable. The absence, unfortunately, of any precise data regarding the terminal conditions of the circuit when these oscillograms were taken, renders it impossible to explain the phenomena theoretically.

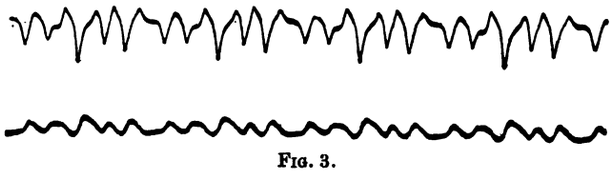

FIG. 3.

Highest Important Frequency in Telephone Waves.—Some tests carried out on loaded lines led to an interesting method of ascertaining the highest important frequency in articulate speech. If the spacing—*i.e.*, distance apart—of loading coils is increased, and at the same time the amount of inductance per mile inserted is unchanged, the attenuation constant also increases gradually, and at one particular spacing increases to an enormous extent.

Fig. 4 shows curves for the variation of attenuation constant with spacing for frequencies of 800 and 1,600 ~. These curves were calculated from formulæ by G. A. Campbell, and have been confirmed by tests made with a sine-wave alternator. As the articulation of a received telephone wave depends to a very great extent on the attenuation of the harmonics present, it was thought that the application of the arrangement just referred to would help to settle the question as to which frequencies determine by their presence or absence the difference between articulate and inarticulate transmission. A series of articulation observations were consequently made on 20 miles of cable for increasing spacing intervals with a constant load of 0·17 henry per circuit mile and commencing with a distribution of one load per mile.

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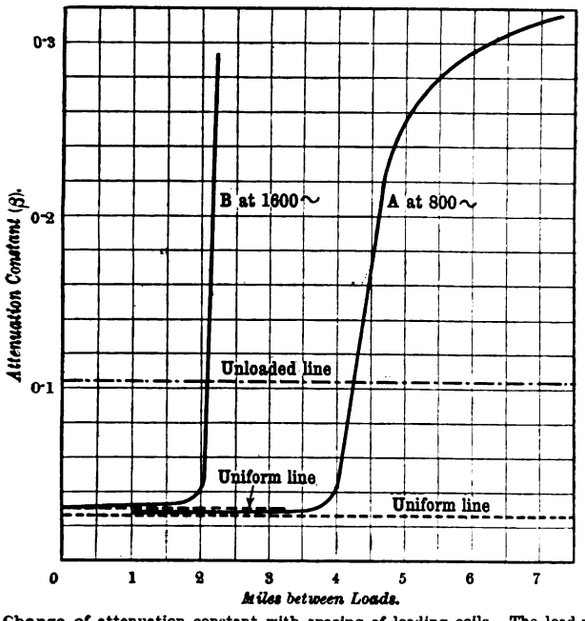
It was found that a 2 mile load was very slightly inferior to the unloaded line of equivalent speaking volume, but still gave excellent commercial transmission. This indicates that harmonics above 1,600~ may be dispensed with (*see* Fig. 4). With 3 mile distribution the articulation was commercial, but decidedly inferior to the unloaded line. The critical frequency for this disposition of the load was about 1,100~, and it is thus apparent that harmonics between 1,100 and 1,600~ are valuable. For 4 mile intervals speech became quite impossible, although the volume was still quite considerable, and we must therefore conclude that the highest indispensable frequency lies between 800 and 1,100~, and also that it is desirable to retain something higher than 1,100~ for really high-grade transmission. Probably 1,500~ would be quite a satisfactory figure to base calculations on.



Change of attenuation constant with spacing of loading coils. The load per mile of circuit being kept constant. 20 lb. cable.
Thus 1 coil every mile, Curve A. 800~
„ 2 coils every 2 miles. Curve B. 1,600~
„ 3 coils every 3 miles, &c., &c.

FIG. 4.

Pupin and other writers use 750 to 800~ for many transmission calculations. It is important to note that this represents a fair average frequency, as damping constants calculated with this value can be obtained experimentally when using actual speech waves.

CURRENT MEASURERS AND MEASUREMENTS.

Two forms of apparatus have been used, the barretter and the thermo-galvanometer. The barretter, otherwise termed the bolometer, is a device for measuring small alternating or fluctuating currents. It consists of a conducting wire or filament, which has a high temperature coefficient and a small mass, so that small currents will appreciably raise the temperature, and thus alter the resistance.

Prof. Kennelly used barretters made of very fine platinum wires. Owing to the extreme delicacy of these wires, Dr. Hayes, of the

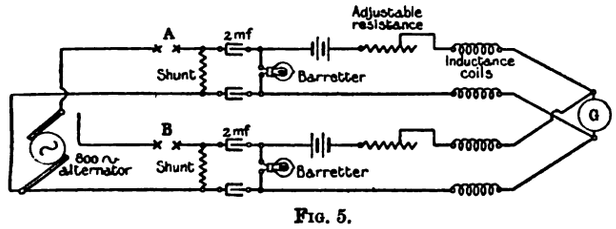


FIG. 5.

American Telegraph & Telephone Co., carried out investigations to discover a barretter more suitable for work outside the laboratory. He found that small low-voltage telephone switchboard lamps gave satisfactory results, and this has been confirmed by experiments carried out by us. The best lamp we have found for this purpose is a special pattern 24 volt curl filament lamp for telephone switchboard use. Following the usual law, the greatest resistance variation with these carbon filaments occurs when using small currents.

Null Method of Working.—The following arrangement of barretters (Fig. 5) has been adopted after considerable experiment:—

The figure shows a source of alternating current such as a sine-wave alternator connected to two branch circuits, in one of which a variable resistance box, A, is inserted. The other arm has the apparatus, or line to be measured, inserted at B. The barretters are connected through adjustable resistances and batteries to the galvanometer, which can be of any pattern. The shunt, which for general work can be varied from 10 to about 500 ohms, helps to eliminate errors due to the impedance of the barretter circuits.

The barretters are first balanced in resistance by the adjustable resistances until the galvanometer indicates no deflection. The alternating current is then applied, the circuit being through the condensers and round the barretters. This current is stopped from passing from one branch into the other, viâ the galvanometer, by the four choking coils. When the resistance box in A is adjusted so that no deflection is indicated on the galvanometer, then the resistance unplugged in A, after making allowance for the impedance of the shunted barretter circuits, represents the impedance of B, and if the two barretters are not exactly similar, a second reading can be taken with A and B reversed and the mean taken. Variations in barretter resistance caused by temperature changes have no effect on this arrangement, as the barretters are fixed close together and compensate each other.

Thermo Galvanometer.—Duddell's thermo-galvanometer has been used for current measurements It has many advantages, and for deflectional methods is probably unrivalled if the source of power is absolutely steady, but it cannot be satisfactorily employed with transmitters in circuit owing to their variability, even although the sound impressed is quite steady. The barretter is somewhat better for this purpose, as the mass of the filaments employed is greater than that of the heaters used in the thermo-galvanometer of the same relative sensibility, and consequently the time of response to a current variation in the thermo-galvanometer is smaller, and the sensibility to mometary disturbances thus much greater.

(*To be concluded.*)

ELECTRIC POWER SUPPLY IN LONDON.—IX.

BY R. L. PEARSON.

(*Concluded from p. 9.*)

It is fitting that this series of articles should conclude with some brief consideration of the financial aspect of electric power supply in London as a whole. For this purpose data have been collected and some of the most interesting points are shown by the following diagrams. Fig. 31 is, perhaps, the most important, for it shows at a glance how the charges set forth in the L.C.C. Bill compare with those at present in vogue. It will be observed that the cost per kilowatt per annum has been plotted against load factor, one curve representing the L.C.C. rates and the other those at present working in the Borough of St. Pancras. For load factors of less than 50 per cent. the St. Pancras rates are the more favourable to the consumer, but between 50 and 100 per cent. the L.C.C. rates are to be preferred. However, it is practically certain that the bulk of the motor load in the metropolis is of such a nature as to work out at less than 50 per cent. Instances of load factors greater than this are comparatively rare. A consumer with a 20 per cent. load factor would save about £2 per kilowatt per annum by taking energy from the St. Pancras mains, and a similar amount would be saved by a consumer having a load factor of 75 per cent. if he took energy from the L.C.C. The consumer with 100 per cent. load factor would, of course, obtain a much greater benefit. It may be observed that the L.C.C. curve is based on an initial charge of £6. 15s. per kilowatt demanded plus 0·33d. per unit for all energy consumed. Such energy would be measured on the consumer's side of any transforming apparatus and would be supplied by continuous current. The cost of transforming, too, would be borne by the Council.

The next diagram (Fig. 32) shows the cost per Board of Trade unit under varying load factors. It is naturally more difficult to ascertain where the two curves cross in this case, nor does this diagram show so clearly how the load factor affects the annual cost. Nevertheless, it does show more strikingly the disproportionate increase in cost per unit when the load factor reaches a very low value. For instance, it shows that a consumer who uses an amount of energy equivalent to the continuous use of his maximum demand for 87·6 hours per annum (a 1 per cent. load factor) would have to pay nearly 1s. 7d. per unit under the L.C.C. rates. In other words, his bill would be 19 times as great as it would have been under the St. Pan-

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cras rates. Of course, it is argued that the suppliers can well afford to dispense with such consumers, and, therefore, the tariff is made prohibitive, but there is still the diversity factor which cannot be neglected, and it is a debatable point whether the low load-factor consumers should be penalised quite so heavily.

In certain of the electric power bills which have been before Parliament, one of the most striking features is the extremely low estimated capital cost per kilowatt of plant installed. Such costs have been based on very large units and have been of a very hypothetical nature. The proposed units were, indeed,

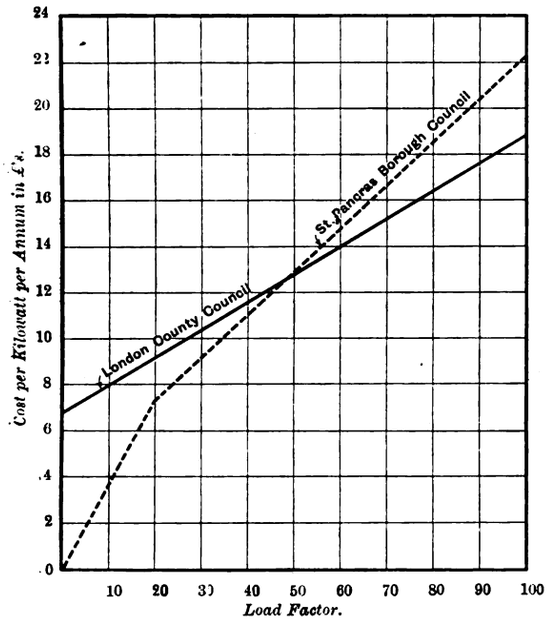

FIG. 31.

of a size greater than any which had been constructed up to that time and would have been, therefore, somewhat in the nature of a costly experiment. Moreover, the costs were for steam turbines and not for reciprocating engines, and it is notorious that where turbines are installed spare plant has to be provided on a more liberal scale than is usually the case otherwise. Moreover, the rating of steam turbines is somewhat indefinite. Nevertheless, it is not to be denied that the cost of generating plant has gone down considerably, and that it is not to be compared with corresponding costs in the early days of the industry. This point may be illustrated by taking an actual example from data kindly supplied by Mr. Kingston, chief engineer to the Charing Cross, City & West End Electricity Supply Co. The Lambeth station of this company came into existence about 13 years ago, and at the present day the capital cost per kilowatt of plant there installed is £31·4 excluding buildings, or £41 per kilowatt, including buildings. Coming now to the new Bow station the corresponding figures are £17 and £26·4 respectively. Further, quotations have been received for an additional 5,000 kw. set in this station, and the cost works out at £8·6 per kilowatt, inclusive of boilers, &c., but exclusive of buildings, which are, however, available. Hence it will be seen that there has been an enormous drop in prices quite recently. Whether these

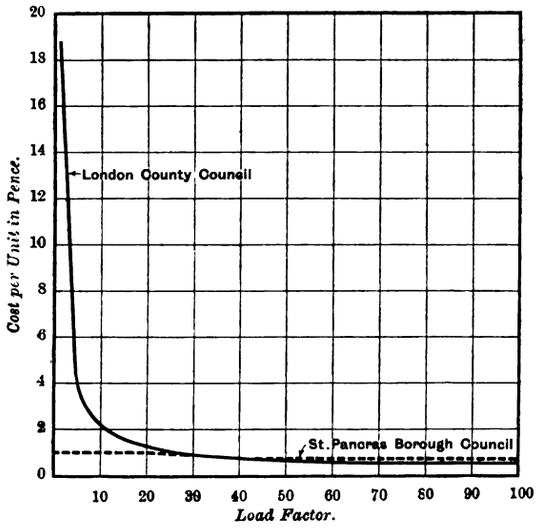

FIG. 32.

low prices will be maintained remains to be seen, but as the price of raw material is going up it is difficult to conceive that the downward tendency can be continued much longer.

So far as the actual generating plant is concerned, then, the proposition is a perfectly sound one; but quite the reverse is the case with regard to mains. Here the cost has not gone down, but has actually gone up to an alarming extent. For the Bow station of the Charing Cross Company, the capital cost on trunk mains, on the basis of maximum output at the sub-station is £10·6 per kilowatt. In this case the

Table I.—*Showing Variation in Prices per unit obtained by Companies in London.*

——	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.
Brompton & Kensington Co.	..	..	..	5·75	5·59	5·53	5·54	5·36	4·96	4·5	4·43
Charing Cross, West End & City	4·85	4·7	4·46	4·36	4·36	4·16	3·95	3·67	3·30	3·14	3·05
Chelsea Electric Supply	6·65	5·88	5·77	5·79	5·62	5·20	5·07	5·05	4·53	4·22	4·22
City of London Electric Lighting	6·5	6·5	6·35	6·22	5·17	4·09	4·54	4·04	3·64	3·20	2·73
County of London Electric Supply	..	..	6·03	5·44	4·71	3·97	3·77	4·58*	4·58	4·39	3·72
Kensington & Knightsbridge	5·48	5·45	5·27	5·08	4·93	4·80	4·65	4·58	4·22	3·95	3·70
London Electric	..	..	..	..	..	..	4·55	4·42	4·28	2·61	2·31
Metropolitan Electric Supply	6·47	6·47	6·35	5·17	5·02	4·96	4 92	4·87	4·81	4·66	4·38
Notting Hill Co.	7·74	7·65	6·91	6·44	5·92	5·77	5·71	5·72	4·72	4·70	4·63
St. James's & Pall Mall	5·40	5·39	5·32	4·78	4·36	4·24	4·21	4·03	3·86	3·73	3·42
Westminster Electric	5·54	5·56	5·54	5·25	4·83	4·75	4·66	4·53	4·00	3·89	3·62

* County and Wandsworth given together.

Table II.—*Showing Variation in Prices obtained by Local Authorities in London.*

——	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906
Fulham	..	..	..	..	..	..	2·85	3·08	3·08	2·48	2·22
Hackney	..	..	..	..	..	..	3·01	2·79	2·79	2·73	2·45
Hammersmith	..	..	3·61	3·15	3·0	2·87	3 38	3·25	3·25	2·72	2·18
Islington	5·6	5·33	5·1	4·15	4·0	4·07	4·19	3·88	3·88	3·95	3·75
Poplar	..	..	..	..	..	..	..	2·49	2·49	2·13	2·0
Shoreditch	..	..	3·45	3·4	3·02	2·8	2·92	3·01	3·01	2·98	2·54
Southwark	..	..	..	..	3·32	3·34	3·65	3·46	3·46	3·21	2·94
Stepney	..	..	..	..	..	2·17	2·46	2·35	2·11	1·87	1·87
St. Pancras	4·78	4·74	3·96	3·68	3·36	3·2	3·71	3·67	3·67	2·86	2·53

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mains are 7 miles in length. Now taking the Bow extensions and disregarding the rise in the price of copper which has taken place since the original mains were put down, the cost works out at £11·9 per kilowatt. This may be expressed more suitably as the cost per kilowatt transmitted per mile of cables, in which case the original cost of the trunk mains from Bow to the sub-stations amounts to £1·6 per kilowatt, whereas for the extensions it would be £1·95. This is accounted for by the fact that three mains would be put down in this instance, whereas there were 10 originally put down, and it is, of course, cheaper in comparison to put down a large number. Further, there is the increased price of copper to be taken into account which has been done in the last figure. It is thus very clear that a point is being reached where the cost of trunk mains becomes of greater importance than the cost of generating plant.

An interesting point in connection with the existing supply in London is the gradual reduction in the amount received by the various undertakings for every unit sold, as shown by the accompanying tables. Perhaps the most striking instance is that of the City of London Company, who received 6·5d. per unit in 1895; 10 years later this had fallen by almost equal decrements to 2·73d. The average price obtained last year by the Charing Cross Company in the City area is even lower, being 2·67d. This figure, it may be mentioned, is one of the lowest, so far as the companies are concerned, in the Metropolis.

With regard to the municipal undertakings, it is obvious that the prices received must be lower than those of the companies. Last year, for instance, the average price in Stepney was only 1·67d., actually the lowest in London. Poplar came second with 2·00d., and Hammersmith third with 2·18d. Still, it must be remembered that public lighting is usually done on a lavish scale by the municipalities and that it becomes the perquisite of the Councils' lighting stations. Moreover, the local authorities are generally of the industrial type, so that a larger proportion of the load is on account of motors than is the case with the companies.

Again, there is generally a very important difference in rent, rates and taxes in favour of the local authorities. In Table III. are given the combined cost of these items per unit in the case of the larger companies already referred to, while Table IV. gives corresponding figures for the local authorities. These lists are not complete, but they include the largest and oldest undertakings. It will be seen that there is a very great difference. For example, Stepney and Shoreditch pay only 0·08d. per unit, whereas the Charing Cross Company pays 0·24d.: this became 0·25d. last year, and for the last quarter of this year there has been an increase of 32 per cent. over the amount for the corresponding quarter of last year. The Notting Hill Company pay 0·32d. and the Kensington and Knightsbridge as much as 0·40d. Taking the average of each table we find that in 1905 the mean charge to the companies was 0·26d., whereas the average for the local authorities was only 0·106d.; in other words the cost to the companies was 145 per cent. higher than to the local authorities. Not only is there this considerable difference at present, but it is one that tends to increase continually. It is sometimes forgotten that high rates have a deterring effect on private enterprise, and that if such undertakings are taken over by municipalities the reduction in the rates must be made good in some other way.

Finally, it must not be forgotten that the cutting of prices has had its effect on the supplier as well as on the consumer. Generation has admittedly become more economical and efficient, but not to the extent indicated by the fall in price per unit. Several companies have felt the pinch very keenly and reductions of revenue with smaller dividends have been experienced. How much longer this kind of thing will go on it is impossible to predict, but obviously it will have to come to an end sooner or later. With the present low charges a small difference in the cost per unit can affect the consumer very little. Very few lighting consumers would care whether they paid 2·8d. or 3d. per unit.

Power consumers may be considered on a similar basis, for except in a very small minority of industries, the cost of energy is only a fraction of the total working expenses. It would, therefore, seem that the expenditure of any large amount of fresh capital on a new power scheme would be utterly futile. After a quarter of a century of troublous life the electric supply industry is just beginning to settle down on a proper basis, with a vast amount of experience to guide it in the future. It is to be hoped, therefore, that for a few years at least it will be left in peace to pursue its way to greater developments, unhampered by fresh legislation, but rid of some of the old, and without the fear of a new L.C.C. Bill before its eyes every succeeding session.

Table III.—*Showing Rent, Rates and Taxes as a Cost per Unit Sold, paid by Companies in 1905.*

Brompton & Kensington Co.	0·3d.
Charing Cross, West End & City	0·24d.
Chelsea Electric Supply	0·24d.
City of London Electric Lighting	0·17d.
County of London Electric Supply	0·24d.
Kensington & Knightsbridge	0·40d.
London Electric	0·10d.
Metropolitan Electric Supply	0·25d.
Notting Hill Co.	0·32d.
St. James & Pall Mall	0 29d.
Westminster Electric	0·28d.
Average	0·26d.

Table IV.—*Showing Rent, Rates and Taxes as a Cost per Unit Sold, paid by Local Authorities in 1905.*

Fulham	0·09d.
Hackney	0·12d.
Hammersmith	0·10d.
Islington	0·10d.
Poplar	0·10d.
Shoreditch	0·08d.
Southwark	0·17d.
Stepney	0·08d.
St. Pancras	0·12d.
Average	0·106d.

WIND POWER FOR THE GENERATION OF ELECTRICITY.

BY W. O. HORSNAILL.

(*Concluded from page 87.*)

Summary.—The Author considers the possibility of utilising wind power for the electric lighting of country houses. Some account is given of actual installations, and the conclusion is drawn from estimates that a wind-power plant is cheaper in both first cost and in running.

The following initial costs are based upon actual quotations, and the running expenses have been estimated by the help of figures obtained from the practical working of such plants.

In the first place a plant driven by a disc type of mill will be considered, the capital outlay being as follows:—

Windmill complete down to lay shaft erected	£220	0	0
Foundations for ditto	10	0	0
Dynamo erected	60	0	0
Dynamo house	10	0	0
Foundations for dynamo	2	0	0
Battery	150	0	0
House and stands for same	20	0	0
Switchboard erected	30	0	0
Total	£502	0	0

The running expenses will consist of:—

Attendance	£5	0	0
Stores	3	0	0
Battery renewals and depreciation at 15 per cent.	23	10	0
Windmill gear and dynamo repairs and depreciation	28	0	0
Interest on capital at 5 per cent.	25	0	0
Total	£83	10	0

This allows 2,000 hours of lighting with an average current of 25 amperes, at 100 volts equals 5,000 units at a cost of 4d. per unit.

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The alternative figures for a four-sailed mill will be reduced as shown below :—

Windmill complete erected	£140	0	0
Foundations for ditto	10	0	0
Dynamo	60	0	0
Dynamo house	10	0	0
Foundations for dynamo	2	0	0
Battery	150	0	0
House and stands for same	20	0	0
Switchboard	30	0	0
Total	£422	0	0
The running expenses amounting to :—			
Attendance	£5	0	0
Stores	3	0	0
Battery renewals and depreciation	22	10	0
Windmill gear and dynamo repairs and depreciation	20	0	0
Interest on capital	21	0	0
Total	£71	10	0

The comparative cost of an oil engine installation will be as follows :—

Oil engine erected	£120	0	0
Foundations	5	0	0
Water piping, &c.	2	0	0
Dynamo erected	50	0	0
Foundations	3	0	0
House	20	0	0
Battery	150	0	0
House and stands for same	20	0	0
Switchboard	30	0	0
Total	£400	0	0
And the working costs :—			
Attendance	£10	0	0
Oil	33	0	0
Stores and lubricating oil	5	0	0
Battery repairs and depreciation at 15 per cent.	22	10	0
Repairs and depreciation on engine and dynamo at 10 per cent.	17	0	0
Interest on capital at 5 per cent.	20	0	0
Total	£107	10	0

From the above figures it will be seen that wind power works out at less cost than a plant driven by an oil engine, but apart from the financial aspect of the subject a windmill installation does not require the occasional skilled attention essential to the satisfactory working of an oil engine. The latter is a delicate piece of mechanism and runs at a high speed, whereas a windmill is a very robust prime mover and revolves slowly, resulting in a very low cost for repairs and upkeep.

It will be noted that the same size of battery has been allowed for the oil-engine installation as for the windmill plant, and at first sight this basis of comparison may appear to unduly handicap the oil engine. Further consideration will, however, show that the battery allowances are just and reasonable in each case. Naturally the position and exposure of a windmill must affect the provision required for power storage, but in the example given above it has been already shown that the battery capacity is sufficient. With regard to the oil engine, allowance has been made for lighting through two nights, during the darkest season of the year, with the engine standing.

No consulting engineer or contractor would provide for less storage than this, for oil engines, which as already indicated, are liable to breakdown, and new parts may have to be sent for from the makers, together with a skilled man to effect the repair. On the other hand, windmills very rarely break down, and many of them have run for years without any repairs whatever, and when such attention is required it is in the form of replacements for worn parts, which work can be done by an ordinary mechanic at any convenient time. It is very seldom, indeed, that any part of a windmill actually breaks and causes a stoppage.

The problem of electric lighting by wind power would appear at first sight to present similar difficulties to those encountered in train lighting, by means of a dynamo driven from one of the carriage axles, and a similar automatic plant could be used; but it is doubtful whether the additional cost would be justified, and some parts of the apparatus are of so delicate and complicated a nature that it would be necessary to apply to the makers when a breakdown occurred. Moreover, no appreciable reduction could be made in the battery capacity owing to the possibility of charging during the whole of the 24 hours, as we have shown already that during calm periods any available wind occurs during daylight; therefore, the only advantage in adopting the train-lighting system would be the reduced cost of attendance, as the plant could be locked up for weeks together. But attendance, only costs £5 per annum, which is scarcely sufficient to cover the capital charges and depreciation on the extra gear required to make the plant automatic, and if extra repairs be included the installation would be more costly than the simple scheme put forward above.

The power of a windmill in any particular situation is rather difficult to estimate, but if records of the wind velocity for 12 months can be obtained from a meteorological station in the vicinity the problem is much more easily solved. The standard recording instrument gives the miles of wind passing it in a diagrammatic form, and from these records the average velocity per hour or per day may easily be read. Therefore, as the power of a windmill increases roughly in proportion to the square of the wind velocity, more power than indicated by the mean speed of the wind can always be obtained.

It is naturally important that the windmill should be erected in a more or less exposed position, and at such a height from the ground as to be above all obstructions likely to interfere with the free passage of wind to it. Fig. 2 illustrates the wind-power installation described above, which may be some little distance from the house. A battery house is also shown, but in some cases the battery can be accommodated in the cellar of the house to be lighted.

Some reference will now be made to existing wind electric plants and the difficulties which have been encountered in running them. The first installation of this nature was erected 11 years ago for the purpose of lighting Mr. George Cadbury's house near Birmingham. The plant consists of a 35 ft. disc windmill coupled to a 35 ampere-shunt dynamo capable of giving out a voltage of 150 for charging the battery. The mill is mounted upon a 50 ft. tower, and is some little distance from the house. The gear up to the dynamo begins with the usual bevel wheels at the top and base of the mill, connected by a vertical shaft. The bottom horizontal shaft runs at a comparatively low speed, and the latter is increased by introducing a countershaft between it and the dynamo, thus involving two belt drives. A considerable proportion of the power in light winds must therefore be wasted in friction. The dynamo is a plain shunt machine running at 750 revs. per min., and the switchboard is of the usual type with cut-in-cut-out switch, charge and discharge switches, &c. The original number of lamps was 200 of 16 c.p., three motors agregating 5 H.P. being also coupled to the mains. The lamp voltage is 100 and the ordinary lighting load is about 35 amperes, increasing to 50 amperes when entertainments are in progress. To compare this plant with the installation put forward above, we must increase 35 amperes in the proportion of 18 : 25, which equals 49 amperes, without the motors, for 2,000 hours per annum. The motors may be taken as running for 300 hours per annum at 10 amperes per horse-power equals 50 amperes; this multiplied by 300 and divided by 2,000 gives $7\frac{1}{2}$ amperes; hence an output of $56\frac{1}{2}$ amperes may be reckoned on for purposes of comparison. The original battery had a capacity of about 300 ampere-hours.

Comparing the two plants we find that the battery should have a capacity of $360 \times 56\frac{1}{2} \div 25 = 820$ ampere-hours; the dynamo should give out 68 amperes and the windmill should measure 30 ft. in diameter, provided that friction be as far as possible eliminated by the use of ball and roller bearings and a single belt drive. In spite of this lack of proportion the engineer managed to keep the lights going on one occasion for six weeks without a break. Some trouble has been encountered from overloads on the dynamo, the governing arrangements on the windmill being not sufficiently sensitive for this class of work, and the cut-in-cut-out switch did not always act promptly, resulting in sudden overloads which on one or two occasions wrecked the gear. Since the plant was originally installed a good many lights have been added besides several motors, and

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it has been found necessary to put in a gas engine coupled to a larger dynamo, the battery capacity also being substantially increased.

Fig. 3 shows a view of this installation, including the engineer's house, which may be seen on the left.

A later wind power electric lighting installation has been put down at West Ardsley, in Yorkshire, and consists of a 30 ft. mill coupled to a specially wound dynamo which charges a battery of large capacity. The lamps connected number

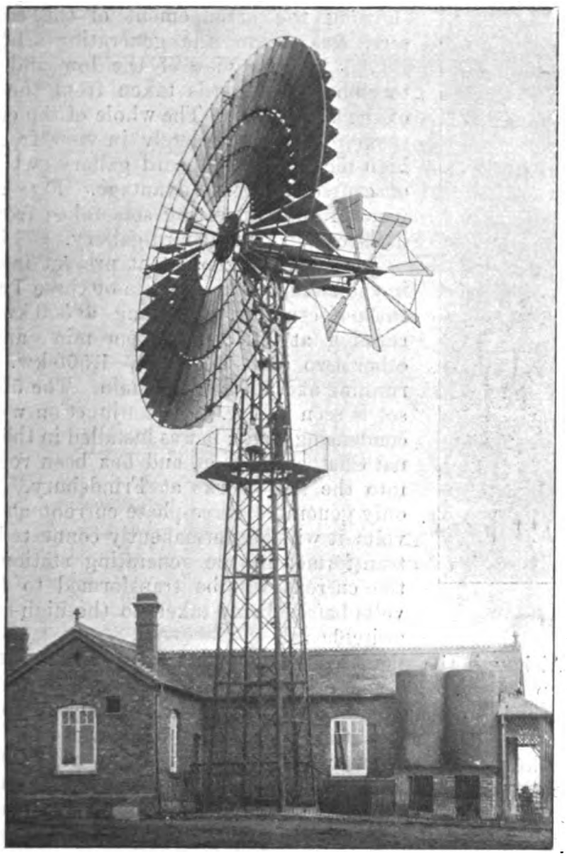

FIG. 3.—WINDMILL PLANT AT MR. GEORGE CADBURY'S HOUSE.

109, the majority of them being of 16 c.p. No auxiliary power is employed, the battery being of sufficient capacity to take charge of the lighting through any calms which occur. The windmill and electrical plant is in charge of a gardener, whose time is taken up to the extent of four hours a week in performing this duty.

The particulars given of this installation are not sufficient to enable a full comparison to be made between it and the ideal plant put forward in this article, but it is evident that the principal points emphasised have been fully considered. Fig. 4 shows a view of the wind engine and the house for the electrical gear.

The above particulars should be sufficient to convince those in doubt that wind power for electric lighting is not only quite feasible, but is a commercial success in exposed positions where the only alternative prime mover is an oil engine.

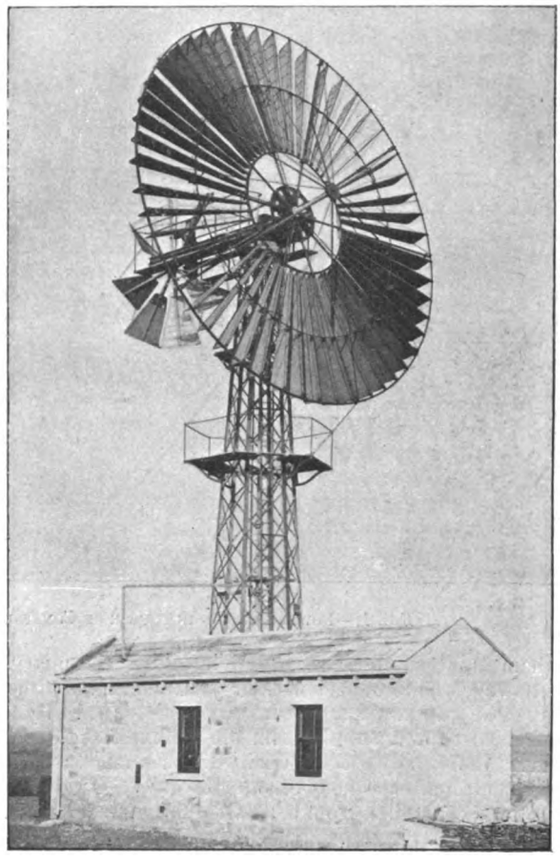

FIG. 4.—WINDMILL PLANT AT WEST ARDSLEY.

In connection with the details of existing plants I am much indebted to Mr. George Cadbury for his kind permission to inspect his installation, and to Mr. Pitt, his engineer, for the trouble he took to show me the windmill and gear, and to explain the difficulties of working it. I am also under obligation to Mr. J. W. Titt, of Warminster, the maker of the West Ardsley wind engine, for particulars and photograph of this plant.

THE KENT ELECTRIC POWER COMPANY.

Another addition to the power companies in actual operation, which aim at giving a supply of power in bulk as distinct from those having a more limited field, was made at the beginning of this year, when the Kent Electric Power Co. opened its first power station at Frindsbury. This company obtained Parliamentary powers in 1902 and 1906, whereby it is authorised to supply current throughout the whole of the County of Kent, with the exception of the Isle of Thanet. As will be seen from the map of the area on p. 133, the most promising parts of the district, as regards a power supply, are the south bank of the River Thames beyond the Woolwich boundary and the banks of the River Medway. It is in the latter neighbourhood that the first generating station has been put down—namely, at Frindsbury, near Strood. From this generating station it is proposed to supply power over an area equal to a circle of 12 miles radius described about the power station as centre. The greater part of the load is expected to be in the immediate vicinity of the generating station, in the neighbourhood of Chatham, Rochester and Strood, so that a considerable load may be obtained without a large expenditure on mains. This is of great importance in the early years of an undertaking, and should enable very satisfactory results to be obtained from almost the commencement of supply. It is estimated that 30,000 H.P. is at present in use by manufacturers situated in the area proposed to be served by the present power station.

The Government Dockyards at Chatham have, of course, a large electrical generating station of their own, and there are also a few private electrical plants in the neighbourhood, but otherwise practically the whole of the existing power is derived from steam engines. The chief industry near Chatham and Rochester is cement making, and the long rows of chimneys form a very conspicuous part of the landscape. Several

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thousand horse-power is in use in these works, which will probably eventually adopt electrical power. Among other consumers may be mentioned Messrs. Cory, with an installation of 300 H.P., the Medway Steel Works, requiring 80 H.P., and Messrs. Aveling & Porter, traction engine manufacturers, who will probably require eventually 600 H.P., of which a first instalment of 160 H.P. is now being connected.

The Kent Electric Power Co. commenced by taking over the Chatham and Rochester electrical undertaking in January, 1905. This, however, had not been in their possession six months when, in June, the station was unfortunately burnt down. By making arrangements for a supply from the Gillingham Corporation, however, the supply of electricity was resumed to Chatham and Rochester after a delay of only 16 days. This temporary supply was controlled from a sub-station, into which the coal stores were converted. This temporary supply from the Gillingham Corporation continued until January 1, 1907, when the company's first generating station was opened. This station is situated at Frindsbury, on the north bank of the river Medway, opposite Chatham and Rochester.

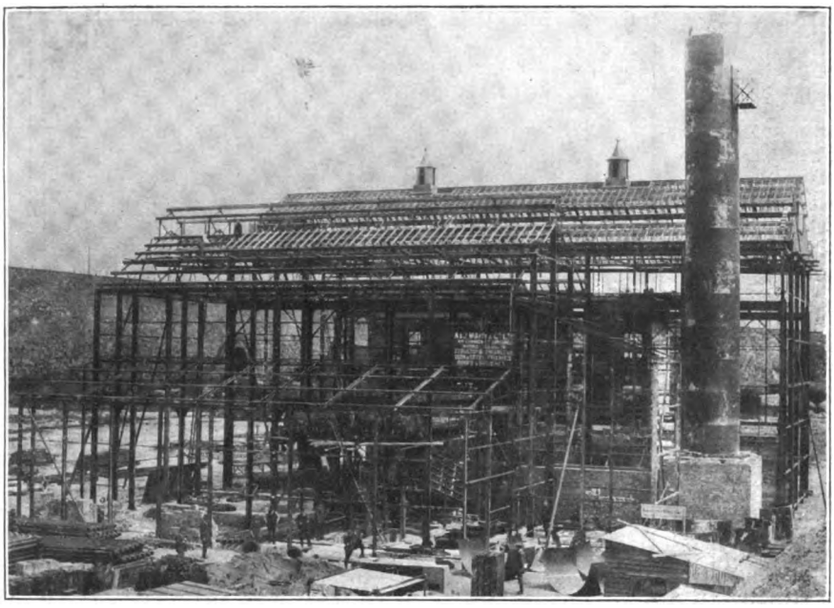

FIG. 1.—POWER STATION IN COURSE OF CONSTRUCTION.

The site is very convenient for a supply of coal, either from a siding of the South-Eastern & Chatham Railway or, as at present, by barges. The coal is unloaded from these and carted into the works, but an adjacent pier, seen in Fig. 2, is shortly to be fitted with a crane for unloading purposes.

The framework of the buildings is of steel, as will be seen from Fig. 1, which shows them in course of construction. Fig. 2 gives a general view of the buildings and their surroundings. In this view the chimneys of the cement works are noticeable, and a good idea is obtained of the situation of the works.

The general arrangement of the generating station is shown in Fig. 3. It will be seen that the boiler house at present contains two Babcock & Wilcox boilers, but additional ones will shortly be installed. The present boilers are each capable of evaporating 16,000 lb. of water per hour, and work at 160 lb. pressure. Conveyors are not at present fixed, but it is intended to instal them when more boilers are added. Arrangements are also made for an economiser to be installed at a later date. Water is delivered to the boilers by two Worthington steam-driven feed pumps.

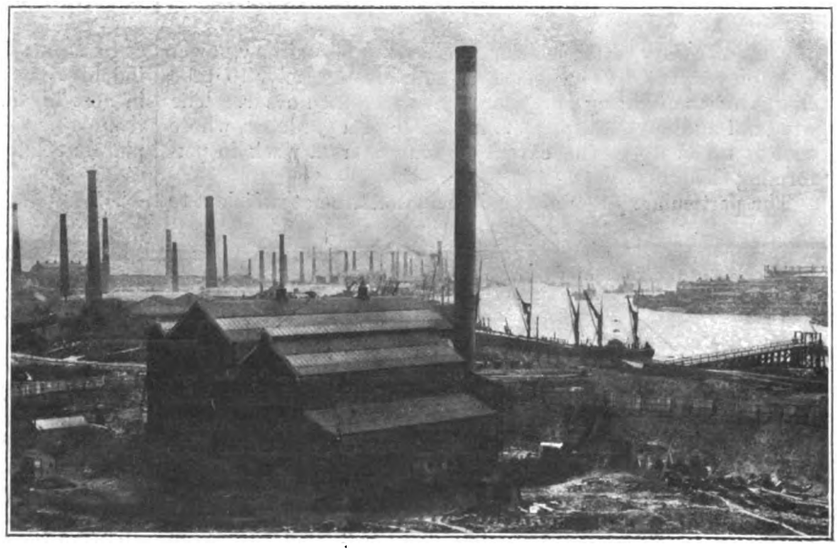

FIG. 2.—VIEW SHOWING POSITION OF POWER STATION.

GENERATING PLANT.

The engine room is arranged on four levels. On the ground level are the condensers, condensing pumps, stores, &c. The generating plant is on the same level as the low-tension switchboards, which are on the first gallery. On the second gallery is the high-tension switchboard, whilst at the top of a still further flight of stairs are the meter stores and test room. A good idea of the arrangement can be obtained from Figs. 4 and 5, Fig. 4 showing the arrangement of the condensers, &c., below the generating sets, and Fig. 5 being a view of the low and high-tension switchboards taken from the level of the turbine sets. The whole of the engine-room plant is completely in view from the high-tension switchboard gallery, which is, of course, a great advantage. Fig. 6 is a view of the generating sets taken from the high-tension switchboard gallery.

The generating plant at present installed in the engine room consists of three Parsons turbo-alternators, one being a 500 kw. set, running at 3,000 revs. per min., and the other two each nominally 1,500 kw. when running at 1,500 revs. per min. The 500 kw. set is seen in Fig. 4 in conjunction with its condensing plant; it was installed in the original Chatham station, and has been removed into the new works at Frindsbury. As it only generates three-phase current at 2,400 volts it will be permanently connected to a transformer in the generating station, and the current will be transformed to 11,000 volts before being taken to the high-tension switchboard.

Although the plant capacity is nominally only 3,500 kw., yet provision has been made for no less than 100 per cent. overload, so that in an emergency each 1,500 kw. set can take up the load of the other set, if they are running in parallel, and if necessary run for some time at 3,000 kw. Such a result is only obtainable with turbine sets, as the pressure on the bearings would render such an overload impossible with reciprocating engines. A turbine set is also especially suitable for a power load, owing to the small variation in its efficiency over a very wide range of load.

The three-phase alternators are of Messrs. Parsons' well-known type, the normal load of the larger sets being 100 amperes per phase at 11,000 volts when supplying a load of power factor equal 0·8. The frequency is 50. The exciting

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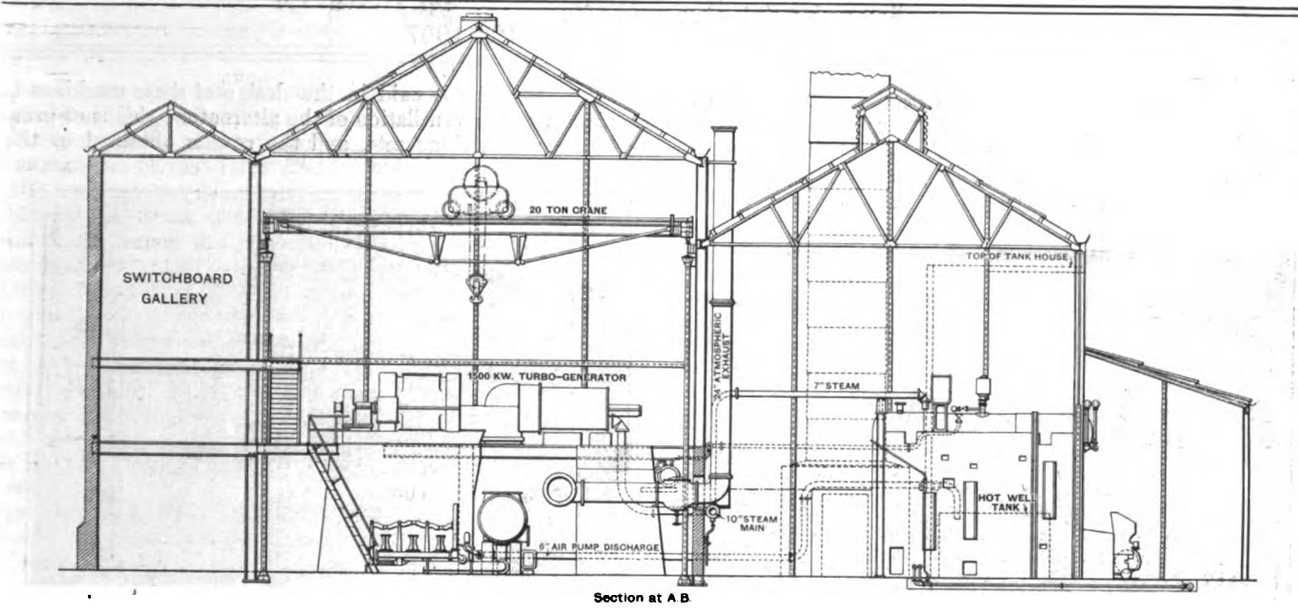
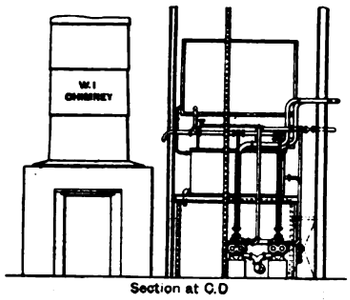
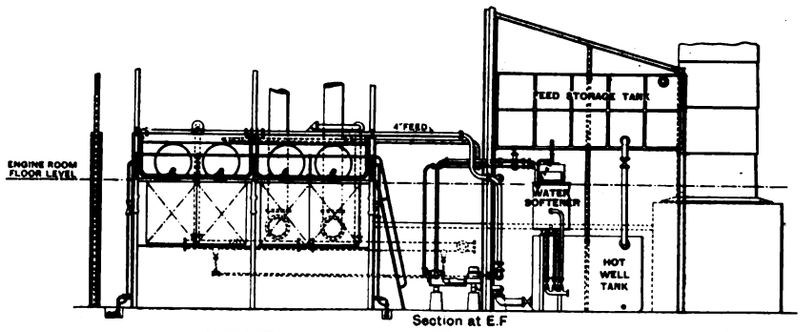


Section at A.B.



Section at C.D



Section at E.F

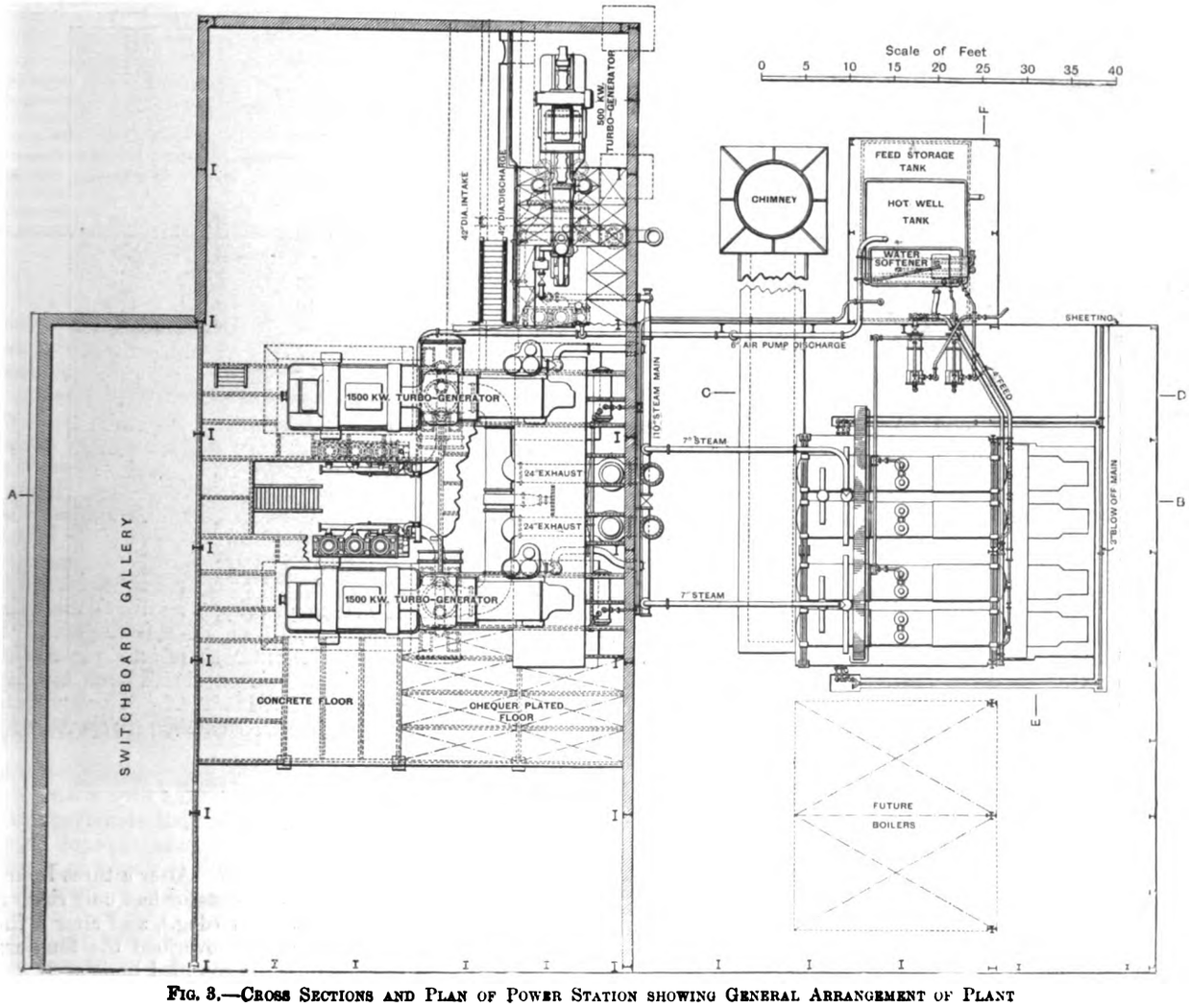


FIG. 3.—CROSS SECTIONS AND PLAN OF POWER STATION SHOWING GENERAL ARRANGEMENT OF PLANT

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current, which was specified not to exceed 100 amperes at 100 volts, is supplied from an exciter coupled to each set.

The specified conditions of test of the 1,500 kw. sets were 150°F. superheat and a vacuum of 27·5 in. The test was however, carried out at 128 deg. superheat and 25·79 in. vacuum. After making the necessary corrections for these, the steam consumption under specified conditions was as follows :—

Full load	17·5	lb. per kilowatt-hour.
Three-quarter load	18·54	lb. ,, ,, ,,
Half load	19·7	lb. ,, ,, ,,

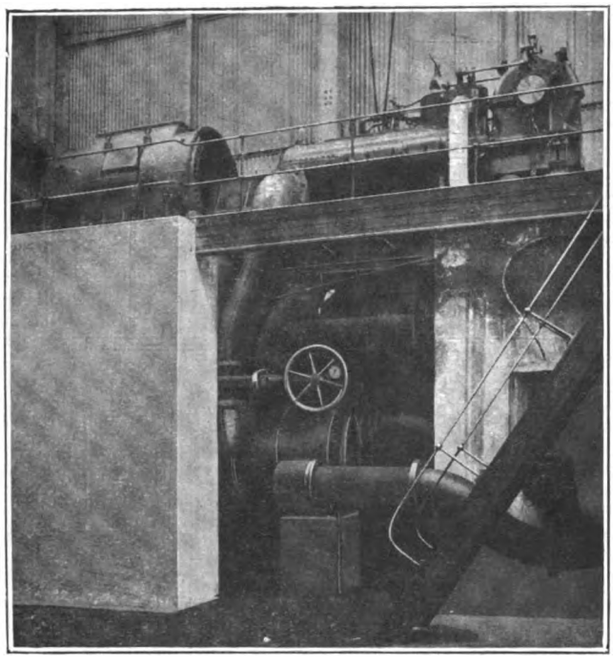

FIG. 4.—500 KW. SET WITH CONDENSING ARRANGEMENTS.

Great attention is paid in the design of these machines to provide thorough ventilation of the alternator; this is of great importance in turbine sets, and the results obtained in the tests must be described as excellent. After a three hours run at full load the temperature of the stator had only risen 36°F. (instead of the specified limit of 70 deg.), and after a further run of three hours at 50 per cent. overload the temperature rise was only 60°F. as against the specified limit of 97 deg.

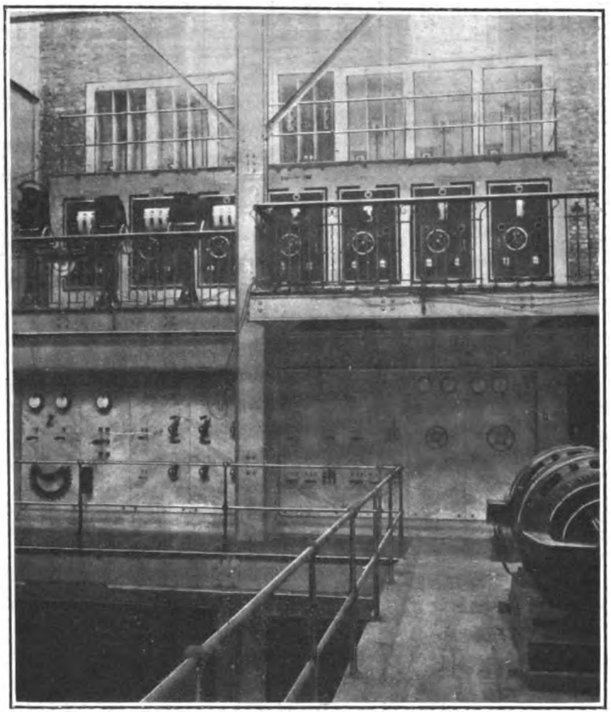

FIG. 5.—VIEW OF L.T. AND H.T. SWITCHBOARDS.

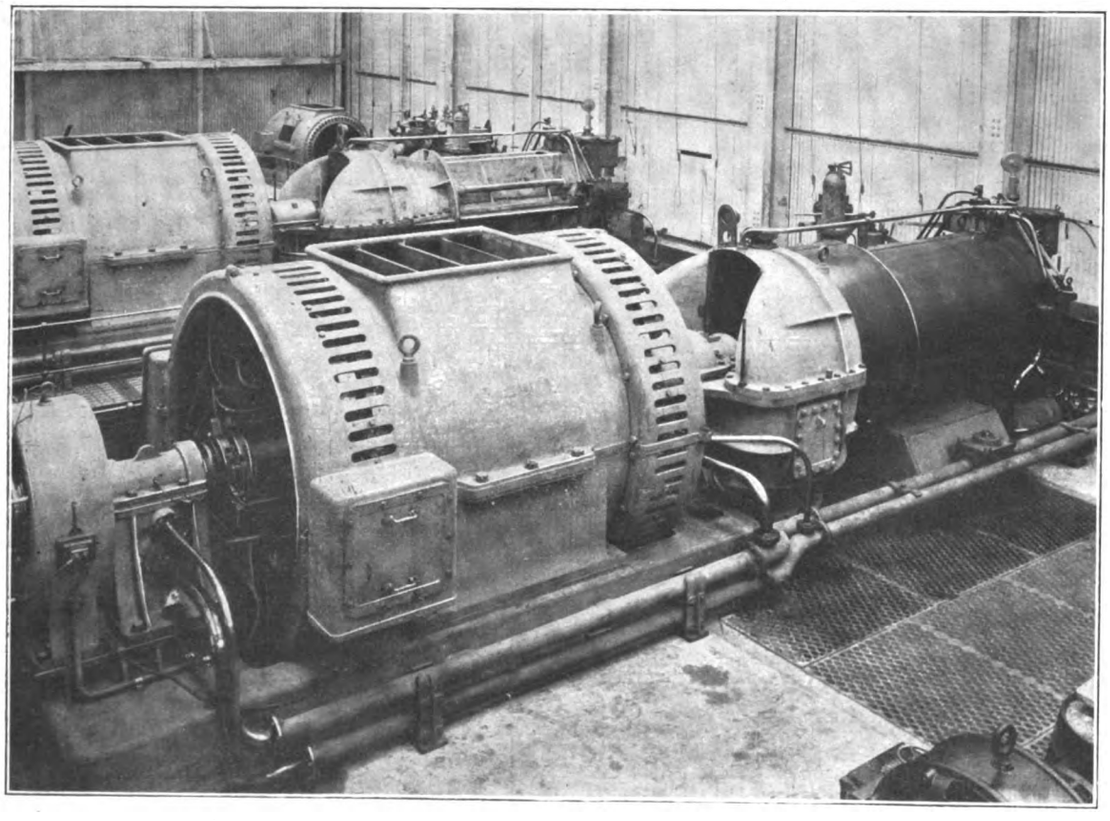

FIG. 6.—VIEW OF GENERATING SETS FROM H.T. SWITCHBOARD GALLERY.

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These tests show that the machines have been designed on very liberal lines, and owing to the output not being limited by the overheating of the alternator, as is usually the case, full advantage can be taken of the wide limits over which the load on the turbines may be economically varied.

The drop in pressure when full load is thrown on was specified not to exceed 17 per cent. on a 0·8 power factor, and 4 per cent. when the load was non inductive.

Oil is supplied to the bearings under pressure, by means of the pipes seen in the front of Fig. 6.

An interesting point in connection with these turbo-alternators is that a sheet of fibre is used to insulate the bearings supporting the rotor from the frame of the machine.

A condenser is fixed adjacent to each set, and arrangements are made for running, when necessary, each of the 1,500 kw. sets in connection with either of the two large size condensers. The condensers are of the cylindrical surface type, the two large ones being fitted with Parsons vacuum augmentors. These consist of auxiliary condensers, the suctions of which

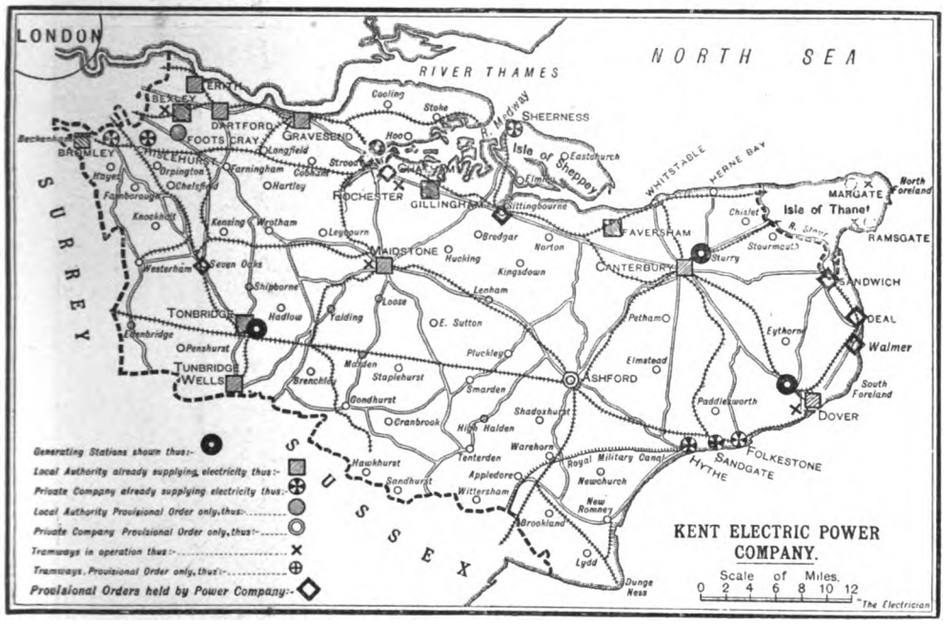

FIG. 7.—MAP OF KENT ELECTRIC POWER CO.'S AREA.

are connected to the main air pumps and serve to improve the vacuum. A vacuum of 29 in. is at times obtained, although the specified vacuum was only 28 in. The circulating water is led into a Harrison's cooling spray pond. Water is obtained at only 3 ft. below the surface of the ground and is used for making up the condensing water losses.

The "make-up" water for the boilers is taken from the town supply, after being passed through an Oscar Guttman patent water softener, which has been supplied by Messrs. Babcock & Wilcox.

The ground is composed of chalk, and thus excellent foundations have been obtained, the site occupied by the generating station having been originally excavated out of the side of a hill.

A 20 ton crane spans the engine room and is of the ordinary type worked by hand.

(*To be concluded.*)

Magnetic Cranes.—The *Electrical World* gives an account of a trial made with a lifting magnet, in the Greenville Yard of the Pennsylvania Railroad, to determine the time saved by the use of this apparatus. Six men were put to work unloading a truck of wheels, while the magnet, which is attended by four men, went to work on a load of exactly the same size, material and weight. The magnet unloaded and loaded its car in an hour, while the men, working at extra high pressure, could not manage to do the work in less than half a day.

A NEW SYSTEM OF SIGNALS.

A new system of signals is being tried on the Pennsylvania Railroad, and the results of its operation are of special interest owing to the fact that this new type will be used in the new Washington terminus. The system was devised by a committee appointed by the railroad to investigate existing methods of signal operation and to recommend a system which could be adopted over all their lines. The committee's report has been fully discussed by both engineers and operating officials of the road, and as a result the system developed is expected to combine the best features of train protection with proper provision of train operation.

The principles which govern the new arrangement are as follows:—

1. *Two arms and two lights will be displayed on every high signal.*—With existing signal arrangements the number of arms and lights is variable and depends upon track conditions so that there may be from one to five on a post. If any arm were broken or a light extinguished an engineer would probably not notice it, as he could not be expected to remember how many there were on each particular post, while if there were always two he would notice the slightest derangement of either of them. A small arm with a lower power light will, at times, be placed further down on the post or on a separate low post, but it will be so far away from the two main signals and of so much smaller size and less powerful light, that it will in no way interfere with the two arm and light principle.

2. *Day indications are given by three positions of the arm in the upper right hand quadrant, and at night each position is indicated by a different coloured light.*—When the arm is horizontal a red light is displayed, when it is raised to an angle of 45 deg. a green light is displayed, and when it is still further raised to a vertical position a white light is displayed. Raising the arm above the horizontal has a distinct advantage over the usual practice of lowering it below the horizontal to an almost vertical position. Accumulations of ice, sleet, &c., on the arm tend to move it downward; with the new arrangement this would indicate caution or stop, while with the old arrangement the downward movement would indicate either caution or proceed at speed.

3. *Three classes of signals will be employed.*—Class A. "Stop and stay" signals, which authorise or restrict train movements, and at which a train, if it is stopped, must stay until the signal is changed allowing it to proceed. This class includes interlocking, train order, controlled manual, manual controlled and telegraph block signals. They may be distinguished by the fact that the lights are vertically over one another and the arms appear the same length.

Class B. "Stop, wait time and proceed" signals, which authorise or restrict train movements and past which a train, if it is stopped, may proceed after waiting time, even though the signal has not changed and still indicates stop.

This class includes automatic signals (and, incidentally, distant signals when the latter are used as independent indications). They may be distinguished by the fact that the lower arm and light are not distinctly under the upper arm and light, but located toward the left, so that the lower arm appears about 2 ft. shorter than the upper one and the lower light shows on the left-hand side of the post, while the upper one shows on the right-hand side. This staggered relation of the two signals is very noticeable both in daytime and at night.

Class C. Signals which give information only and do not authorise or restrict train movements; switch indicators, both home and distant; flag station, water tank and stop and slow signals, indicated by horizontal lights and special designs for day indicators. These signals are all low and do not interfere with the two-signal principle used on the high poles.

4. *Signals designate the speed of the trains rather than the routes* at points where interlocking systems are used.

The top arm governs the high-speed track, provided no cross-over movement is included in the route. It indicates proceed at highest speed permissible, modified, of course, by curves or any arbitrary order placed upon the speed.

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The second arm governs medium speed movements, and refers to a divergence from the high-speed routes, such as an easy cross-over upon which a speed of 40 or 50 miles an hour is proper.

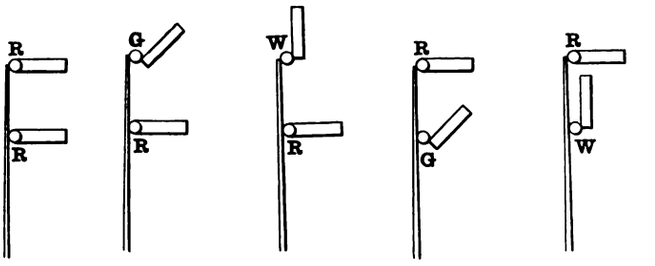
The third arm governs low-speed movements, over short cross-overs, against traffic, into sidings, &c. This arm is shorter than the other two, has a short range light and is placed much lower down the post than the two main signals.

Interpretation of Signals.

Red Light and Arm Horizontal.—"Stop."

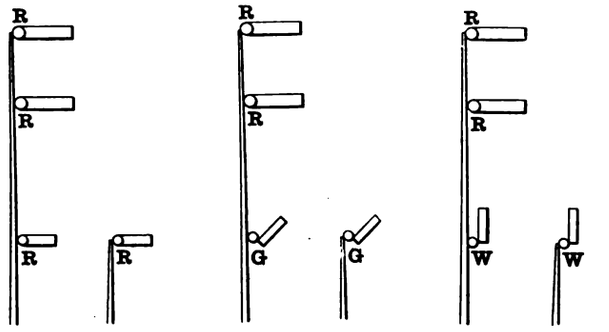
Green Light and Arm at 45.—"Caution." Proceed to next signal which is now at "stop."

White Light and Arm Vertical.—"Clear." Proceed at speed, next signal at "clear" or "caution."



Stop and Stay. | Proceed with Caution to next Signal on High Speed Track. | Proceed at High Speed on High Speed Track. | Proceed with Caution to next Signal on Moderate Speed Track | Proceed at Moderate Speed on Moderate Speed Track.

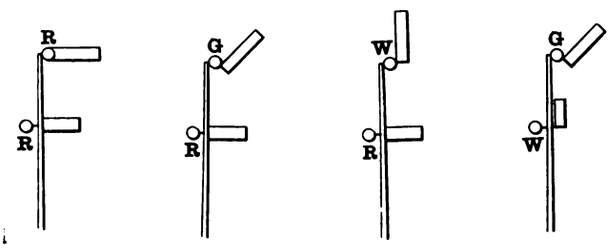
High and Moderate Speed.



Stop and Stay. | Proceed with Caution on Low Speed Track. | Proceed at Low Speed on Low Speed Track.

Low Speed on High and Low Posts.

Class "A" Stop and Stay Signals for Interlocking and Train Order.



Stop and Proceed after waiting time. | Proceed to next Signal prepared to Stop. | Proceed at Speed next High Speed Signal at Caution or Clear. | Proceed at Moderate Speed, next Moderate Speed Signal at Caution or Clear.

Class "B" Stop, Wait Time and Proceed Signals for Automatic System. (Also for Distant Signals when the latter are used as Independent Indication.)

Note.—Letters in Circles indicate Colour of Lights.—R = Red, G = Green, W = White.

Fig. 1.

All interlocking signal arms remain normally in the horizontal position, and at night show a red light. Arms are moved one at a time, so that an engineer could not pass any signal post unless the signal for his particular movement was at "caution or clear." The other signals on the post would all be at "stop."

On signal posts where no high-speed route exists the top arm is fixed in the horizontal position, and the light is always red. At signal posts where no crossovers or moderate-speed routes exist the second arm is fixed in the horizontal position and the light is always red. The only case when the top and second signals would both be out of horizontal position at the same time is on an automatic signal pole, where the lower arm would act as a distant signal for a medium-speed route controlled by an interlocking tower ahead.

Fig. 1 shows clearly the signal movements and their meaning.

Description of Apparatus.

The two interlocking plants of this installation are mechanical, but all signals are electro-pneumatic. Compressed air at 90 lb. per square inch and electricity at 500 volts are furnished from a centrally located plant. The air is transmitted through a 2½ in. main and the electricity by a No. 6 B. & S.G. copper wire. Electricity for operating the track circuits and signals is taken from storage batteries located at various signals. The batteries are charged in series from the 500 volt supply, eight hours at a time, four nights a week. The batteries are type 5 E chloride accumulators, each signal pole being supplied with two cells. One cell is used to operate the 16 ohm signal cylinder magnets and also to feed the track circuit in the rear through a 1 ohm resistance in connection with the rails. The other cell is in circuit ready for charging. The system of circuits is known as the "polarised wireless," the only wires used being those for the charging line, approach indicators, locks for interlockings and indication locks of the signals.

The high signals are iron, inside connected, and provided at their bases with a suitable box for holding the storage batteries, cut-out switches, &c.

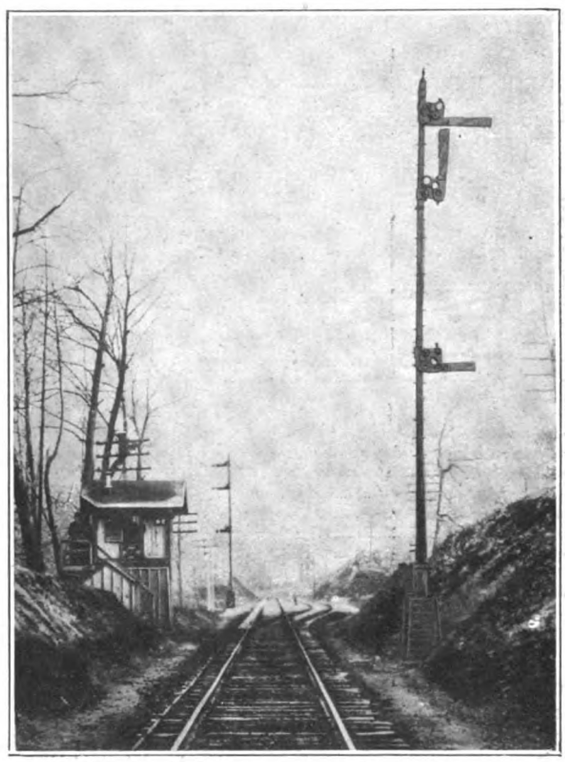


Fig. 2.—Stop and Stay Signals on Post.

The signal cylinders are tandem and the arms are pulled "clear" by a $\frac{3}{16}$ in. rod instead of being pushed "clear" by a ¾ in. pipe or a 1 in. rod. This new construction saves considerable power. The relays are 5 ohm universal, neutral polar, and the pole changers are pneumatic. It has developed so that an ordinary mechanical pole changer would probably be as well suited to the work.

All switches are equipped with rotary circuit controllers which shunt the track through two No. 6 B. & S. wires when switches are open. All boot-leg wires are No. 6 B. & S. plugged through web of rail with channel pins and running direct to battery, relay or pole changer without splices.

All sidings are equipped with pipe connected derails, a number of the Hayes type, operated from the main track-switch lever. Both ends of the main-line cross-overs are operated through switch and lock movements from one ground lever placed in the middle of the cross-over tracks, making it impossible for careless trainmen to close the switches and clear the signals with a light engine standing on the cross-over, and avoiding the use of special circuits to protect this danger point.

At first, trainmen unfamiliar with the device used too much force on this lever, and connections were sprung or switch timbers moved. This trouble has practically ended, but it is thought that in future installations it will be preferable to use this lever to lock the points only for main track, operating them from ordinary switch stands,

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and thus making flying switches possible while insuring that switches must both be locked before the signals will clear, the circuit closer being operated by the lock itself instead of by the switch.

All interlocking home signals are power operated, semi-automatic controlled through stick indicators so arranged that they go to stop on the passage of train, and cannot be operated again until the train has left the circuit, and the operator restored his lever normal and again reversed it. Approach indicators and approach locking are provided, taking effect one block in the rear of the distant, and so arranged that if the home lever latch has been raised it cannot be put down to release the machine locking until a period of two minutes has elapsed. The circuits are so arranged that if a portion of the train is left on the approach circuit, the locking automatically releases when engine enters the home signal circuit, so that no hand or time release is required for ordinary trailing drill movements, but if a second train enters the section the approach locking will become effective as soon as the home signal is cleared for it to proceed. The circuits are simple and ingenious and have been employed at points in the system with great success.

FIG. 3.—STOP, WAIT TIME, AND PROCEED SIGNALS ON POST.

The slow hand release, so-called, is really a time release, operated pneumatically and so arranged that it is out of control of the operator. This is another ingenious device and its first application was made at Morton. Special lamps and brackets were provided, as it is known that with those in ordinary use the lost motion between the lamp socket and bracket was sufficient to allow the lens in many cases to angle so much to the side as to prevent its focusing properly along the track.

Fig. 2 shows a "stop and stay" signal. Note the clear indications given by the two signals at the top of the post. The second signal shows perfectly in its vertical position. The signals are directly under one another in this case, and by comparison with Figs. 3 and 4, in which the second signal is offset to the left, the visible difference between "stop and stay" and "stop and proceed" signals will be apparent.

At night this difference is very marked, for the signals are about 6 ft. apart vertically and the lower light is located 2 ft. to the left.

The installation is on the central division, running south-west from Philadelphia.

Under ordinary circumstances the pole changer on a given signal reverses as soon as the signal moving from stop reaches the caution position, thus clearing the signal in the rear which has assumed the caution position on the passage of the train from its block.

With all interlocking signals semi-automatic, as on the Central Division, it is impossible to attach cars or switch engines to trains, or to close trains in, except under hand signals. The same difficulty exists on all roads in automatic limits, when the interlocking home signals are semi-automatic. It is now proposed to make the low speed arm semi-automatic, from caution to clear only, and to so arrange the locking and circuits that it may be displayed at caution for any route, including the high speed routes, if the latter are blocked by cars within the interlocking limits.

In other words, if a high speed route is clear and next signal clear, the top arm will clear. If the track is clear and the next signal at stop, it will assume the caution position If the track is occupied the top arm will indicate stop, but the low speed arm may be shown at caution, thus combining the safety of the semi-automatic feature for high speed movements, and the elasticity now attained where, at outlying interlockings, the signals are not semi-automatic, and hand signals are the exception rather than the rule.

The decimal system of numbering is used. Each signal is numbered in tenths of miles from Broad Street Station, Philadelphia, odd numbers for westbound signals, corresponding with the odd numbered trains, and even numbers for eastbound trains, the nearest tenth being taken. By this system, signals can be added without inserting half numbers, &c., and the location is quickly determined by dispatchers when one is reported out of order.

The installation has been in service about six months and its operation has been highly satisfactory. The operation of signals is very frequent and the requirements for their proper operation to prevent delay and insure safety are very exacting. There are 40 signals in service, equal to 80 home and distant. During December there were three failures in operation—one due to broken wire, one due to weak battery and one cause unknown. The percentage of failures on the home and distant basis is, therefore, 0·038 per cent.

It is probable that if the system goes into general use the colours of lights will be changed as recommended by the Committee. The indication "clear" will be given by green instead of white, and the indication "caution" will be given by yellow instead of green.

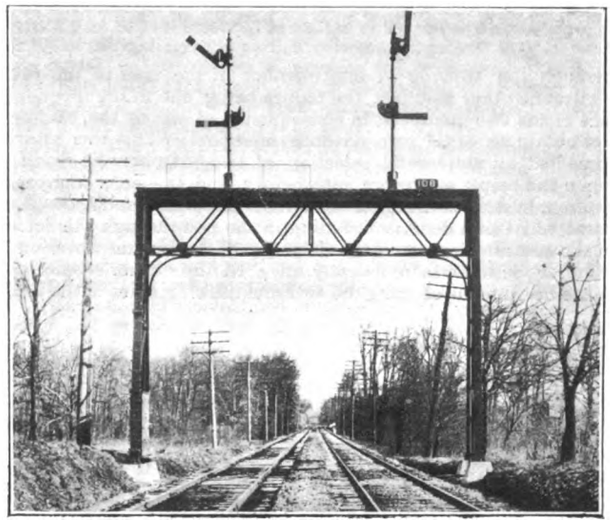

FIG. 4.—STOP, WAIT TIME, AND PROCEED SIGNALS ON BRIDGE.

This change will do away with the use of a white light and is an important improvement, for the breakage of a red or green lens can now be made to give the indication "clear," while if the new arrangement of colours is adopted a broken lens gives a white light, which does not signify anything except that the signal is improperly displayed.

THE USE OF WOODEN POLES FOR OVERHEAD POWER TRANSMISSION.*

BY C. WADE.

(*Concluded from page 103.*)

Summary.—In this Paper the author discusses the use of wooden poles for the support of overhead mains, and gives the results of a series of tests, the first set of which showed that the compound pole of A type was very much stronger than a single pole of equal area. He also describes the different methods of fastenings used for compound poles of the A type.

The author has carried out experiments with different forms of castings designed to hold the two members together at the top, both when scarfed and unscarfed. The poles were placed together side by side and held together at the top by the castings.

First experiments were made with a casting (Fig. 5) which enveloped the two members of the "A" pole, after scarfing, between the two usual oak arms. This casting was made in two separate

* Abstract of a Paper read before the Institution of Electrical Engineers.

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halves, held together by three strong bolts passing through them and between the two members of the "A" pole. The casting was so designed that when drawn up tight on the pole the two halves of it did not quite meet, and at each end of it flanges were formed for the attachment of the two oak arms, these arms being let into the pole to assist in preventing twisting of the members of the pole.

The second casting was formed to envelop the two members of an "A" pole when tied together at the usual angle (Fig. 6) without being scarfed or bored in any way at the top, and it was made in two pieces as in the previous case, but was bolted together at the edges as well as in the centre. This failed in the first instance

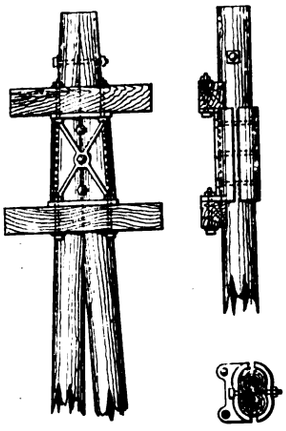

FIG. 5.

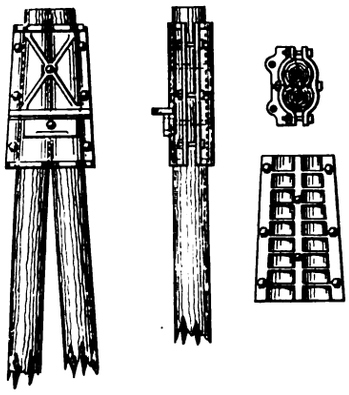

FIG. 6.

through the slipping of one member of the pole in the casting, whilst the other held fast, the failure being due to the inequality in size of the two members, in consequence of which the casting did not obtain an equal grip on both members. This was afterward remedied by the careful selection of two members of equal size, when the result was more satisfactory, and the pole, with one exception, sustained a higher load than any other and gave a comparatively small deflection, failing in the end through the buckling of the compression member. The slip of the two members on each other at the top was practically nil. In the author's opinion this is the best means of tying the two members together at the top, and

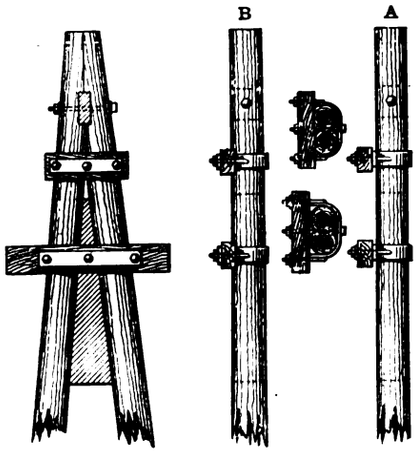

FIG. 7.

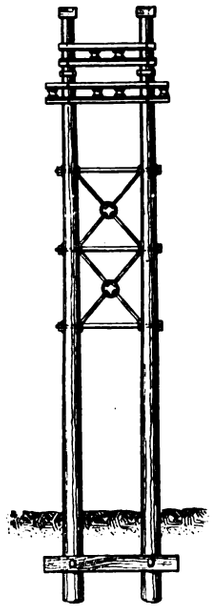

FIG. 8.

would seem to justify the extra cost involved by the more satisfactory results obtained.

A means of holding the two poles together was also tried (Fig 7A) in which the two members were scarfed together in the usual way and the arms were secured to the poles by wrought-iron bands, the ends of which passed through the arms. A centre bolt was also passed through the backing plate to the other side of the clamp as an additional means of tightening up. An oak wedge was driven up between the two poles to give rigidity, and was held in place by these bolts, and as an additional precaution both members were bolted together by a through tie bolt passing through them at the top and also through an oak block inserted in the scarf at this point. The result obtained was distinctly good, the load being high before failure, although the deflection was fairly large.

This method of holding was considerably improved (Fig. 7B) by placing the oak arms below the plates and letting them into the poles, as shown, which gave them an additional means of preventing twisting. The result obtained showed a great improvement, the load being higher and the deflection distinctly less.

A method was also tried in which a solid casting was placed over the two members after being scarfed, and having been closely fitted, was secured by a bolt passing through the two poles at its base. This gave good results, but the casting shifted considerably out of the perpendicular under load.

In this series of tests, a heavy "A" pole, each leg of which being about 11 in. in diameter at 5 ft. from the butt, which had been previously tested, was tested again, in order to determine the comparative merits of the two methods of holding it in the housing, and it was found that the loads sustained were considerably higher than before, and the failure in the end was caused by the twisting of the oak blocks in the scarf. These, which had been made nearly square, were replaced by longer ones.

Tests were also made with "A" poles spread to different widths at the bottom. The spread which gives strength combined with cheapness of erection was found to be about 4 ft. on a 32 ft. pole, or

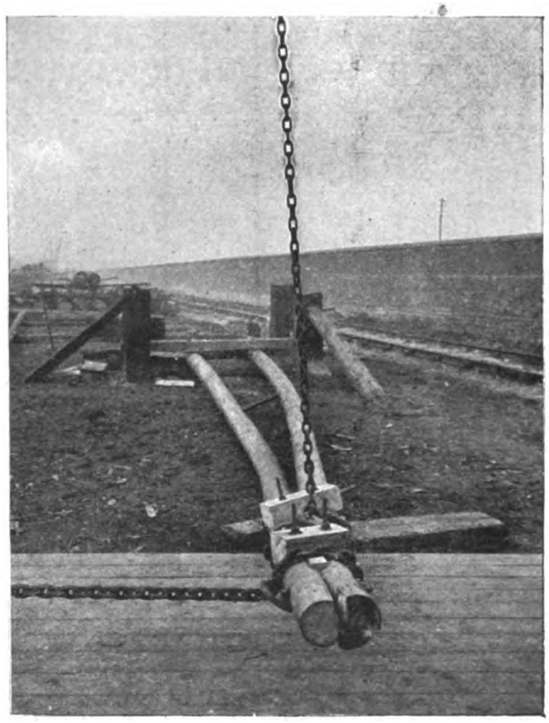

FIG. 9.

a taper of about 1 in 8, the measurement being made between the centres of the bolts holding the brace, which tied the members together near their butts. If a smaller spread than 4 ft. is adopted the poles are not so strong, while a greater spread, though giving some extra strength, increases the cost of excavation and way-leaves.

All figures given in the tables were taken from tests of "A" poles with a 4 ft. spread, measured as above, except where otherwise stated.

A favourite form of constructing a double pole is the "H" formation (Fig. 8), wherein the two members are erected parallel to each other, and are held together by the arms at the top, being strengthened lower down by cross-bracing, or by tie bolts. Their strength depends, of course, entirely on the method and amount of bracing, and if this is extensively done they will no doubt be as strong, if not stronger, than "A" poles of equal size. They have the advantage of presenting a greater surface than an "A" pole to which to attach wires, and are especially useful for terminals of lines for this reason. When used as terminal poles they are stayed with two or four steel rods or wire ropes at the back, to take the stress of the line.

This "H" formation is also extensively used by the leading users of telegraph lines and telephones for main routes, where the poles have to carry a large number of wires, and where a single or "A" pole would not give the requisite surface.

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One advantage of wooden poles that the tests have conclusively proved is their great flexibility and recuperative power after severe deflections from the perpendicular, caused by abnormal stresses. Such stresses are frequently caused during frosts by the contraction of the wires. Where wooden poles are employed, in the very unlikely event of the breaking of all the wires on one side of a pole, the first pole on each side of the break would deflect, and each pole further on in either direction would deflect proportionately, thereby preventing any poles breaking, and reducing the probable cost of repairs to a minimum.

Iron poles, steel lattice masts, and reinforced concrete poles have been used for this class of work, but the author considers that in the event of a breakage, as mentioned above, they would not have sufficiently flexibility to enable them to recover. Moreover, they would cost more to buy and erect, and would be much heavier and need better foundations than wooden ones. Again iron or steel poles would need to be repainted at least once in three years, and, however much care was taken to preserve them, their corrosion would be so great that frequent renewals would be required, whereas a wooden pole, which had undergone an effective preserving process, will last for 50 years or more without attention. Creosoting has been generally adopted by the General Post Office, the National Telephone Co., the leading railway companies and all large users, and gives general satisfaction.

It is most important in creosoted poles not to cut the treated surface if it can be avoided. Cutting away renders useless the most valuable part of the process, as the oil penetrates chiefly the outside or soft part—which is sapwood—of the timber, and any part which it is found necessary to cut after creosoting should be thoroughly tarred over.

An appendix by Prof. Goodman is included in the Paper, and gives a theoretical treatment of the bending of the poles tested, and compares the estimated values with those actually obtained.

In the experiments on the breaking strength of single poles it was found that they did not break where expected, viz., at the section close to the ground where the stress was greatest, but at a section 6 ft. or 7 ft. above the ground, where the stress was less than at the ground level. It was thought that this peculiarity might be due to the strength of the timber being greater at the butt than at sections higher up the pole, but experiments showed that this was not the case.

The theoretical treatment of single poles is a tolerably simple matter, and can be relied upon within narrow limits, but the same cannot be said with regard to "A" poles, as there are so many uncertain factors. If we could be quite certain of the joint at the apex of the poles and knew exactly the conditions as regards the end holding, we could probably obtain from first principles quite reliable expressions for the strength and behaviour of such poles; but since both of these are very uncertain quantities, we are obliged to resort to experiments.

It will be seen that when an "A" structure is loaded, as in Fig. 4, the one leg is subjected to tension and the other to compression; the structure may therefore fail by tearing apart the tension pole, by buckling the compression pole, or by shearing the apex joint. With the exception of one faulty pole, none of the "A" poles tested failed in tension. Several, however, failed by shearing at the top joint. This source of weakness was, however, overcome by adopting an improved joint, details of which are given in Mr. Wade's Paper. Most of the poles failed when under test through the buckling of the compression pole (*see* Fig. 9).

DISCUSSION.

Prof. J. GOODMAN said that one of the most important points dealt with had been that of the stress which caused the poles to come apart. The weight of the cables themselves was a negligible quantity, the principal troubles in the ordinary course being the wind and trees. They were, perhaps, aware that the Board of Trade insisted on a high wind pressure—namely, 30 lb. to the square foot. This was quite justified in the early days, and, in the absence of any definite information regarding this subject, the Board of Trade had acted wisely in insisting on high factors of safety. They had now some information about A poles, and knew within a comparatively small margin what they would carry, and he thought the Board of Trade should lower their factor of safety. 30 lb. to the square foot was perhaps somewhere near the mark in very exposed positions, such as the seashore, but such a pressure from the wind was rarely to be found inland and never in towns and protected places. Nearly 40 lb. per square foot had, of course, been recorded in some places, but this was very rare. For the purpose of Mr. Wade's tests they had made a great many inquiries as to failure of poles, but had been unable to discover more than two or three instances where poles had failed through breaking. They had, however, come across a number of cases of drawing out, and it was evident that rather more attention had to be paid to the foundation of the pole than to the pole itself. In these tests on A poles the compression pole buckled in almost every instance. If side buckling could be prevented the strength of the pole would be doubled. As to H poles, he would point to one very prevalent defect: the central ring to which the bracing bars were attached was very bad indeed and was easily broken. As to the bending stress on poles when the wires were accidentally or intentionally broken, he had calculated this out and found that the stress on the poles either side of the break was, in the case of single poles, almost exactly twice as great as the stress due to wind pressure on the basis of 30 lb. to the square foot, and in the case of A poles the stress was about equal.

Major W. A. J. O'MEARA (chief engineer to the Post Office) said that with regard to the author's statement that the tests had been carried out because there was no reliable data available on the use of poles, he would point out that there was a work in existence which had been in use for many years and copies of which could be obtained for 1s. 6d. from the Stationery Office. In that book was given the cumulative experience of the Post Office during the past 37 years, and he was struck by the similarity of the engravings in the book and in the Paper. Post Office tests were carried out with full-sized poles in 1885, and nothing had since been done in that direction as they were quite satisfied with the results. The Post-Office construction did not perhaps come up to the Board of Trade standard for high-pressure lines, but their single pole lines were perfectly satisfactory to the department, as they were able to carry from 48 to 60 wires without difficulty. The Post Office fully realised the advantages of the A pole, and in the old days A poles were used for telegraph lines to a great extent, particularly for straight lines. The great enemies to their lines were trees and snow. They did not experience much trouble from wind. He had seen miles of telegraph wires down, but had never seen a broken pole. What occasionally happened was that the poles were pulled out of the ground. Mr. Wade had estimated the life of a pole at 50 years, but his experience in telegraph work had been that the average life of creosoted poles was 20 years, although some of the Post Office poles had been up for 40 years.

Major O'Meara, in a written communication, supplemented his remarks with the following particulars as to the life of wooden poles:—Burnettised poles: These poles had an average life of from 7 to 10 years, but were very unreliable, some decaying after being erected 3 or 4 years. Boucherised poles: Unreliable, average life 20 to 25 years, frequently found full of wet rot below ground, whilst upper part perfectly dry. Creosoted poles: When properly seasoned before being creosoted, individual poles would last 30 to 40 years. Rot took place inside, whilst the shell remained good. The poles were quite good provided the shell remained 2 in. or 3 in. thick. The nature of the soil had some bearing on the life of the underground portion of creosoted poles. Clay and chalky soils tended to prevent loss of creosote and so preserved the timber. Sandy soils allowed the preservative to escape, and dry rot was likely to set in reducing the life to 15 years. Boggy land, especially if iron was present, reduced the life to 15 to 20 years.

Mr. A. P. TROTTER said that some tests were carried out by Sir Wm. Preece on telegraph poles some years ago, and he had read a paper on the subject before that Institution, but Post Office practice with regard to the use of wooden poles almost ended where electrical transmission work began. The question of safety was of the most vital importance. Mr. Wade had said that there were about 50 miles of transmission line in this country, but, as a matter of fact, it was nearer 60 miles, and notwithstanding the past heavy winter, with heavy gales and snowstorms, not a single case of accident had occurred so far as he was aware. The author had referred to the old Board of Trade rules as though they applied to modern work. These regulations asked for 50 lb. pressure, whereas 12 lb. was practically safe in many situations. The Board of Trade as a matter of fact dealt with each case on its merits. They were bound, however, to adopt a fairly high factor of safety owing to the varying qualities of timber. If they were dealing with steel poles it would be easy to reduce the factor of safety. Mr. Wade did not state what his poles were made of; he presumed they were red fir, as in the Post Office specification red fir was given. Larch poles had been used in some countries, but he believed that they had not been found satisfactory. He thought 30 years sufficient allowance for the life of a creosoted pole. As to the author's statement that single poles were no good at all, he probably meant from an economical point of view. If poles were wanted to stand heavy strains, the single pole was out of the question compared with A poles as regards cost, as for a large-size single pole a very large tree had to be used and the top half thrown away.

Mr. F. GILL (engineer-in-chief, National Telephone Co.) said that his company found single poles the best for their purpose, principally on account of the space occupied. The twist in A poles was also very awkward, and they could get single poles along the roads better. Single poles took up less space, and much less ground was disturbed in their erection than was the case with A poles, and the holding power of the undisturbed ground was, of course, greater. On the question of economy, the first cost had very little to do with it; the question of upkeep was what had to be considered. The capital cost came out at 55 for single poles as compared with 100 for A poles, and the annual cost at 73 for single poles to 100 for A poles. With the single poles stayed on both sides the capital cost came out at 80 for the single poles to 100 for A poles, and the annual cost about equal.

Mr. C. H. K. CHAMEN (Lancashire Electric Power Co.) said that with regard to the factor of safety it was obviously necessary in every case to be on the safe side. Before reducing the factor of safety to a low figure, account must be taken of the fact that no pole had been tested to destruction. In ordinary overland work A poles, which were composed of small poles and could be fitted together at the place of erection, were preferable to heavy single poles, the difficulty and cost of haulage of which were considerable.

Mr. C. J. GREENE (Callender Cable & Construction Co.) said that he was quite convinced that A poles were the proper things to use in electrical transmission work. They had learned a good deal about the breaking of poles. One would have thought they would have broken off clean and sharp near the point of support, but as a matter of fact the breaking occurred about 8 ft. from that point, showing that the fibres of the wood received some sort of local support from the ground. As to the buckling of

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A poles, he was of opinion that a slot and a pin, which would allow some play, would be as good as anything.

Mr. W. A. CHAMEN (South Wales Power Co.) said that a difficulty with electrical transmission lines was that they were not allowed to go along roads. The South Wales line had been put up in a very substantial manner, as they preferred to be on the safe side. All the A poles used had been about 8 in. in diameter at the top. It was a very heavy line and doubtless cost more than it need have done. He would like to see A poles standardised in a similar manner to railway sleepers, which had to be of one uniform thickness at the points where the rail cradles had to be bolted, so that all cutting and boring could be done before the poles were creosoted.

Mr. J. GAVEY said they had made some inquiry into the condition of Post Office poles. Some that had been in the ground 14 years had been pulled out to see if they had lost any of their strength, but it was found that these old poles differed but slightly from new ones. If poles were to be durable it was necessary to see that the creosoting was thoroughly well done. Badly creosoted poles would not stand in the ground more than 8 or 10 years. As to ground disturbance necessary for A poles, the chief difficulty was to get a thoroughly suitable foundation. On the question of decay, this was found to occur inside beyond the point reached by the creosote, and when this did occur it was more difficult to find it out than in the case of uncreosoted poles,

Mr. J. H. M. WAKEFIELD (communicated) said that Mr. Trotter in his remarks had stated that generally speaking power undertakers commenced where telephone and telegraph undertakers left off, but in the absence of details as to the definite stresses put on the poles by the power wires it was difficult to make a comparison. In many cases telegraph and telephone poles, in his opinion, were subjected to quite as much stress, if not more, as power circuit poles. The wind pressure in the case quoted by Major O'Meara, viz., 64 wires on single poles, would be for a 60 yds. span of 200 lb. copper wire (11½ S.W.G.) about ½ ton; if the wires were pulled up to the usual tension—say, 66 lb. at 60°F.—the static stress would approach 2 tons. It should not be forgotten that telegraph and telephone poles were much higher than power circuits, as a rule, and therefore the moment of pressure was considerably increased.

Mr. C. WADE, in reply, said he had been quite aware of the existence of the Post Office book to which Major O'Meara had referred, but what they more particularly required was information regarding A poles, which would be required for overhead high-tension lines. He thought he was right in saying that there was no information available on A poles. As to the life of poles, of course 50 years was a high estimate, but there were cases where poles had lasted that time.

STENO-TELEGRAPHY.

We have before us an interesting descriptive account of "Stenocode," which is described as a new development intended to effect a degree of economy and efficiency in submarine cable transmission which has hitherto been unattainable. The process is owned in this country by the Steno-Telegraphy Co., of Copthall-avenue, London, E.C., and is based upon the principle of a revision of the alphabet so as to reduce to a minimum the number of impulses required for each character used in the work of telegraphic transmission. Mr. Murray's system, which has been already described fully in *The Electrician*, goes some distance in this direction, but, it is claimed for the Stenocode system that it is a great advance upon anything that has been accomplished hitherto. By this method the number of contacts required for the letter is lessened, and the number of spaces is reduced or entirely eliminated, so that a large saving in time is secured, independently of mere mechanical speed.

As our telegraphic readers are aware, in the Morse code tape-notation of the Kelvin recorder three elements are used—viz., a right and left movement (according to current direction) and the zero or spacing element. In the Stenocode notations there are five elements, namely, a strong right, a strong left, a weak right, a weak left (according to current direction and strength), and a zero element, used for signalling and not always for spacing purposes. For practical purposes the following abbreviated letter forms are used to describe these elements:—SOR (for strong right), WER (for weak right), SOL (for strong left), WEL (for weak left), ZE (for the zero element), and the centre holes of the perforated slip are called "time units" or simply "units."

The following particulars of the system have been supplied to us by Mr. A. C. Baronio, the inventor of the Stenocode system:—

Whereas on the perforated slip, as now used in automatic signalling on submarine cables, only a single row of signalling perforations is employed on each side of the central or zero line, on the Stenocode slip an extra row of perforations is arranged upon a line on one side of and parallel to the central line. These extra perforations, when they occur, actuate a device for changing the battery power simultaneously with the contact which sends the current into the cable; but when no such extra perforation occurs the normal battery power alone is used, as at present. This enables the apparatus to be available for the transmission of the existing code also, and gives an advantage which would, of course, be of practical value during the period of change from the use of one code to that of the other. The Stenocode Perforator is designed so that the extra perforation of the tape, when wanted, is made simultaneously with the dot or dash perforation, as the case may be. It is a 5-keyed perforator, all the five keys being in use when the extra row of perforations is wanted, and only three when the present normal perforations are required. It is so arranged as to be conveniently manipulated by the four fingers and thumb of one hand, so that the operator at the punching up station need never take his eye off the copy before him. At the intermediate stations messages are recorded either by the Stenocode Apparatus or by Siphon Recorder in the ordinary way, or a facsimile slip is reproduced punched up ready to be fed through another transmitting instrument, and so on throughout the service. If necessary a printing device can also be used to record the message, thus limiting the possibility of errors, arising from human fallibility, to the punching up of the slip in the station of origin.

There are many alternative ways of applying the principles thus briefly outlined to produce a complete system of telegraphy, but two of these only are considered in the following:—Plan A simply applies Stenocode principles to the existing Morse Code with a few modifications, and is therefore not the most economical; and Plan B, though more drastic in the changes it effects in the present Morse Code, yet gives the full and complete benefits of the Stenocode principles—claimed to be increased speed, efficiency and accuracy.

Plan A.—In the Morse code the number of units allotted to each character was determined by the frequency of its use in the English language; hence there are characters of 1, 2, 3 and 4 units (without counting spaces) for vowels and consonants indiscriminately. This is, of course, of no advantage in telegraphing in other languages, and is, in fact, a positive disadvantage in dealing with code words as at present defined; therefore, in the Stenocode method, three slight exchanges of the present characters are suggested, so that all the vowels may be of one or two units and the consonants of three or four units each. The changes are:—

— for O exchanging with T which becomes — — —
— – „ U „ „ N „ „ – – —
— — „ Y „ „ M „ „ — – — —

By these alterations the alphabet is made to consist of two vowels of one unit each, four vowels of two units each, eight consonants of three units each, 12 consonants of four units each, and the additional battery power is used for the purpose, so to speak, of superimposing the vowel upon the consonant, much in the same way as is done in ordinary stenography (hence the name Stenocode). Initial vowels and vowels which do not immediately follow a consonant cannot of course be superimposed.

The extra power is applied on the first contact of the preceding consonant to indicate the vowel A, on the second ditto E, on the third ditto I, on the first and second ditto O, on the first and third ditto U, on the second and third ditto Y. With this understanding it will be seen that the preposition "BY," for example, would then be coded as: WEL-SOR-SOR-WER, or four units instead of nine.

The accompanying diagram (Fig. 1) showing recorder slips, drawn on a uniform scale of 10 units to 1 in. for the sake of comparison, illustrates the system, and make quite clear the gain in speed which it is claimed is attained by its use: No. 1 is the siphon recorder slip in accordance with the present Morse code, No. 2 a like slip with the vowels O, U and Y changed as suggested, No. 3 a siphon recorder slip with the vowels superimposed, No. 4 the corresponding perforated slip, showing the extra line of holes which put on the extra battery power for superimposing the vowels; while Nos. 5 and 6 are two other forms of the Steno recorder slips, showing (in No. 5) the use of two siphons (one for recording the consonants and the other for recording the vowels), and (No. 6) indicating the vowels by pencil dots.

Obviously this plan would give much greater advantage with words strictly running alternate consonant and vowel than in the case of words which do not fulfil that requirement; and this brings us to a description of

Plan B.—In this it is proposed to form from the five elements SOR, SOL, WER, WEL and ZE a uniform two-unit alphabet of 24 characters, requiring no separating spaces, and therefore occupying half the present number of time units for transmission. Analysis of this two-unit alphabet shows that the letters on each line, read across as a pronounceable artificial word, will serve as a mnemonic designation to indicate the corresponding Steno character as it would appear on the recorder or perforated slip, and at the same time give its reading, thus making it easier to learn. For example: WERWELAAR represents the two impulses, "a weak right" and "a weak left," which form the character for the letter "A," or the Stenocode biliteral syllable "AR." Similarly ZEWERONE, when following the figure prefix SORZE, designates "a zero unit" and "a weak right impulse," meaning the figure ONE.

In addition to increased speed owing to the less number of contacts used, Stenocode characters afford an economical and effective check system, enabling the receiving operator to ascertain whether his recorded slip is what the sender intended it to be, thus providing for the correction between stations of errors arising from failure of contact, or from characters becoming changed through misreading of strong current impulses for weak ones, or vice versa. But such a system of check need only be considered in connection with code or cypher messages, as the context is sufficient check in plain language.

In regard to the Steno alphabet, each Stenocode character, in addition to its letter value, has a syllabic value formed of a vowel combined with one of the four consonants R, S, N, T. If, therefore, code words are formed of five of these Stenocode biliteral syllables (making 10-letter combinations), each such code word could be signalled by 10 units, instead of 40 as at present.

It is pointed out that under the existing limitation of mere pronounceability, which in practice amounts to no limitation at all, a considerable loss is inflicted on telegraph administrations, and especially on cable companies with their strictly limited carrying power, in that it enables the user of codes to pack as much as two six-figure groups into

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one 10-letter word, and the words so produced are often composed of such combinations of letters as to require four beats and a space for each letter, thereby reducing the speed of transmission through the cable, and the rate of working of the clerk, while increasing the percentage of errors. As an example of how far this limitation is being stretched, a system is daily coming more into use by which a code is prepared from the permutations of a number of dots and dashes, without spaces, so that when a message is coded it becomes a continuous line of such dots and dashes. For the purpose of transmission this line is cut up into letters of as near as possible four characters each to form ten-letter words pronounceable enough to be smuggled through. As often as can be managed, therefore, a word is made to consist of letters which take the greatest possible number of time-units to transmit. If, however, all code words were composed of five biliteral groups of alternate vowel and consonant, or vice versa, producing pronounceable words of never more nor less than 10

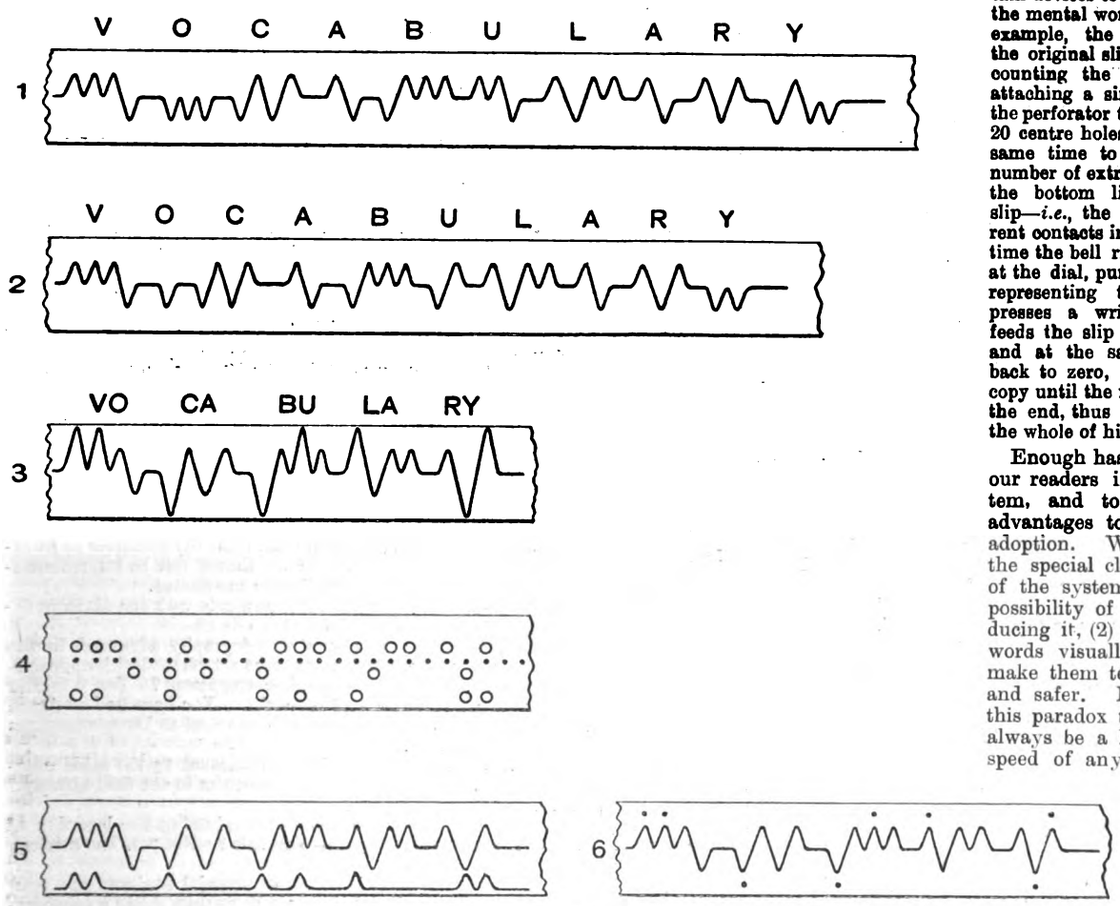

FIG. 1.

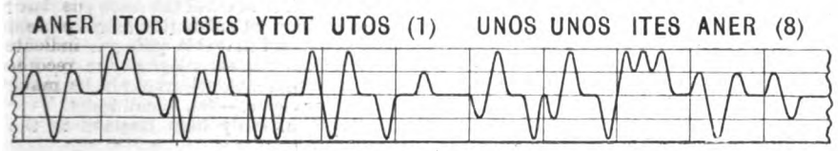

FIG. 2.

letters (with the possible exception of the last word of a message) the use of the maximum number of time units could only be necessitated in a few cases, and could never occur at all if the suggested alterations in the signalling of the vowels were adopted. Speed and accuracy of working would also be greatly increased, for the operator would be helped by his knowledge of the construction of the words in deciphering the recorder slip and would be warned that an error had occurred when the alternation was disturbed or the number of letters varied from 10 in any word. All the numerous class of errors caused by the running together or splitting of characters, failure of contact, and misreadings by which a vowel is changed into a consonant, or vice versa, would be capable of detection and immediate correction by each operator as the message passes through his hand. A yet greater advantage, it is claimed, results from the use of code words composed of Stenocode syllables, in that it is possible to give the public the benefit of 20-letter code words and yet double the speed of signalling, while providing a specific safeguard against error. A further advantage of the system is that if for any reason the proper apparatus broke down so that signalling by the Stenocode alphabet became temporarily impossible, it would be quite easy to signal such code words by the ordinary alphabet without making any change, thus:—

ANER would be signalled as CE in the ordinary Morse
ITOR " " LO " "
USES " " RF " " &c., &c.

And Stenocode messages can in this manner be carried by present apparatus on sections where the gain in speed is not so imperative as to justify the use of Stenocode apparatus.

The characteristic uniformity of construction, while reducing the mechanical work received in transmitting a message, also enables certain devices to be employed to reduce the mental work of the operator. For example, the operator punching up the original slip may be relieved from counting the signals he makes by attaching a simple ratchet device to the perforator to ring a bell after every 20 centre holes (or units), and at the same time to indicate on a dial the number of extra holes punched along the bottom line of the perforated slip—*i.e.*, the number of strong current contacts included in them. Every time the bell rings the operator looks at the dial, punches up the character representing the figure indicated, presses a wrist spacing key which feeds the slip forward to centre holes and at the same time sets the dial back to zero, and proceeds with his copy until the next ring, and so on to the end, thus automatically checking the whole of his message.

Enough has been said to interest our readers in the Stenocode system, and to show the possible advantages to be derived from its adoption. We may perhaps add the special claims of the inventor of the system, which are (1) the possibility of gaining speed by reducing it, (2) the manufacturing of words visually longer in order to make them telegraphically shorter and safer. Mr. Baronio explains this paradox thus:—(*a*) There will always be a limit to the working speed of any apparatus, and the excess of this limit must lead to improper definition of the signals, which will result in misreadings and consequent loss of time in repetitions. By shortening the characters as proposed in the Stencode system, a large saving of time is effected without exceeding a moderate working speed. (*b*) The length of a word, telegraphically, is not determined by the number of letters it contains, but by the number of impulses required to transmit it. This principle is demonstrated in the example shown in the illustration Fig. 2, where 20 letters represent but the length of five letters as now used, and in addition afford a perfect check which the operator can follow as the message passes through his hands.

Finally, it is interesting to note that a complete apparatus on this system will, if desired, be exhibited and demonstrated at the forthcoming International Telegraph Conference to be held in Lisbon next year.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"A Handbook of Wireless Telegraphy." By James Erskine-Murray. (London: Crosby, Lockwood & Son.) 10s. 6d. net.

"The Construction of Dynamos (Alternating and Direct Current).' By Tyson Sewell. (London: Crosby Lockwood & Son.) 7s. 6d. net.

"Agglutinants of all Kinds for all Purposes." By H. C. Standage. (London: Archibald Constable & Co.) 6s. net.

"Proceedings of the Royal Society," Vol. LXXIX., No. A. 528. Series A—Mathematical and Physical Sciences. (London: Harrison & Sons.) 2s. 6d.

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PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

On Thursday last week, Mr. JOHN GAVEY, C.B., late Engineer-in-Chief to the Post Office, gave a demonstration of wireless telegraphy at the General Post Office for the information of the Radio-Telegraph Committee, who are considering the question of the ratification of the Convention relating to wireless telegraphy formulated by the International Conference at Berlin last year. Mr. Gavey described the principal systems, and especially the Poulsen method of using undamped waves to secure more rapid oscillation. Demonstration was given of the use of an ordinary untuned system, and afterwards the possibilities of tuning by means of a combination of capacities and inductances. A tuned system fitted up for three tunes was shown, and the means of tuning out station "A" while signalling with station "B" and vice versa. It was also shown to be possible for a powerful transmitting station to interfere with the communication of other stations although using a different wave-length.

When the Committee met on Tuesday, Sir WILLIAM PREECE, formerly Engineer-in-Chief to the Post Office, was called, and said he had been at work on the subject of wireless telegraphy for 12 years before Mr. Marconi came to England, and had carried out several very successful experiments—more, in fact, than experiments—real work. In 1892 he signalled across the Bristol Channel, between Penarth and Flat Holm, and it was a remarkable fact that the first message sent to Mr. Gavey was the announcement of the death of his (Sir William's) predecessor at the Post Office. In 1895 the Post Office maintained wireless telegraph communication for three weeks between Oban and the Isle of Mull when the submarine cable was broken, and on that occasion messages were freely sent. This appeared in the Press, and was considered an immense success. Later Bathlin Island was placed in communication with the mainland of Ireland. This was established as a Lloyds station, and later on was transferred from Lloyds to the Post Office, and there it had been ever since conducting the commercial business of the Post Office. After that the success of wireless telephony was secured, when Mr. Gavey established communication between the Skerries and Holyhead, a distance of about four miles. That was in 1901, and the service was now used for public messages. The main point of his coming there was to endeavour to show that wireless telegraphy was a free system open to the whole world. It was not patented by the Post Office, but it was developed by the Post Office, and when Mr. Marconi came here he only came with a new way of doing an old thing. He claimed that the system was in operation before Mr. Marconi came here, and that it was developed by the Post Office in his department. When Mr. Marconi came to witness, with a letter of introduction from Mr. Campbell Swinton, he came at a very fortunate time, for witness was just then smarting under the disappointment of having made a failure in communicating with the East Goodwin lightship. In fact, the system the Post Office had developed did not communicate with moving ships, and Mr. Marconi came to them with a plan by which they could use Hertzian waves applied to a coherer—a very delicate instrument—and witness saw at once that this was something which would enable them to communicate with moving ships, and at his recommendation every possible facility was given to Mr. Marconi. He had not one word to say either for or against Mr. Marconi (whose credit was well preserved), but what he wanted to impress upon the Committee was that Mr. Marconi did not and could not patent wireless telegraphy, for it existed before Mr. Marconi came here. Witness, with Mr. Marconi, carried out experiments across the Bristol Channel from Lavernock Point to Brean Down. These were the first experiments Mr. Marconi had ever made across sea. It was after these experiments in May, 1897, that the Marconi Co. started, and then Mr. Marconi and the Post Office broke all connection, and the Post Office lost all interest for a time in the Marconi system. He wished to impress upon the Committee that the Post Office left wireless telegraphy free to the whole world.

The CHAIRMAN: What are your views with regard to the exceptional advantages that the Marconi Co. has enjoyed in recent years?—It is due to the facts that Mr. Marconi has been able to maintain communication between shore stations and moving ships and between moving ships with each other, and that he uses Hertzian waves which had not been used before, and we have been able to extend the distance to which we can communicate very much by using the Hertzian waves, as Mr. Marconi did. As regards other systems, I have taken the deepest interest in every step in advance, and I am acquainted with the Lodge-Muirhead, the DeForest, the Poulsen, the Telefunken, the Rochefort and the Fessenden systems.

Provided intercommunication was allowed between these several systems, do you consider the progress of wireless telegraphy would proceed with success?—I have not the slightest doubt about it, for the whole effect of the operations of the Marconi Co. has been to check, and really to stop, the growth of wireless telegraphy, both as a convenience to navigators and as a commercial undertaking.

You do not recognise the objections that have been raised to the proposed ratification of the Convention?—I take quite the reverse view. The only reason that has been given in favour of granting a monopoly to the Marconi Co. is that in attempting intercommunication we should attempt to infringe their patent. On the other hand, I should say if there is any value whatever in the patent, the fact of other systems being able to communicate with Marconi stations, instead of proving the infringement, would show that the Marconi system was based upon the same idea as the others. There had been three or four great steps in advance during the last few years. The syntonic method was patented by Lodge in 1897, and I believe in the strength of his position under that patent. Other advances made have been in the delicacy of the receivers used, and the most practical, not perhaps the most delicate, but one of the best receivers, is called by Sir Oliver Lodge his coherer and he described it in his evidence. Another great step in advance is an electrochemical receiver—a German invention—which formed the basis of the De Forest and Fessenden systems, and lastly a great advance has been made by Duddell and Poulsen in the use of persistent waves. This is a great step in advance as to economy of power and ease in tuning.

Will you kindly give us a definition of persistent waves?—A simile which might be taken to describe the persistent waves is the rattle of a row of drums, a continuous rattle, compared with a boom on a big drum followed by descending booms rapidly disappearing. The waves were produced by Mr. Duddell by means of the Simian arc, and that was the system adopted by Poulsen also, but since then there have been several systems proposed by which these persistent alternating currents can be maintained.

You have had occasion to examine minutely into many of these systems?—Yes, and I confirm what has been said by previous witnesses in describing them.

Do you see any serious objection to the ratification of the Convention?—No, I think it would be a serious evil to this country if the Convention were not ratified. It is essential that we should take any steps that will make wireless telegraphy a free trade, and we want to encourage small ships to use wireless telegraphy, not for the amusement of passengers, but to enable ships to know the conditions around them. The Convention will practically attain for us the monopoly that the Marconi Co. are endeavouring to secure, and it will lead to the organisation and regulation of all the telegraphic business of the world. We have a Convention controlling international telegraphy and it has produced between the different countries a great alliance. The telegraph business of the world is conducted on well-regulated principles, and unless this is done with wireless telegraphy there will be a great confusion. In the case of submarine telegraphy, nearly all the cables were laid by private enterprise, and these private companies are all parties to a Convention. A Conference takes place every five years. The proposed Wireless Convention is simply an extension of the existing Telegraph Convention.

Has wireless telegraphy advanced to that position where you can have combination and organisation?—There is no difficulty whatever in intercommunication. I see no reason why there should not be intercommunication between all the seven systems I have mentioned.

Mr. LEE: Can the Poulsen system communicate with the Marconi?—Not in its present form, but it can be made to do so.

Sir GILBERT PARKER: Has wireless telegraphy advanced to the position when this general organisation can be established with no resistance, so to speak, being given to scientific development?—Yes, it is now in a practical stage; it is at least 12 years old. You have had evidence from one of the naval witnesses who was able to read at Dover messages from 20 or 30 other stations.

Mr. GWYNN: When the international agreement by the cable companies was arrived at were there several companies in the field already?—Yes, with established businesses.

Do you say there are several companies conducting the business of public wireless telegraphy on a commercial scale?—Not yet. The analogy breaks down to that extent.

There is only one company conducting a commercial business on a considerable scale?—In England, but there are companies doing a considerable public business in America. They are not restricted there. There are the De Forest and the Fessenden companies. The Fessenden is at present trying to communicate across the Atlantic from a point near Boston to England. There is also the Telefunken Company in Germany.

Sir GILBERT PARKER: Is it the case that cable telegraphy has reached a state of perfection?—I will not say quite perfection, but it has reached a practical stage, and scientific discovery will only, perhaps, improve existing apparatus.

Do you think that wireless telegraphy has reached the same position?—I think it has reached the same position as submarine telegraphy for communication within 300 or 400 miles, and that it is quite practicable.

The CHAIRMAN: Do you think that wireless telegraphy to-day has reached the same stage of development that cable telegraphy had reached when the Telegraph Convention was arranged?—Yes, scientifically.

Can wireless messages be sent systematically from England to the United States now?—No.

But when the International Telegraph Convention of St. Petersburg was made messages could be sent across by cable telegraphy?—Yes; to that extent wireless telegraphy may be a year behind.

You hope that in a year from now wireless telegraphy will be established systematically between England and the United States?—Yes; but nobody has attempted it, however, except the Marconi Co. and Fessenden. The Fessenden experiments were stopped by the breakdown of the masts by a gale at Ballachulish. I do not believe, however, that wireless telegraphy will compete commercially with cable telegraphy, but it will be generally used for shorter distances. I think wireless telegraphy has, for the purposes to which it is to be put, advanced to the same position as submarine telegraphy had at the time of the Telegraph Convention.

Sir GILBERT PARKER: Do not the purposes of wireless telegraphy include long-distance messages as well as short?—I do not think there is any commercial necessity for these long-distance messages, and I think it is a waste of money to endeavour to establish signalling across the Atlantic.

Would it not be advisable to have wireless telegraphy between, say, the New Hebrides and Australia?—If there were a large traffic it would be conducted by cable. It costs more to work wireless telegraphy than a

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submarine telegraph cable. I have had to report on the feasibility of connecting outlying islands with the mainland, and I have shown that for short distances it is cheaper to lay down a cable, for with wireless telegraphy, although your capital expenditure is not serious, you must have an expert to work it and you cannot have an expert without paying him fairly well. This makes wireless telegraphy costly.

It was stated by a previous witness that an ordinary telegraph operator might be trained in a fortnight as an operator for wireless telegraphy. Do you think a fortnight's training would necessarily increase his salary?—He must already be a skilled expert to be competent to absorb the training in a fortnight and the cable telegraphist is not necessarily an expert.

The CHAIRMAN: Mr. Marconi said wave-lengths had been dealt with in the Convention, but other factors had been ignored, and that this would militate against the success of wireless telegraphy with intercommunication. Will you give us your views on that?—I noted that statement with surprise. I could not quite follow Mr. Marconi. There are, of course, several factors. He referred only to length of wave and amplitude. Amplitude is simply the strength of a wave, which is analogous to the intensity of light or the loudness of a note. In the Post Office experiments two or three years ago waves of all kinds were measured, and the results indicated that the whole of the factors involved were fully known. I was surprised at what Mr. Marconi said on the subject, because I can only account for his having come to his conclusions by assuming that his magnetic detector had not got such a range as some of the other detectors—that is, a range of varying intensity in receiving the different currents. With a coherer like Sir Oliver Lodge's there is no difficulty in picking up waves whatever their amplitude above a certain point, and I take it that the Convention, by specifying the wave-length and the power, has specified all that is necessary. The power regulates the amplitude of the current of a wave that leaves a station, but the wave that comes to a receiving station may have passed overy various obstacles; the trees on an island absorb a little of the energy and the wave arrives with a smaller amplitude, but assuming the receiver to have a wide range that is no objection.

You consider that leaving the factor of amplitude out of the provisions of the Convention will in no way interfere with satisfactory communication?—On the contrary I think the introduction of amplitude would be most confusing. I know no practical wireless telegraphist who would not be ready to accept the factors of power and wave-length as sufficient.

Mr. Marconi said he was of opinion that the Convention would stifle progress?—I do not agree. What we want is free trade, so that everyone may use and test various systems. The Marconi Co.'s claim for a monopoly is based on the assumption that their patent is strong, and I say it is weak.

Why do you think we should ratify the Convention?—Because if we decline to do so we shall be the laughing stock of the world and we shall throw into the hands of those who are striving to get it all the wireless telegraph business of the world. Although England occupies geographically a magnificent position and has a great deal of shipping, her coast is very small compared to France, Spain, the United States and other countries, and to improve commercial communication we want to enter into a partnership with other countries. If we do not there are 26 or 27 others who will go on in spite of us.

Sir GILBERT PARKER: Do you think that systems other than the Marconi would develop better under the Convention?—Yes, and the Marconi Co. would also be improved, because the effect of the Convention would be to increase the number of ships fitted.

Mr. GWYNN: You admit that practical wireless telegraphy was made a working institution by the Marconi Co.?—Yes. I agree with that.

In what sense do you mean the Marconi Co. desire to have a monopoly?—Their claim for a monopoly is based upon the value they attach to their patent.

Does Lloyds' monopoly of the shipping information business rest upon a concession granted by Government or upon its superior commercial efficieney?—Upon its commercial efficiency entirely.

Sir GILBERT PARKER: Has the Marconi Co. such a monopoly as would prevent the Post Office granting licences to other companies?—I think not.

Mr. GWYNN: Has your attention been drawn to Mr. Marconi's statement that the more systems became developed the less suitable they would be for intercommunication?—I could not agree with that; I think as the science becomes more developed all systems will work with persistent current waves rather than with rapidly damped ones. I am referring to the principles involved in the Poulsen system, which means practically the use of persistent currents, and the use of these currents is so promising as an economic agent in the matter that I think all companies will eventually have to adopt the persistent currents in preference to the damped currents.

Can the apparatus of the Poulsen system communicate with Marconi or Lodge-Muirhead apparatus?—I know of no reason why it should not.

Mr. Maskelyne told us that the Poulsen system cannot do so?—He meant in its present form. I see no reason why all the systems cannot be made to intercommunicate.

Sir GILBERT PARKER: Suppose a company, say those working the Marconi or the Poulsen systems, developed some new factor such as the persistent waves you speak of, and it was found advisable to have this development incorporated in the general system, would there not be some difficulty in securing this scientific improvement when there are a number of parties to agree?—There has been no difficulty with regard to the International Telegraph Convention, and I see no reason why there should be any difficulty in the case of wireless telegraphy. The convention would tend to encourage improvement. The merits of particular systems would come to the front, and they would be adopted as they are in the submarine cable world. The Berne Bureau issue communications to every contracting State, and if the improvements are real improvements they are readily adopted.

It has been stated that the development of Marconi's system was the result of co-operation between Mr. Marconi and the Post Office?—There has been a great deal of nonsense related before this Committee about my connection with the Post Office. Prof. Slaby has been accused of stealing ideas he picked up at the trials referred to by Mr. Marconi, but I entirely dissent from that statement.

How long do you think an ordinary telegraph operator would take to become expert at wireless telegraphy?—Six months.

Mr. LEE: You said something about the commercial inefficiency of the Marconi Co.?—I only referred to the commercial management of the company. As regards the public service its organisation is, as far as I can see, highly efficient.

Do you think England would lose her present commanding position in regard to wireless telegraphy if the Convention were not ratified?—I think there would be a tendency in that direction. At the present moment the majority of ships want to communicate with Great Britain because they are fitted with Marconi apparatus and there is no other system on our coast to communicate with. It is advisable to make it possible for ships to communicate with any shore and in that way the Convention would facilitate business.

You would not suggest that a ship would alter its normal course to communicate with a foreign station if it were nearer to a British station?—No.

Therefore would not foreign ships, even if they resented our non-adherence to intercommunication, still have to use our stations on the British coast?—Yes, for their own convenience.

England would not lose the advantages that she has from her geographical position if the Convention were not ratified?—She would not, perhaps, lose what she has, but she would lose the development which would occur if the Convention were ratified.

The POSTMASTER-GENERAL: The Convention would be suited for any system as it develops?—I think so.

Mr. LEE: There is a conflict between your evidence and that given on behalf of the Poulsen Co. Suppose it became a fact that the Poulsen system could not communicate with the Marconi, would you then maintain that the regulations adopted by the Convention are suitable for the regulation of both systems?—The Poulsen Co. would suffer. If the Poulsen system does not communicate it will be bad for the Poulsen system. There might be something in the suggestion if it were scientifically difficult or impossible to make the two systems intercommunicate, but I think that is not difficult.

Mr. GWYNN: Assuming that it was impossible for them to intercommunicate, and the Poulsen system found themselves hindered by the Convention, you think the interests of the public generally should outweigh their objection?—Yes.

The POSTMASTER-GENERAL: Suppose a system could not intercommunicate and the Convention enforced all systems to adopt some mode of intercommunication?—I think a very small modification would enable all systems to intercommunicate.

The CHAIRMAN: You do not see any difficulty in obtaining communication between the spark and other systems?—No; I endorse the position taken up by Sir Oliver Lodge on that point.

This concluded Sir William Preece's examination.

(PARLIAMENTARY INTELLIGENCE *continued on page 149.*)

Induction Motor Hoist.—The *Electrical World* gives an account of an induction motor hoist which has lately been placed on the market. The motor is arranged with a comparatively large clearance between the rotor and stator to provide against unbalancing the rotor on account of the wear of the bearings. The gearing is enclosed in a box which forms one end of the hoist frame. The gears are of cast-iron, and grease lubricated, and the pinions are of machine steel. The hoist is provided with two brakes; one, an ordinary mechanical or "tongs" brake operated by a cam attached to the controller shaft, and the other a load brake of the disc type, mounted on the armature shaft. The former brake is lifted from the pulley when the hoist is in operation and presses against the pulley with maximum force when the controller is in the "off" position. The latter brake works only when the hoist is lowering and is provided with a roller pawl which permits the friction disc to turn freely when the hoist is lifting its load. The friction depends on the tension of a spring, and this is adjusted to sustain the rated load regardless of the action of the mechanical brake, so that were the latter to fail the load brake would still hold the load. The limit switch consists of a screw on which is mounted a movable and two stationary nuts. On the end of the screw is a small sprocket wheel and on the end of the controller shaft is another, both being connected by a chain gear. When the moving nut engages the stationary nut at either end, the sprocket wheel is rotated and the controller turned to the "off" position, which causes the brake to act and stop the hoist.

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ELECTRIC POWER SUPPLY IN LONDON.

During the last two years, since the time when Mr. MERZ introduced the power scheme of the Administrative County of London Company, there has been a popular idea that London is devoid of any adequate supply of electrical power. Popular ideas in such matters may generally be discarded, but when it is a case of obtaining Parliamentary sanction to any scheme the popular idea on the subject becomes of more than usual importance. For this reason we have taken some trouble to look into the facts of the case, and the result of these inquiries, as shown by Mr. R. L. PEARSON'S articles on the subject, the last of which appears in our present issue, is that the popular idea is a very exaggerated idea indeed.

To start with, there is a popular notion that existing suppliers of electrical energy supply light and not power, this idea having arisen probably from the fact that most of the companies are called electric lighting companies, and also from the fact that few undertakings have catered successfully for power when their business was small;

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moreover, since higher prices are obtainable for light than for power, the first years of an undertaking are apt to be dependent upon supplying light rather than power. This idea has also been emphasised by the recent advent of companies calling themselves exclusively "power companies," that aim at supplying electric energy exclusively which may nevertheless be used subsequently for light or power purposes as desired by the consumers availing themselves of the supply.

A little inquiry, however, shows that existing suppliers of electrical energy in London are doing a large amount of business in supplying electric power as distinct from light, though in making any such investigation it must not be forgotten that many parts of London are of such a character that very little power will ever be required in those parts unless the use of electrical energy for heating and cooking becomes general. In fact, a great deal of the London area is of a purely residential character, where a lighting load is all that can be expected at the present time.

Another idea seems to be that the power available is comparatively small. Nevertheless, the fact remains that in the area of the London County Council the plant available at generating stations amounts to about 300,000 H.P., and this amount is being continually increased. It is true, of course, that this power is divided up into a large number of stations; but, even so, most of them are of such considerable size that the economies which might be effected by having larger but fewer stations would not amount to a very great deal. The idea, however, which is most fixed in the popular mind is that the power required in the London area is enormous, and that the cost of power at present obtainable is very high. No doubt a large amount of power is used in London, but it does not follow that people would readily change to electric driving, however favourable the terms might be. The reason for this is partly that people have to be educated to the idea of using something different from what they have used all their lives, and partly because the cost of power is, as a rule, not the most important cost in manufacturing. In some cases the cost of power is, of course, very important, as, in electrolytic manufactures and in the refining of copper, where cost of power is large in proportion to cost of labour. Generally speaking, however, the cost of labour and establishment charges form a large proportion of the whole, and, therefore, the manufacturer is loth to throw out his existing steam plant or gas plant (which stands at a certain value in his books, and for which he would probably get very little) and to substitute electric driving in its stead. It is, therefore, found very difficult to induce manufacturers to change from their existing methods, although when they do so they express complete satisfaction at the result.

With regard to the cost of electrical energy, this is dependent to a large extent upon capital cost of the plant put down. In the case of companies this cost was very high at first, because they had to undertake all the pioneer work and to erect generating stations when the cost of plant was high, and when only small units, which necessarily cost more per horse-power, were obtainable. At the present time, however, both companies and local authorities are putting down units of such a size that the cost per horse-power installed is very low, and the companies are feeling less and less the effect of their initial high capital expenditure. The result is that the cost at which electrical energy is now supplied for power purposes has fallen very much during the last few years, and stands at as low a figure in many districts as that at which the London County Council propose to supply in their scheme which is now before Parliament once again. In some cases the figures are even more favourable than those of the London County Council. This being so, it will readily be realised that nothing can be gained by putting down huge generating stations to supply this supposed demand, and thereby expending enormous sums of money which would not be reproductive for a long time to come. The only effect of such a procedure would be to increase rather than diminish the cost of electricity supply, though it might be that the increased cost would be felt only indirectly, deficits being made good in another way. What is much more important than such a scheme is that existing suppliers should, as far as possible, be coupled together, so that one supplier can, if necessary, supply another. By so doing a large amount of spare plant would be rendered superfluous, and economy might result, not only in capital cost, but also in running cost. Three is at present a scheme of this kind before Parliament in connection with the supply companies, and if the local authorities would also join in, a considerable advance would be made.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Electrician" Wireman's, Linesman's and Mains Superintendent's Pocket Book. Edited by F. C. RAPHAEL. New edition. (London: "The Electrician" Printing & Publishing Co.) 5s. net.

This pocket book is conveniently small, and indeed pocketable, though large in the volume of information it contains. No other publication covers the same ground, and to the various classes to whom its title is addressed it should prove most useful.

It betrays no ambition to be a text book, and gives in most cases just the amount of explanation required to make the large number of valuable facts it contains intelligible.

The contents are divided under seven headings:—

(A) House wiring, (B) Underground lines, (C) Overhead lines, (D) Electric tramways, (E) Electricity in mines, (F) Electric bell and interior telephone wiring, (G) Miscellaneous.

Section A is remarkably complete, and the diagrams of connections for the various types of alternating-current motors are very clear, as are also the pages devoted to meters and their connections.

If a list of central stations is not out of place in a pocket book, it would, we think, add to its value if the price per unit were added to the rest of the detailed information given.

We would call the author's attention to the fact that the system of wiring intermediate switches shown on p. 30 has been, to an important degree, superseded by the introduction of the tumbler form of intermediate switch, such as Lundberg makes.

The lower table of the first page of section B is not of much use without the column which is obviously missing; otherwise this section is very satisfactory. The only suggestion one could make for improvement would be to ask for a little more information on the subject of arc lighting. Space might be found for this by eliminating the description of the "Bare Strip" system of underground conductors, which, though it exists in a few places, is not likely to be used much more in its present form in the near future. The information given under the head of "Cable Testing" and "Fault Localisation" is very complete, as would be expected from the author, who is an authority on this subject. The sections on overhead

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lines and tramways are both adequate, but that on "Mines" might be expanded with advantage, as it now consists merely of the Home Office special rules.

Section F, dealing with bell and telephone wiring, is not full, but as the book is not primarily intended to deal with the ordinary wiring contractor's work it is sufficient.

A few of those inevitable nuisances—printers' errors—have crept in—*e.g.* :—

On p. 32 line 9, p. 35 line 5, and p. 44 line 3 "above" refers to a diagram "under"; on p. 198 line 4 should read "Table X., p. 16"; on p. 224 a block is reversed; and on p. 253 reference to "Fig. 135" is an error.

We will conclude our criticisms by suggesting that it would be useful if the author added an explanation of the difference between 2,500 megohm grade cables and cables having an insulation resistance of 2,500 megohms per mile, as we find this is a point very frequently misunderstood by all sorts of people who should know, owing to the advantage derived from this confusion by all sorts of other persons who do know. We would also suggest that secondary batteries might, with advantage, be afforded another page or two.

Although there may be a few passages in this book which are reminiscent of our familiar friend the trade catalogue, a little revision would quite clear the book of this imputation, from which it is really singularly free.

In conclusion, we feel that it is due to the author to point out that our criticisms are not intended in any way to modify the opinion stated at the beginning of this review—namely, that the book is the best of its kind we have seen, and that every wireman, linesman and mains superintendent would be well advised to add it to his pocket collection.

MERVYN O'GORMAN.

Trattato di Telefonia. By I. BRUNELLI ed E. LONGO. (Rome G. Scotti.) 16 lire.

This is a volume of 584 pages quarto, handsomely printed in good type and on good paper. It contains a description of modern systems of telephony, with an historical account of their development. There are chapters on apparatus, on line installation, on cables, the equipment and service of large stations, and on urban and interurban communications. There are numerous articles on such special subjects as tariffs, wireless telephony, Poulsen's telegraphone, and a long appendix giving some particulars of the telephone service in the different countries of the world.

The work is by no means exhaustive, and no attempt is made to give complete details of any subject for which we have examined it. But the ground is fairly covered. The style is easy and scholarly, and the subject is treated in an interesting way. It seems to us to be very well done, and might be valuable for reference when precise and exact detail is not what is required. It would be a useful addition to the library of any electrical engineer to whom Italian is not an obstacle.

"FLEXIBLES," WITH NOTES ON THE TESTING OF RUBBER.

We conclude this week the discussion on Prof. Schwartz's Paper on "Flexibles," read on April 18th before the Institution of Electrical Engineers, and of which we have given an abstract in our three preceding issues.

Mr. A. WHALLEY said there was a very great need for a reliable test for rubber. At present the method of testing was of a complicated character, and could only be carried out by men with long experience in dealing with rubber. The author recommended the use of cotton next to the conductors, but in his opinion it was not advisable, as the cotton threads pierced the rubber and caused low insulation. The author expressed a preference for pure rubber for high temperatures, but it should not be forgotten that even at a temperature below 150°F. pure rubber became tacky.

Mr. H. HUMAN said it was gratifying to know that the flexibles in use were not so weak as they had imagined them sometimes to be. The Paper explained also something which had hitherto been inexplainable—the comparative absence of fires due to the use of flexibles in shop windows. He, personally, had no idea that the ordinary flexible in use would be shown to be capable of withstanding 6,000 volts. As to the bending tests, comprising as many as 30,000 double journeys up and down, in ordinary use this would mean a life of something like 170 years. Rubber and all insulating material depreciated with age, and this age depreciation was more important than the damage done by bending. It was thought that running the flexible over a little wheel as in a counterweight fitting would lead to fracture, but Prof. Schwartz had shown that this was not the case. With lamps giving out considerable heat, pure rubber flexible was doubtless the best thing, but in some cases he should prefer vulcanised to pure rubber. He did not know of anything which would admit of so many adulterations as would rubber. Many of these adulterations were justified, and led to increased strength, but many of them were not justified, and until they could formulate some standard for rubber they were absolutely in the hands of the cable makers.

Mr. E. C. WANSBROUGH said the advantages of pure rubber had been made much of that evening. The author had given them some account of the extraordinary things which went to make up the ordinary rubber cable. He hoped that the new wiring rules would show a strong preference for pure rubber, as if they did so it would probably improve matters in that direction.

Mr. MERVYN O'GORMAN said that in his opinion vulcanised flexible was bad and a material to be avoided in all cases. Practical experience over some years had led him to that opinion after having begun as an enthusiast in favour of vulcanised cable. Prof. Schwartz's experiments practically led to the same conclusion. Vulcanised rubber was almost always under-vulcanised owing to the dread of having too much sulphur. A satisfactory test for flexibles was badly wanted. All that would appear to be known at present was that flexible could be obtained that would stand 2,000, 6,000, 8,000 or even 9,000 volts, but this did not prove enough. With regard to the new flexible which had been associated with his name, he was naturally enthusiastic over it, but the credit for its production was undoubtedly due to the British Insulated & Helsby Cables Co. It was a very remarkable material. He had tried it very severely during about 18 months under conditions which no other flexible had stood. Concerning a stretching test, he considered it was the best way of testing a cable and he doubted whether a material which would be no good at all after, say, three months' use, as remarked by one speaker, would stand such a test. It was important to have a stretching test both from the point of view of the buyer and the consulting engineer, unless absolute reliance was placed upon the name of the maker, which would shut out firms who were building up businesses but who were none the worse for that. It should be in the interest of the large manufacturers to prove that the material they turned out was better than the shoddy materials produced by other firms.

Mr. LOUIS T. HEALY, in a written communication, said he agreed with the author's opinion that the flexible was the weakest part of an installation. He had found it to be the cause of a large number of electrical fires, and it could undoubtedly become a source of personal danger through the falling of heavy counterweights and clusters owing to the severance of the conductors. The whole subject was a very important one, and up to the present time had been much neglected. With regard to the effects of bending, a case had recently come under his notice where some 50 counterweight fittings in an office building rapidly began to fail after about two years' use, the breakage occurring in every instance close to a pulley wheel. The flexibles were of the thin vulcanised class, and upon examination he found the rubber to be in good condition, but the conductors in the parts of the cord which had been most frequently passing over the pulleys were in very bad condition, the strands being not only brittle, but in some cases broken up into short pieces. Most of the failures appeared to have started by an arcing between these broken strands and not by a short-circuit. He had never found anything suitable for counterweights except pure rubber-insulated flexibles of the best possible quality. The greatest amount of trouble due to bending at lampholders was, in his opinion, caused through the use of switch lampholders. He did not agree with the author's opinion that pure rubber insulated flexibles were best suited for high temperatures. He had recently examined some workshop flexible, which had been subjected to a temperature of 98°F. for about 12 months in a linoleum factory, and found that the rubber had entirely disappeared, the cotton being quite dry.

Mr. C. BEAVER, in a written communication, said that, excellent as the Paper generally was, and ingenious as some of the deductions were, it would be apparent to those intimately connected with the manufacture of flexibles, insulating rubber, &c., that there was a certain lack of intimate knowledge of manufacturing conditions and details which slightly detracted from the value of some of the conclusions arrived at. With regard, for instance, to the matter of the conductivity of small stranded conductors, the S.W.G. diameters of 36s and 38s wires were compared with the diameters of tinned wires (presumably measured), and the difference was assumed to represent the thickness of the tin coating. That this assumption was erroneous would be apparent to anyone who was accustomed to make, test and use tinned copper wires, and could easily have been checked by analytical estimation of the tin, or similar methods. A simple calculation would then show the actual thickness of tin to be unmeasurable. Later on the author used the above erroneous assumption to account for certain differences between measured resistance of stranded conductors and equivalent resistance of solid wires. The discrepancies in both instances were probably simply due to variations in the gauge of the wires, which were recognised as inevitable and duly allowed for in the standard tables. With reference to the remarks on "Insulation of Flexibles," he would like to correct the impression given by the author that "cut" strip rubber was the most expensive and generally used for high-class cable work. It was neither the one nor the other. With regard to the author's remarks as to pure rubber insulation withstanding immersion in water, this was largely a matter of the time elapsing between manufacture and the experiment. The pure rubber became firmer and more homogeneous in course of time and the

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overlaps became closely sealed up by the natural adhesive properties of the rubber applied under tension. In several statements on the subject of vulcanised rubber the author was also at variance with facts. The author's notes on "Oxidation of Rubber" reminded one that, conversely, the rate of oxidation under certain accelerated and controlled conditions might be advantageously used as a guide to the comparative durability of rubbers, &c. As regarded the coefficient of vulcanisation and the deductions which might be drawn from it, the author had apparently overlooked the fact that vulcanised rubbers used for insulating purposes might contain mineral substances, such as litharge or magnesia, which had a considerable effect on the coefficient of vulcanisation. The use of such substances was quite legitimate, and, although they tended to give a high coefficient, it was certain that the durability of the rubber was not impaired but improved by them if used in correct and limited proportions. The standard hysteresis loop suggested by the author was in principle more scientific and thorough as a test than the elongation test, which was sometimes specified; but he could not agree that good behaviour under this test, even when the sample showed a reasonably good insulation test, indicated durability. It was possible to insulate flexibles with rubbers which would comply fully with stretching and other mechanical tests, and give a fair insulation resistance, but would be the reverse of durable. Cable makers in this country would take exception to the statement that the pressure test usually specified for flexibles was very rarely carried out in practice, and the author would be pleased to know with reference to his opinion that C.M.A. vulcanised flexibles should have the high voltage test applied after immersion in water, that this was standard practice and had been so ever since such flexibles were first made. The "longitudinal method," as it was called, of applying the vulcanised rubber to small sizes of wire was very efficient. In large sizes it was admittedly less efficient, and lapping methods were generally used in this country for medium and large sizes of cable. In conclusion he would add that makers of good flexibles, &c., in this country would be only too delighted if the author's future work produced some simple series of tests by which easy comparisons could be made by buyers. At present the good makers suffered from the lack of a simple means of demonstration of the superiority of their goods.

Mr. J. CONNOLLY, in a written communication, said that he would give the first place in importance to the hysteresis curves. Tests, similar to those on which those results were based, had been used on a rough scale by manufacturers of vulcanised elastic thread, who placed great confidence in estimating the insulation of the thread by observing its tractile strength against varying loads. He thought that similar experiments on the insulation of larger size wires and cables were desirable. Second in importance he would place the results shown by the heating tests, which he thought proved beyond doubt that by subjecting samples to a heat of between 70°C. and 100°C. or any convenient heat below the melting point of sulphur for several days and examining the fall in their elasticity and strength it would be possible to foretell their comparative durability, and to place them in the exact order of their merit. The so-called Admiralty heating tests were quite misleading and ought to be abolished. It was a physical impossibility for the ideal cable covering, having a layer of vulcanised pure indiarubber without any trace of sulphur next to the wire to stand this test, as the rubber became permanently soft at a much lower heat, while if the pure indiarubber was vulcanised, which was not really as good, it might pass the test. As to chemical tests, he did not place any reliance on the author's recommendations. The only simple and reliable test that the average person could carry out was the ignition test, which determined the approximate amount of mineral matter in the compound. He thought they should dispense altogether with insulation tests for conductors insulated with lappings of pure indiarubber, and to rely upon other observations in determining their quality. Tested dry the results were quite unreliable and immersion in water not only lowered but permanently destroyed the insulation on account of the creeping of water between the layers, which moisture could not subsequently be removed. There was very little unvulcanised pure indiarubber used nowadays in covering wires, probably none at all for flexibles, as the rubber was always more or less toughened or surface vulcanised by the cold cure process, and it was for the manufacturer to determine the best thing to use in that respect. He did not think the author's hysterises loops would be of any use in that direction. The best thing the user could do was to see that a substantial thickness had been used and at least two layers put on with a moderate tension, and that the layers were fairly adhesive to one another and did not unwrap or fly back when the outer coverings were removed. With regard to tying knots in flexibles inside ceiling roses and elsewhere, he thought this a great mistake and should not be allowed. It was putting an unnatural and permanent strain on the covering, and other means ought to be found to support the flexible and keep the strain off the terminals. With that object in view his firm had devised a nipple of soft indiarubber that would answer the purpose and at the same time effectually seal the entrance to the ceiling rose.

Mr. F. LAMB, in a written communication, said that whilst much time and care had been devoted to standardising the quality of wires and cables, flexibles had been left pretty much to take care of themselves, with the result that what was at present being very largely used was a foreign-made vulcanised flexible, the word "rubber" being dropped, for very little of that material entered into its composition, the mysterious compound being squirted on to the wire through a die, and whilst plastic and flexible when new, soon became hard and brittle, breaking up and becoming of very little use as an insulator. These remarks, of course, only applied to the "cheap and nasty" foreign-made flexible so commonly used, and which none of the British manufacturers would make. He was distinctly of the same opinion as the author and Mr. Sparks, who spoke on behalf of the Wiring Rules Committee, that pure rubber insulation was decidedly better than vulcanised rubber, but hitherto the difficulty had been to point to any standard specification which would ensure a reliable pure rubber flexible. This deficiency, however, had now been removed, so that the following statements in the Paper were incorrect: "The vulcanised rubber C.M.A. flexible which is the only standard material on the market," and farther on, "As things stand at present the Cable Makers' Association only make C.M.A. flexibles in vulcanised rubber." The Wiring Rules committee of the I.E.E. had given a specification for pure rubber flexible and this had been embodied in a specification which had been adopted by the C.M.A. as follows:—

Association Pure Rubber Flexibles.—Conductors: The conductors to be of annealed high-conductivity untinned copper to the standards of Engineering Standards committee and of the same sizes as the vulcanised C.M.A. flexible—viz. 23/36s equal to No. 20, 40/36s equal to No. 18, 70/36s equal to No. 16, 90/36s equal to No. 15, 110/36s equal to No. 14.

The conductor to be covered with one lapping of cotton of 4 mils radial thickness, then two lappings of pure Para rubber laid on in opposite directions, the total minimum radial thickness of rubber being 20 mils; then two lappings of cotton laid on in opposite directions, each lapping to have a radial thickness of 6 mils, giving a total radial thickness of cotton lapping over the rubber of 12 mils, then braided silk or glace cotton.

Weight of rubber in grains per yard of single conductor:—

L.S.G.	Grains.	L.S.G.	Grains.
23/36	35	90/36	60
40/36	40	110/36	70
70/36	50		

This was placed upon the market last month.

CORRESPONDENCE.

JOINTING LEAD-COVERED CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was much interested in reading Mr. Welbourne's letter on the above subject in your issue of April 26th.

As I understand, he advocates the hand-made soldered joint protected by a lead sleeve wiped on to the cable sheath for all-round reliability; paying for that work good wages to a capable jointer. On the other hand, he objects to the compound gland joint box, which, he says, demands the services of a very careful and conscientious workman, and he calls this method a "penny wise and pound foolish" one.

As to lead jointing, strong objection must be taken. Firstly, on the grounds of cost and increased wages; secondly, the cost of extra time and money, owing to the capable man taking longer for the work; and thirdly, great difficulty in obtaining capable jointers as and when required. On the other hand, there are compounds and compounds; but the proper sort should only require the services of an average intelligent workman, as all the specialist work should be done in the laboratory.

The defects now attributed to most compounds have been the danger of a volatilisation of the liquid products and the usual deterioration and cracking under extremes of temperature; this danger is slow, but very sure, and then comes in the accumulation of moisture. Moisture spells expense in time, labour, loss of current, and what is more serious, useless deterioration of the machinery in producing waste energy.

There is a new product in the market which, in my opinion, has obviated all these dangers, for evidently the specialist has produced an exceedingly ductile material of considerably more agglutinativeness than that of bitumen, whilst it is a perfect electric insulator of the first quality and non inflammable, and has the additional advantage of being considerably cheaper than most compounds.

One is too apt to find fault with workmen, when the scientist should prove the unreliability of the material; for insulation, to be perfect, must be absolutely non-conducting and permanent and able to overcome changes of temperature.

I am not desirous of advertising the owners of this product here, but will be pleased to send their name to those who care to test their compounds.—Yours, &c., S. W. KELSEY.

44, Southampton Buildings, Chancery-lane, W.C., May 2.

ELECTRONS AND ELECTRIC DISCHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The editorial note at the foot of my letter in your issue of the 26th inst. tempts me to ask you to give a little further space in your journal.

I do not for a moment wish to say that you are wrong in holding that because ions are formed in gases by collision the

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electrons are caused to free themselves from the cathode by the same means. My point is that authorities differ on the subject. Sir Oliver Lodge, in his book on "Electrons," p. 38, says: "These positive ions then pass along *comparatively slowly* towards the cathode, creep towards it as best they can in face of the bombardment: and then, at the last, experiencing the violent gradient of potential in its immediate neighbourhood, rush up against it and by their *shock* produce a fresh supply of electrons."

On the other hand, Fournier d'Albe, in his excellent work "The Electron Theory," p. 76, states: "When, however, the air is ionised—*i.e.*, filled with particles each linked with an electron or positive atom—these ions beat against the terminal opposed to them in sign and shake or *pull* the opposite charge out of the metal." The italics in both cases are mine.

We will as an instance in point assume that in a particular vacuum tube the cathode is not sufficiently charged with electrons to enable them to escape by their own mutual repulsion or motion. The molecules of the gas do not tend to *pull* the electrons out, but when there are positive ions in the gas these move towards the cathode and may be regarded as being fairly evenly spread over the surface immediately in the neighbourhood of the cathode, and to be approaching it at low speeds compared with the velocity of light. Being brought under the influence of these positive ions the electrons in the solid free themselves, and as the resultant of the pulls of the positive ions is on the whole normal to the surface the electrons are projected in a direction normal to the surface. If they were knocked off we should have to rely upon the repulsion of electron for electron for giving them direction. In the case of the disruption of a radium atom the particles fly off in all directions.—Yours, &c., R. M. DEELEY.

Derby, April 30.

VECTORS AND WATTFUL CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We are much pleased to see in your issue of May 3rd a letter from Mr. Turnbull, in which he suggests the expression "wattful component" as a substitute for "power component." Curiously enough, we had embodied this very term "wattful" in a pamphlet which is now going through the press. We felt at first some diffidence about bringing it forward, but now that it has the support of Mr. Turnbull in your columns we shall feel that we can safely do so, and it certainly seems to us to be a term that is badly wanted.

In this connection there is another expression that we have been doing our best for some time to get rid of, and that is "idle current ammeter." The instrument in question is certainly not an ammeter, and does not measure the idle current. The term "wattless wattmeter" would probably be more correct, but has a rather uncouth sound, so that we have, up to the present, described these instruments as "idle current wattmeters." Perhaps someone can suggest a better name.

It may, perhaps, be objected that these questions of nomenclature should be left to theorists to decide, but we feel strongly that manufacturers by using a particular term in their trade literature, exercise, whether for better or for worse, a very considerable influence. For example, we have been much gratified at the success of our efforts to secure the adoption of the term "moving-iron" which we have for some time employed as a substitute for "gravity control," "electro-magnetic," "solenoid type," and so forth.

Although the writer suggested this with Mr. Punga in an Institution Paper some three years ago, he would probably have been unable to secure its adoption without the co-operation of his firm. The term has now become practically universal.

There are several other monstrosities which we should like to discuss (such as "recording wattmeter" for "watt-hour meter"), but we will not trespass further on your space.—Yours, &c., EVERETT, EDGCUMBE & Co. (Ltd.)

Kenelm Edgcumbe, Director,

87, Victoria-street, Westminster, S.W., May 7.

DEPRECIATION OF COMPANIES' ASSETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The discussion upon the depreciation question and the very important point raised by Mr. A. A. Campbell Swinton as to the difference between depreciation for companies and local authorities are evidently some of the most important questions electric lighting companies have now to consider. Town councils and others have power to purchase undertakings at the end of the period on the basis of "the then value of the plant, machinery and apparatus as a going concern"—*i.e.*, in a somewhat similar manner to tramways purchased by local authorities—but the valuer will find great difficulty in arriving at the correct value of a number of underground mains and other plant compared with tramways upon which the valuer invariably deducts the depreciation item from the value shown in the companies' books.

Take the case of an electrical company, with a capital of £100,000, who have written off for depreciation £40,000 at the end of 21 years, when the property has to be sold "at its then value." The company have distinctly proved that, although they have spent £100,000 capital, and may have well maintained the property during the 21 years, yet, notwithstanding, it has depreciated in value to the extent of £40,000, and it is difficult to see how any valuer or arbitrator can value the property at more than £60,000 in the face of these figures.

The valuer will very naturally say, You admit your property has depreciated to this extent, how can I value it at more? You yourselves prove its present value at this sum, and your official staff ought to know how the plant deteriorates better than anyone else.

It certainly appears advisable to carry out Mr. Swinton's suggestion, and, with the exception of a small renewals fund, put all moneys unexpended in dividends outside the company into other investments.

As the point is rather more a legal than an engineering one, all companies should take immediate steps to have the question settled by eminent counsel.—Yours, &c.,

London, May 6. A CONSTANT READER.

BERMONDSEY ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Corporation of the Borough of Bermondsey applied to the Board of Trade last December for a provisional order under the Electric Lighting Acts in respect of the portion of the borough heretofore known as the St. Olave district. The Board of Trade having recently refused the application, a committee of the Corporation has issued a report regretting the result, "because the Council had lost a profitable portion of the borough, and because the inhabitants of that portion will not be able to get a cheap supply of electric energy."

As this report has been published, it is important that the true facts should be made known.

My company and the London Electric Supply Corpn. are supplying energy in the St. Olave district, and the decision as to the grant of the order depended upon the answer to the question whether the Corporation or the companies could give the cheaper supply, and the refusal of the order asked for by the Corporation was based upon the evidence given that we could and were, in fact, giving a cheaper supply in the St. Olave district than was given by the Corporation in the adjoining district, or proposed to be given by them in the St. Olave district.—Yours, &c., H. B. RENWICK, Secretary,

London, May 7. County of London Electric Supply Co.

TESTING JOINTS IN SUBMARINE CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When making final joints in gutta-percha core out at sea, a skilled jointer is generally considered sufficient guarantee; cases may, however, arise where it would be desirable to check the jointer—for instance, in gutta-percha core where air bubbles have appeared before, or in indiarubber core. For such occasions the following method is very suitable:—

A metal trough filled with water is suspended by a piece of gutta-percha core, and a lead to the testing room is clamped on

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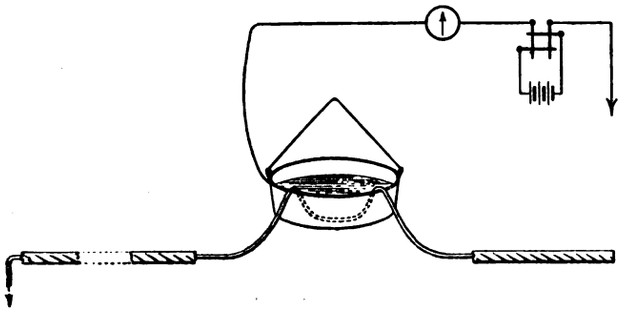
to the metal trough. A battery giving a high pressure is connected to this lead through a sensitive galvanometer, and one pole of the battery is connected to earth as well as one end of the cable. Any steady deflection due to leakage to be noted.

When the joint is ready for cooling, and a foot or so of the gutta-percha core on both sides has been bared, carefully cleaned with spirits of wine and dried by the flame of a spirit lamp, the joint is immersed. If this produces an additional deflection on



the galvanometer the joint should be rejected. The test incurs no delay in splicing through, as the joint must anyhow be immersed for cooling. Another noteworthy feature is that a fault or low insulation place in the cable does not render this test impossible or insensitive.—Yours, &c.,

C.S. "Store Nordiske." M. JOHANSEN.

THE ELECTROLYTIC LIGHTNING ARRESTER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. John F. Kelly writes in your current issue pointing out that the electrolytic lightning arrester is a very old idea. I do not think, however, that Mr. Kelly has correctly understood of what the electrolytic lightning arrester, properly so called, really consists. Mr. Kelly says that about the year 1893 he designed an arrester consisting of a series of iron plates in alkaline liquid. I do not think, however, that this is an electrolytic lightning arrester at all; it is simply an ordinary liquid resistance. Liquid resistances as lightning protective apparatus have been in use now for a number of years. When they are effective they suffer under the great disadvantage of wasting a large amount of energy. The electrolytic lightning arrester to which I referred in the letter which I

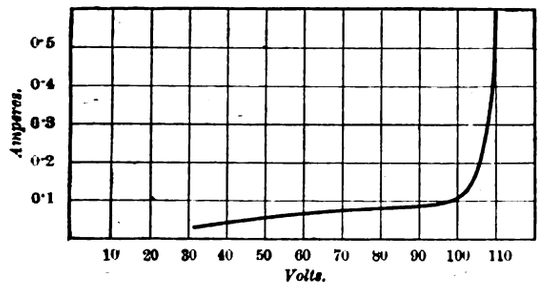


FIG. 1.

Nearly saturated solution of $K_2Cr_2O_7$ and sodium phosphate. Two aluminium electrodes, dipping into solution about 2 in.

wrote in your issue of March 15th depends for its action on the peculiar action of aluminium, and certain other metals, when used as anodes in certain solutions.

This property can be best illustrated by a curve (Fig. 1). It will be seen that up to about 100 volts the aluminium anode interposes a very large resistance to the passage of the current. Immediately above this voltage, however, the resistance breaks down and a very large current passes. The aluminium anode acts, in fact, as a kind of valve, which remains closed for any current which comes along at a voltage below a certain value. This value is about 100 volts for bichromate solutions. For sodium phosphate solutions it is higher. With a number of such aluminium cells in series, the seat of the resistance is the microscopically thin layers of aluminium hydroxide which form on the surface of the anodes. The volt drop across the electrolyte is very small in comparison.

With ordinary liquid resistances, however, such as are formed by iron plates dipping into an alkaline solution, the seat of the resistance is the electrolyte itself, and there is no appreciable drop of volts at the surface of the electrodes.

It is true that a somewhat similar curve to Fig. 1 can be obtained with any solution and with any electrodes. This is illustrated in Fig. 2, which is taken from a research carried out by Dr. Glaser at the Physical Chemical Laboratory of the University of Göttingen in 1897. The solution in this case was one of caustic potash. It will be seen there is a kink in the curve somewhat similar to the case of the aluminium curve. This is, however, due to a totally different cause—viz., the electrolytic decomposition of the electrolyte. It takes place at a voltage of between 1 and 2 volts, and for this reason it is totally impossible to utilise the effect for the construction of a lightning arrester. For example, an arrester depending upon this principle would require to have 7,000 or 8,000 elements for a 10,000 volt line. Ordinary liquid resistances work at a volt drop between the electrodes much higher than 1 or 2 volts, and, therefore, the effect illustrated in Fig. 2 is never observed.

I think, therefore, that the first electrolytic lightning arrester was the one which I constructed, and which was covered by Mr. Ferranti's patent in 1901,

It might be as well to add that another point about the electrolytic lightning arrester proper is that it acts as an electric condenser of very high capacity, and as such is capable of passing to earth an electric disturbance of high frequency at a voltage below the breakdown value. I do not think, however, that in the practical application to lightning arrester work this plays so important a part as the breaking down of the film;

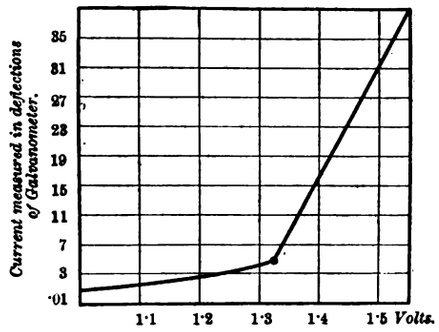


FIG. 2.

still it is a valuable property of the arrangement, owing to the high-frequency disturbances which are, as is well known, set up occasionally in transmission lines.

I would also like to call attention to Mr. Ferranti's earlier patent, No. 3,113 A of 1892. In this patent the use of non-inductive liquid resistances as mentioned by Mr. Kelly is very fully described. Claims 18 and 19 of this patent read as follows:—

"18. The combination substantially as described with high-tension dynamo circuits of non-inductive resistances in such manner as to admit of the escape of current when shocks of excessive pressure from any cause occur.

"19. The combination substantially as described with high-tension or dynamo circuits of non-inductive resistances in combination with air-gaps in such manner as to admit of the escape of current when shocks of excessive pressure from any cause occur."

On p. 7 of this patent the following words occur:—

". . . as is represented in Fig. 36, the non-inductive resistance may be made of a number of cells of water in series with electrodes dipping into each cell. Or, as in Fig. 37, they may consist of long tubes filled with water and being of sufficient section to conduct any desired amount of current. The object to be sought after being that they should have as little self-induction as possible. Moreover, the liquid resistances are desirable from the point of view that a momentary rush of current can take place through them more easily. Their resistance only coming up after current has flowed for some little time. . . . discharges may also be used as lightning arresters for continuously conducting away and transmitting to earth

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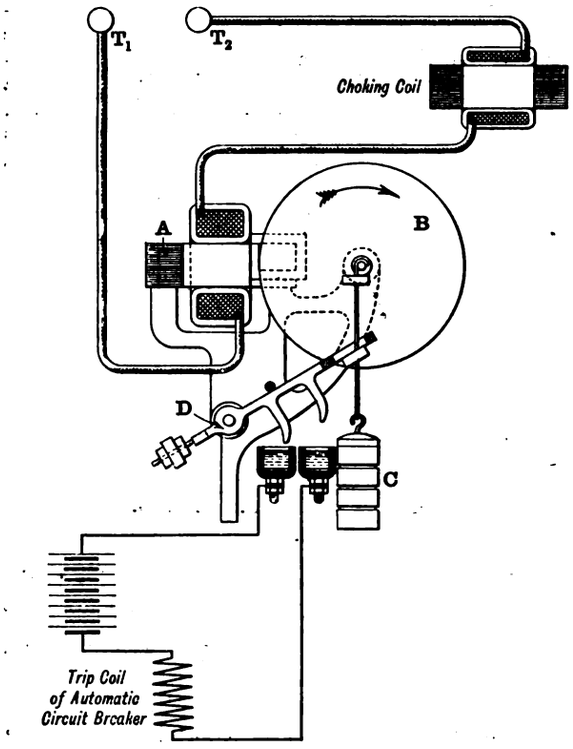
any electrical charge, rather than letting it accumulate until it has reached a sufficient E.M.F. to break down the insulation of the system."

I have only given a few extracts from this 1892 patent, which is a rather long one, and fully describes the use of various combinations of non-inductive resistances for the purpose described. It will be seen that, even at this early date, the idea of having an arrangement which would act as an electric valve building up resistance to prevent the continuous passage of large currents to earth was conceived. With the application of the aluminium cell in 1901, however, a vast improvement was made.—Yours, &c.,

Hollinwood, Lancs., May 3. CHARLES C. GARRARD.

ALTERNATING-CURRENT NO-VOLTAGE CIRCUIT-BREAKING APPARATUS.

It is often desirable to have an apparatus suitable for automatically opening an alternating-current circuit on the failure, or excessive lowering, of the voltage of supply. Such apparatus has usually consisted in the past of an electro-magnet excited by a shunt coil fed by the supply. When the voltage falls, or fails entirely, the



armature of the magnet falls away and opens the circuit breaker. The great disadvantage of this form of apparatus is that, on a sudden and momentary failure of the supplied voltage, the cut-out operates. This is a great disadvantage, as the following example will show:—

Suppose a number of motors are fed from a network which is fed by a feeder having considerable length. Each motor is protected by a no-voltage release. If now a short-circuit occurs on the network, causing the fuse to blow on the same, or one of the motors is started up too quickly, a very large rush of current occurs which, owing to the resistance of the main, causes a momentary drop of voltage in the network. Should the motors be equipped with the usual form of no-voltage release, which operates instantaneously, all of them would be cut out of circuit.

A new form of no-voltage release, designed by Dr. C. C. Garrard, has been put on the market recently by Messrs. Ferranti, Limited, which is illustrated above. In this no-voltage release the disadvantage enumerated above of the usual form is obviated by combining with the no-voltage release mechanism a time element.

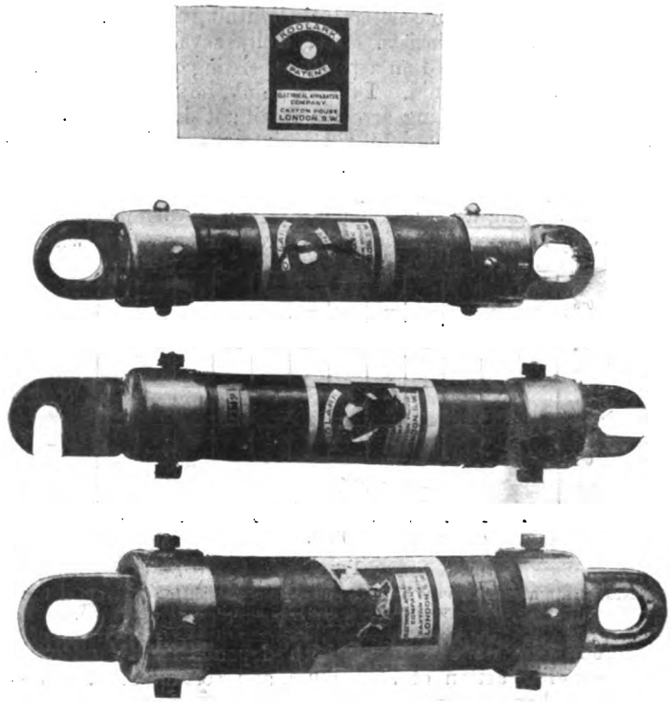
Referring to Fig. 1, the release consists of a shaded pole electromagnet "A." This shaded pole electro-magnet is energised by a shunt current connected across the mains, or to the secondary of a potential transformer connected across the mains.

Between the poles of the shaded pole electromagnet a metal disc, B, is pivoted. It is so arranged that when the coil on the electromagnet is energised by the supply voltage the disc rotates and winds up a suspended weight, C. The string to which the suspended weight is attached has two stops fastened to it, one above and one below a slot in a pivoted lever, D, which lever carries contacts which, when the weight is in its bottom position, come against two fixed contacts and complete an electric circuit between them. The completion of this circuit causes current to flow round a trip coil, which is adapted to cause the controlled circuit-breaker to open circuit. When the voltage of supply is at its full value, or above a certain minimum, the rotateable disc will keep the suspended weight at its top position, and thus contact is not made between the two fixed contacts. When the supply voltage, however, falls below a certain minimum, the suspended weight is too large to be held up by the reduced voltage; thus, it begins to fall, and when it reaches the bottom of its travel, contact is made between the two fixed contacts and the switch is open-circuited. It will be seen that when the weight is wound right up, the bottom projection on the supporting string engages on the bottom side of the pivoted lever. When the weight is in the bottom position, the other projection on the string engages on the upper side of the pivoted lever. The time taken by the weight to fall gives the time element, as contact is not made between the fixed contacts until the weight has fallen to, or nearly to, its bottom position.

The current required to operate the trip coil is preferably taken from some other source, which remains unaffected when the supply voltage falls. In some cases, however, the current for working the trip coil could be taken from a current transformer included in the same circuit as the controlled apparatus. In this case, the trip coil would be normally short circuited by the pivoted lever; and this short circuit would be removed when the time element had elapsed after the supplied voltage had fallen below the fixed minimum.

SHORT-CIRCUIT TESTS OF ENCLOSED FUSES.

The true value of an enclosed fuse can probably be only ascertained under short-circuit conditions. Normally the circuit will be opened



"KOOLARK" ENCLOSED FUSES AFTER SHORT-CIRCUIT TEST ON 500 KW. D.C. GENERATOR.

by the fuse without noise or, in fact, any indication that trouble has arisen. The same fuse might burst with a loud report on a "short" backed by plenty of power. In this connection some interesting fuse tests took place at the Deptford station of the London Electric Supply Corpn. on Friday last, when a series of short circuits was made across a 500 kw. 550 volt set with various sizes of special "Koolark" fuses made by the Electrical Apparatus Co., of Caxton House, Westminster. A description of these fuses appeared in "The Electrician" INDUSTRIAL SUPPLEMENT for March.

Each fuse was in turn connected to the 'bus bars by short cables, and the only other apparatus in circuit was a switch and a circuit breaker set at 3,500 amperes. Each fuse was in turn switched

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across the generator terminals, so that they were tested under exceedingly severe conditions. In every case we understand that the fuse acted instantaneously without explosion or appreciable noise, and until the generator attendant was notified, he was unaware that the tests were taking place. These results are attributed to the "Koolark" feature of the fuse by which a cooling fluid is set free on short circuit. The London Electric Supply Corporation has, so we are informed, at various times tried every other fuse on the market, but hitherto no fuses have been able to stand the severe conditions without exploding. The adjoining illustration shows several fuses after the test, and the table below gives details of the tests:—

Rating of Fuse.		Effect of Short Circuit on Fuse.		Remarks.
Volts.	Amps.	Flash.	Report.	
550	50	Slight	Slight noise	The circuit breaker was set at 3,500 amps., and in no case did it open.
550	75	None	None	
550	75	None	None	
550	100	Slight	Slight noise	
550	100	None	None	

There was no explosion effect or mechanical effect on the fuse in any of these tests. The tests were made in the presence of Messrs. Feetham & Ellis, of the London Electricity Supply Corpn., and Mr. Amberton, of the Electrical Apparatus Co.

"MORRIS & LISTER" KNIFE SWITCH.

These switches are of novel design and embody a number of interesting points. The blade is of cast aluminium, equal in conducting power with the ordinary copper blade. Without increase in weight, the increased section gives a stiff blade and ensures in every way a mechanically strong and rigid switch. The contact surfaces of the blade and the sides of its bearing are milled at one operation, so that the surfaces are perfectly true and parallel.

The quick break is effected by an auxiliary copper blade let into a slot on the inner surface of the aluminium blade. The auxiliary blade is pivoted to the main blade at its lower end, and makes contact in an extension of the upper copper stalk. The switch cannot therefore break circuit on the main contacts. The fact that the quick-break blade is hidden from sight, except when the switch is being operated, adds much to the neat appearance of the switch.

A novel feature of the design is the construction of the main contact clips. These consist of two U shaped pieces of hard copper strip, both ends of which are secured into the brass block in which the main copper stalk is screwed. The blade works between these copper clips, and, when it is pushed home, the clips do not curve outwards, but tend to move out parallel to the blade, thus ensuring contact over the whole of the contact surface of the blade. The construction of the clips also admits of a larger pressure than usual being exerted on the contact surface.

The makers claim a much better contact than is usually obtained and a correspondingly reduced heating and voltage drop, tests showing that the voltage drop is less than one-half that occurring with contact clips of the well-known "M" pattern. At the nominal capacity of the switch, the current densities in the current-carrying parts do not exceed 1,000 amperes per square inch in copper (even in the contact clips themselves where the current density is frequently high) or its equivalent in the aluminium blade. The contact density is not greater than 60 amperes per square inch at the contacts as they are at present rated.

The same type of clip is employed by the makers for a line of switch fuses of the tubular porcelain handle pull-out type.

PARLIAMENTARY INTELLIGENCE.

LONDON ELECTRICITY SUPPLY BILLS.

In the House of Commons last night (Thursday) the London County Council (Electric Supply) Bill, the Administrative County of London and District Electric Power Bill, and the London Electric Supply Bill came on for second reading.

The London County Council (Electric Supply) Bill was taken first, and Mr. COURTHOPE moved its rejection, contending that the powers of increasing the indebtedness of London were almost unlimited under the Bill, and that it was the height of folly to set up a sinking fund extending over 65 years, such a period being many times the life of electrical plant. With the advance of modern invention, existing plant would have to be replaced over and over again before the money was repaid. He also objected to the power to trade in electrical appliances, on the ground that it would be a dangerous interference with wholesome competition and private enterprise.

Sir SAMUEL SCOTT seconded the rejection.

Mr. MACKINNON WOOD, in supporting the second reading, denied that the proposals, if the intentions of the late Council were carried out, would have the effect of extinguishing private enterprise. As to increasing the indebtedness of London, they could raise no money by loan without coming to Parliament year by year. Marylebone and Woolwich were excluded because, instead of obtaining powers and setting up a municipal supply, they had committed the initial mistake of allowing to be set up companies which had afterwards to be bought out at enormous cost, and the County Council hesitated to encumber the projected municipal undertaking with the enormous premium which had had to be paid—£700,000 in the case of Marylebone alone.

Mr. W. F. D. SMITH (Strand) and Mr. BONAR LAW (Dulwich) both supported the Bill, and the PRESIDENT of the BOARD of TRADE (Mr. LLOYD-GEORGE) said he should vote for the second reading on the ground that the Bill represented the unanimous recommendations of the Parliamentary Committee of last Session.

The debate was proceeding when we went to press.

RADIO-TELEGRAPHIC CONVENTION.

(Continued from page 141 of the present issue.)

Sir William Preece was followed by Dr. J. A. Fleming, F.R.S., who submitted a lengthy statement, which we give nearly in extenso.

Dr. FLEMING: I have been closely and practically connected with the progress of electrical engineering during the past 30 years. I have made electric wave research a speciality. In 1899 I was invited by Mr. Marconi to act as scientific adviser to his company. I assisted him in designing apparatus for the first power station in the world for long-distance wireless telegraphy, and am intimately acquainted with his work, as well as that of other inventors on this matter. I may say, however, that my knowledge of the subject of wireless telegraphy is purely on its scientific and engineering side, and I have no connection with the business of commercial management of the Marconi or any other company. I have read the evidence laid before the Committee and also the report of the Conference held at Berlin. In reading the evidence laid before the Committee I am much impressed with the rather disjointed manner in which the scientific aspect of the subject has been presented to the Committee. I venture to think it may be an assistance if I were to place before the Committee a more connected view of the present condition and future prospects of electric wave telegraphy, with the object of enabling the Committee to judge whether the mode of regulating it proposed by the Convention will achieve the purposes desired, or, on the other hand, have the effect of hindering the progress of an art which is still extremely young, although immensely useful.

The idea of telegraphing between places not connected by a continuous wire is not new. As far back as 1838 Steinheil, of Munich, who suggested the earth return in telegraphy, anticipated that in time telegraphy might be conducted altogether through the earth without wires. Morse and Gale at Washington in 1842 began experiments on telegraphy across rivers without connecting wires, and were followed by Lindsay in England. After the invention of the telephone Trowbridge, Preece, Rathenau, Strecker, and many others prosecuted researches in the same direction, and later on Edison, Gilliland, Pheps, and others invented a form of telegraphy to moving trains. From and after 1886 Sir William Preece devoted himself to the subject, and his work and that of the Post Office officials on the so-called conductive-inductive method has been described by Mr. Gavey in his evidence before the Committee. These earlier methods of limited range were thrown into the background by the rise and invention of electric or Hertzian wave telegraphy. In 1892 Sir William Crookes, in a remarkable magazine article, made the suggestion that Hertzian waves might be used for this purpose, having had his imagination stimulated by Nikola Tesla's brilliant experiments on high-frequency electric currents. In 1894 Sir Oliver Lodge gave his well-known lecture at the Royal Institution on "The Work of Hertz and Some of his Successors." In that lecture there was not the slightest reference to the use of Hertzian waves in telegraphy. Subsequently it was stated that members of the audience, notably Dr. Muirhead and Mr. Campbell Swinton, had been stimulated by the experiments shown to attempt to apply the methods for telegraphic purposes. The important matter, however, is not what they tried, but what they succeeded in doing, and there is no contemporary record that they had any such success as to constitute it a new technical advance. At that date the attention of physicists was more directed to the extension of Hertz's work on its scientific side than its application to transmit intelligence to a distance. Distance effects had, however, been observed and imperfectly understood facts noted. As far back as 1879 the late Prof. D. E. Hughes had shown that a tube full of metallic powder in connection with a telephone and voltaic cell was curiously affected by an electric spark at a distance. Branly, in France, had discovered the effect of a distant electric spark on the conductivity of a loose metallic contact, now called the coherer action, and Popoff in Russia had applied the same for observations on atmospheric electricity. Although the rudiments of electric wave telegraphy were to be found in these experiments they did not rise beyond laboratory experiments or out-of-door effects transmitted much less than a mile, and although these things were well known it was clear that additional invention was required before they could be utilised for practical telegraphic purposes. That invention was made and added when Marconi connected one end of a Hertzian wave-oscillator to the earth and the other end to an insulated elevated plate carried on a long wire at the transmitting station, and likewise connected one end of a greatly improved form of Branly coherer or metallic filings tube at the receiving station to earth and the other end to an insulated elevated wire and plate. The effect of this device was to change entirely the capabilities of the apparatus and render possible actual telegraphy by electric waves, and this, together with the other improvements introduced by Mr. Marconi at the same time converted a mere laboratory apparatus into a telegraphic appliance. However much Mr. Marconi may have benefited by the work of his predecessors, the fact remains that, whilst before his work in 1896 there was no electric wave telegraphy, since that date it has gone forward with giant strides and there has been a flood of inventions, patent improvements and research starting from his fundamental improvements. The value of an idea of this kind is not to be measured by its intrinsic simplicity, but by the degree to which it stimulates further

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invention on the part of numerous other people. In the evidence already before the Committee a great deal has been said about various "systems" of wireless telegraphy. It should be clearly understood that no form of wireless telegraphy has yet been devised which has any practical importance or extensive use at the present day except that involving electric or Hertzian waves. Moreover, all the various so-called "systems" make use in some form of the antenna or aerial, air wire or elevated insulated conductors at both sending and receiving ends, which characterised Marconi's first successful form of telegraphic apparatus. The modifications which have been introduced are in details not essential principles. It has been found, for instance, that for short distances, or even up to, say, 50 miles or so, the earth connection introduced by Marconi at the sending and receiving end can be replaced by a large capacity or condenser. Instead of connecting the antenna directly to the earth, it may, as Sir Oliver Lodge has pointed out, be connected through a large condenser, but as high frequency currents pass freely through such a condenser, this is electrically equivalent to a metallic earth connection. Again, instead of exciting the oscillations in the antenna by charging it with electricity and discharging it suddenly, it was found to be better to connect it directly or inductively to another circuit containing a condenser of large energy storage in which powerful electrical oscillations can be set up by charging and discharging the condenser suddenly. A large number of devices has been invented for detecting the oscillations created by the electric waves in the receiving antenna, but these cannot in any proper sense of the word be said to create a new "system" of wireless telegraphy. The Lodge-Muirhead system, Slaby-Arco-Braun system, the De Forest system, and the Fessenden system of wireless telegraphy, which have been mentioned to the Committee as separate systems, are all similar in principle to the Marconi system in that they involve (i.) the use of electric or Hertzian waves as the means of communication; (ii.) they all make use of the antenna at receiving and sending stations, first introduced by Marconi; (iii.) they all make use of an earth connection at both ends, or what is equivalent to it; (iv.) they all employ a Hertzian or oscillatory electric spark at the transmitter; (v.) they all create a disturbance in the universal ether, called an electric wave, by the high frequency or rapid electric currents set up in the antenna at each oscillatory spark; (vi.) they all employ some means of detecting the feeble oscillatory electric currents set up in the receiving antenna by the arriving electric waves. The more recent forms of transmitter differ from the earlier only in the number and energy of the waves sent out at each discharge spark.

In the early form of Marconi transmitter at each electric discharge of the antenna a very few electric oscillations are created in it which moreover rapidly die away. They are said to be strongly damped. The sparks made by the ordinary induction coil used come at the rate of about 50 per second, and each spark may excite only a very few oscillations in the antenna and radiates corresponding waves. In more modern forms of transmitter these trains of oscillations and waves are not only more energetic, but in each train the oscillations are more numerous and die away more slowly. They are called feeble damped waves. In the most recent form of transmitter the trains of waves are continuous, or nearly continuous, and do not die away at all. They are called undamped waves. There are three methods of creating undamped waves: (i.) A mechanical method, by means of a high frequency alternator; (ii.) the electric arc method, due to Duddell and improved by Poulsen; and (iii.) a mechanical and highly effective method which is a recent invention of Mr. Marconi and not yet described in detail. In some ways these undamped wave transmitters are an advance on the Hertzian spark transmitters. The arc method of Poulsen is by no means the only, or the best, method known for producing these undamped oscillations, though very considerable prominence has been given to this method lately. It is much more difficult to use than the simple form of spark transmitter. Each of these forms of transmitter for creating strongly damped, feebly damped and undamped electric waves has its own appropriate form of associated receiver and, it may be said, exhibits its own peculiar virtues and vices. The strongly damped spark transmitter is an easily managed device of great simplicity but the corresponding strongly damped receiver is sensitive to nearly every stray or vagrant electric wave passing through space. The feebly damped spark transmitter requires a little more skill to handle it and tune it. The corresponding feebly damped receiver is much more selective in its wave reception, and is sensitive to electric waves of only a certain limited wave-length and damping. The question of how wide or narrow may be the limits of wave-length and damping within which it is affected is a complicated question. It is partly (*a*) a matter of the energy of the incident wave, (*b*) partly of the skill of the operator and (*c*) partly of the damping of the receiver.

The arc method of producing undamped oscillations is much more difficult to handle than the simple spark transmitter. Mr. Marconi has recently, however, invented a new and very simple method of creating powerful trains of continuous or undamped waves, which, I venture to think, will exhibit a great advantage over the arc method, at least for large powers. The antenna which is used for the reception of undamped waves can be made still more selective in its action as compared with the feebly damped receiving antenna, but it then requires more skill to keep its corresponding transmitter in tune with it. There are, thus, three characteristic qualities of the electric waves used in telegraphy, viz., wave length, wave energy and damping. These correspond to the tone, loudness and duration in the case of sound signals. In the regulations of the Berlin Conference the last two qualities are entirely ignored, and waves are differentiated merely by wave-length. This is quite unscientific. As regards the means for making any particular antenna sensitive only to waves of one particular length and damping, the means so far employed are based chiefly on the facts of electrical resonance. Every electric circuit containing capacity and inductance, or electric inertia, has its own particular rate of vibration like a tuning fork and is set in vibration most easily when acted upon by impulses at that rate. But their are other methods at least as promising, illustrated by Mr. Anders Bull's method, in which privacy is secured, not by the use of a particular wave-length but by the use of certain agreed intervals between the wave trains. I mention this to show that invention has by no means reached its finality in the methods for securing privacy of communication. Again, there is the important question of locating the direction from which waves are coming and limiting the all-round diffusion of the emitted radiation. Mr. Marconi has achieved a good deal towards this end by the use of bent antennæ, and you have heard from one witness that Lieut. Ryan, R.N., has made some observations of this effect. Prof. Braun, of Strasburg, Mr. de Forest in America, and others have worked at it with a certain degree of success.

Another matter to which I wish particularly to draw the attention of the Committee is the difficulties which surround electric wave telegraphy arising from the ever-varying transparency of our atmosphere to Hertzian waves. There is an absorptive effective on long and strong electric waves over great distances, due to electric charges existing in our atmosphere. This is technically termed atmospheric ionisation, and is chiefly due to sunlight, radioactive matter in the soil and cosmical action. The transparency of our atmosphere to long Hertzian waves varies from hour to hour and day to day. Its laws of variation are slowly being discovered, and it accounts for much of the irregularity in transmission which puzzled early experimentalists. Under some conditions transmitters of small power will send messages over unusually great distances; under others transmitters of large power are curiously limited in their range. This altogether vitiates the calculations of those who think that there is a hard and fast limit to the sphere of influence of any one transmitter. All these things support the conclusion that electric-wave telegraphy is still a young art. Hundreds of patents are taken out every year for improvements, and the chief workers are still actively engaged in struggling with its outstanding problems. Electric wave telegraphy has, moreover, this peculiarity, on which I wish to lay very great stress—viz., that experiments for its improvement cannot be carried out on a small scale. To make any useful invention in it each idea must be tested for some time in real practical telegraphic work. To overcome the difficulties of trans-Atlantic telegraphy we must experiment across the Atlantic. It is not the slightest use to try the proposed methods across the English Channel. Valuable additions can only now be made to the art by experiments on the scale of 12 in. to the foot. Much has been accomplished, but still more remains to be done. Again, wireless telephony, or the transmission of speech by electric waves, has made more than a beginning, and I have the strongest belief that the problem of trans-Atlantic telephony is not only solvable but quite practicable.

Now, at this stage of the development of a progressive but infantile and yet important art, the proposed International regulation of it amounts to a suggestion to put a lusty infant into a close-fitting suit of armour, the ostensible purpose of which is to increase its usefulness, but the real effect of which will be most certainly to stop its growth. That this is not an imaginative fear is clearly seen when we look back at the history of electric lighting. In 1882 electric lighting was very much in the same stage of progress as wireless telegraphy is now. It had emerged from a laboratory into a certain practical condition. The British Government of that day, moved by a fear of monopolies, thought the time ripe for legislation, and Mr. Chamberlain introduced and carried through Parliament an act entitled "An Act for facilitating Electric Lighting." Now we all know what happened. This premature legislation crippled the industry. Five years afterwards it had to be reconsidered and amended, and so far from "facilitating" electric lighting it caused this country to lag greatly behind others in which no such artificial regulation of it had taken place. I am not suggesting for a moment that there is a parallel between the nature of the regulations in the two cases. I am only using it as an illustration of the fact that the wisest statesmen may be greatly mistaken in the effects they anticipate will result from the legislative control of a young but growing art. When the bandages of official regulations are imposed on a technical application of science in the early stages of its development, the immediate effect is to hinder and delay the introduction of improvements. Thus, for example, it is acknowledged that our means of isolating wireless stations is still somewhat imperfect. Very well, then, let stations continue to interfere, and the pressure of necessity will sooner or later bring forth the required invention, overcoming the difficulty. If, however, we endeavour to make bureaucratic regulations supply a more speedy but artificial remedy we may purchase a slight immediate advantage, but we delay or hinder the natural evolution of the art and the discovery of the true remedy. In much which has been laid before the Committee on the subject of interference the evidence has not always been as complete as could be desired. For instance, the Committee have heard from witnesses that interference and overhearing takes place between various stations. The important question is whether this overhearing was voluntary or involuntary. Were the operators doing all that could be done—*i.e.*, had they the skill and apparatus to prevent overhearing if they desired? There is a great difference between not being able to avoid overhearing what is said in a room because the walls are too thin or the speaking too loud, and putting one's ear to the keyhole on purpose to hear. Now, the remedy of the Convention is to define the wave-lengths to be used in commercial work and reserve other ranges for naval and others for trans-oceanic work. There are no regulations limiting the damping or the maximum wave energy in a train which may be used, yet a station emitting a powerful strongly-damped wave of legal wave length is a far greater offender and nuisance than a station sending out a wave not of correct legal wave-length but less maximum energy and feebly damped. I point this out to show that the Conference, in the laudable desire to make short and simple rules, has overlooked important scientific facts. The true remedy for

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wireless interference is not to define a couple of wave-lengths and make all else illegal, but to let the pressure of necessity develop the full scientific solution of the problem. If the commercial organisations now conducting wireless telegraphy are left to themselves to develop the invention in accordance with the natural laws, the mere struggle for existence will compel improvements. If, however, we interfere with the operation of this natural process by bureaucratic regulations we artificially foster the unfit, remove the strongest stimulus for improvement in the fit, stereotype existing imperfections instead of allowing them to work out their own salvation, and condemn the art to be content with a less degree of perfection than it would otherwise attain. It is to be hoped, therefore, that the Committee, in arriving at their decision, will take this broad view of the case and look to the future as well as the present. The real danger is not the upgrowth of a monopoly, but the artificial restriction of the development of an art of the greatest importance to the world.

We must defer the conclusion of Dr. Fleming's interesting statement to our next issue.

The Committee did not sit yesterday (Thursday),

L.&N.W. RAILWAY CO.'S EUSTON-WATFORD ELECTRIC RAILWAY.

A Select Committee of the House of Commons (presided over by Sir L. McIver) has passed the scheme for the construction of an electric railway from Euston to Watford.

Sir RALPH LITTLER, K.C., in opening the case for the promoters, pointed out that the L. & N.W. Rly. Co. had four lines of railway running out of London, but they had come to the conclusion that it would be unwise to add to the number of platforms at Euston, and that the best way to deal with the matter would be to construct an entirely new electrical railway, with an underground station at Euston. The proposal, therefore, was to make a railway which would start at Watford Junction. There would be a branch to Croxley Green, and the railways would join at a station in Watford. The line would run in the open along the western side of the existing railway till it reached Loudoun-road. Then it would go underground, and the up line would pass to the eastern side of Euston station and the down line to the western side. They would have a constant service, with no shunting. It would cost £2,366,500 to construct the line.

Mr. L. TRENCH, assistant engineer of the company, said that the proposed line would be 22½ miles long, of which 2½ would be underground. Only one-tenth of the line was in the County of London.

Mr. POLLOCK, K.C., urged that the committee should insert the London County County clause with regard to workmen's trains, as in the case of the North-East London line. Workmen's trains could not be forced on the company by the Railway Commission. All they could do if the company refused to give those trains was not to allow a remission of the passenger duty.

After discussion, the Committee drafted the following clause: "Provided facilities be provided for the carriage of workmen to and from their work over the railway at fares which shall not exceed the fares at present charged for workmen in respect of corresponding journeys over the company's existing line between Watford and Euston. This clause shall not in any way operate to the prejudice of the Cheap Trains Act."

Sir R. LITTLER agreed to the insertion of the clause, and the committee declared the preamble on this part of the bill proved.

Coventry Corporation Bill.—The preamble of this bill, which provides for the extension of the area of electricity supply, for further borrowing powers, &c., has been found proved by the House of Lords Committee. Evidence was given by the city electrical engineer (Mr. Joseph A. Jeckell), who submitted tables showing the great development of electricity supply in the district, the increasing demand for energy for power and lighting, and the improved financial position.

Miscellaneous Bills.—The Richmond (Surrey) Electricity Supply Bill has been read a second time.

The Great Northern & City Railway Bill has been ordered for third reading.

The Central London Railway Bill has been read a second time.

LEGAL INTELLIGENCE.

Thermit (Ltd.) v. Weldite (Ltd.)

On April 27 Mr. Justice Warrington delivered judgment in this action brought by plaintiffs to restrain alleged infringement by defendants of a patented chemical and metallurgical process of producing metals from their compounds. The case occupied several sittings of the Court, and a great deal of technical evidence was given. The facts sufficiently appear from the following judgment:—

His LORDSHIP said: Plaintiffs are the registered owners of three letters patent, all said to have been infringed by defendants. The first, No. 16,685 of 1896, is for an improved method of producing metals from their oxides, sulphides and chlorides. The other two are for a method of employing the metal so produced and the intense heat generated in its production for the joining of separate pieces of metal. The principal practical application of the three inventions is the joining in situ of tramway rails. Defendants deny infringement and attack the validity of the 1896 patent upon the grounds of want of subject matter, prior user and lack of utility in reference to certain metallic compounds specified in defendants' further particulars. As to the patents of 1901 and 1902, the attack on the validity of the patents was not pressed, except that it was contended that unless a particular construction is adopted, which (as defendants say) would entitle them to succeed on the issue of infringement, the patent of 1901 is lacking in subject matter. Aluminium has a strong affinity for oxygen, and if mixed in a powdered condition with the oxide of certain metals and brought to the temperature of fusion it combines with the oxygen in the compound. The result is a molten mass, consisting of (1) alumina slag or oxide of aluminium and (2) the pure metal. The heat developed in the process of combination is extremely intense. Aluminium has a similar affinity for sulphur and chlorine, and acts in a similar manner on the sulphides and chlorides of certain metals. In 1894 Claude Vautin obtained letters patent for "an improved process for the extraction of metals from oxides and sulphides." This was, in effect, for a practical means of utilising, for the production of metals in a pure state, the affinity I have mentioned and the high temperature developed in the combination of the aluminium with the oxygen or sulphur. No express directions are given in the specification of 1894 as to the mode in which the temperature necessary to start the reaction is to be obtained, but it is common ground that it was to be by external means. In fact, this invention does not seem to have been put into practice except by Vautin himself and his assistants. The means employed were, in the case of larger crucibles, heating in a coke furnace, and in the case of small ones, heating by means of a blow pipe flame applied externally and over a considerable area. It was found that in the case of some metals, and notably that of iron, the reaction, when brought about by external heat, was of so energetic a character as to partake of the nature of an explosion and to occasion the loss of a large portion, if not the whole, of the material. In the case of some metals, and particularly chromium, the reaction was quieter. The invention for which the letters patent of 1896 were granted was intended to meet the difficulty mentioned. The complete specification of this patent commences with certain statements of fact, and it is called "an improved method for the production of metals and alloys." The first paragraph is as follows: "If metallic compounds containing oxygen, sulphur or chlorine, for instance, oxides, sulphides and chlorides, are heated with aluminium"—I take it that means in connection with aluminium, in contact with aluminium—"the metal of the compound is separated out. When the aluminium is employed in excess an alloy of aluminium and the metal of the compound is obtained. If different metals are reduced at the same time an alloy of these metals is obtained. This method may also be employed for the production of an alloy of a metal or metals with a metalloid or with metalloids as silicium"—which is the same thing as silicon—"arsenic, and so on. The aluminium should be employed in a finely-pulverised state if good results are to be obtained, and it is necessary to heat only a little portion of the whole mixture to the temperature of reaction. After having brought this little portion to reaction by the heat of a flame, of a burning piece of magnesium or by electricity, the adjacent parts of the mixture are ignited successively and automatically by the parts being already in reaction; by this method a very soft reaction without explosions is gained." The first of those paragraphs (from line 15 to line 21) merely states in general terms the effect of the reaction when certain metallic compounds are heated with aluminium; and I think that statement is plainly confined to those metallic compounds with which the reaction can take place when they are heated with aluminium. The second paragraph is a statement in general terms of the nature of the invention which he is afterwards going to describe. Another paragraph begins:

"When the whole mixture of the pulverised aluminium and the compound to be reduced is heated to the point of fusion, by an exterior source of heat, such an energetic reaction takes place that by its vehemence a certain quantity of the material is ejected and thrown out of the crucible before the reduction of the compound is fully effected, so that the said quantity of material and the fuel consumed for heating the same are wasted as far as the operation is concerned." In that paragraph he is obviously referring to the process as he had previously described it in the specification of 1894, and is pointing out the defect and difficulty alluded to. Another paragraph begins: "Now it is the object of my invention to remedy this defect or loss, and to this end I cause, as already mentioned, the reaction, instead of taking place simultaneously throughout the whole mass, to take place at one point or place only of the mass; in other words, I initiate the reaction at a certain point or place in the mass, and then cause it to proceed or spread from this portion of the mass to the remaining portion of the same." There he is going back to the second paragraph, and pointing out how that which he has mentioned in that paragraph will meet the difficulty which he has mentioned in the third paragraph. Then he proceeds to show how he is going to do it: "To start the reaction I may, for instance, ignite the mixture of pulverised aluminium and of one or the other of the compounds above mentioned in a finely pulverised state"—the next words, I think, are very important—"(or, more precisely, a small portion of that mixture) by means of a blow-pipe flame directed against it, or by means of a piece of sheet or band magnesium which is inserted into that portion of the mixture and is then ignited. I prefer, however, to make use of a special igniting mass for starting the reaction, such igniting mass being composed of a similar mixture to that to be treated, but which generates greater heat and gives rise to a more intense reaction on being reduced. The combination or compound forming the mixture must, therefore, be easily reducible, and I may mention as examples of such a mixture oxide of lead and baric peroxide with aluminium, but other similar oxides and peroxides may be used, if desired, in combination with aluminium." I think it is quite plain that when he speaks of starting the reaction and gives those instances of the means by which it may be done he is referring exclusively to the employment of those means for igniting the mixture inside the crucible. Further on he says: "The igniting mass may either be loosely strewn upon the material or mixture to be treated, and may be ignited by a magnesium band or by a match, or it may be formed into

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balls or similar bodies by pressure, or by means of a suitable cement, and a magnesium band may then be put into each of the said balls or bodies. The latter are slightly pressed down upon and into the material or mixture to be treated, and when ignited they start the reaction of the said material or mixture. The reaction may be continued by adding fresh material to that contained in the crucible, and I prefer to press the said fresh material into the shape of cubes, prisms and the like."

As I understand, the method adopted by plaintiffs is that of ignition powder. A little ignition powder is put on the top of the mixture in a crucible and lighted with a match, and in about 30 seconds the whole contents of the crucible are in a molten condition of intense heat which I have already mentioned. The only point which is mentioned for the first time in this specification in that paragraph is the continuation of the process by adding fresh material. That seems to me to be a point of considerable importance, because, at all events with oxide of iron and those as to which the reaction is violent, it would have been impossible to add the fresh material under the process involving external heating. It could only be done where the reaction, as in this case, is quiet, as here described. In the next two paragraphs Vautin says: "The aluminium may be replaced by a mixture or an alloy of aluminium and magnesium. By making use of the improved method above described I am enabled to produce refractory metals, such as chromium, manganese and the like, in large quantities and on a commercial scale, and I can also produce alloys of refractory metals, as well as of a refractory metal, with aluminium, and also of a refractory metal or metals with an alkali metal or metals, with a metal or metals of the alkaline earths, with the metals of a rare earth or earths, and so on. The metals are gained perfectly free from carbon, silicium" (or silicon) "and other impurities, and that is a great advantage of this method." I am satisfied on the evidence that the statements of fact contained in those two paragraphs are true. After giving certain examples of how he carries it into effect he says: "In the same manner all the metals or their alloys, as already mentioned in the first part of the specification, can be gained." It was suggested by defendants that those words show that the inventor had deliberately informed the world that this process could be carried out in such a manner with all the metals that all the metals could be gained. In my opinion, to a chemist, as M. Vautin is, and to those to whom this specification was addressed, that would be an absurdity. He then claims his invention in nine separate claims. Claim 9 is as follows: "The described method of producing metals and alloys from metallic compounds containing oxygen, sulphur or chlorine alone, or two of or all, such method consisting in finely pulverising the compound, mixing it with finely-pulverised metallic aluminium or aluminium and magnesium, heating a small portion of the mixture to start its reaction and afterwards adding the remaining or main portion, so as to heat it from the heat of reaction of the first portion, whereby the reaction automatically spreads throughout the whole mass, substantially as set forth." That refers to the reference as to continuing the process. It was said by defendants that claim 9 would cover the heating by external heat of the small portion and then the adding of the further portion, and that therefore it was anticipated by the patent of 1894, or, at all events, the claim here made was without sufficient subject matter. In my opinion that is not the construction of the claim. I think if you read the claim with a view of ascertaining its real meaning, Vautin is, in that claim as in all others, referring to the internal heating.

To sum up, in the first place, bearing in mind (as I have already stated), that it is intended to be read by chemists, I am of opinion that it must be read as referring only to these metallic compounds which are capable of reduction by the action of aluminium—in other words, it is a supplement to the specification of 1894, substituting internal for external heating as the means of producing the temperature of reaction. Secondly, the internal heating is to be of a strictly local character affecting only a small portion of the mixture, leaving the rest cold. Thirdly, claim 9 is intended to be confined to the internal heating of the small portion and does not comprehend external heats of such small portion. Defendants contended that the claim ought to be construed in the more comprehensive manner, and so construed is too wide. I think the narrower construction is correct. If the specification is construed as I think it ought to be, then, in my opinion, on the evidence, there is ample subject matter, and that defence of want of subject matter, therefore, fails. With regard to prior user, there is no evidence of internal heating having been employed to produce the temperature of reaction, and this defence, therefore, also fails.

There remains the defence founded on the fact that the process will not work with certain metallic compounds. The invention is useless with the compounds mentioned in par. 5 of the defendants' original particulars, and the results cannot be obtained. But the answer, in my opinion, is that the suggestion as to the scope of the claim is unfounded: it did not extend to all oxides, sulphides or chlorides, but only to those which are capable of being reduced by aluminium under the conditions described in the specification. There are certain compounds in reference to which a chemist could say from thermal data readily accessible whether they would or would not come within the above description. There are others which are on the border line, and it might be necessary as to those to try by experiment, but the experiment would be merely for the purpose of ascertaining whether a particular compound answers a certain description sufficiently indicated in the specification; and the fact that in certain cases an experiment of that kind might be necessary ought not, in my opinion, to affect the validity of the patent. Now as to infringement. Defendants have beyond question carried out the reduction of oxide of iron in the manner described in the specification, with one exception, namely, that they have replaced a small portion of the aluminium by silicon, another metal capable of reducing oxide of iron. In my opinion, the true result of the evidence on this point is that this change is a mere colourable variation, that the reduction, notwithstanding the variation, continues to be substantially a reduction by aluminium such as is described. Viewing the question in this light I have not, in my opinion, to consider, and do not determine, whether on the evidence a mixture of silicon and aluminium was a known chemical equivalent for aluminium. The patent of 1901 is described by the patentee as "A new and improved process for welding metals." Defendants' case in reference to this patent is that they have not infringed because it is not proved that the pieces of metal on which they have operated were actually welded together. Further, they say that if the patent covers a mode of joining such as they are proved to have practised—namely, without welding, then the patent is void for lack of subject matter. The material facts are as follows: In 1899 Dr. Goldschmidt (the patentee of 1901) obtained letters patent for an improved process for welding metals. The essence of this invention was the employment of the intensely hot fluid resulting from the chemical process described in Vautin's specification of 1896 to bring the two metal surfaces to be joined to such a temperature that under pressure welding could take place. This was effected by pouring the hot liquid into a mould surrounding the joint. The hot liquid in the crucible consists of aluminia slag and pure iron. The iron is the heavier, and in the application of this process it was essential to keep the iron from coming in contact with the pieces to be joined, and accordingly provision was made for ensuring that the aluminia slag should first make a protective covering, the iron being poured into the mould only after this had been done. The function of the iron in this process was only to create or communicate the necessary amount of heat. Another method of joining metals known and practiced before 1901 was Falk's method, which consists simply in casting iron, at the ordinary temperature of molten cast-iron, round the joint. The patentee of that process suggests that this cast-iron would adhere to the two sides of the joint and would thus hold together. On the evidence before me I doubt whether it would so adhere with sufficient strength to make a firm connection, and Falk met this by providing holes on either side of the joint into which some of the cast-iron would run, so that the pieces to be joined would be held together by a link of cast-iron. As to the specification of 1901, the patentee describes his invention as follows: "My invention relates to a new and improved process for welding metals. In the processes known up till now for welding metals with the aid of the heat produced by the chemical reaction between aluminium and oxides of metals or other oxygen containing metal compounds (especially oxide of iron) the reaction mass is used only as calorifying agent, and the metal produced by the reaction serves only as a heat conductor. Therefore in these alumino-thermo processes care was taken that the molten aluminia-slag at first came in contact with the pieces to be welded, and only after the same had formed a protecting cover or coating around the pieces the molten metal was cast around the welding pieces. In most cases this succession took place already by the mere casting of the reaction mass out of the crucible or melting pot, as naturally at first the aluminia floating above flows out and afterwards the metal. Hereby it was avoided, that the molten metal could come in direct contact with the metal pieces to be welded and that this metal could join with the metal pieces." So far he is describing the process of 1899. "By my new process it is attained that the molten metal comes directly in contact with the welding pieces or with part of the same, so that the metal may partly join with the pieces, thereby strengthening the joints whereupon the whole reaction mass begins its operation as calorifying agent for the welding process. The process shall now be described as, for example, used for joining rails or the like, and with reference to Figs. 7, 8 and 9 of the drawings." The process he there describes, which I need not read, is shortly this: that a crucible containing a mixture of ferric oxide and aluminium is placed in a tripod over the faces to be joined. These are surrounded by a mould; the crucible is provided with a tap hole at the bottom; the reaction being effected, the tap hole is opened and the iron flows out first, surrounding the lower part of the rails to be joined, the aluminium filling up the rest of the mould and covering the upper part of the rails. The patentee then proceeds: "The aluminia flowing out after the iron has a double effect upon the pieces to be joined. Firstly, the heating attained by the same may effect the welding of the joining faces, assuming of course that a sufficient pressure is applied to them; secondly, the heating of the upper part of the rails prevents the bending up of the rails near the joining faces, which bending up was tried to be done away with until now in similar processes by holding the joining faces down by means of clamps and the like." He sums up as follows: "It will be seen that the joints produced by this process are produced partly by welding the joining faces together and partly by surrounding the same with metal. Hereby a great strength and elasticity of extension of the joints is attained, as by the process not only the thermo-energy of the reaction, but at the same time the physical qualities of the metals are used in that way, that these physical qualities become highly advantageous for the purpose produced by the process, that is to say for the firm joining of the metal pieces. Contrary to the known process"—he is now referring, I think, to Falk—"consisting in casting metals around the lower part of the rails, I obtain by the new process described above a better welding or joining of the metal cast around the rail foot, with this rail foot by reason of the high superheat of the metal, whereby the joining faces are so joined that one continuous metal piece is formed." In this case I must read the claims. They are: "1. Process of joining metals by means of the heat arising by the reaction taking place between aluminium and oxygen containing metal compounds, consisting in bringing one part of the metal pieces to be joined together in contact with the highly overheated molten metal arising from the reaction, while the other part of the metal pieces is brought in contact with the molten aluminia-slag, substantially as and for the purpose set forth." "(2) Process of joining metal pieces consisting in surrounding the ends to be joined with a mould, into which the highly overheated molten metal and molten aluminia-slag are cast, in such

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manner, that the parts to be welded come in contact with the molten alumina, while the other parts come in contact with the molten metal, substantially as and for the purpose set forth." "(3) Process of joining metal pieces, consisting in surrounding the ends to be joined with a mould, over which a crucible provided with a tap hole in the bottom is situated, bringing into the crucible a mixture fit for the alumina-thermo process, bringing the mixture to reaction and then opening the tap hole, thus causing the products arising from the reaction to flow around the ends to be joined, substantially as and for the purpose set forth." Claim 4 only refers to a particular form of tap hole, or rather to the mode in which the tap hole is to be stopped.

Now what is the real meaning of this specification and its claims? In my opinion they mean no more than this: "I show you a means whereby you can effectually join two rail ends or other pieces of metal by means of the alumino-thermal process in such a way that you can, if you are so minded, actually weld the two ends together, or some part of those two ends, and you will in any case join them effectually by means of the superheated iron cast round the lower part, which, owing to its heat, will become united with the joining pieces." I cannot think that the actual welding of the whole of the joining faces was essential to the patentee's claim. He no doubt contemplated a welding, but I think he would be within the patent in carrying out the process as there described, but so arranging the materials that there might be no actual welding or only a partial welding of the joining faces. Even if the specification is so construed, I find, contrary to defendant's contention, abundant invention in the application of the superheated iron for strengthening the joints, and, therefore, sufficient subject matter for a patent, even according to this construction of it. In the view I take of the ambit of this invention there is no question that defendants have infringed the letters patent. They have done the very thing described in the specification, except that an actual welding of the faces was not effected. But I find further on the facts that, even if actual welding is an essential part of the claims, defendants threatened and intended to effect this, and that it was by accident rather than by design that in the cases of which evidence was given this is not done. The patent of 1902 is merely for an improved mould for use in the 1901 process. Taken by itself, there is really no dispute either as to infringement or validity. I find, as the result of the whole case, that the plaintiffs are entitled to an injunction as to all the patents.

Claim for Damages for Wrongful Dismissal.

Before Judge Woodfall and a jury at Westminster (London) County Court on Saturday Mr. Frank Morley, theatrical electrician, claimed damages for breach of contract and wrongful dismissal against Mr. Charles Frohman, theatrical lessee.

This was a new trial, a jury at Manchester having on a previous occasion found for plaintiff for £60.

Mr. F. M. ABRAHAMS, for plaintiff, said Mr. Morley had been a theatrical electrician for 22 years, and was for 13 years in charge at the Empire, London. He was to have been in charge of the Avenue Theatre but for the accident which smashed up that theatre. He then got into communication with Mr. Dion Boucicault, who was producing "Peter Pan" at Prince's Theatre (Manchester) for defendant. Plaintiff commenced his duties at the Duke of York's Theatre, London, one of the theatres of which Mr. Frohman was lessee or director. He then went to Manchester and worked night and day to get the electric light installed. After many hours of duty he went out to obtain refreshment, and then and there received notice that he was not to return to work, and next morning he was summarily dismissed on the ground of drunkenness. There was no justification for this dismissal. Plaintiff (in his evidence) said his contract with defendant was for a salary of £4 a week. No complaint had been made about his work or behaviour. The run of the piece lasted 21 weeks, and he lost £4 a week all that time.

For the defence, Mr. MACINTYRE WICKSTEAD, manager for defendant, deposed that plaintiff was unfit on several occasions for his work. On the night of his dismissal he was the worse for drink.

Mr. DION BOUCCICAULT said he complained frequently of plaintiff being incompetent, slovenly and fuddled, and warned him about it. The success of the play depended very largely on the lighting effects, and these were in the hands of plaintiff.

WILLIAM GOSLING, assistant electrician to plaintiff at Manchester, said he was more or less the worse for drink all the time he was at Manchester.

Mr. J. R. WOOD, property master, said he could not swear that the state of plaintiff was not due to weakness, the result of being hard at work without food.

His HONOUR summed up and the jury retired, but were unable to agree. After three retirements they found for plaintiff for £84, and judgment was given accordingly, with costs of both trials.

Cowman v. Goodall.

At Manchester Assizes last week plaintiff sought to recover damages for breach of contract. It appeared that plaintiff obtained in May, 1906, a licence to work a patent for the manufacture of Birch's detachable shade holders for electric fittings, and got into communication with A. Fengl & Co., in which firm defendant (G. J. Goodall) was a partner. On July 24 Fengl's accepted a contract from plaintiff to make and deliver 100 gross of shade holders at 9s. per gross, first delivery on or before Sept. 5; but on July 27 Goodall began proceedings in Chancery to have his partnership with Fengl set aside and a receiver appointed. Plaintiff's contract was not executed and he had to place it elsewhere, paying a higher price for the goods. The difficulty between the partners arose through inability to raise sufficient capital, and Fengl's affairs were afterwards wound up in bankruptcy.

Mr. LANGDON, K.C. (for defendant), contended that the contract was placed by Cowman with Fengl on a date when Goodall had withdrawn from the partnership. Fengl had advertised for a partner with capital, and Goodall got into communication and afterwards had an interview with him. He accepted the statement Fengl made as to the liabilities and assets, but discovered that Fengl's liabilities were considerably in excess of what he had been led to believe. On July 7 he had become acquainted with the actual state of affairs, and terminated the partnership on the spot, taking away whatever belonged to him. The partnership was a partnership at will and defendant repudiated his liability for any debts incurred subsequent to his withdrawal.

After hearing evidence, Mr. Justice LAWRENCE summed up, and said the question was whether defendant was liable to Cowman for damages sustained by reason of the non-fulfilment of the contract placed with Fengl & Co. What Fengl said was that he was in partnership with Goodall from April 23 to July 7, on which date a difference arose. It was for the jury to say whether what took place on that occasion operated as a dissolution of the partnership. It was a partnership at will, and therefore terminable without notice; its termination might or might not affect third parties, according to the circumstances of the case; but, as between the partners, any definite and final statement by one or the other that he withdrew would amount to a determination of the partnership. In that case either would be precluded from pledging the credit of the other or entering into any agreement to bind him.

The jury found that the partnership was terminated on July 7, and judgment was entered for defendant.

Clements v. Warwick.

Mr. Justice Ridley and a jury yesterday (Thursday) heard an action in which plaintiff claimed £143 for work done and goods supplied. Defendant admitted part of the claim, but as to the rest pleaded that plaintiff was incompetent to do the work and the materials supplied were useless for the purpose.

Mr. GRIMWOOD MEARS, for plaintiff, said the issue of fact was whether at certain interviews plaintiff advised defendant to have two electric motors of 10 H.P. and 15 H.P. respectively, or whether he simply ordered them without asking plaintiff's advice. The amount claimed was the balance of account for fixing and supplying the motors and for electric lighting work. Plaintiff's case was that defendant asked him for a quotation for some electric cables and asked if he could find him a second-hand 15 H.P. motor. He did not say then what he wanted the motor for, but it transpired that he had some public entertainment grounds at Cleethorpes, and one of the attractions was a revolving platform half-way up a tower on which 150 people stood and were taken round about twice a minute. He afterwards told plaintiff that he had worked it with a 3 H.P. electric motor, but he wanted to turn it into a flying machine, and he proposed to have boats revolved by some mechanism inside and swung outside from the tower. Defendant also had a "Fairy River," and he wanted a 10 H.P. motor to serve that concern, but when he told plaintiff that his dynamo, from which he got the current to drive the motors was 20 H.P., plaintiff told him he would never get 15 and 10 H.P. out of the motors. Defendant, however, said he should not want 10 H.P. for the Fairy River, and under these circumstances plaintiff obtained the motors.

After hearing further evidence, the Judge referred the case to a referee

Bass v. Krieger Electric Carriage Synd. (Ltd.)

Yesterday Mr. Justice Phillimore and Mr. Justice Bray heard defendants' appeal from a decision of Judge Woodfall at Westminster County Court in favour of plaintiff for £75. The decision was set out in *The Electrician* for Jan. 18, 1907, p. 543.

Their LORDSHIPS held that the evidence in the Court below did not clearly show that the chauffeur, in making the deviation in his route, went on a frolic of his own account, and they dismissed the appeal with costs.

Lynch v. Macartney, McElroy & Co. (Ltd.)—We are informed that the defendants in this action (reported in our issue of the 3rd inst.) propose to appeal, and a stay of execution has been granted.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Salford Electricity committee invite applications for the position of deputy electrical engineer. Applicants must have had previous experience in the generation and distribution of electrical energy in large undertakings (both a. and d.c.), and be thoroughly conversant with the electrical details of same. Salary £250, rising to £400 per annum. Particulars from the borough electrical engineer (Mr. Victor A. H. McCowon), Electricity Works, Frederick-road, Pendleton, Salford. Applications to town clerk (Mr. L. C. Evans), by mid-day, May 13. See also an advertisement.

A vacancy occurs at Barnsley electricity works for a pupil. Applications to Mr. E. A. Barker, borough electrical engineer. See an advertisement.

A junior electrician is required for the Straits Settlements, with knowledge of wiring, dynamos, switchboard construction and general electric work. Commencing salary £200, rising by £20 per annum to £260, with passage out and home. See an advertisement.

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A large power company in the north of England require a junior engineer in their consumers' department. See an advertisement.

A foreman is required for Long Eaton electricity works. Salary £2. 10s. per week. Applications to the Engineer and Manager by 6 p.m. May 13.

The Governing Body of the Battersea Polytechnic (London) invite applications for the position of principal, to date from September next. Commencing salary £800 per annum, increasing to £1,000. Particulars from the Clerk. Applications by May 25.

The Governing Body of Battersea Polytechnic also require an assistant lecturer in physics and electrical engineering; full time; teaching experience essential. Commencing salary £180. Particulars from the Secretary.

Mr. Wm. Sillery, borough electrical engineer at Wrexham, has been unanimously appointed burgh electrical engineer of Partick.

Mr. F. Edmondson, engineer of the Manx Electric Railway Co., has been appointed general manager and engineer of the company, in succession to Mr. Harold Brown, who is leaving for Canada.

Mr. D. H. Ogley, of Stafford, has been appointed assistant lecturer in electrical engineering at the Royal Technical Institute, Salford.

Battersea (London).—As soon as the London County Council sanction a loan the Council will proceed with the work of extending the mains to the Park Town estate.

Conway.—The Council have invited the North Wales Power & Traction Co. to submit terms for the supply of electricity in bulk in the district, and an extension of the Conway provisional order of 1905 has been applied for.

Depreciation.—The lecture recently delivered by Prof. L. R. Dicksee to the members of the Chartered Accountants' Students Society of London on "Depreciation, with Special Reference to Accounts of Local Authorities," has been issued in pamphlet form. Prof. Dicksee, who is a high authority on the question of depreciation, treats his subject from a scientific point of view, all political considerations being excluded. Those of our readers who are interested in depreciation and municipal accounts should procure a copy of the lecture, which is published by Messrs. Gee & Co.

Electricity in Mining.—At the recent meeting of Joseph H. Pearson (Ltd.) the new electric power plant at Parkhouse colliery, Chesterton, was started.

The plant consists of two Crompton three-phase generators, having an output of 250 k.v.a. at 500 volts, direct-coupled to 300 H.P. Belliss engines and two direct-current 25 kw. steam sets for exciting purposes and for supplying current for lighting the offices, surface and underground roadways. The steam for the engines is at present supplied by the existing boilers of the old egg-end type, but which are immediately to be replaced by modern boilers. The steam is conveyed to the engines through heavily-lagged pipes, fixed in a brick culvert, which has been specially built for this plant. From the switchboard the current is carried down the shaft by cables in wooden casing, the lighting and telephone cables being fixed in similar manner. At the bottom of the shaft there is a distribution box. The underground plant consists of a 3-throw pump (delivering 300 gallons per minute against a head of 1,040 ft. to the surface), driven by a 150 H.P. motor. A 50 H.P. main and tail gear and two 10 H.P. 3-throw pumps are also provided. The whole of the mechanical part of the plant has been supplied by M. B. Wild & Co., Birmingham.

Exhibitions.—The Board of Trade, 73, Basinghall-street, London, E.C., have now available for British firms copies of the prospectus of the International Exhibition of Hygiene, Art, Trades and Manufactures to be held in Madrid from September to November next.

After a lapse of several years, a Laundry Exhibition will be held in London this month, and will be opened on Saturday at the Agricultural Hall, N., under the auspices of the Society of Laundry Engineers and Allied Trades and the Launderers' Association, with Messrs. Cordingley & Co. as business directors. There should be a larger field for electrical operations in the laundry than at present exists.

The Dublin International Exhibition was officially opened on Saturday.

The Balkan States Exhibition, which is being held at Earl's Court, London, S.W., was opened by the Lord Mayor of London on Saturday.

C. Larkins & Co. inform us that they have been appointed official contractors to the "Organiser" Exhibition, to be held at Olympia in July.

Framwellgate Moor.—The local electric supply company have arranged to supply electric current for private lighting in the district.

Each house is to be supplied with three 16 c.p. lights for 1s. per fortnight. If a consumer is ill or out of work he is exempt, such cases not to exceed 5 per cent. of the total number of houses using the light. For large consumers special arrangements are to be made on a basis of 3½d. per unit. At a recent meeting of residents these terms were accepted.

Gainsborough.—The Board of Trade have agreed to defer revocation of the Gainsborough electric lighting order (1904) for 12 months from June 24 next, but if at the end of that time the undertakers cannot furnish the Board with evidence that the order is being put into force, it will be revoked without further notice.

George Town, Penang.—The third annual report (for 1906) of the electricity supply department states that during the year extensions of the plant were carried out, including a 300 kw. Allen-Westinghouse steam dynamo, Babcock & Wilcox water-tube boiler, &c.

Additional feeder and distributor cables were also laid, aggregating over 10,000 yds. 70 new services were connected for private lighting (representing an aggregate of 2,002 8 c.p. lamps) and some small extensions of the public lighting were also carried out. At the end of 1906 the equivalent of 12,470 8 c.p. lamps was connected for public and private lighting. 440,522 units of electrical energy were sold (against 224,063 in 1905), including 132,814 for traction, 159,062 for private and 148,649 for public lighting. The revenue amounted to $71,484.57, against $40,212 84. The average price obtained per unit sold was 17.94 cents, and the total costs came to $51,730.15, an increase of $15,895.99 over 1905. The total costs per unit sold in 1906 were 11.74 cents, compared with 16.88 cents in 1905. The year's gross profit was $19,754.42, or nearly 5 per cent. on the capital expended, but the net result was a deficit of $7,756.

The engineer-in-chief (Mr. O. V. Thomas), reporting upon the year's work, states that "the undertaking is still in its initial stages, and the number of lamp connections per yard of main is very small. The comparatively small demand for current per lamp fixed from private consumers (4·87 units per lamp) is accounted for by the fact that a large proportion of the lamps is installed in private residences, chiefly Chinese, which are seldom fully occupied. Comparatively small progress has been made in the introduction of fans and industrial motors." At the end of the year there were only 314 fans and two small motors on the mains. The improvement of the day load and the encouragement of small consumers by some system of free or assisted wiring will have an important bearing on the whole question and the financial prospects of the undertaking.

The report on the electric tramways department states that the electric service was inaugurated on Jan. 1, 1906. The capital expended on the department at the end of the year was $356,054.15. 1,547,375 passengers were carried and 161,204 car-miles run. The total operating costs came to $33,952.15 (or 21·06 cents per car-mile). The total receipts came to $45,887.27, and the result of the year's working is a gross profit of nearly 4 per cent. on the capital outlay. The result is considered satisfactory, as for the greater part of the year only a portion of the system was open to traffic.

Glasgow.—Last week the sub-committee of the Tramways Committee appointed to consider the question of increasing the plant at the Pinkston power station recommended that:

Two members of the staff of the department be authorised to visit Continental towns to obtain the fullest information on the question of turbines, and that the electricity department be asked to allow their electrical engineer to accompany the two members of the staff of the tramways department.

Mr. J. McFarlane, in moving the recommendation, said they had had offers from the recognised makers of turbines, including the Continental firm who made the Zoelly turbine, which showed remarkable economical features from a coal-consumption point of view.

After discussion an amendment that the recommendation be remitted for further consideration was carried.

Great Grimbsy.—On Tuesday the Council decided to apply for sanction to borrow £4,000 for additional generating plant.

Hackney (London).—The Electric Lighting committee recommend the Council to add 3 Babcock & Wilcox superheaters with the necessary pipework connections to the three destructor boilers, at an estimated cost of £510, and that the cutting away and making good of the brickwork be carried out by the works maintenance staff at a cost of £50.

Holborn (London).—The Metropolitan Electric Supply Co. have reduced the charge for electric current to the Council's buildings from 4d. to 3½d. per unit.

Incandescent Lamp Tests.—A specification for glow lamps has been issued by the Westminster Electrical Testing Laboratories, which differs essentially from that of the Engineering Standards Committee, in that the lamps are run at the working pressure instead of rated efficiency, and the *spherical* candle-power is measured. In the pamphlet we have received a number of limits are given within which the average candle-power, efficiency, &c., must fall. The initial rating test is discarded.

Italy.—In a report on the trade of the Consular district of Rome for 1906, Mr. Consul Morgan states that the United Kingdon is now entering into the business of importing electric lamps and electric fittings into Italy, and during 1906 fairly good orders were sent to the United Kingdom. There is believed to be an opening in Italy for these goods. The value of electric lamps imported into Rome in 1906 was £1,201, compared with nil for the previous four years. At one time there was a large importation into Italy of arc lamps and accessories, but this demand appears to be now met by Italian firms, who have established themselves in the manufacture of these goods.

The craze for municipalisation appears to have taken a strong hold of Rome, and it is stated that many public services now under the

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control of private companies are likely to come under municipal control in the near future. The utilisation of a portion of the Tiber and of the waterfalls near Rome for the generation of electric energy, and the reorganisation of the electricity supply service in the city, are projects which are under consideration.

The "Gazzetta Ufficiale" contains a law authorising the Societa Ferrovie e Tramvie Elettriche Varesine to construct and work an electric tramway (1·10 m. gauge) from Luino to Lake Maggiore.

Leeds.—Yeadon Council have again asked Leeds Corporation to extend their tramway system from Horsforth to Yeadon and Guiseley.

London County Council.—On Tuesday it was agreed—

That the terms and conditions with regard to the rate of interest and the repayment of principal of the loan of £1,415,000 to Marylebone Council for purchase money and compensation, &c., in connection with the acquisition of a portion of the undertaking of the Metropolitan Electric Supply Co. be varied, for so much of the said terms and conditions as relate to the rate of interest upon the loan subsequent to Dec. 31, 1906, and to the repayment of the balance (£1,400,000) of the loan outstanding at that date. From Jan. 1, 1907, the rate of interest is to be 4 per cent. per annum (calculated quarterly), the principal to be repaid by such equal half-yearly payments of principal and interest combined as will within 35½ years (from Dec. 31, 1906) repay the amount borrowed.

Invention.—It was agreed to allow Mr. C. Garrod, an official in the engineer's department, to take out a patent for his invention of an improved point for use in connection with the side-slot system of conduit tramway electrical traction.

Tramway Estimates.—Mr. A. F. Buxton, chairman of the Finance committee, in submitting the estimates for the current financial year, said that the most important of their undertakings (the tramways) was still largely in a transitional state, owing to the large works of reconstruction going on in what used to be called the northern system. The Council would note that in future the tramways accounts were to be divided only as between the horse traction and electric traction systems, it having been found impossible to keep separate accounts for the southern and northern systems owing to the difficulty of apportioning charges now that the undertaking was being worked as a whole. The really vital financial consideration arising on the tramways estimates appeared to him to be the probable results of the electric working of the system. The estimates for 1907-8 showed a surplus on working the electric portion of no less than £557,085, on the basis of traffic receipts at 1s. per car-mile and working expenses at 7¼d. per car-mile. He found the actual traffic receipts of the year 1906-7 over the whole of the electrically-worked system averaged 11·94d. per car-mile, while those of the year 1905-6 were 12·09d. per car-mile. In the ensuing year, for various reasons, they were expected to again reach 1s., but even if they should fall slightly below that figure, he understood the estimate of the mileage to be run had been taken on a low basis, thus allowing a considerable margin on the total estimate of receipts. In all their calculations as to financial results they had taken the total revenue (including receipts from advertisements, &c.) at 1s. per car-mile, so that events were proving that their calculations had been on the safe side. The estimate of working expenses had been taken in such calculations at 7d. per car-mile including power expenses. The actual expenditure for 1906-7 was not yet precisely ascertained, but was expected to work out at about 7¼d. per car-mile, while the estimates for 1907-8 showed a figure of 7¼d. per car-mile. The Highways Committee had good grounds for hoping that it might be possible to reduce this figure as the power load at their Greenwich generating station was increased. During 1907-8 the station would not be used to its full capacity, and therefore not at its lowest cost per unit. Against the estimated surplus of £557,085 on the electric system must be set the estimated deficiency of £49,640 on the horse lines. There was consequently a balance of £512,945 to meet interest and sinking fund and other charges amounting to £471,157, leaving a net surplus of £41,788 on the year's working. Of this it was proposed to set aside £35,000 to renewals reserve, the same amount as was transferred last year instead of £62,500 which appeared in the estimates. Including this year's figures the amounts set aside under that head would amount to £140,000, representing about ½d. per car-mile instead of 1d., which was the least at which they ought to aim. Since the work of reconstruction for electric traction had been in hand the yearly surpluses on the undertaking had not been large and the practice had been to carry to renewals reserve round sums (£35,000 in each of the last three years) representing practically all the available surplus. The financial results of operating a large undertaking of that kind in which the Council had already invested nearly £7,000,000, and on which it was committed to expend about £5,500,000 further, could not but be a matter of serious and constant concern to the Council. At present he felt that it would be advisable to thoroughly review the financial position and prospects of the undertaking and of the other trading ventures of the Council, and the Finance Committee were considering what steps should be taken in order that the fullest possible light might be thrown on various points connected with all those undertakings.

The discussion was then adjourned.

Electric Power Bills.—The Parliamentary committee reported on the Council's Electric Supply Bill. After dealing with the history of the Council's procedure and the recommendations of the joint committee which considered previous power bills, the committee proceed:—

"There are three bills now before Parliament affecting the proposed area of supply. None of these bills in themselves constitute, in our opinion, a satisfactory settlement of the question apart from the Council's own bill, and consequently the withdrawal of the Council's bill would postpone the solution of this most important and pressing question for an indefinite period. The Council's bill as drawn contemplates two alternative courses: the Council may either itself carry out the whole of the undertaking and raise the capital required or may assign or transfer its powers to some company or body, leaving the transferee to find the whole or the bulk of the capital and to carry on the business. We think these alternative provisions may be utilised for the purpose of securing some arrangement under which the financial risks to which the Finance committee have called attention may be avoided, and the business of supply of electrical energy be carried out by private enterprise under control of the Council; and the bill should be proceeded with with that object in view. At present we are unable to indicate the nature and extent of the arrangement which the Council may eventually enter into, but we are strongly of opinion that any such arrangement must be in the direction of providing for a cheap supply of electric power, with a sliding scale of prices and dividends and a satisfactory purchase clause for the Council with regard to the undertaking. This will necessitate certain modifications in the Council's bill, and render desirable the deletion of the clauses relating to the compulsory acquisition of the undertakings of the Metropolitan Borough Councils. As regards the transfer to the Council of the powers of purchase over the companies' undertakings which are vested in and inure to Metropolitan Borough Councils in most cases in 1931, we think these provisions should be distinguished from those relating to compulsory acquisition, and that therefore the Council might consider whether it is not advisable for the Council to possess these powers. The bill is put down for second reading in the House of Commons on May 9, and we ask the Council to decide as to the course to be taken at that stage. In combination with the Highways committee we recommend 'that the London County Council (Electric) Supply bill be submitted for second reading in the House of Commons with a view to securing an arrangement under which private enterprise undertakes, subject to control of the Council, the business of the supply of electrical energy, and on the understanding that such alterations as may be required in the bill to effect this object and to deal with any other matters of importance which may arise on the bill, will be reported to the Council for its approval as soon as possible.'"

The Hon. W. R. W. Peel, in moving this recommendation, said the committee considered that by placing the supply in the hands of a company, with the Council retaining control, they would provide an efficient and economical supply of electrical power for London. The reason they had included the outside area was that it was agreed to be essential for the cheap production of electricity that it should be generated on a large and comprehensive scale.

Mr. T. McKinnon Wood, M.P., moved to delete all the words in the recommendation after "House of Commons." He said he had no desire to stop the second reading of the bill, but he declined to tie the hands of the Council to place the matter in the hands of private enterprise.

After discussion the amendment was negatived and the recommendation adopted.

Municipal Telephony.—The accounts just issued of the Hull telephone undertaking show an excess of income over expenditure for the year 1906-7 of £1,388. 12s. 7d., compared with £403. 2s. 9d. for 1905-6. Capital expenditure during the year amounted to £7,430, bringing the total to £52,865. The revenue was £8,989 and expenses £4,842. Of this sum Post Office royalty represents £910. Instalments towards repayment of loan and sinking fund amounted to £1,281. 1s. 8d., and interest on loan, &c., £1,527. 1s. 6d.

Oldham.—The question of the charge to be made for electrical energy for power in mills, &c., has been referred to a special subcommittee for report.

Lees District Council have offered to transfer their provisional order of 1902 to Oldham, but Oldham Council have only powers to supply electricity in bulk at the boundary.

Oulton Broad.—The Oulton Broad Electricity Co. and Lowestoft Corporation have both given notice of intention to apply for a provisional order.

Post Office Appointments.—The Civil Service Commissioners have prescribed a fee of £8 to be paid by candidates attending examinations for the situation of second-class engineer in the Engineer-in-Chief's department of the Post Office.

Post Office Telegraphs.—An account has been issued showing the gross amount received and expended on account of the Telegraph Service during the year ended March 31, 1906. The gross amount received in respect of telegrams, telephone rentals, private wire rentals, &c., during the year was £4,410,269. 8s. 2d., less £544,463. 17s. 4d. paid to the submarine cable companies and £4,060. 1s. 11d. telegram money refunded, making a nett total of £8,861,745. 8s. 11d. £228,208 was received in respect to royalties from the National Telephone Co. and other licencees, and £62,423 is put down as the value of the telegraph service performed for the other public departments without remuneration. After paying annual expenses and meeting various items of the nature of capital expenditure there is a balance of expenditure over receipts of £740,823. 19s. 2½d. The total sums spent on the acquisition, construction and extension of telegraphs and telephones to March 31, 1906, was £22,298,830, the total capital expenditure on telephones being £5,750,000.

St. Albans.—The transfer of the St. Albans provisional order (1903) to the North Metropolitan Electric Power Supply Co. has been sanctioned by the Board of Trade.

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St. Pancras (London).—The borough electrical engineer (Mr. Sydney W. Baynes) has prepared a scheme for enlarging King's-road station so as to accommodate three turbines in addition to the one on order.

These further turbines are part of a scheme for a proposed concentration of generating plant at King's-road. The proposals of Mr. Baynes for the extension of the engine-room involve an expenditure of £4,800 for buildings and £400 for a travelling crane, and these have been approved by the Electricity committee.

Mr. Baynes reported that recently another turbine armature gave out and only one of the four was available for the load, making it an awkward task, with both turbines dismantled, to prevent a serious fall in pressure. To maintain the supply it was found necessary to feed the mains on the positive side of the system from the Regent's Park station, and to maintain the negative pressure from the King's-road station. Notwithstanding the intricacies and danger involved by the temporary manipulation of the plant for this purpose, the work was carried out without mishap. The repair of the armature was effected so promptly that the armature was ready to take the load on the following evening. The staff had rendered him (Mr. Baynes) valuable assistance both early and late throughout the period of stress.

The committee passed a resolution approving the action of the engineer, and of appreciation of the efficient manner in which he and the staff had grappled with their difficulties.

Southport.—The borough electrical engineer (Mr. R. S. Downe) has tendered his resignation owing to his being appointed general manager of an industrial company. Mr. Downe has been borough electrical engineer at Southport for the past six years.

Stepney (London).—Some time ago the Electric Lighting committee were asked to prepare a preliminary report on the most suitable method of meeting the future demands for electrical energy in the borough. It was agreed that the terms offered by the promoters of the County of London & District Electric Power Bill of 1905 could not now be obtained from the promoters of the present power bills, and it was thought the Council could not do better than proceed at once with the erection of another station at Blyth's Wharf. On Monday the report of the borough electrical engineer (Mr. W. C. P. Tapper) on this subject was circulated.

From this we find that the capital expenditure is estimated at £36,900, made up as follows: Buildings £6,500, generating plant £11,650, boilers and accessories £5,750, river work £6,000, coal and ash handling gear £2,000, and converting machinery £5,000. During 1909 £16,950 would have to be spent to enable Blyth's Wharf to generate continuously for supplying Osborn-street in bulk, viz., buildings £3,000, generating plant £3,000, boilers, &c., £3,450, coal-handling plant £500, converting machinery £5,000, and contingencies and engineer's charges £2,000.

Mr. Tapper's estimate of the financial result of the combined supply from Blyth's Wharf and Osborn-street as compared with a bulk supply (taking the year 1909-10) was as follows: 6,750,000 units at 1·7d, £47,812; total cost of combined supply £44.640, cost of combined supply from Bulk Co. and Osborne-street £58,639.

The Finance committeee pointed out that notwithstanding the low rates charged for electrical current, no payments had been made from the rates towards the support of the undertaking, and they saw no reason to doubt that the capital expenditure at Blyth's Wharf would prove remunerative, and therefore they approved the estimate of £54,000.

The Electric Lighting committee stated that they had decided to entrust the whole of the work to Mr. Tapper, of whose services they had the highest appreciation.

During the year ended March 31 £14,570. 19s. 7d. was expended on the electricity undertaking, bringing the total expenditure to £265,072. 6s. 1d. Off this amount £1,279. 19s. 1d. is to be written off. The total income was £36,992. 2s. 2d., an increase of £3,217. 8s. 7d., and though the annual expenses increased by £1,546. 3s. 3d., the cost per unit sold decreased from 1·07d. to 0·97d. The gross profit for the year was £15,657. 3s. 5d. 4,751,182 units of electrical energy were sold, an increase of 704,977 over the previous year. After paying interest (£8,398. 16s. 8d.) and sinking fund instalment (£4,936. 7s. 6d.), cost of temporary work (£443. 0s. 7d.), &c., the net profit was £2,125. 1s. 8d.

Stockport.—Application has been made for sanction to a loan of £12,000 for extensions of the electricity generating plant and mains.

Sunderland.—On Wednesday the Council resolved to apply for sanction to borrow £10,000 for extensions of the electric lighting mains and house services.

The Engineering Trades.—Particulars of the new arrangement between the Engineering Employers Federation and the Allied Engineering Trades Unions have been made public, and the new terms are based on the 1898 settlement.

The clauses relating to employment are in substance what they were, and employers may employ whom they please, irrespective of whether the operatives are members of a trade union or not. The unions undertake not to object to non-unionists, and the employers not to prefer non-unionists. In regard to piece-work there is a concession to the men in the shape of a guarantee of the day rate, irrespectively of piece-work earnings. Overtime and night-shift allowances are also to be made, as in the case of time work. At present, not more than 40 hours' overtime may be worked by any man in any four weeks. On behalf of the societies it was proposed to reduce this to 20 hours per man per four weeks, but after discussion it was agreed to fix the limit at 32 hours. There are important clauses dealing with the "selection, training and employment of operatives and manning of machine tools." The employers adhere to the right of employing on machines "those whom they consider best adapted to the various operations carried on in their workshops, and to pay them according to their ability as workmen." They also claim full discretion "to determine the conditions under which all machine tools shall be worked." The employers, however, agree that when they are carrying out changes in their workshops which will result in displacement of labour, consideration shall be given to the case of the workmen who may be displaced, with a view, if possible, of retaining their services on the work affected, or finding other employment for them.

The provisions for avoiding disputes have not undergone material alteration although the period between the application for and the holding of a local conference must not exceed 14 days. "There shall be no stoppage of work, either of a partial or of a general character, but work shall proceed under the current conditions until the procedure provided for above has been carried through."

The Postmaster-General and Tramway Undertakings.—Another conference of municipal tramway authorities was held in London on Friday in connection with the proposal of the Post Office to use tramway standards for the support of overhead telegraph and telephone wires.

Ald. WAINWRIGHT (Manchester) presided and about 50 local authorities were represented. A deputation, consisting of Messrs. J. M. M'Elroy (Manchester), J. Dalrymple (Glasgow), J. B. Hamilton (Leeds), A. Baker (Birmingham), and A. R. Fearnley (Sheffield) was appointed to meet representatives of the Post Office. The deputation subsequently met Sir Robert Hunter (solicitor) and Major O'Meara (engineer-in-chief), and at the conclusion of the conference the Post Office authorities practically agreed to adopt the safeguards suggested by the tramway authorities. One of these was that telegraph wires should not be placed above the level of the overhead tramway trolley wires. On other minor points a settlement was arrived at. The Post Office also acquiesced in the contention that it would be right that the Postmaster-General should become responsible for damage done as the result of Post Office wires being affixed to the tramway standards.

Subsequently, the conference of the municipal authorities was resumed and instructions were given to the Parliamentary agents to draft a clause embodying the provisions agreed upon.

Tunbridge Wells.—Last week the Council had before them a report from the Lighting committee to the effect that they had received an application from the borough electrical engineer (Mr. H. L. P. Boot) to vary the terms of his appointment, and they (the committee) recommended as follows:—

"(1) To accept the resignation by the borough electrical engineer of his present appointment; (2) to appoint Mr. H. L. P. Boot, during the pleasure of the Council, as consulting electrical engineer of the Corporation, at £350 per annum (a reduction of £150 per annum from his present salary) on the terms following: Mr. Boot to take the sole responsibility for the general management of the undertaking; Mr. Boot to advise the Council on all capital outlay and extensions that may be necessary during his tenure of office; Mr. Boot to attend the committee meetings and generally supervise the undertaking."

The recommendation was adopted in a slightly modified form.

Vienna-Budapest Electric Railway.—It is announced that a syndicate has been formed to obtain authority to construct an electric railway between Vienna and Budapest. The promoters are said to command £4,000,000 capital.

Walthamstow.—An inquiry has been held into the application of the Council for sanction to a loan of £26,295 for electricity supply.

There was opposition by ratepayers, who thought the proposed steam plant was of greater capacity than was required.

The clerk (Mr. C. S. WATSON) said the amount was made up as follows:—New plant £26,259, air compressor £96, four arc lamps £40. There was to be a steam plant. Provisional contracts had been entered into.

The electrical engineer (Mr. G. R. SPURR) said that the demand for electrical energy was increasing. They could, however, manage with plant of less capacity than was proposed.

The inquiry was, therefore, adjourned to give the Council an opportunity to reconsider the matter.

Wandsworth (London).—Wandsworth Gas Co. has suggested to the Council that, with a view of preventing the accumulation of gas in street boxes, &c., each box should be filled with light and easily removable material, and the ends of the pipes carrying the lines into the chamber sealed with plaster or clay, and the Highways committee of the Council have called the attention of the Postmaster-General, the L.C.C. and the County of London Electric Supply Co. to the matter.

Watford.—At the third sitting of the L.G. Board inquiry into the application of the Council to borrow £8,079 for the electricity department,

The inspector (Mr. H. Ross Hooper) submitted the electrical engineer (Mr. J. R. WESTON) to a lengthy cross-examination.

In reply to objections, the clerk to the Council (Mr. H. MORTEN TURNER) contended that it was not incumbent upon the Council to have a reserve fund. It was sufficient if the Council kept up their annual repayments of principal, and it would be unfair to the ratepayers of to-day to set aside a depreciation fund for the benefit of those who were to come after them. A large amount of ratepayers' money had been invested in the electricity undertaking, and the question was not now whether they should go on, but whether the money for which they now asked was not essential for the well-being of the undertaking, and whether it was probable that the ratepayers would benefit by it. In deference to the wishes

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of the inspector, they had abandoned that portion of the application relating to coal conveying plant, and the Council were considering the question of lighting new streets with gas instead of electricity. Within the last few weeks electric light had been installed in the old Parish Church, whilst that week St. John's Church was being wired, and he understood, too, that the electricity was to be installed at Oxhey Church. Added to that had to be considered the steady progress in the growth of Watford. Building operations were still going on. Having gone so far with the undertaking they could not go back, and they asked for the necessary funds to enable them to go forward.

Wireless Telegraph Litigation in America.—We have received notification from the National Electric Signalling Co., Brant Rock, Mass, U.S.A, that, in a recent decision, Judge Townsend, of the U.S. Circuit Court, Southern District of New York, has denied the motion for a preliminary injunction made by the Marconi Wireless Telegraph Co. of America *v.* the American De Forest Wireless Telegraph Co., on the ground that the latter's use of the liquid barreter and antennae infringed the Marconi fundamental patent. In denying the injunction, Judge Townsend stated :—

Prof. Ives, one of the experts for defendants, in support of his claim that defendants' device is a perfect electrical contact, quotes from the opinion of Judge Wheeler in National Electric Signalling Co. *v.* De Forest Wireless Telegraph Co., supra, as follows : "An immersion of platinum of a diameter of ·00001 of an inch to the depth of ·00002 of an inch is mentioned in the specification, 'for example,' but there is added : 'The immersion of the terminals should be such as to insure what is known in the art as a perfect contact between the terminals and the liquid.' This perfect contact appears to be the operative and material thing and the defendants' device in question appears to, and must to be of any use, have that. In that case, defendant De Forest Co., which used the detector herein complained of, was enjoined against its use, on the ground that it was a perfect electrical contact, while in this case an injunction is sought on the ground that said detector is an imperfect electrical contact."

In the suit above referred to the National Electric Signalling Co., we are informed, obtained a decision against the De Forest Co., carrying with it costs and damages and also an injunction.

Wrexham.—The borough electrical engineer (Mr. W. Sillery) has tendered his resignation owing to his having been appointed burgh electrical engineer at Partick.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Belfast.—For the year ended March 31 the total income of the electricity department was £51,171. 13s. 5d., and expenses £25,620. 12s. 7d. After paying interest on loans, sinking fund and income tax (£14,072) the net profit for the year was £11,479, against £6,691 in the previous year.

At the meeting of the Council in committee last week, the accountant (Mr. Dyer) stated that current was supplied for the tramways at cost price, and that the increase in electric traction was largely responsible for the amount of current used during the past year. It was resolved that the whole of the net profit be added to reserve, increasing this fund to £26,183. The committee are entitled to have a reserve of £28,000.

The city electrical engineer (Mr. T. W. Bloxam) said he expected the profits to go on increasing, and every effort would be made before the end of the present year to make further reductions in the charge for current.

The total output of the electricity works for the past year was 9,653,709 units. 6,536,486 units were supplied to the city tramways, and 3,117,223 were sold for lighting and power (against 2,535,094 units last year), an increase of 23 per cent. The increase in units sold for lighting was 15 per cent. and for power 36½ per cent. The total revenue for the year was £51,133 against £37,453, an increase of 36½ per cent. Revenue from sale of energy for lighting and power and motor rent amounted to £34,928, against £30,793 last year, increase 13 per cent. The average price obtained was 2·647d. per unit, against 2·857d. The cost of production had been reduced to ·635d. per unit, against ·918d. per unit for the previous year. They had a total equivalent of 270,982 8-c.p. lamps connected (including 3,596 H.P. in motors), an increase of 15 per cent. for the year. Applications had been received for a further equivalent of 16,062 8-c.p. The maximum combined load during last winter occurred on 3rd Jan., 1907, and amounted to 5,695 kw. The maximum lighting was 3,199 kw. on 4th Jan., 1907—viz., 3,000 kw. lighting, and 2,695 kw. traction. The maximum traction load occurred on Easter Monday, and reached 2,860 kw., including 286 kw. for the Cavehill Tramway.

Bolton.—The Electricity committee have allocated towards the rates £6,000 out of the profits of their undertaking, and the Tramways committee £9,000.

Burton-on-Trent.—The annual report of the Electricity department for the year ended March states that it is only possible to place £484. 1s. 4d. to renewal fund, against £1,073. 5s. 2d. last year.

Generating expenses amount to £3,704. 6s. 8d. (against £3,392. 1s. 6d.), distribution expenses £281. 3s. 1d. (against £134. 1s. 3d.), management expenses £590. 3s. 10d. (against £625. 16s. 3d.), and rent and taxes, insurance, bank interest, re-payment of loan, interest on loans, &c., £4,983. 12s. 4d. (against £4,853. 9s. 2d.) The income was £10,838. 2s. 5d. (against £10,124. 19s. 10d.) For lighting, 310,382 units were used against 311,772 units), for power and heating 260,601 units were sold and brought in £1,309 (against 103,100 units and £649 in 1906). The tramways department took 551,758 units (against 553,512). Works costs were 0·621d. per unit (against 0·874d. in 1906); the total works costs being 1·090 per unit (against 1·192 last year), and the total costs 2·127d. per unit (against 2·227d.) The equivalent of 30, 116 8-c.p. lamps is converted to the mains, compared with 28,775, and the horse power in motors to date is 475·1 (last year, 311·5); the total horse power for heating and other purposes 24·95 (17·15); the total equivalent 8 c.p. lamps for lamps and motors connected to date is 41,877 (36,662); the total maximum load, 886 k.w. (742 k.w.).

Derby.—The receipts of the electric tramways department for the year ended March 31 were £37,257. 17s. 7d., against £33,398. 13s. 3d. the previous year. Of this increase £1,369 is attributed to extra traffic caused by the Royal Show. The car-miles run were 849,248, and the passengers carried 8,501,460. The cost of running was 10½d. per mile. The year's profit is about £7,500.

Maidstone.—The accounts of the tramways department for the year ended March 31 show a gross income of £5,913. 2s. 5d., the gross profit being £1,859. 11s. 8d. After paying interest, sinking fund, &c., the net profit was £374 15s. 6d. The percentage of working expenses to receipts was 68·5, average traffic revenue per car mile 8·6d., average working expenses per car mile 6·2d., and average working expenses per passenger 0·82d.

Nottingham.—The income of the tramways department for the past year was £139,992, and the expenditure (including interest on loans and stock, contribution to sinking fund and redemption of loans) £115,348, leaving £24,644.

Out of this £17,000 has been contributed to the rates, £900 written off motor omnibus account and £6,744 carried to reserve. 40 cars have been fitted with top covers and 115 cars are now supplied with improved lifeguards. There has been no accident of a fatal character during the year. The service of motor 'buses resulted in a loss of £250, but the 'buses carried 573,646 passengers, and met a public want.

Poplar (London).—Last week the Council adopted the report and recommendations of the Electricity committee (reported in our issue of April 26) with regard to extensions of plant at a cost of £5,900.

The borough electrical engineer (Mr. J. H. Bowden) reported that the current sold during the year ended March showed an increase of 38·38 per cent. over the previous year. For private lighting 929,738 units were sold, against 817,430; power 2,423,538 units, against 1,379,620; public lighting 855,026 units, against 814,050. The net income increased from £25,640 to £30,454. For 1907-8 it was anticipated that 4,835,000 units would be sold, and the estimated net available balance was £2,550 as a contribution to reserve and working balance.

Salford.—For the year ended March 31 the traffic receipts of the Corporation tramways amounted to £232,542, and with interest on investments and miscellaneous receipts (£4,900) the total income was £237,442.

Working expenses were £142,193. The gross profit was £95,249, an increase of £13,431 over 1905-6. Interest and sinking fund charges (£40,795), rents to other authorities (£25,410) and miscellaneous items (£1,155) left a net profit to £27,889. The Tramways committee have decided to transfer £13,000 of relief of rates and to carry the balance (£14,889) to depreciation and renewals. In the report of the manager (Mr. G. W. Holford) it is stated that for the first time since the undertaking was started, no fatal accident had occurred in the running of the cars during the 12 months. They had carried over 43½ million passengers and travelled 5,268,933 miles during the period.

South Shields.—The gross profit of the electric tramways during the past year was £11,900, and after paying interest and sinking-fund charges the net profit was £4,648.

"The Electrician" in Canada.—The circulation of *The Electrician* in Canada has for many years past included a considerable number of the leading electrical engineers in the country, and most, if not all, of the principal manufacturing and supply houses. The recent changes in the postal arrangements, under which *The Electrician* can be posted to Canada for 1d. per copy, will enable us to cover a wider field in that country, and we have made arrangements by which all persons and firms engaged professionally and industrially in electrical engineering in Canada will receive copies of *The Electrician*.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Hammersmith (London) Borough Council invite tenders for supply of e.h.t. feeder, l.t. distributing mains and house service cables. Specifications from the borough electrical engineer (Mr. G. Gilbert Bell), 85, Fulham Palace-road, Hammersmith, W. Tenders to the town clerk (Mr. H. Thompson), at the Electricity Works, by 4 p.m. Friday, May 17. See also an advertisement.

Hull Electric Lighting Committee invite tenders for supply and erection of one 500 kw. high-tension continuous-current dynamo, coupled direct to a Belliss engine. Forms of tender and specifications from the city treasurer, Mr. T. G. Milner. Tenders to the Chairman of the committee, Town Hall, Hull, by noon May 23. See also an advertisement.

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NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

Sheffield Electric Lighting committee invite tenders for steam turbine, alternator, exciter, condenser and other accessories. Specifications from the general manager and engineer (Mr. S. E. Fedden), Corporation Electricity Supply Dept., Commercial-street, Sheffield. Tenders by 10 a.m. May 27. See also an advertisement.

Bedford Corporation invite tenders for supply of high and low-tension cables for 12 months. Specifications from the borough electrical engineer (Mr. R. W. L. Phillips), Cauldwell-road, Bedford. Tenders by noon 25th inst. See also an advertisement.

Lanark County Council require tenders from manufacturers of electrical generating machinery and from manufacturers of secondary batteries, for the construction and erection of one 70 kw. motor-generator, alternating and direct-current switchgear, one battery charging booster, and one battery of 282 cells. Tenders to the county clerk (Mr. Thos. Munro), County Offices, Hamilton, N.B., by May 22.

London County Council require tenders by 10 a.m. May 14 for wiring for power, lighting and bells at Westminster Technical Institute. Forms of tender from the chief engineer, Spring-gardens, S.W.

The Metropolitan Asylums Board require tenders for supply of builders', engineers', smiths', plumbers' and gasfitters' ironmongery, miscellaneous engineering stores and electrical accessories. Official forms of tender at the offices of the Board, Embankment, London, E.C., where tenders are to be sent by 10 a.m. May 15.

Acton (London) Council invite tenders for supply of direct-coupled electrically-driven turbo or centrifugal pumping machinery for sewage works, including motor pumps, automatic control apparatus, switchboard, pipework, &c. Applications to Sir Alexander Binnie, 9, Great George-street, London, S.W., by May 13.

Goole District Council is prepared to receive competitive schemes for the erection of electricity supply plant and the necessary distributing mains to supply electricity within the compulsory area of supply. Particulars from the clerk to the Council, Mr. James Wm. Johnson. Schemes by Friday, May 31.

Bristol Electrical committee invite tenders for a.c. and d.c. flame arc lamps, to be supplied and delivered within the city. Tenders to the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol, by 10 a.m. May 20.

Barnes District Council invite tenders for supply, delivery and erection of a section of steam exhaust and other piping. Tenders to the Clerk, Council House, Mortlake, by noon, May 14.

Applications are invited from contractors willing to tender for wiring the new *Morley* secondary and technical school. Applications to Mr. W. E. Putman, Town Hall, Morley, by May 13.

The Deputy Postmaster-General, *Brisbane*, Queensland, wants tenders by noon June 24 for 2 tons bolts and nuts, 500 w.i. brackets, 10,000 Acme insulators, 500 leading-in insulator screws, 3,000 Acme spindles ($\frac{3}{4}$ in.), 2,000 Acme spindles ($\frac{5}{8}$ in.), 500 No. 1 galvanised carriers, 20 miles insulated wire, 5 miles lead-covered wire, 15 tons 200 lb. galvanised-iron wire, 10 miles fancy-covered wire, 144 pints of bakers' fluid, 500 porcelain tubes, 10 cwt. sheet copper, 12 gross connecting screws, 5 tons sulphate of magnesia; 3,000 No. 2 Leclanché zincs, 500 No. 1 Leclanché zincs, 1,000 No. 2 carporous pots, 500 No. 1 carporous pots, 1 ton of sal ammoniac, 144 two-way switches, 2,000 Ericsson fuse tubes, 60 Delville microphones and fittings, 10 gross No. 2 brass terminals, and 10 gross No. 3 brass terminals. Specifications, &c., from Comptrollers of Stores, Brisbane, Sydney, Melbourne and Adelaide.

The Deputy Postmaster General, *Brisbane*, also requires tenders by noon Sept. 2 for four sections of a common battery switchboard and 650 subscribers' telephones. Specifications from the Comptrollers of Stores, Brisbane, Melbourne, Sydney and Adelaide. A deposit of 5 per cent. of the amount of the tender up to £1,000 and $2\frac{1}{2}$ per cent. for any amount in excess is required.

TENDERS RECEIVED AND ACCEPTED.

Fulham Electricity committee received 16 tenders for the annual supply of nutty slack, and the tender of J. H. Gilman & Co. has been provisionally accepted for the supply of 2,000 tons of West Hallam nutty slack at 12s. 3d. per ton (delivered alongside the Council's wharf), with option of an additional 1,000 tons at same price during the period. The committee have also accepted the tender of the Underfeed Stoker Co. for two underfeed stokers, including draught gauges, steam-tight ash pit doors and a spare motor for £523. 10s.

On the recommendation of the Highways committee, London County Council have accepted the tenders of Bolckow, Vaughan & Co. (£16,173. 17s. 6d.) for track rails, and of the Frodingham Iron & Steel Co. (£5,804. 10s.) for slot and conductor rails. The tender of Messrs. P. & W. MacLellan was nearly £500 lower than that of the Frodingham Co., but the committee pointed out that as it was proposed to sublet the manufacture to a Belgian firm the cost of inspecting and testing the rails in Belgium would involve considerable expense.

Wrexham Council have accepted the following tenders for annual stores:—

Hy. Caldwell & Co., engine-room stores; Siemens Bros. & Co., cable jointing requirements; W. H. Keys, bitumen and joint box compound; Cable Accessories Co., service cut-outs; Sloan Electrical Co., arc lamp carbons; Davies Bros., wood troughing; Lee, Howl & Co. and Acme Chemical Co., boiler solution.

The tender of Cloke's Breeze (Ltd.) has been accepted by Bermondsey Council for removing flue dust and clinker from the electricity station, &c. Flue dust (estimated quantity, 4 to 6 tons per week), 1s. 6½d. per ton; clinker (estimated quantity, 130 to 160 tons per week), 1s. 6½d. per ton.

Hackney (London) Electric Lighting committee received 13 tenders for foundations, &c., for a 1,500 kw. generating set, varying in amount from £1,629. 13s. 11d. to £2,380, and that of Abbott & Charlton at £1,641 6s. 4d. is recommended for acceptance.

Beckenham Council have accepted the tender of C. C. Wakefield & Co. for 12 months' supply of lubricating oil at 1s. 6½d. for engine oil and 2s. 6d. for cylinder oil.

Edgar Allen & Co. have obtained the contract for the supply and construction of the whole of the special track work, lay-outs, cross-overs, &c., required for the Osaka tramways.

Accrington Corporation have accepted the tender of W. T. Glover & Co. for 3,500 yds. of cable, and that of the British Insulated & Helsby Cables for three distributor pillars.

Halifax Council have accepted the tender of the Chloride Electrical Storage Co. for supply of a regulating booster at £750, and switchboard at £150.

Five tenders were received by Bermondsey Council for a voltmeter reading 400-600 volts, and that of Crompton & Co. was accepted at £5. 13s. 4d. (less $2\frac{1}{2}$ per cent.)

Salford Council have accepted the tender of R. Johnson & Co. for supply of trolley heads and accessories, and that of J. Wolstenholme & Sons for c.i. pipes for the turbo-generator.

Portsmouth Education committee have accepted the tender of T. Potter & Sons for wiring the Technical Institute at £1,199.

Hastings Corporation have, we are informed, placed an order for 51 C type time switches with Venner & Co.

St. Pancras (London) Council have conditionally accepted the tender of Crompton & Co. for two motors at £113. 14s. each.

W. J. Fryer & Co. have received an order from Woolwich Guardians for wiring the infirmary at £105.

Burton-on-Trent Education committee have accepted the tender of Barnett & Soans for wiring the Pupil Teachers' centre.

Condensing Plant.—The Mirrlees Watson Co. have recently received orders for condensing plant for various works, including surface-condensing sets for Hereford electricity works (duty 7,500 lb. steam per hour) and for the new turbine works of the French Thomson-Houston Co. at Lille (one set, duty 22,000 lb. steam per hour).

British Tenders for Foreign Contracts.—A correspondent draws attention to the fact that Copenhagen Municipality recently invited tenders in this country by public advertisement for two 3,000 kw. steam turbines, complete with electrical generators and surface condensers. Offers were received from leading manu-

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facturers in this country, the Continent and America, and some of the prices quoted were as follow :—

Brown, Boveri & Co.	Kr.362,000
Richardsons, Westgarth & Co.	380,000
British Westinghouse Co.	416,000
Burmeister & Wain	426,000
Willans & Robinson	437,000
Mather & Platt	443,000
Siemens-Schuckertwerke	508,000
Allgemeine Elektricitäts Gesellschaft	590,000

After carefully examining the merits of the various tenders and the constructive details of the turbines offered, Willans & Robinson's tender received the support of the technical adviser and of the manager of the electricity undertaking, but after prolonged discussion the municipal authorities decided to place the work with the local firm (Burmeister & Wain) in spite of the fact that their experience in the building of turbines had (it is stated) been limited to the construction of one or two turbines of smaller size. It is regarded as surprising, after inviting tenders and issuing specifications in three different languages, thereby inviting outside manufacturers to compete and to send in proposals, that so strong a preference should have been shown in favour of a local manufacturer, and it is obvious that such action on the part of Copenhagen Municipality will tend to discourage British manufacturers from competing in future for contracts in Denmark.

BUSINESS NOTICES.

Bruce Peebles & Co. announce that from May 1 the address of their Newcastle office will be Pilgrim House, Pilgrim-street, the telegraphic and telephonic addresses remaining as before (Peebles Newcastle-on-Tyne, 2620 Central). The office will, as before, be under the management of Mr. F. B. Sinclair.

The partnership between Herbert S. Wood, John N. Scott and Carl Brown (trading as H. S. Wood & Co.), electrical engineers, 3, Clarence-street, Manchester, has been dissolved so far as concerns H. S. Wood. Debts by Messrs. Scott & Brown, who continue under the old style.

Geo. Arthur Yarwood and Chas. Clements (trading as the British Rheostat Co.), 185, Deritend, Birmingham, have dissolved partnership. Debts by Mr. Clements, who continues.

John A. Haywood & Frank A. Woolley, electrical engineers, 14, New-street, Birmingham, have dissolved partnership. Particulars of debts to Mr. A. J. Cale, 14, New-street, Birmingham.

The Kevan Electric Co. (Ltd.), 88, Charing Cross-road, London, W.C., have opened a business dealing chiefly with lighting material comprising a new patent silvered-glass reflector, incandescent electric lamps, flexible and cable and Schiff carbons and carbon brushes.

BANKRUPTCIES, LIQUIDATIONS, &c.

An application was made on Tuesday for the discharge of Hugo Bock and Julius Hupfeld, patent brokers and commission agents, trading as the Trading & Industrial Association in London at 25, Victoria-street, Westminster.

Mr. E. S. Grey, official receiver, reported that the firm failed in Nov., 1904, with debts £8,029 and assets valued at £15,870, but which had realised nothing whatever. The bankrupts (both German subjects) came to this counntry in 1900 and commenced business without capital. Their first speculation was in connection with the chronophone clock, over which they expended £900 borrowed money. Another speculation was over an electric accumulator for an option on which they paid £1,000, also borrowed. Other transactions were to acquire the option to purchase a patent miner's lamp with the object of floating a company on the English market, a patent for an electric alarum bell, and the promotion of the British Automatic Alarum Bell Co. (Ltd.), &c.

The discharge was suspended for five years.

Francis Williams, electrician, 17, Orchard-street, Bemerton, Salisbury, has been adjudicated bankrupt.

In the bankruptcy of W. Francis, electrician, 17, Orchard-road, Bemerton, Salisbury, the first meeting of creditors will take place on May 16 at City-chambers, and the public examination on May 23 at the Council House, Salisbury.

Kevin C. Moran (trading as K. C. Moran & Co.), electrical engineer, 80A, Teddesley-street, Walsall, has been adjudicated bankrupt. The first meeting of creditors will take place on May 18 at the O.R.'s, Wolverhampton, and the public examination on May 30 at the County Court, Walsall.

The first meetings of creditors and contributories of the British Electric Equipment Co. (Ltd.) will be held on May 14 at 33, Carey-street, London, W.C.

Townshend's Art Metal Co. (Ltd.) is being wound up voluntarily. Mr. T. M. Attlee, 113, Edmund-street, Birmingham, is liquidator.

The W. R. Sykes Interlocking Signal Co. (Ltd.) is being wound up voluntarily for reconstruction, and Messrs. W. Ives and R. Sykes, the younger, 26, Voltaire-road, Clapham, London, S.W., have been appointed liquidators, with authority to consent to the registration of a new company with the same name.

A meeting will be held at 48, Swanston-street, Manchester, on June 10 to receive an account of the winding up of the Otto Electrical Mfg. Co. (Ltd.).

Sale by Auction.—Messrs. Wheatley Kirk, Price & Co. have been instructed by the receiver of Lionel Robinson & Co. (Ltd.), (Mr. Herbert J. Page, F.C.A.) to sell by public auction, on May 16, at 11 a.m. at the works premises, Ferry Works, Thames Ditton, Surrey, in the lots of the catalogue, the whole of the modern plant, machinery, tools, electrical instruments, stock and effects, including 15 H.P. gas engine and producer plant, 15 lathes of sliding, capstan, screw-cutting and other patterns, nine radial and other drilling machines, milling, shaving, grinding, polishing, shearing, stamping, &c., machines, electric lighting and testing installation, testing instruments, loose tools and utensils for a hundred hands, quantities of testing and other instruments, switchboards and fittings, dynamos, motors, accumulators and contents of general stores. Catalogues from Mr. Herbert J. Page, F.C.A. (Messrs. Annan, Dexter & Co.), 21, Ironmonger-lane, London, E.C., or from the auctioneers, 46, Watling-street, London, E.C., and Albert-square, Manchester. See also an advertisement.

Plant for Sale, &c.—Messrs. L. G. Tate & Co., 20, Bucklersbury, London, E.C., advertise for sale a 14 B.H.P. Crossley gas engine, an Elwell-Parker dynamo, and 50 E.P.S. 23-plate L type cells, with belting, piping and switchboard complete in running order; also 2, 5, and 7 H.P 460 volt slow-speed motors.

Mr. T. G. Slater, 47, Greenhill-road, Cheetham Hill, Manchester, advertises for sale a D'Arsonval galvanometer, Wheatstone bridge and an Ayrton bridge key.

Business for Sale.—A brassfounder's and finisher's plant, tools and stock are advertised for sale as a going concern.

"The Journal."—Part 183 of "The Journal" of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

CATALOGUES, &c.

Cables and Wires.—The India Rubber Company are sending out lists Nos. 40 and 40A, which deal respectively with electric light cables and wires and concentric and high tension cables and flexible cords. The lists are very comprehensive, and give a mass of information.

"Prescot" Specialities.—The British Insulated & Helsby Cables make a speciality of ears for trolley wires. Some details of these are given in pamphlet P41, which will be found of great interest to tramway engineers. Similarly, pamphlet P40 will prove valuable for the useful details given of "Prescot" trolley wire. The illustrations on the cover of the latter show a specimen of grooved wire with six twists in it.

Tumbler Switches.—The two-way switches of A. P. Lundberg & Sons are famous for their flexibility and ease of adjustment to various conditions of control. We have to acknowledge receipt of a special booklet from the firm, giving useful diagrams and illustrations of these switches adapted for electrolier and radiator lighting. A number of diagrams of connections are included to explain the methods of coupling up.

Carriage Batteries.—The D.P. Battery Co. (Ltd.) send their latest list Tr. 1, which is a revised price list of D.P. cells for electric carriages, for which we understand there has been a very good demand recently.

G.E.C. Progress.—Our old friend the G.E.C. electrical progress sheet is now to appear quarterly in more substantial style. The May issue, just received, deals with a variety of subjects, from type controllers to telephones. We understand that binders to conveniently keep the sheets, will be supplied free on application by customers. Other G.E.C. booklets give prices of "Angold" miniature shuntless arc lamps for continuous currents.

Hot Wire Instruments.—A very complete range of hot wire ammeters and voltmeters both for switchboard and portable use is made by Johnson & Phillips, whose latest publication gives illustrated particulars of these instruments and prices, together with details of scales.

Wattmeters.—Everett Edgcumbe & Co., 87, Victoria-street, London, S.W., have issued a sheet list describing their dynamometer type wattmeters for direct and alternate currents. These are made in standard and industrial patterns, and we learn that the error due to variations in power factor down to 0·25 does not exceed 1 per cent. either way.

"Installation News."—Unlike many new publications, "Installation News," issued by Simplex Conduits (Ltd.), has not found it

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necessary to increase its subscription rate, or to double its circulation by selecting Canada as its field of operations. The subscription remains at its previous figure, while the value and interest of the contents have appreciably approved.

Portable Tools.—A complete publication is to hand from Kramos (Ltd.), 47, Victoria-street, London, S.W., dealing with portable electric tool equipments, mono-rail transporters, brake magnets, capstan switches and other Kramos specialities.

Accessories.—A complete accessories list has just been issued by G. Straus & Co., 211, Upper Thames-street, London, E.C., which deals with electric light wires, flame arc lamps, fans, and incandescent lamps.

Telephones.—There are still numberless opportunities for the extension of the use of the telephone, and some idea of the purposes which it can serve is given in Gent & Co.'s latest publication on the subject. The chief of the specialities dealt with is the "Parsons-Sloper Secret Telephone."

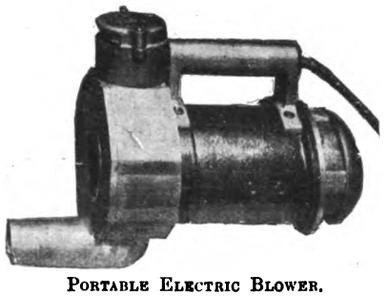
Multipolar Dynamos.—The 4th edition of Mather & Platt's publi cation on multipolar dynamos has been published, and deals with machines having an output of from 44 kw. to 1,200 kw.

Ignition Accessories.—A large budget of booklets reaches us from the Electric Ignition Co., Sparkbrook, Birmingham, and should be in the hands of every motorist.

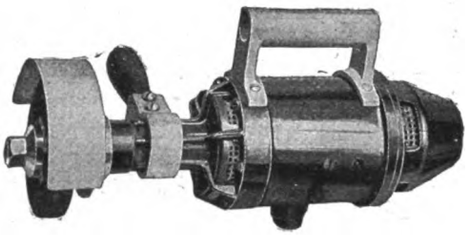
Fans.—The fan season is already opened, and we are receiving details of various makers' products in this particular. Verity's publications Nos. 525-528 give details and prices of their "Typhoon" table fans and "Aston" ventilating fans.

Electric Thermal Baths.—The vapour bath cabinet is too well-known to require description, but oil or gas heating has generally been relied upon for the production of the vapour. Messrs. O. C. Hawkes, Aldersgate-street, London, E.C., make a number of electric thermal baths which dispense with the necessity for vapourising, and depend upon air heating alone. Bulletin B5, just issued, goes very thoroughly into this subject.

The Consolidated Pneumatic Tool Co. have placed on the market two interesting portable tools. One of these is an electric blower suitable for removing dust from electrical machinery. The machine has a small motor, which can be connected to any adjacent lamp-holder by a plug adaptor. The fan and motor are direct-coupled, and the former gives a powerful blast of air at the nozzle. The weight of this machine complete is about 12 lb. The other machine is a portable grinder, made in three different sizes. The smallest size has a wheel 5 in. by ½ in., the second size 8 in. by 1¼ in., and the third (a special design for grinding up tramway rails) has a wheel 8 in. by ⅝ in. The latter is wound for 500 volts, and may be used in conjunction with special 500 volt portable drills for tramway and railway track work. These are in use on several electric tramways and railways with, we understand, satisfactory results. Both machines are illustrated herewith.



PORTABLE ELECTRIC BLOWER.



PORTABLE ELECTRIC GRINDER.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from May 1 to 6, with the ports of destination:—

Africa—Alexandria, £182 (including £169 telegraph paper); Cape Town, £108 (including £25 telegraph material); Delagoa Bay, £174; Durban, £2,870 (including £291 telegraph material and instruments); Mombassa, £95; Suakin, £152; Sudan, £493 (telegraph material). *Australasia*—Adelaide, £309; Auckland, £14; Brisbane, £35; Hobart, £653; Launceston, £458 (including £360 telegraph wire); Melbourne, £263; Perth, £17; Sydney, £1,118. *Azores*, £8. *Belgium*—Brussels, £332 (including £272 telegraph material). *Burma*—Rangoon, £46. *Canada*—Montreal, £77; Toronto, £375. *China*—Shanghai, £237 (including £37 telegraph material); Tientsin, £686 (telegraph material). *Denmark*—Copenhagen, £11 (telegraph material). *France*—Boulogne, £68. *Germany*—Bremen, £24; Hamburg, £45. *Greece*—Syra, £51 (telegraph material). *Holland*—Amsterdam, £145 (including £95 telegraph material); Flushing, £31; Rotterdam, £113 (including £17 telegraph material). *Hong Kong*, £902 (including £28 telegraph material). *India*—Bombay, £7,395 (including £24 telegraph material); Calcutta, £880 (including £150 telegraph material); Madras, £738. *Japan*—Kobe, £682; Yokohama, £611. *Malta*, £198, and 2 tons tramway material. *Mexico*—Coatzacoalcos, £2,386 (including £191 telegraph material); Salina Cruz, £195 (telegraph material). *Russia*—Kurch, £1,944. *Siam*—Bangkok, £100. *Straits Settlements*—Singapore, £475. *Sweden*—Stockholm, £2,159 (telegraph cable). *Zanzibar*, £599 (telegraph material). Total, £28,454, against £21,788 in the corresponding week last year (May 2 to 8).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

February 25, 1907.

297A/06 & 297B/06 SAYERS. Turbines. (Date applied for, 4/1/06.)†
4,574 OPPERMANN. Secondary batteries.
4,576 RAWSON & BUCHHOLTZ REVERSIBLE TURBINE SYND. Turbines.*
4,578 BREMAECKER. Controlling electric currents.*
4,583 BROOKES. (Foote & Wolfe, U.S., & Young, Germany.) Automatically opening and closing circuits.*
4,593 MARCONI & MARCONI'S WIRELESS TELEGRAPH Co. Wireless telegraphy.
4,607 SIEGFRIED. Supporting motors. (Date applied for, 3/3/06.)*†
4,609 DUNOYER. Electromagnetic compass or apparatus for determining true magnetic deviation. (Date applied for, 5/3/06.)*†
4,615 NICOLAS and GASTON DE MALHERBE. Batteries. (Date applied for, 26/2/06)*†

February 26, 1907.

4,645 PARSONS. Telephone systems and exchanges.
4,667 ALDGIERI. Electrode-contacts for sparking plugs.*
4,685 FAIRWEATHER. (Brown Hoisting Machinery Co., U.S.) Support for antennæ wires for electric masts.*
4,706 HOWORTH. (Akt.-Ges. Brown, Boveri & Cie., Switzerland.) Single-phase alternating-current motors.
4,709, 4,712 & 4,714 FESSENDEN. Signalling by electromagnetic waves.*
4,710 & 4,713 FESSENDEN. Transmission of energy by electromagnetic waves.*
4,738 ALLGEMEINE ELEKTRICITÄTS GES. Electric percussion tools. (Date applied for, 27/2/06.)*†
4,742 B.T.-H. Co. (G.E. Co., U.S.) Alternating electric current motors.
4,743 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric conductors.
4,744 B.T.-H. Co. (G.E Co., U.S.) Electric resistances.

February 27, 1907.

5,893A/06 B.T.-H. Co. (G.E. Co., U.S.) High-tension electric switches. (Date applied for, 10/3/06.)†
4,751 TYRER. Automatically operating points of tramways.
4,758 DAVIS & PEARCE. Electric light fittings.
4,761 WIGNALL. Brakes for tramway vehicles.
4,764 DAVIS. Electrical apparatus for firing explosion charges.
4,772 PARSONS, SIBLEY & WEAVE. Automatic telephonic burglar alarm.
4,782 BROADBENT. Switches.
4,783 BROADBENT. Transmission of power.
4,799 POULSEN. Wireless telegraphy.*
4,801, 4,802 & 4,809 POULSEN. Signalling in wireless telegraphy.*
4,814 SIEMENS & HALSKE A.-G. Filaments from tungsten or mixtures thereof with other metals. (Date applied for, 10/3/06.)*†
4,828 BERLAND. Prepayment electric meters. (Date applied for, 10/7/06.)*†
4,831 FETT. Electrical alarm apparatus.
4,832 CHRISTENSEN. Voltaic cells.*
4,833 B.T.-H. Co. & GARTON. Regulation of electric motor-generator sets.

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

2,019 SULLIVAN. Electric relays and recorders.
2,067 BERRY. Construction of electromagnets.
4,606 CHADBURN'S (SHIP) TELEGRAPH Co. & GRANT. Ships' telegraph apparatus.
6,651 MATHER & PLATT, CHORLTON & SMITH. Dynamo-electric machines.
6,690 LEITNER. Regulating circuits.
13,413 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric apparatus.
14,697 LATOUR. Single-phase alternating-current series motors. (Date applied for, 28/6/05.)†
19,639 SIEMENS BROS. & Co. (Siemens & Halske A.-G.). Electric semaphore signals.
20,233 FELTEN & GUILLEAUME-LAHMEYERWERKE A.-G. Compensated single-phase alternating-current machines. (Date applied for, 2/10/05.)
21,308 EVANS. Fire-preventing device for electric installations.

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21,675 HUBBELL. Incandescent lamps.
22,035 WENGELIN. Electric transporting devices operating with solenoids.
22,137 GILLMOR. Self-locking wedged railway or tramway rail joint.
22,342 MIDDLETON & MIDDLETON. Insulating covering for the couplings or terminals of cables.
22,605 SIEMENS-SCHUCKERT-WERKE. Alternating-current commutator machines having compensation windings. (Date applied for, 13/6/06.)
22,606 PRESTED. Tremblers for induction coils.
22,690 GELPKE & KUGEL. Turbines, turbo-compressors, turbine fans, &c.
22,873 RAWSON. (Gerard.) Attaching an electric lead to a dynamo brush.
23,075 RAWORTH & RAWORTH. Controllers for electric vehicles.
23,309 BIRNBAUM (Telephon Fabrik A.-G. vorm. J. Berliner). Combined intercommunication and exchange telephone system.
23,380 ATKINSON & CHURCHMAN. Variable candle-power incandescent lamps.
23,531 KLEINSTEUBER. Production of metal-lined screws in insulators. (Date applied for, 29/12/05.)†
23,569 JANSSEN. Electric pedal for railways.
24,078 SKELTON & WARE. Binders for telephone switchboard cords.
24,346 MEHLHARDT & SCHÜSSLER. Safety fuses for electric circuits.
24,756 THEWLIS. Electric railways and tramways.
25,229 ELECTRICITÄTS A.-G. VORM. SCHUCKERT & Co. Enclosing boxes for switches. (Date applied for, 10/11/05.)†
27,178 AITKEN. Telephone transmitters.
27,601 PREDIGER. Incandescent arc lamps. (Date applied for, 4/12/05.)
28,101 SIEMENS-SCHUCKERTWERKE GES. Insulation of overhead conductors for electric railways and tramways. (Date applied for, 30/5/06.)
28,260 HOLMAN. Telephonic apparatus for divers.
28,960 HIORTH. Electric induction furnace with electrodes. (Date applied for, 2/6/06.)
28,961 HIORTH. Operating electrical smelting furnaces. (Date applied for, 6/11/06.)
29,616 HOPFELT. Incandescent lamps containing mercury vapour. (Date applied for, 16/1/06.)

1907 SPECIFICATION.

1,597 DAVIS & HICKS. Car steps. (Date applied for, 21/5/06.)

COMPANIES' MEETINGS AND REPORTS.

Willans & Robinson (Ltd.)

At an extraordinary meeting held on Friday last the resolution for the reduction of the company's capital, which was passed at meetings held on April 9, was submitted for confirmation. Mr. MARK ROBINSON presided, and said that, added to the unanimity shown at the meetings on April 9, the number of proxies which had been sent in to the directors showed an extraordinary figure. The greatest possible number of votes was 133,000 and they had received just upon 100,000. Considering the large number of shareholders abroad who could not be communicated with at short notice, he considered this was strong evidence of the general agreement among the shareholders in favour of the resolution. Having read the resolution and indicated the alterations that would be necessary in the articles of association, he put the resolution to the meeting. This was seconded by Sir GILBERT E. CLAYTON EAST and carried nem. con. A cordial vote of thanks to the chairman and directors for having carried the scheme through was proposed by Mr. HOLLAND and seconded by Mr. TUSTIN and carried unanimously. The CHAIRMAN having replied, the proceedings terminated.

AUCKLAND ELECTRIC TRAMWAYS CO. (LTD.)—The chairman (Mr. C. G. Tegetmeier) stated at the meeting on Tuesday that with the exception of a short extension of about ½ mile opened for traffic in August, they had been working the same route mileage as in 1905, and their traffic receipts had increased from £121,879 to £130,336, an average of approximately £6,800 per route mile, and an increase of about £300 per route mile. They carried over 21,000,000 passengers, an increase of about 1,300,000. For the first four months of this year they had carried 300,000 more passengers, and had taken in receipts £1,800 more than in the corresponding period of last year. Their capital expenditure for the year amounted to £9,768, bringing the total to £592,992. In a few months they expected to have a total of 72 cars, which would be, they thought, sufficient for the service. The important question of the amount to be set aside for depreciation and renewals had been considered by the Board. He did not think there had been sufficient experience of electric traction to enable them to say with any exactitude what proportion of the receipts or of the amount per car-mile run should be set aside annually to meet renewals and depreciation, as distinct from ordinary expenditure on repairs and maintenance, but it was obvious that provision for that purpose must be made before the net profits available for distribution could be accurately stated. The amount of such provision must necessarily depend upon the particular circumstances of each undertaking. Their system at Auckland was worked to a high degree of its capacity, and the wear and tear upon all parts of it was correspondingly great. Last year they spent £16,915 on ordinary repairs and maintenance out of revenue. They also spent £865 on permanent way renewals, which had been charged to depreciation. During the present year the account would be charged with considerable expenditure in respect of the reconstruction of track. Since the close of the year new capital had been raised by the issue of £50,000 in 6 per cent. preference shares of £1 each, a considerable portion of which was needed for extensions. The cost of the new cars and of the increase in the power-station plant from 1,525 kw. to 2,125 kw., further items of capital expenditure, they would have to meet during the year. The Board had been fortunate in securing the services of Mr. J. J. Walklate, now on his way to Auckland, to take the position of general manager and engineer of the company, in place of Mr. Hansen, resigned.

BUENOS AYRES & BELGRANO ELECTRIC TRAMWAYS CO. (LTD.)—The chairman (Mr. J. B. Concanon) stated at the meeting on Tuesday that the results of the year's working were disappointing. The total receipts showed an increase of £10,842, but the total expenditure was greater by £15,853. The agreement for the sale of the undertaking to the Compagnie Generale de Tramways de Buenos Ayres was approved.

EASTERN TELEGRAPH CO (LTD.)—The report of the directors for the *three months* to Dec. 31 last will be presented to the seventieth ordinary general meeting on May 14, and shows that the revenue for the period amounted to £326,621. 12s. 2d., from which are deducted £101,673. 16s. 2d. for ordinary expenses and £15,270. 5s. 2d. for expenditure relating to maintenance of cables, depreciation of spare cable, sundry differences in exchange and income tax payable abroad, leaving £209,677. 10s. 10d., added to £117,089. 16s. 6d. brought forward, making together £326,767. 7s. 4d. After providing for income tax in England, interest and preference dividend, absorbing in all £42,014. 18s. 8d., there is a balance of £284,752. 8s. 8d., out of which the directors have placed £3,500 to reserve for maintenance ships and £150,000 to general reserve. The directors now recommend a final dividend on the ordinary stock of 1½ per cent. and a bonus of 2 per cent., amounting together to £130,000, both payable 15th inst., tax free, and making, with previous payments on account, a total distribution of 5¾ per cent. for the *nine months* ended Dec. 31, 1906. £1,252. 8s. 8d. is carried forward.

EASTERN EXTENSION AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—The report of the directors for the half-year to Dec. 31 last will be submitted to the sixty-seventh half-yearly ordinary general meeting on the 15th inst., and shows that the gross receipts amounted during the period to £296,393. 18s. 2d., against £317,100. 1s. 3d. in the corresponding half-year of 1905. Working expenses (including £12,854. 15s. 7d. for maintenance of cables) absorbed £139,549. 9s. 7d. against £135,597. 8s. 8d., leaving £156,844. 8s. 7d. From this is deducted £3,410. 14s. 5d. for income tax in England and donations to China relief funds, and £15,048 for mortgage debenture interest, leaving as net profit for the half-year £138,385. 14s. 2d. Added to £88,958. 15s. 3d. brought forward, making £227,344. 9s. 5d. One quarterly interim dividend of 1¼ per cent. has been already paid for the half-year, and it is proposed to distribute another of like amount on 16th inst., making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year 1906. £75,000 has been transferred to general reserve, and £17,344. 9s. 5d. is carried forward.

The company's New Zealand and China cables have been partially renewed during the past year, and the cost (£44,160) has been charged against general reserve. With a view to further improving telegraphic communication with the Far East, the directors have obtained a concession from the Dutch Government for the laying and working of a submarine cable between Java and the Cocos Islands, which communication is expected to be opened towards the end of the current year, and will provide an alternative route for the company's traffic.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—It has been decided to alter the date of the financial year to May 31 instead of April 30. In addition to the final dividend on the ordinary shares 8d. per share will be distributed in respect of the month of May, representing one-third of the interim dividend of 2s. usually paid in the first quarter of the New Year.

MIDLAND ELECTRIC CORPORATION FOR POWER DISTRIBUTION (LTD.)—The report for 1906 submitted at the meeting last week stated that the gross revenue had increased from £13,646 to £20,387, and the debit had been reduced from £14,632 to £11,392. During the year an additional sub-station at Darlaston had been built and fully equipped, whilst another at Willenhall was in course of erection. Mr. Thomas Parker and Mr. G. Crosland Taylor had resigned from the board owing to pressure of private business, and Mr. G. H. Nisbett had been elected a director.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—At the meeting on Monday Mr. L. B. Schlesinger said the progress of the undertakings in which the company was financially interested had been satisfactory. The profit on the Musselburgh tramways was sufficient to pay the debenture interest and preference dividend, with a substantial amount to reserve, in spite of the fact that the earning power of the electric lighting portion of the undertaking was not yet fully developed. The extension of the line to Port Seton had been delayed by Musselburgh Council, but the chairman of the Standing Orders committee dispensed with Musselburgh's consent, and at the inquiry in Edinburgh last week the committee passed the order on fair terms. Portions of the Torquay and of the Mexborough and Rawmarsh tramways were now opened, and the traffic receipts were entirely satisfactory. They were making good progress with the construction of the Rhondda tramways, and hoped to have the work completed towards the end of the year. They had made arrangements to take electric current from the South Wales Electrical Power Distribution Co., but that company was not now in a position to give a supply owing to financial troubles, and they would therefore have to build their own power station. Their consulting engineer stated that the saving in the price of current would more than compensate for the extra capital expenditure to be incurred. They had secured concessions for tramways in West Yorkshire, Folkestone, Sandgate and Hythe, and the city of Oxford. Under their arrangement with the Dolter Electric Traction (Ltd.) they were the sole contractors for laying the Dolter surface

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contact system for a certain period. The system is laid under their guarantee at Mexborough, Torquay and Hastings, and, subject to its working satisfactorily, it would no doubt be chosen for Folkestone and Oxford, where the overhead system was not to be permitted. They had secured a contract for a tramway between Dewsbury and Ossett, the capital to be provided by the local authorities.

PERTH (W. AUSTRALIA) ELECTRIC TRAMWAYS CO. (LTD.)—At the meeting last week Mr. A. H. P. Stoneham, after referring to the satisfactory year's working, said that, owing to the state of the money market, they had expended upwards of £22,000 out of the profits in extensions, and had paid £1,100 income tax upon it, although they had not touched a single penny of this £22,000. The question of capital expenditure and of carrying out extensions was receiving attention. They had originally intended to build 17 miles, but were now operating 26 miles, and he had no hesitation in saying that the principal factor in making their success was building the first extra 2¾ miles into the suburb of Subiaco, and that their subsequent success had been obtained through the suburban extensions made during the last four years, during which time the profits had increased 350 per cent.

READING ELECTRIC SUPPLY CO. (LTD.).—The directors' report for the year ended Dec. 31 last shows total capital expenditure £159,110. The issued and paid-up capital is £144,000. The revenue for 1906 amounted to £14,529, and the expenditure, including £2,200 written off to depreciation, was £9,401. The balance available on the year's operations is £5,966, and the directors recommend a dividend of 4 per cent., tax free, on the ordinary shares for the year. The reduction in charge for electrical energy, which came into operation at the beginning of the year, represents a concession to consumers of over £2,500, and to this is due a slight drop in the dividend for the year owing to decreased revenue. The directors are satisfied that the reduction in the charge was a wise one, and will have a good effect on the development of the business. During the year there was an increase in lamp connections equal to 7,687 8 c.p., bringing the total connections to the equivalent of 99,033 lamps, including 1,299 H.P. for motors.

SUBMARINE CABLES' TRUST.—The revenue for the financial year to April 15 amounted to £25,277. 11s. 4d., and the expenses to £1,162. 7s., leaving £24,115. 4s. 4d., to which is added £114. 15s. 10d. from last account, making an available balance of £24,230. 0s. 2d. After providing £18,627 to meet payment of coupons, £5,149. 8s. has been transferred to redemption fund, leaving £453. 12s. 2d. to be carried forward. During the year 43 certificates have been redeemed by purchase in the open market with the surplus funds of the Trust.

WEST AFRICAN TELEGRAPH CO. (LTD.)—The directors' report for the year to Dec. 31 states that the revenue amounted to £66,158. 7s. 7d. From this is deducted £15,506. 4s. 10d. for ordinary expenses and £9,224. 1s. 10d. for expenditure relating to maintenance of cables, leaving £41,428. 0s. 11d., added to £1,510. 11s. 7d. brought forward. £30,000 has been transferred to general reserve, an interim dividend of 2 per cent. (tax free) absorbed £4,621. 16s., and the directors now recommend a final dividend of 2 per cent. (tax free), making 4 per cent. for the year. £2,155. 1s. 5d. is carried forward.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—The directors' report for the year ended Dec. 31 last states that the gross receipts amounted to £68,048. 3s. 8d., against £50,808. 17s. 11d. in 1905. Working expenses were £34,173. 14s. 3d., compared with £31,114. 6s. 2d. After providing £6,000 for debenture interest and £800 for interest on income bonds there remains £27,074. 9s. 5d., added to £1,661. 6s. 4d. brought forward, making £28,735. 15s. 9d. Out of this £22,000 has been placed to general reserve and £2,000 to maintenance ship's reserve, and the directors recommend a dividend of 2½ per cent., tax free, leaving £1,922. 15s. 9d. to be carried forward.

WEST INDIA & PANAMA TELEGRAPH CO. (LTD.)—The report for the six months ended Dec. 31 states that the amount to credit of revenue is £34,203. 9s. 7d., against £28,031. 13s. 9d. for the corresponding half-year of 1905. Expenses were £21,611. 19s. 7d., against £23,231. 10s. 10d., leaving £12,591. 10s., added to £1,547. 10s. 6d. interest on investments and £312. 16s. 8d. from last account, making £14,451. 17s. 2d. Payment of 8s. per share on the first preference shares, being 2s. balance of arrears and 6s. dividend, six months to Dec. 31, absorbed £13,825, leaving £626 to carry forward. The traffic receipts for the six months show an increase of £5,460. 19s. 1d. compared with the corresponding period of 1905.

The shareholders will remember that in May, 1902, the Dominica–Martinique and Martinique–St. Lucia cables were interrupted and partly destroyed by the eruption of Mont Pelé, Martinique, and that, owing to the subsequent volcanic disturbances, it was thought desirable to postpone the work of repairing them. The directors now report that in March last the work of restoration was effected, the two cables being joined up into one between Dominica and St. Lucia, instead of being landed at Martinique. The cost will appear in the next half-yearly accounts. The completion of this work re-establishes the duplication of the company's cables between Cuba and Trinidad. The disastrous earthquake in January last in Jamaica destroyed the company's office and several miles of the landlines in and near Kingston. Fortunately the staff, with one exception, escaped personal injury, and owing to their prompt and energetic action telegraphic communication was re-established within a few hours. A temporary office was opened at Bull Bay, a few miles outside the town and beyond the limit of the devastated area, thus affording the governor and public of Jamaica the only telegraphic means of communicating with the rest of the world at the time of the catastrophe and during the events which followed. The Jamaica–Colon cable was also interrupted by the earthquake, and has since been repaired. Fortunately, the company's four cables which land at the eastern end of the island were uninjured. Telegrams relating to the Mansion House Relief Fund were transmitted free of charge over the cables of this and connecting companies. Certain losses have been sustained by the staff in Kingston owing to the partial destruction of their homes, and the shareholders will be asked to sanction payment of them.

WESTERN TELEGRAPH CO. (LTD.)—The report of the directors for the half-year to Dec. 31, 1906, states that the revenue for the period amounted to £340,687. 3s. 6d. and working expenses to £128,094. 13s. After providing £16,000 for debenture stock interest and £3,415. 16s. 1d. for income tax, there is a balance of £193,176. 14s. 5d., added to £2,663. 4s. brought forward, making £195,839. 18s. 5d. First and second interim dividends, amounting to £62,379, have been paid, and after transferring £100,000 to general reserve, £5,000 to maintenance ships' reserve, £10,000 to marine insurance fund, and £10,000 to land and buildings depreciation fund, there is a balance forward of £8,460. 18s. 5d.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

FORS ACCUMULATOR CO. (LTD.) (93,192.)—Reg. May 1, capital £10,000 in £1 shares, to acquire patent No. 17,238, 1905, for improvements in electrodes for secondary batteries, and the benefit of applications for patents for other inventions relating to improvements in batteries and certain trade-marks relating thereto, to adopt an agreement with H. F. Joel, and to carry on the business of electrical engineers, manufacturers of and dealers in accumulators and electrical appliances of all kinds, &c. Reg. office, 110-111, Strand, London, W.C.

INTERNATIONAL WORKS CONSTRUCTION CO. (LTD.) (93,176,)—Reg. April 30, capital £200,000 in £1 shares, to construct, improve, develop, work and control any tramways, railways, sidings, canals, wharves, factories, electric works, &c., to acquire running powers, rights or easements over any railway or tramway, to carry on the business of an electric light and power company, &c.

STATUTORY RETURNS.

BRITANNIA ELECTRIC LAMP WORKS (1905) (LTD.)—Return to April 11 (filed April 22) gives capital as £25,000 in 10,000 preference and 15,000 ordinary shares of £1 each, of which 9 preference and 15,000 ordinary have been taken up. £1 per share has been called up on 9 preference and 250 ordinary, and 12s. 6d. per share on 1,000 ordinary, and £812. 10s, has been paid. Mortgages and charges, £200.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—In return to March 13 capital is £400,000 in 14,000 ordinary and 6,000 preference shares of £5 each, of which 49,436 ordinary and 6,000 preference have been taken up. £5 per share has been called up on 37,770 ordinary and 6,000 preference and £218,850 has been received. £58,330 is considered as paid on 11,666 ordinary shares. Mortgages and charges, £175,000 debenture stock.

LONDON ELECTRIC SUPPLY CORPN. (LTD.)—According to return to March 7, capital is £1,050,000 in 200,000 ordinary shares of £3 each and 90,000 preference shares of £5 each, of which 111,000 ordinary and 69,840 preference have been taken up. £3 per share has been called up on 11,000 ordinary and £5 per share on 69,840 preference and £682,360 has been received, including £160 paid on 160 forfeited shares. Mortgages and charges, £374,395.

SCARBOROUGH ELECTRIC SUPPLY CO. (LTD.)—The capital in return to March 7 is £100,000 in £10 shares, all of which have been taken up and paid for in full. Mortgages and charges, nil.

SOUTH LONDON ELECTRIC SUPPLY CORPN. (LTD.)—Return to April 9 gives capital as £325,000 in 65,000 shares of £5 each, all of which have been taken up and paid for in full. Mortgages and charges nil.

MORTGAGES AND CHARGES.

SUPPLIES (LTD.)—Issue on April 17 of an £800 5 per cent. debenture, part of series created same date, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (May 9).—Bank rate 4 per cent. (since April 25, 1907) Price of silver 30d. per oz. Consols $85\frac{5}{16}$—$85\frac{6}{16}$ for money, $85\frac{5}{16}$—$85\frac{7}{16}$ for account; 2½ per cent. annuities 83½—84. Consols Pay Day, June 3; Stocks and Shares Continuation Days, May 13 and 28, Ticket Days, May 14 and 29; Pay Days, May 15 and 30; Mining Share Carry-over Day, May 10.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—Mr. H. R. Beeton has been appointed a director of this company.

DEUTSCHE UBERSEEISCHE ELEKTRICITATS GESELLSCHAFT.—A dividend of 9½ per cent. has been declared for 1906, against 9 per cent. in 1905

MARKET DRAYTON ELECTRIC LIGHT & POWER CO. (LTD.)—At the end of 1906 the equivalent of 8,772 8 c.p. lamps was connected to the mains. The profit on the year's working was £534. 17s. 1d.

SAO PAULO TRAMWAY LIGHT & POWER CO. (LTD.)—The gross earnings for 1906 were $2,018,703. It is expected that during the present year further contracts for power will be concluded, calling for an additional 4,000 H.P.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 1	1,252	+ 5	48	65,980	+ 1,756
Airdrie	April 25	213	- 3	16	3,585	- 7
Anglo-Argentine	May 6	17,395	+ 1,703	18	295,625	+ 25,343
Ashton-under-Lyne Corp	,, 4	366	+ 71	6	2,322	+ 340
Ayr Corporation	,, 4	240	+ 38	51	14,326	- 46
Baker St. & Waterloo Ry.	,, 4	2,500	+ 1,086	8	18,585	+ 6,696
Barnsley	April 25	157	+ 19	16	2,573	- 70
Barrow	,, 25	218	+ 15	16	3,577	- 13
Bath Electric Trams, Ltd.	May 1	714	+ 65	18	12,203	- 62
Birkenhead Corporation	,, 5	1,038	- 57	...	...	...
Birmingham Corporation	April 27	5,643	...	5	27,985	...
	May 4	5,943	...			
Birmingham & Mid.	April 19	707	...	15	11,561	...
Blackburn Corporation	May 1	961	+ 88	§5	6,124	+ 488
Blackpool Corporation	,, 2	486	+ 41	5	3,166	- 882
Blackpool and Fleetwood	,, 4	387	+ 79	5	2,277	- 152
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 6	2 211	+ 296	5	10,568	- 317
Bournemouth Corporation	,, 1	1,511	+ 126	¶4	7,581	- 134
Bradford Corporation	,, 4	4,426	+ 229	5	22 489	+ 138
Brighton Corporation	,, 5	774	- 43	5	4,164	- 457
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 4	4,735	+ 58	12	56,466	- 291
Buenos Ayres & Belgrano	April 28	3,763	+ 192	17	63,991	+ 4,315
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	May 4	1,160	- 2	5	4,590	- 268
Burton Corporation	,, 5	270	- 24	5	1,362	- 166
Bury Corporation	April 28	931	...	4	3,807	...
Calcutta Tramways Co.	May 6	R15,376	‡ R1,719	18	R210,015	+ R5,551
Camborne-Redruth	,, 4	119	+ 18	18	1,965	+ 58
Cardiff Corporation	,, 4	1,945	+ 68	5	9,944	+ 29
Cavehill	April 25	67	+ 8	16	1,116	+ 25
Central London Railway	May 4	6,089	- 741	18	111,540	- 11,281
Chatham & Dist. Lt. Rys.	...	...	...	...	...	...
City & South London Rly.	,, 5	2,905	+ 208	18	53,147	+ 857
City of Birmingham	April 25	2,557	...	15	43,581	...
Colchester Corporation	May 1	181	- 9	...	...	...
Cork Electric Trams Co.	,, 2	449	+ 25	18	7,373	- 142
Croydon Corporation	,, 3	1,329	+ 13	‡5	6,556	- 534
Devonport & Dist. Trams	April 25	419	+ 9	16	7,111	+ 103
Dover Corporation	May 4	192	- 9	5	1,045	- 114
Dublin & Lucan Railway	,, 3	99	+ 4	18	1,736	- 17
Dublin United	,, 3	5,162	+ 303	†18	84,461	+ 2,847
Dudley Stourbridge	April 25	753	+ 32	16	12,925	- 159
Dundee Corporation	May 1	1,070	+ 89	58	51,686	+ 7,266
East Ham Council	,, 4	877	+ 151	5	1,345	- 223
Exeter Corporation	,, 3	279	+ 39	‡5	1,483	+ 117
Falkirk and District	,, 1	270	...	5	1,150	...
Gateshead & Dist. Trams	April 25	918	+ 73	16	15,855	+ 487
Glasgow Corporation	May 4	17,270	+ 1,326	48	818,108	+ 65,937
Glossop	,, 4	136	+ 6	18	2,394	+ 63
Gravesend—Northfleet	April 25	223	+ 20	16	3,586	+ 104
Great Northern & City Rly.	May 4	1,833	+ 70	18	33,135	+ 53
Gt. Northern, Piccadilly, &c.	,, 4	4,205	...	18	68,589	...
Greenock & Port Glasgow	April 25	640	- 27	16	9,962	+ 63
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 25	251	+ 8	16	4 107	- 252
Hastings Elec. Trams Co.	May 3	788	+ 178	18	14,726	...
Hong Kong	...	...	...	...	...	...
Huddersfield	,, 4	1,448	+ 119	5	7,750	+ 422
Hull Corporation	,, 4	2,395	+ 282	5	11,409	+ 336
Ilford District Council	,, 4	450	+ 6	5	2,360	- 177
Ilkeston District Council	,, 1	121	+ 12	5	679	+ 90
Ipswich Corporation	,, 4	349	- 14	5	1,813	- 143
Isle of Thanet Co.	,, 4	342	- 30	31	8,989	+ 142
Jarrow	April 25	118	...	16	1,790	...
Keighley Corporation	May 2	147	+ 17	44	6,602	+ 515
Kidderminster & District	April 25	92	+ 2	16	1,560	- 73
Kilmarnock Corporation	May 4	145	+ 4	51	7,984	+ 118
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 2	1,103	+ 288	18	18,628	+ 3,645
Lancashire United	,, 1	1,126	+ 361	§18	19,961	+ 5,438
Leamington	April 25	131	- 11	16	2,261	- 116
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	May 4	2,138	+ 38	18	37,587	+ 210
Leith Corporation	,, 4	178	+ 33	§51	25,658	+ 6,341
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 5	1,525	+ 114	18	28,248	+ 160
Liverpool Corporation	April 27	10,515	+ 297	17	176,268	+ 2,283
London County Council	,, 27	28,996	+ 1,260	4	115,442	+ 10,647
London United	May 3	5,815	+ 378	†18	96,972	+ 2,644
Lowestoft	,, 4	110	+ 23	31	4,723	+ 610
Maidstone Corporation	,, 4	103	+ 9	5	521	- 10
Manchester Corporation	,, 4	13,620	+ 1,394	5	68,046	+ 5,501
Mersey Railway	,, 4	1,814	+ 166	18	32,947	+ 1,417
Merthyr	April 25	185	+ 6	15	3,269	+ 191
Metropolitan Dist. Railway	May 5	8,037	- 64	18	140,993	- 2,572
Metropolitan Elec. Trams	April 26	3,954	+ 814	16	64,918	+ 11,632
Middleton	,, 25	301	+ 21	16	5,185	+ 59
Nelson Corporation	May 4	131	- 1	6	861	+ 79
Newcastle-on-Tyne Corp.	,, 4	4,035	+ 272	5	19,979	- 176
Newport (Mon.)	,, 4	601	+ 40	5	3,207	+ 140
Northampton Corporation	,, 3	390	+ 9	‡5	1,966	- 63
Oldham, Ashton & Hyde	April 25	561	+ 71	16	9,454	+ 611
Oldham Corporation	May 5	1,871	+ 208	6	11,650	+ 1,204
Perth (N.B.) Corporation	,, 1	131	+ 8	50	7,697	...
Perth (W.A.) Elec. Trams	,, 3	1,426	- 102	18	26,867	- 366
Peterborough	April 25	103	+ 2	16	1,788	+ 10
Pontypridd District Conn.	...	...	...	...	...	...
Portsmouth Corporation	May 1	1,778	+ 203	5	9,133	- 234
Potteries	April 25	1,772	+ 18	16	29,591	+ 256
Preston Corporation	May 1	684	+ 61	5	3 643	+ 161
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 2	549	+ 341	‡5	2,633	+ 573
Rothesay	April 25	102	- 34	16	1,383	+ 40
Salford Corporation	May 6	4,494	+ 338	5	23,049	+ 118
Sheerness	April 23	49	- 4	16	806	- 21
Sheffield Corporation	May 5	5,455	+ 462	6	32,234	+ 1,620
Singapore Trams	,, 4	$9,794	+ $1,496	5	$50,327	+ $7,839

(a) These comparisons are with the corresponding period last year. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days. ¶ Plus 3 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	May 1	277	- 13	5	1,416	- 139
Southport Tramways	April 25	213	- 13	16	3,851	- 387
South Metropolitan	,, 25	689	...	16	11,364	...
South Staffs	,, 25	837	+ 141	16	14,201	+ 1,040
Stalyb'dge, Hyde, &c., Jt. Bd	May 4	786	+ 170	5	3,796	+ 128
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 5	1,385	+ 149	5	6,675	- 78
Sunderland and District	,, 1	461	+ 145	18	7,328	+ 912
Swansea Trams	April 25	770	- 6	16	13,015	+ 329
Swindon Corporation	May 1	153	- 8	5	851	- 115
Taunton	April 25	40	- 2	16	646	- 50
Tynemouth and District	,, 25	172	- 23	16	2,722	- 329
Tyneside Trams Co.	May 1	408	+ 53	18	7,196	+ 610
Victoria, Elec. Supply Co. of	March 31	1,070	+ 219	1	1,070	+ 219
Wallasey District Council	May 4	761	+ 59	5	3,847	+ 67
Walsall Corporation	,, 4	454	- 28	18	8,345	- 444
Warrington Corporation	,, 2	369	+ 22	5	1,883	+ 80
West Ham Corporation	,, 2	2,178	+ 166	5	11,835	+ 530
Weston-super-Mare	April 23	63	- 23	16	714	- 28
Wolverhampton Co.	,, 25	389	+ 40	16	6,759	+ 85
Wolverhampton Corpn.	May 1	778	+ 20	16	13,359	...
*Worcester	April 25	249	+ 4	16	3,981	- 101
Wrexham	,, 25	90	+ 11	16	1,568	- 24
Yorkshire W.R. Trams	May 5	1,110	+ 345	18	19,251	...
Yorkshire Woollen District	April 25	927	+ 134	16	14,946	+ 941

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., May 8.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to May 8. Highest.	Business Week to May 8. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	Anglo-Argentine Ord. Shares	7 7/16—7 11/16	5 6 0	Ap, Oct	7 13/16	7 11/16
5	2/3	Do. 5½ per Cent. Cum Pref.	5 3/4—6	4 12 0	..	5 15/16	5 11/16
St.	6¾	Do. Permanent 6% Deb. Stock	133 —136	4 8 8	..	134½	..
St.	5¾	Auckland Elec. Trams. 5% Deb. (red.)	104 —107	4 13 6	..	105½	104
5	..	Brisbane Electric Trams. Invest. Ord.	2¼—2¾	3 15 0	..	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	4¼—5¼	4 18 9	..	5	4 13/16
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	93 —102	4 8 0	..	..	..
St.	7¾	†British Columbia El. Ry. Df. Ord.	1·3 —127	4 14 3	..	..	..
St.	5¾	Do. Pref. Ord. Stock	106 —111	4 10 0	..	109	..
St.	5¾	Do. 5% Cum. Perp. Pref. Stock	102 —1 6	4 14 3	..	104⅞	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	99 —10 ⅞	4 8 0	..	100⅜	..
100	4½%	Do. Vancouver Power Debs.	102¼—1 4½	4 6 0	..	104½	..
5	3/0	Buenos Ayres & Belgrano Ord.	3½ - 4	3 15 0	..	3 15/16	3 13/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref	5 —5½	5 9 0	..	5⅝	5⅜
5	3/0	Do. "B"	4¼—5¼	5 11 6	..	5 1/16	..
St.	5¾	Do. 5 per Cent. Debs.	105 —115	4 7 0	..	..	..
St.	5¾	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	..	102½	..
St.	5¾	Buenos Ayres Elec. Trams. (1901) Ltd.	98 —101	4 19 0	..	..	..
1	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	100 —104	5 5 9	..	..	..
1	6%	Do. 6 per Cent. 1st Deb. Bonds	100 —105	5 14 0	..	..	..
5	4·6	†Calcutta Tramways (1 to 137,610)	7¼—8	5 0 0	..	8 1/16	7¾
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5¾	4 7 0	..	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	103 —108	4 3 3	..	..	..
S	..	Cape Electric Tram Shares	8 ¾	..	..	..	..
..	5%	†Colombo Tr. & Ltg. 5% 1st Mt. Db	96 —100	5 0 0	..	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 - 90%	5 11 0	..	..	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 —95	5 5 0	..	92¾	..
5	6%	Do. 6 per Cent. "B" Ditto	80 - 84	7 2 6	..	82	..
5	1/0	Lisbon Elec. Trams. Ord.	1 1/16—1 1/8	3 9 6	..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1 1/8	5 1 0	..	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	98 —101	4 19 0	..	..	..
St.	5%	Madras Elec. Trams. 5% Deb Stk.	93 —101	4 19 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 —104	4 6 6	..	..	..
St	4%	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	..	..	..
..	6%	Sao Paulo Tramway, Light & Power Co. $100 Stock	125 —130	3 1 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	95%—97%	5 3 0	..	96½	95¾
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¾—5½	5 14 0	..	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7¼—8⅜	5 15 0	..	..	..
St.	4½	Do. 4½ per Cent. Deb. Stk. (red.)	97 —100	4 10 0	..	97⅛	97
5	3 3	Calcutta Elec. Supply Ord.	7¾ - 8¾	4 17 0	..	8⅜	8⅛
5	0/8	Do. £4 paid	6¼—7¼	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	..	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2¾	..	..	..	..
St.	5%	Do. 5 per Cent. Deb Stock	88 —92	5 8 6	..	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 - 98	5 2 0	..	97⅜	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 —109	5 10 0	..	..	..
1	0 7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	⅞ 1	..	..	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94⅛—97½	5 2 6	..	93	..
1	1 6	Rand Electric	1 - 1⅛	..	..	..	..
1	..	River Plate Electricity Co. Ord.	⅝—¾	..	..	11/16	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	⅝—1	6 0 0	..	⅝	..
St	5%	Do. 5 per Cent. Deb. Stock	97 —101	5 0 0	..	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	..	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	93 —100½	5 0 0	..	99	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

Shrs.	Last Dividend	Name.	Price Wed., May 8.	Rate % Yielded.	£ s. d.	Dividend Due.	Business Week to May 8. High- est.	Low- est.
		ELECTRICITY SUPPLY.						
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	9⅛–10⅛	6 16 6				
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾–10	4 10 0		.. ..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10½–10⅝	5 11 8		.. ..	..	..
St.	4¼%	Do. 4¼ per Cent. Deb. Stock (red.) ..	101 –104	4 6 6		.. ..	10⅛ ..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜–5½	5 5 0		.. ..	..	..
St.	4½%	† Do. Do. 1st Debs.	97 –99	4 11 0		.. ..	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 – 9	5 11 0		.. ..	..	..
5	3/6	Do. 7 per Cent. Pref.	7 – 8	4 7 6	Mar, Sept	.. ..	8⅜ ..	..
St.	4%	Central Elec. Sup. Co. 4½ Guar. Db. Stock	100 –103	3 17 6		.. ..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜–4½	5 18 0	Feb, Aug	8½ ..	..	..
5	2/3	Do 4½ per Cent. Pref.	4 –4½	5 0 0	Feb, Aug	4½ ..	4⅛ ..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	93 – 99	4 1 0		.. 96½	96	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅞–4½	5 9 0		.. ..	..	..
5	2/3	Chelsea Electric Supply Ord.	3¼–4½	5 6 0	March ..	.. ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 –107	4 4 0	June, Dec	.. ..	..	..
10	7/0	City of London Electric Lighting Ord..	10 –10½	5 14 0	Feb, Aug	10⅝ ..	11⅛	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11½–12½	4 16 0	Jan, July	11⅞ ..	11½	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.),.....	121 –124	4 0 9	June, Dec	125 ..	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0		100 97	..	..
5	5%	County of Durham Elec. P.D. Ord.	4¼–4½	4 7 0	April, Oct	.. ..	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾–5	5 4 0	April, Oct	.. ..	..	..
10	6/0	County of London Elec. Supply Ord.....	8 –8½	5 17 6		.. ..	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10¾–11½	5 4 0	Mar, Sept	11 10	..	..
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)...	1 6 –110	4 2 6		.. 108½	106	..
St.	4½%	† Do. Second Deb. Stock Prov. Certs....	95 –98	4 12 0		.. 96½	96	..
5	3/6	Folkestone Electricity Supply Co. Ord	4⅜–5⅜	5 2 0		.. ..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0		.. ..	..	..
St	4½%	Do. 4½ 1st Deb. Stock (red)	97 –100	4 10 0		.. ..	..	..
5	5/0	Hove Electric Lighting Ord.	7 –7½	6 0 0		.. ..	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼–9¼	5 5 0		.. ..	..	..
6	6%	Do. 6 per Cent. 1st Pref.	6 –7	4 5 9	Jan, July	.. ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 –100	4 0 0		.. ..	..	..
St.	4%	Kensingtn. & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 –1 2	3 13 0		.. ..	..	..
3	2 4½	London Electric Supply Ord.	1⅞–2⅛	5 13 0		.. 1⅞	..	..
5	3 0	Do. 6 per Cent. Pref.	4¾–5½	5 14 0		.. ..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	£5 – 98	4 2 0	Mr, Jn, S, D	.. ..	..	..
5	4/0	Metropolitan Electric Sup. Ord.	6 – 6¼	6 3 0	April, Oct	6¼ ..	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 –5¼	4 5 6	Jan, July	.. ..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 06 –109	4 2 9	June, Dec	.. ..	..	..
St.	3¾%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	92 – 94	3 14 6		.. 88	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –93⅞	4 12 0		.. ..	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅝–9⅜	5 8 1	Feb, Aug	.. ..	..	..
100	4½%	Do. 4½ per Cent. Deb.	99 –101	4 10 0	Jan, July	.. ..	..	..
5	8%	Newcastle Elec. Supply Ord.	7¼–7½	5 8 1	Feb, Aug	— ..	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛–5⅜	4 7 9	Feb, Aug	.. ..	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	93 –100	4 0 0	Jan, July	.. ..	..	..
1	3%	Northern Counties Elec. Sup.	1 –1⅛	2 16 6	Mar, Aug	.. ..	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 –101	4 10 0	Jan, July	.. ..	..	..
10	9 0	Notting Hill Electric Ord.	12 –13	5 15 0	March ..	.. ..	..	..
5	4 6	Oxford Electric Ord.	6 –6⅜	5 8 0	March ..	.. ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	93 – 93	4 1 6		.. ..	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	7⅜–8⅛	6 1 6	Feb, Aug	8 7⅛	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅜–7⅛	4 18 0	Feb, Aug	.. ..	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	93 –95	3 13 9		.. ..	..	..
5	.	Smithfield Markets Electric Sup. Ord...	1¼–2¼	.. ..		.. ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	73 –77	5 4 0		.. ..	..	..
5	3.0	South London Electric Supply Ord.....	2¼–2⅝	6 8 0		.. ..	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝–¾	3 6 9		.. ..	..	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.	1⅛–1⅜	4 15 0		.. ..	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 –103	4 7 6		.. ..	..	..
5	2/6	Urban Electric Supply Ord.	1¼–2¼	10 0 0		.. 2	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	3 –4	6 5 0		.. ..	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.	95 – 98	4 12 0		.. ..	..	..
5	6 6	Westminster Elec. Sup. Ord.	9½ 10	5 14 3	Mar, Sept	9⅛ ..	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛–5½	3 13 3		5⅜ ..	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.						
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 –95	4 4 0		.. ..	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	2⅝–3⅜	5 8 0		.. ..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3⅜–1	5 0 0		.. ..	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ..	95 –100	4 10 0		.. ..	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 – 99	4 11 0		.. ..	..	..
10	9½	Bristol Tramways & Carriage Ord.	14⅜–14⅞	6 8 0	Feb, Aug	.. ..	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 –9¼	4 5 0		.. ..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 –102	3 17 6	Feb, Aug	.. ..	..	..
10	..	British Electric Traction Ord.	2 – 2⅛	12 0 0		.. 2⅜	2⅛	..
10	£/0	Do. 6 per Cent. Cum. Pref.	£⅛–6⅞	8 13 0	Feb, Aug	6⅞	6⅞	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 –104	4 15 0		.. 10⅜	100	..
St.	4½%	† Do. 4½ per Cent. 2nd Deb. Stock	79 –82	5 9 6		.. ..	..	..
St.	4%	Central London Ordinary Stock	72 –74	5 8 0	June, Dec	7⅛ 7⅜	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0		.. ..	..	..
St.	4%	Do. Deferred Stock	55 – 58	6 18 0		.. ..	..	..
100	4%	Do. 4 per Cent. Debs.	103 –106	3 18 6		.. ..	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db Stk.	83 –86	4 13 0		.. ..	..	..
5	2/6	‡City of Birmingham Trams. 5% Cm. Pref.	4½–5	5 0 0		.. ..	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 –1 1	3 19 0		.. ..	..	..
St.	2%	City & South London Rly. Con. Ord. ..	41 –43	4 19 0	Feb, Aug	4½ 4¾	..	..
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	119 –123	4 2 0	Feb, Aug	.. ..	..	..
St.	5%	Do. (1896)	115 –118	4 4 9		.. ..	..	..
St.	5%	Do. (1901)	115 –118	4 4 9		.. ..	..	..
St.	4%	† Do. 4 per Cent. Perpetual Debs.	1 2 –105	3 16 0	May, Nov	104½ ..	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	14⅛–15½	8 18 6		.. ..	..	..
10	£/0	Do. 6 per Cent. Pref.	13⅛–14⅜	4 2 9		.. ..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2⅞–3	.. ..		.. ..	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0		.. ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 – 88	4 11 0		.. ..	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	93 –101	4 9 0		.. 99½	..	..
10	9%	‡ Imperial Tramways Ord.	12 – 13	6 18 6	Mar, Sept	.. ..	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11½	5 6 6	Mar, Sept	.. ..	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	100 –102	4 8 0	Jan, July	.. ..	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 –2	.. ..		.. ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	63 –73	5 9 6		.. ..	..	..
St.	47/6	Lancs. Utd. Trams 5 · Prior Lien Db. St.	95 –98	.. ..		.. 96½	..	..
10	..	Liverpool Overhead Railway Ord.	1⅜–1⅝	.. ..	Feb, Aug	.. ..	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	.. ..	..	..
St.	4%	Do. 4 per Cent. Deb.	83 –90	4 9 0	Jan, July	.. ..	£⅝ £¼	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜–7⅝	5 14 3		.. ..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 89	4 10 0		.. ..	..	..
St	..	Mersey Con. Ord. Stock	3 – 5	— ..		.. ..	..	..
St.	..	Do. 3 per Cent. Perp Pref.	7 –10	— ..		.. ..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅛–⅜	.. ..		.. ..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜–½	5 3 0		.. ..	..	..
St	4½%	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0		.. ..	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½ – 1⅜	.. ..	May	.. ..	..	..
10	8/0	†Potteries Electric Traction Ord.	5⅞–6⅛	6 8 9		.. ..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 –7⅜	6 13 3	Feb, Aug	.. ..	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	98½–101½	4 8 6		.. ..	..	..
1	3·56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	5⅝–1⅞	5 16 6		.. ..	..	..
St.	3¾	Do. 4 per Cent. Deb. Stock	84 – 87	.. ..		.. ..	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	88 –90	5 11 0		.. 80½	..	..
..	5%	Underground Elec. Rys. Co. of London...	76 – 79	6 6 6		.. ..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 –1⅜	— ..		.. ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅞–1	— ..		.. ..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 – 95	4 16 9		.. ..	..	..

Shrs.	Last Dividend	Name.	Price Wed., May 8.	Rate % Yielded.	£ s. d.	Dividend Due.	Business Week to May 8. High- est.	Low- est.
		ELECTRIC MANUFACTURING, &c.						
1	..	Aron Electricity Meter Ord.	½–¾	.. ..		.. ..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅞–1⅛	7 7 9		.. ..	..	..
1	9/4½	†Babcock & Wilcox Ord .....xd & bonus	3⅜–4	5 0 0		.. ..	4	3⅞
1	0/7½	† Do. Pref.	1⅛–1⅜	3 17 0		.. ..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅞–7	7 3 0		July, Feb	6⅞	..
5	3/0	Do. 6 per Cent. Pref.	5½–6½	4 16 0		Jan, July	6⅝	5⅝
St.	4%	Do. 4% per Cent. 1st Mort. Deb. (red.)	102 –1 5	4 5 9		.. ..	..	..
St.	4½	British Thom'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3		.. ..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 –1⅛	.. ..		.. ..	1¼	1⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£4 –£8	5 18 0		.. ..	67	66½
2	1/0	Brush Electrical Engineering	⅝–¾	—		March ..	..	..
2	2/4½	Do. 6 per Cent. Pref. non-Cum.	1⅛–1⅜	6 17 0		Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 92	4 13 0		Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 – 78	5 14 6		Jan, July	..	..
5	5 0	Callender's Cable Con. Ord.....	10 – 11	6 13 0		Jan, July	10⅜	10¼
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜–5⅞	4 7 0		Jan, July	..	..
St	4½%	Do. 4½ per Cent. 1st Mort Debs (red.)	106½–108½	4 3 0		Nov, May	..	..
1	0/8⅜	Castner-Kellner Alkali Co.	1⅛–1⅜	5 14 0		.. ..	1¼	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0		.. ..	99½	99⅛
1	0/9⅜	Chadburn's (Ship) Telegraph Ord.	1⅜–1⅝	7 5 0		.. ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜–1⅝	5 4 0		.. ..	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 54,000).....	1⅞–2⅛	3 10 8		Jan, July	2	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96¾–99¾	5 1 0		Jan, July	97⅛	96
5	2/0	Dick, Kerr & Co. Ord.	1⅛–1⅜	6 8 0		Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 16 0		Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 – 105	4 5 6		.. ..	10½	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1⅛–1⅜	9 8 0		Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛–2⅜	4 11 6		Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	85 – 87	4 12 0		June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 – 92	5 8 6		.. ..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	1 –2	10 0 0		H'lf-yearly	2⅛	1¾
5	3/0	Do. 6 per Cent. Cum. Pref.	2 – 3	10 0 0		.. ..	2⅝	2½
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	87 – 90	5 0 0		.. ..	..	..
2	..	Electric Construction Co.....	⅝–¾	.. ..		July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	½–⅝	7 0 0		July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8¾–9⅜	5 7 0		.. ..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0		.. ..	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅜–12½	6 2 6	Feb, Aug	12	..	..
5	2/3	Do. 4½ per Cent. Pref.	5¼–5⅜	3 18 8	Feb, Aug	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 –109	4 2 6		.. ..	108	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15½–16½	6 2 6	Feb, Aug	15½	15¼	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 –100	4 0 0		.. ..	..	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	⅜–⅝	7 6 0		.. ..	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	⅝–1	6 0 0		.. ..	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 –100	4 10 0		.. ..	..	..
1	..	Simplex Conduits Ord.	1⅛ ..	.. ..		.. ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	6½ ..	.. ..		.. ..	..	..
12	24/0	Telegraph Construction & Maintenance	31 –32	5 12 6	Mar, July	31½	31	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100½–103½	3 17 0	Jan, July	102	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛–2⅜	5 19 0		.. ..	2⅜	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅝–1⅞	4 1 0		.. ..	1⅞	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 –117	4 5 6		.. ..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	103 –105	3 16 6		.. ..	104½	103
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 –107	4 4 0		.. ..	..	..
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½–10	5 0 0		.. ..	..	..
5	..	Willans & Robinson Ord.	1⅛–1⅜	.. ..		Apr, Oct	1⅜	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅞–4⅛	.. ..		Apr, Oct	4⅛	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	79 –83	4 16 6		May, Nov	..	..
		TELEGRAPHS.						
10	..	Amazon Telegraph	3 –3½	—		June, Dec	..	—
100	5%	Do. 5 per Cent. Debs. (red.)	88 –91	5 10 0		.. ..	..	..
St.	15/0	Anglo-American	6½–6¾	6 0 6	F, My, Ag, N	.. ..	..	..
St.	30,0	Do. Preferred	10⅜–10⅞	5 12 6	F, My, Ag, N	10⅞	10⅝	..
St	13%	Do. Deferred	20⅜–21⅜	4 2 3	F, My, Ag, N	21⅜	21	..
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	93 –95	4 4 0	Jn, Ap, Jy, O	94½	93½	..
10	5 0	†Cuba Submarine Ord.....	8 –8½	5 15 0	Feb, Aug	..	..	..
10	10/0	† Do. Preference 10 per Cent.....	16 –17	5 19 0	Feb, Aug	16½	..	..
5	2/0	Direct Spanish Ord.....	3⅜–3⅝	5 10 6	April, Oct	3⅝	..	..
5	5,0	Do. 10 per Cent. Cum. Pref.	8½–9½	5 8 0	April, Oct	..	..	..
5	4½%	Do. 4½ per Cent. Deb.....	98⅝–101⅞	4 9 0	Jan, July	..	..	..
20	4/0	Direct United States Cable	15½–15⅝	5 17 6	Ja, Ap, Jy, O	15⅝	15½	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	..	..	..
St	25/0	Eastern Ordinary	140 –143	4 18 9	Ja, Ap, Jy, O	142	139	..
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 – 91	3 17 0	Ja, Ap, Jy, O	90½	90	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.).	104½–106⅛	3 15 0	May, Nov	106⅛	104½	..
10	2/6	Eastern Extension	13⅝–14	5 0 0	Ja, Ap, Jy, O	13⅞	13⅝	..
St.	4%	Do. 4 per Cent. Deb. Stock	105 –107	3 14 9	Feb, Aug	105	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –101	3 19 0	Feb, Aug	..	..	..
25	4%	† Do. 4% Mauritius Sub. Debs. (red.) ..	£8⅞–100¼	4 0 0	May, Nov	98	..	..
10	3 0	G.N. (of Copenhagen), ex Coupon 69 ..	34 –36	6 19 0	Jan, July	35	33½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.	100 –102	4 8 0	June, Dec	..	..	..
25	12/6	Indo-European.....	59 – 61	5 6 6	May, Nov	6½	..	..
100	4%	Mackay Companies Common	70⅞–72½	5 10 0	Jan, July	..	..	..
100	4%	Do. Preference	71½–72	5 11 6	Ja, Ap, Jy, O	..	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞–1	.. ..		.. ..	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99¼–100¼	3 19 6	June, Dec	..	..	..
10	4/0	West African Telegraph Shares	10 –10½	3 16 0	.. ..	..	..	..
2½	..	West Coast of America	1 – 1⅛	.. ..	.. ..	..	1⅛	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	99½	..	..
10	..	West India & Panama	⅝–¾	.. ..	May, Nov	⅝	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	8 – 8½	7 1 0	May, Nov	8⅛	..	..
10	..	Do. 6 per Cent. 2nd Pref	6¼–7½	.. ..	May, Nov	6⅝	..	..
100	5%	* Do. 5 per Cent. Debs.	10⅜–10⅜	4 17 0	Jan, July	..	..	..
10	3/0	Western Telegraph	13⅝–13⅞	5 2 6	Mr, Jn, O, D	13⅞	13⅝	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 –105	3 16 0	.. ..	102	—	..
		TELEPHONES.						
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 –94	4 5 0		.. ..	93⅜	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 –101	4 19 0		.. ..	100½	..
5	3 0	Chili Telephone	6¾–7¼	5 11 0	August ..	7⅛	..	..
1	0/4½	†Monte Video Telephone Ord.	1⅛–1⅛	4 14 0		.. ..	..	..
1	0/6	† Do. 5 per Cent. Pref.	⅞–1	5 0 0		.. ..	..	..
St.	6%	National Co. Pref. Stock	103 –110	5 9 0		.. ..	109½	108½
St.	£4%	Do. Def. Stock.....	104½–106½	5 3 0		.. ..	105⅝	104½
10	£/0	Do. 6 per Cent. Cum. 1st Pref.	11½–13⅜	4 9 0	Feb, Aug	12⅝	..	..
10	£/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	..	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅝–5⅞	4 10 0	Feb, Aug	5⅞	..	..
*	Do.	Do. Deb. Stock 3½ per Cent. (red.) ...	95⅜–97½	3 11 9	June, Dec	96	95⅝	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –102	3 18 0	.. ..	101½	100⅜	..
1	0/9⅜	†Oriental	1⅝–1⅞	4 17 6	April, Oct	1¾	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	1⅜–1⅝	4 16 0	.. ..	..	..	..
St.	1%	Do. 4 per Cent. Red. Deb. Stock	95 – 95	4 2 0	.. ..	..	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	99 –102	4 7 0	.. ..	..	..	..
5	8/0	United River Plate.....	6⅞–7¼	5 9 6	July	7⅛	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 15 0	June, Dec	..	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	109 –112	4 9 3	June, Dec	..	..	..
		FINANCIAL, INVESTMENT, &c.						
5	8,0	Elec. & Gen. Investment 6% Cum. Pref.	4 – 5	6 0 0	.. ..	..	..	..
10	2 0	Globe Telegraph & Trust.....	10⅜–11	5 0 0	Ja, Ap, Jy, O	11⅛	10⅜	..
10	3,0	Do. 6 per Cent. Pref.	14 –14½	4 4 0	Ja, Ap, Jy, O	14⅜	14	..
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

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NOTES.

Ships of the Future.

IN his Presidential Address last week to the Iron and Steel Institute, Sir HUGH BELL, after looking back upon the great advances made during the last century, took a glimpse forward, and gave a pleasing picture of what we may expect before another century has passed. Ships will no longer be propelled by steam engines with a lot of complicated machinery on board, requiring huge supplies of coal; but, in the words of the author, "with little or, mayhap, no machinery on board, with barely any crew, she speeds on her way drawn by the electric force generated at Niagara and transmitted over the Atlantic by wireless telegraphy. She crosses to New York, takes her cargo, and returns as she came. Strange as my forecast may seem, it is no more incredible than what has happened since 1807. The things which are to us commonplaces would have been deemed impossibilities by our forefathers. The world moves on in a succession of dreams and their fulfilment. The wild imaginings of one age become the splendid realities of the next." It is not often that an engineer allows his imagination so much freedom. The task of the prophet, however, is at best a thankless one, and that of his critics is little better. We will, therefore, say no more than express the hope that the picture may come true.

The Imperial College of Science and Technology.

IT will be remembered that about three months ago the President of the Board of Education decided that the scheme for establishing in London an Imperial College of Science and Technology, on somewhat similar lines to the well-known institution at Charlottenburg, was not to be delayed. A further step has now been made by the publication of the Royal Charter, from which we learn that the proposed Governing Body will consist of 40 members. Of these, eight are to be appointed by various technical societies, the Institutions of Electrical, Mechanical and Civil Engineers appointing one each. The London County Council are to have the nomination of five members, and we notice that the General Purposes Committee of that body have already provisionally selected their representatives—namely, Mr. A. A. ALLEN, M.P., Mr. H. P. HARRIS, Sir CLEMENT KINLOCH-COOKE, Mr. R. A. ROBINSON and Mr. J. T. TAYLOR.

THE question of the control to be exercised over the College by the University of London is also referred to in the Charter, which states that, until the question of the incorporation of the Imperial College with the University has been settled, the College is to be temporarily established as a school of the University. The Governing Body are also to co-operate with the University authorities for the purpose of co-ordinating the work of the Imperial College with that of the University. We are pleased to see that there is to be no delay in furthering the proposed scheme, which must soon be a settled matter, since any petitions for or against the grant of the Charter are to be sent to the Privy Council on or before June 6th.

Varying Prosperity.

A NOTICEABLE feature in the electrical industry at the present time is that although certain companies are doing very well there are many large firms which are far from prosperous, and very often there seems to be no obvious reason for the difference. Thus it might be thought that the cable-making companies would be suffering from the

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high price of copper, which would tend to make electricity supply undertakings unwilling to extend their mains beyond what was absolutely necessary. No doubt a waiting policy has been adopted by many undertakings as far as this is possible, but nevertheless the annual report by the directors of Callender's Cable & Construction Company shows a very satisfactory state of things. A dividend of 10 per cent. per annum on the ordinary shares is proposed, together with a bonus of 5s. per share. Moreover, the Company's foreign trade shows a considerable increase, so that the shareholders will not feel they have any great cause for anxiety. On the other hand, the Brush Electrical Engineering Company, which has weathered so many storms in the past, appears to be in troubled waters once more. According to the latest report, the net profits have fallen from £34,719 to £24,134, and apparently the whole of this surplus is to be placed to reserve, so that neither the preference nor the ordinary shareholders will receive any dividend. This falling off in profits is said to be due to the continued cutting of prices and to labour troubles. Presumably the Trades Unions will view the result with short-sighted satisfaction.

Temporary Mains.

It frequently happens that, although there is a field for a small supply of electricity in parts of a district, the probable demand is insufficient to warrant the laying down of mains on systems now usually adopted, especially when the present extremely high price of copper is taken into account. The capital charges on mains are a constant quantity, whether a supply is given by them or not. In many cases, therefore, it would be a great advantage if cheap temporary mains could be laid down for a time, until the heavy expenditure entailed by larger mains could be justified. In order to cope with these conditions at West Ham, Mr. Seabrook is about to put in temporary services consisting of rubber cables laid in pipes, so that the necessary supply can be given to certain consumers without entailing any great outlay. As soon as the demand increases sufficiently the mains will be extended and these cables will be removed. We hope that Mr. Seabrook will in due time give some information as to whether this temporary method of giving a supply is, on the whole, satisfactory.

The Hammersmith Workhouse.

As a satire upon the present socialistic tendencies in general and upon Poor Law Administration in particular, the Local Government Board inquiry into the expenditure on the Hammersmith workhouse and infirmary is certainly amusing, and justifies the laughter with which much of the evidence was received. But to the unfortunate ratepayer at Hammersmith it is by no means pleasing to learn that in many of its details the workhouse is equal, if not superior, to any nobleman's mansion in the land, and can vie in many respects with some of the most expensive hotels in London. He will derive very little consolation from the fact that the cost amounted to about £335 per head, or that the cooking apparatus cost as much as £3 per pauper. Naturally, the electric lighting is in keeping with the rest of the establishment. The master of the workhouse has expressed the opinion that two-thirds of the outside lighting, equivalent to 2,300 lamps, are unnecessary for the working of the Institution, and the fact that 24 lamps are fixed in subways where two would have been ample, gives a fair idea of the lavish expenditure. We fear that expenditure of this kind is, unfortunately, characteristic of many municipal undertakings. Mr. Horace Boot, who has been identified for many years with municipal work, admitted the truth of this view when, in reply to the question whether he had ever seen such extravagance elsewhere as was evident in the transforming plant, he remarked that he had seen similar extravagance by many borough councils. The different attitude on capital expenditure so often noticeable between companies, who have to pay dividends, and local authorities, who are free to draw on the rates, is certainly one of the weakest points in municipal trading.

Personal.—Mr. H. Bateman has been elected to the readership in mathematical physics, recently endowed by Prof. Schuster at Manchester University for the purpose of encouraging research in mathematical physics.

Obituary.—We regret to have to record the death of Mr. G. R. Dunell on Sunday last. Mr. Dunell was a well-known contributor to *The Times* and *Engineering*, and devoted most of his time to literary work.

Faraday House Old Students' Association.—Mr. C. P. Sparks, chief engineer of the County of London Electric Supply Co. (Ltd.) has been elected President of this Association for 1907, in succession to Mr. S. F. Beevor who has resigned.

Glasgow Local Section.—The annual general meeting of the Glasgow Section of the Institution of Electrical Engineers was held on Tuesday evening last. Prof. F. G. Baily was elected chairman of the section for the next session, and the appointment of secretary was left to the newly appointed committee.

Institution of Civil Engineers.—It is announced that the fifteenth "James Forrest" lecture will be delivered on Tuesday, June 18th, by Dr. F. Elgar. The subject is "Unsolved Problems in the Design and Propulsion of Ships." The fourth Engineering Conference will be held on June 19th, 20th and 21st, commencing each day at 10 a.m., and the Annual Conversazione on the evening of June 20 at the Royal Albert Hall.

Wireless Telegraphy Notes.—It is stated by Reuter's agency that experiments have lately been made at Cartagena on the explosion of fixed torpedoes at a distance by means of Hertzian waves. The apparatus employed is the invention of Señor Balsera, a telegraph official. The results of the trials are declared to have been satisfactory. The inventor has asked for facilities to study the application of his system to the working of submarines.

According to the *Norddeutsche Zeitung*, arrangements are being made to establish a wireless telegraphy company in Morocco. The capital necessary to equip the stations with "wireless" plant will be found in Germany, France and England. The company will be under the management of Herr Popp, and will be carried on in comformity with the Algeciras Agreement.

Institution of Electrical Engineers.—The annual general meeting of the Institution of Electrical Engineers (Members, Associate Members, and Associates only) will be held at 92, Victoria-street, Westminster, S.W., on Friday next, May 24th, at 5 o'clock, to receive the Annual Report of the Council and the Statement of Accounts and Balance Sheet for the twelve months ended December 31, 1906. The announcement of the election of the new Council will be made at this meeting.

Cable Interruptions.	Date of Interruption.
Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
New Brunswick—Prince Edward Island	Jan. 9, 1907
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907
Dakar—Konakry	April 24, 1907

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The Tramways and Light Railways Association.—The official circular for May of this Association deals with the reports on "Brakes" at the International Tramways Congress at Milan last September. These reports were given fully in *The Electrician* some time ago. Mr. Panton's Institution Paper on Congestion is also published, and an article by Mr. J. S. Warner on his method of recording the riding qualities of tramcars.

Institution of Mechanical Engineers.—On Wednesday evening last, a conversazione was held by the President (Mr. T. Hurry Riches) and Council of this Institution in their building at St. James' Park, when a number of distinguished guests were present. An interesting lecture was given by Dr. H. S. Hele-Shaw on "Aerial Navigation." The lecturer showed several models, and demonstrated the principles of flight by means of paper swallows. Mr. F. W. Howard's model, which performed so successfully at the Alexandra Palace, flew the length of the hall in which the lecture was given. A number of lantern slides and cinematograph films showing numerous models in the process of flight were also shown.

Auxiliary-Pole Motors for Traction Work.—According to the *Street Railway Journal*, the Boston Elevated Railway Company has recently ordered 100 quadruple car equipments for its surface cars. Each car will be equipped with four motors designed to operate at 600 volts. They are provided with interpole field windings, and are fitted with steel gear and pinions with a gearing ratio of 71:15. The armatures will be of the drum type with three turns per segment. The weight of each motor is 2,700 lb. These motors are purchased under three guarantees, namely, (1) that they shall commutate successfully in operation; (2) that they are to commutate successfully with a full-load current at 750 volts; (3) that when running at 750 volts they are to withstand interruption and reapplication of the full-load current without flashing over or serious arcing, the duration of the break to be 1 to 5 seconds.

A Large Single-phase Railway Motor.—The *Elektrotechnische Zeitschrift* gives an account of a single-phase commutator motor, of the Winter-Eichberg type, for railway work. The motor has six poles, and its excitation can be regulated in two steps, any further adjustment being obtained by altering the terminal voltage. The output is 350 H.P. at 400 revs., or 250 H.P. at 500 revs., at a normal voltage of 850. The weight is 6½ tons. The motor drives the axle through gearing, the ratio being 1 : 4·15. A locomotive carrying four motors can reach a speed of 30 miles per hour, and at a speed of 15 miles per hour can exert a tractive force of 33,000 lb. The motors are air-cooled, the air being driven through the motor from the gearing end. The cast-steel housing of the motor into which the stator laminations are fixed can be separated on a vertical diameter. The motor is lubricated under pressure.

Application of Electricity to Mines.—According to *Page's Weekly*, very considerable progress is reported in the application of electricity to mining. A large installation for Kirkby Colliery has recently been completed, in which two horizontal engines of 500 H.P. drive two 310 kw. three-phase generators, and the current is utilised for driving six endless-rope haulage gears. Since the completion of this plant, this colliery has been worked practically electrically throughout, as, in addition to the underground equipment, the whole of the screens and surface works are driven by three-phase motors. At Manton Colliery, near Worksop, is one of the most complete power stations at a colliery in the United Kingdom, the plant consisting of three horizontal condensing engines of 600 H.P. connected to three-phase alternators, capable of developing 400 kw. at 50 cycles 500 volts. The current is at present utilised for driving three sets of main shaft pumps.

Royal Meteorological Society.—Among the Papers read at the first of the afternoon meetings of this society's present session was one by Colonel J. E. Capper, giving an account of a captive balloon being struck by lightning at Farnborough during a thunderstorm on April 11th. The lightning flash appeared to travel along the wire until it reached the wagon. Then a sudden bright light appeared and ran right up the wire into the clouds in which the balloon was hidden. The wire was fused, being burnt entirely away where it first touched the iron pulleys which guide the wire when running out. One side of the balloon and net was burnt, probably owing to the hydrogen catching fire, but the other side was uninjured. Prof. A. Herschel also described a remarkable excavation made by lightning in peat earth in a moorland district of Northumberland.

British Association.—It is announced that the inaugural meeting at Leicester this year will be held on Wednesday, July 31st, at 8:30 p.m., when Sir David Gill, K.C.B., LL.D., D.Sc., F.R.S., president-elect, will assume the presidency and deliver an address. On Thursday, August 1st, the mayor of Leicester (Ald. Sir Edward Wood, J.P.) will hold a reception at a fête to be given by him in the Abbey Park; and on Tuesday, August 6th, there will be a soirée in the Museum Buildings. On Friday, August 2nd, a discourse on "The Arc and Spark in Radio-telegraphy" will be delivered by Mr. W. Duddell; and on Monday, August 5th, a discourse on "Recent Developments in the Theory of Mimicry" will be delivered by Dr. F. A. Dixey. The concluding meeting will be held on Wednesday, August 7th, at 2:30 p.m. Excursions will be made on Saturday, August 3rd, to places of interest in the district, such as Chatsworth, Haddon Hall, Belvoir Castle, Warwick, Kenilworth, Stamford and Peterborough. A special excursion will be made to the Charnwood Forest.

The "Central."—We have received a copy of the April issue of this magazine which fully maintains its uniform excellence. The most important article of electrical interest is a discussion of the advantages and disadvantages of alternating and direct current for railway electrification. The writer is not very optimistic over the single-phase system for main-line working, but hopes for a development of the high-tension continuous-current system with motors designed for, say, 2,000 volts. There is also an article on "Electrical Test-shop Measurements," giving a number of practical hints. Other articles are on the construction of a new railway and on Carlisle's new water supply. The issue also contains an exceptional amount of information concerning the doings of old students. We notice that the Senate of the University of London have recently passed a resolution that "students who have or shall have passed, before or in the year 1908, the special intermediate examination in engineering at the Central Technical College be exempted from the intermediate examination in science."

ARRANGEMENTS FOR THE WEEK.

SATURDAY, May 18th.

JUNIOR INSTITUTION OF ENGINEERS.

3 p.m. Visit to the Scientific Instrument Works of Messrs. W. F. Stanley & Co. and the Stanley Technical Trade Schools at South Norwood.

THURSDAY, May 23rd.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Meeting at the Society of Arts, John-street, Adelphi. Papers on "The Present State of Direct-current Design as influenced by Interpoles," by Messrs. F. H. Page and F. J. Hiss, and on "Hot Wire Meters and Oscillographs," by Mr. J. T. Irwin.

FRIDAY, May 24th.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Papers on "The Measurement of Mutual Inductance by the Aid of a Vibration-Galvanometer," by Mr. A. Campbell; and on "Note on the Rate of Decay of Active Deposit from Radium," by Messrs. W. Wilson and W. Makower. An exhibition of an "Apparatus for Relay Working of Long Submarine Cables" will be given by Mr. S. G. Brown.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:30 p.m. Meeting at the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Paper on "Some Experiments on the Magnetic Character of Vessels," by Capt. W. Bartling.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street. Lecture on "Recent Contributions to Electric Wave Telegraphy," by Prof. J. A. Fleming, F.R.S.

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ELECTRIC FURNACE METHODS OF IRON AND STEEL PRODUCTION.—VII.

BY JOHN B. C. KERSHAW.

Summary.—In these articles, after briefly giving the history of the electric furnace and stating the present position of the industry, the author describes the Héroult, Keller, Kjellin, Stassano, Gin, Conley, Ruthenberg, Rossi, and Willson furnaces, and finally deals with the question of yields and costs.

Yields and Costs.

A very large number of figures for the yields and costs of the electric furnace methods of iron and steel production have been published during the last six years, and the practical metallurgist in search of correct information is likely to be somewhat dismayed by the mass of statistics and by the great variations which are found on reducing these figures to a common basis of comparison.

It is necessary to remember, however, that many of the figures are only estimates, and that these do not possess the value or weight of figures based upon actual trial of the processes. Again, the variations in the cost of electric power in different localities, and the different methods of working tbe electric furnace for iron and steel production, all contribute to the variations in the cost per ton of finished steel. The consumption of electric power and the total costs are, of course, highest iu those cases in which the process is worked as a reduction process, and the raw materials, iron ore, lime and coke, are charged into the furnace without any preliminary heating. On the other hand, the consumption of electric power and total costs are lowest when the process is conducted solely as a refining process, and molten pig iron from the blast furnace is used as raw material in the electric furnace. Between these two extremes there are many intermediate values, due to modifications in the methods of conducting the process and in furnace design. In the following pages an attempt will be made to discriminate between figures of weight and those of little value. Comparisons between yields and costs for different furnaces and processes will only be made when the conditions under which the trials were carried out are similar in character and a fair comparison is possible.

The furnaces and processes will be dealt with in the order followed in Articles II. to VI. of this series, the authority for the figures being given in brackets after the same :—

I.—Héroult Furnace and Process.

(a) Steel Production from Pig Iron and Scrap charged cold into crucible type of Furnace with Carbon Electrodes.

Trial No. 1.—882 kw.-hours per metric ton of 2,204 lb. (Goldschmidt.)
Trial No. 2.—1,000 kw.-hour per short ton of 2,000 lb. (Canadian Commissioners.)
Trial No. 3.—1,000 kw.-hours per short ton. (Canadian Commissioners.)
Trial No. 4.—653 kw.-hours per short ton. (Canadian Commissioners.)

The quality of steel produced in No. 1 trial was not stated ; in No. 2 a dead soft steel was produced ; in No. 3 a hard tool steel ; and in No. 4 trial a steel adapted for structural purposes.

(b) Steel Production from Scrap melted and over-oxidised in an Open Hearth Furnace.

Trial No. 1.—360 kw.-hours per metric ton of 2,204 lb. (Eichoff.)

This trial was made at the Remschied works in Germany ; the quality of steel produced was not stated.

(c) Pig Iron Production.

Trial No. 1.—3,080 kw.-hours per short ton. (Canadian Commissioners.)
Trial No. 2.—2,306 kw.-hours per short ton. (Haanel.)
Trial No. 3.—2,342 kw.-hours per short ton. (Haanel.)

The iron produced in No. 1 trial was a close-grained grey pig, in No. 2 a grey iron, high in carbon and silicon, and in No. 3 trial a similar iron containing between 3 and 4 per cent. of nickel.

A large number of other figures have been published for the Héroult process, but these are mere estimates and lack the weight of the above results. They are therefore omitted from this comparison. Taking the mean of the above values for each product we have the following figures for the Héroult process and furnace :—

1. Steel from cold pig and scrap.—864 kw.-hours per 2,000 lb.
2. Steel from molten open-hearth steel.—329 kw.-hours per 2,000 lb.
3. Grey pig-iron from ore.—2,693 kw.-hours per 2,000 lb.
4. Ferro-nickel pig from ore.—2,342 kw.-hours per 2,000 lb.

II.—The Keller Furnace and Process.

(a) Steel Production from Ores and Slagging Materials charged Cold.

Trial No. 1.—2,800 kw.-hours per metric ton. (Goldschmidt.)

(b) Steel Production from Pig Iron charged Cold.

Trial No. 1.—730 kw.-hours per short ton. (Canadian Commissioners.)

(c) Pig Iron from Ores and Slagging Materials charged Cold.

Trial No. 1.—3,110 kw.-hours per short ton. (Canadian Commissioners.)
Trial No. 2.—1,475 kw.-hours per short ton. (Canadian Commissioners.)

In No. 1 trial a grey pig containing a considerable percentage of silicon and manganese was produced. In No. 2 trial a pig suitable for steel manufacture by either the acid Bessemer or Siemens process. The great difference in energy consumption was ascribed to a change of furnace and to inaccurate estimation of the weight of unused ore.

(d) Steel from molten Pig Iron.

Trial No. 1.—694 kw.-hours per metric ton. (Neumann.)

Arranging these figures as before, we have the following yields for the Keller furnace and process :—

1. Steel from cold pig and scrap.—730 kw.-hours per 2,000 lb.
2. Steel from molten pig, 631 kw.-hours per 2,000 lb.
3. Grey pig iron from ore and raw materials charged cold, 2,292 kw.-hours per 2,000 lb.
4. Steel from ore and raw materials charged cold, 2,800 kw.-hours per 2,000 lb.

III.—The Kjellin Furnace and Process.

Steel from Pig Iron and Scrap charged Cold.

Trial No. 1.—970 kw.-hours per metric ton. (Goldschmidt.)
Trial No. 2.—966 kw.-hours per metric ton. (Neumann.)
Trial No. 3.—757 kw.-hours per short ton of 2,000 lb. (Canadian Commissioners.)
Trial No. 4.—947 kw.-hours per short ton of 2,000 lb. (Canadian Commissioners.)

No details are available relating to the character of the steel made in trials Nos. 1 and 2. Sample No. 3 contained 1·08 per cent. carbon, 0·194 per cent. of silicon and 0·24 per cent. of manganese, while No. 4 contained 0·417 per cent. of carbon, 0·145 per cent. of silicon and 0·110 per cent. of manganese. Owing to the lower temperature attained, as compared with the Héroult process, the purity of the product depends largely upon the purity of the raw materials charged, and there is no burning out of the impurities as in the latter process. The Kjellin furnace and process are not adapted for the production of pig iron or steel direct from the ores. No trials have yet been made using molten pig for charging in place of cold materials.

Taking the average of the figures given above, we have the following yield :—

1. Steel from cold pig and scrap, 866 kw.-hours per ton of 2,000 lb.

IV.—The Stassano Furnace and Process.

(a) Steel from Ore, Coke and Lime charged Cold.

Trial No. 1.—2,866 kw.-hours per metric ton. (Goldschmidt.)
Trial No. 2.—3,155 kw.-hours per metric ton. (Neumann.)
Trial No. 3.—3,230 kw.-hours per metric ton. (Stassano.)

No details of the character of the iron produced in these trials are available. The purity of the product depends largely upon the purity of the materials used.

(b) Steel from Scrap charged Cold.

Trial No. 1.—1,360 kw.-hours per metric ton. (Stassano.)
Trial No. 2.—1,200 kw.-hours per metric ton. (Stassano.)

No figures relating to the character of the steels produced in these trials are available. Owing to the high temperature of the arc and the closed furnace the product is similar to that obtained in the Héroult furnace.

Taking the averages of the above figures we have the following :—

1. Steel from ore coke and ime-charged cold.—2,804 kw.-hours per ton of 2,000 lb.
2. Steel from scrap charged cold.—1,164 kw.-hours per ton of 2,000 lb.

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V.—The Gin Furnace and Process.

So far as the writer is aware, no practical results based on trials of this furnace and process have been published, and the figures given in the somewhat voluminous papers and reports prepared by M. Gin are mere estimates based on study of theoretical data. For this reason the figures for the Gin furnace and process are less important than those previously dealt with, and only one estimate will be given—namely, for

Steel from molten pig iron.—680 kw.-hours per metric ton, equivalent to 618 kw.-hours per ton of 2,000 lb.

VI.—The Girod Furnace and Process.

This furnace and process have received actual trial, and the following figures are based upon the result :—

Steel from Scrap charged Cold.

No. 1 trial.—1,060 kw.-hours per metric ton.
No. 2 trial.—1,440 kw.-hours per metric ton.
Mean.—1,136 kw.-hours per ton of 2,000 lb.

No details of the character of the steel produced in these trials are available.

VII.—The Harmet Furnace and Process.

(*a*) *Steel from ore in combined reduction and refining type of furnace, the ore and other raw materials being heated by waste heat from the later stages of the process.*

No. 1 estimate.—1,837 kw.-hours per metric ton.
No. 2 estimate.—2,646 kw.-hours per metric ton.
Mean.—2,242 kw.-hours. per metric ton, equivalent to 2,038 kw.-hours per ton of 2,000 lb.

Combining the results set out above for purposes of comparison, we have the following :—

—	I. Héroult.	II. Keller.	III. Kjellin.	IV. Stassano.	V. Gin.	VI. Girod.	VII. Harnet.
Steel from scrap and pig (cold)..	864	730	866	1,164	..	1,136	..
Do. (hot)	329	631	..	..	618	..	..
Pig iron from ore coke and lime (cold).	2,693	2,292	..	..	..	..	..
Steel from ore coke and lime (cold).	..	2,800	..	2,804	..	..	2,038
Nickel pig from ore ..	2,342	..	..	..	..	..	..

All results are given in kilowatt-hours per ton of 2,000 lb.

These figures show that, as regards the manufacture of steel from scrap and pig iron, charged cold, the Héroult, Kjellin and Keller furnaces all yield results in the neighbourhood of 800 kw.-hours, while the Stassano and Girod furnaces have an energy consumption 50 per cent. higher. The Héroult and Keller furnaces and processes are able to deal with more impure materials than the Kjellin furnaces, since the use of the electric arc as a source of heat produces a much higher temperature than induction heating, and this enables all the impurities of the raw iron to be oxidised and removed in the slags. On the other hand, the Kjellin furnace and process gain by the absence of carbon electrodes and by the generation of heat entirely within the material contained in the furnace. The costs of operating and of maintenance are thus greatly reduced, and this saving balances the higher expenditure upon raw materials. It is, however, probable that each type of furnace will be found adapted for the production of steels of special quality, and that both the arc type of crucible furnace (represented by the Héroult and Keller furnaces) and the induction type (represented by the Kjellin and Hiorth furnaces) will attain a permanent position in the steel industry of the future.

The figures given for the energy consumption when the steel and scrap are charged into the furnace in the molten condition are hardly comparable, since it is evident that the Keller and Gin trials were made under conditions dissimilar from those obtaining in the Héroult trials. It has been calculated by Neumann that 433 kw.-hours are necessary to raise 1 ton of iron to the molten state, and it is therefore certain that when the iron is charged in this condition into the electric refining furnace, a reduced power consumption of 400 kw.-hours per ton of steel produced should be obtained. The figure given by Eichoff for the working of the Héroult process at Remschied—namely, 320 kw.-hours—may possibly be too low, but working under these conditions a power consumption of only 410 kw.-hours per ton of steel produced should be attainable.

This reduction of 50 per cent. in the electric power required is so important that it is evident the development of electric furnace work in the iron and steel industry in the near future must proceed along these lines. At Remscheid, in Germany, and at Syracuse, in America, a Wellman open hearth furnace is being employed for the preliminary heating of the metal, in order to obtain an over oxidised product as raw material for the electric refining furnace. The next step will be to dispense with this intermediate furnace process, and to transfer the pig iron, as it runs in the molten condition from the blast furnace, directly to the electric crucible furnace—for the final refining operation. The present writer prophesied this development some years ago, and he still expects to see it realised.

The figures for the power consumption when the electric furnace is employed to reduce the ores and to produce pig iron or steel in one operation are less hopeful than those given above. For pig-iron production the power consumption appears to lie between 2,300 kw.-hours and 2,700 kw.-hours, these figures being for the materials charged cold, and a reduction of between 300 kw. and 500 kw. being possible, if the raw materials are partially melted before bringing under the heating action of the electric current. It is improbable, however, that the electric power required for producing iron or steel from the ores, even with preliminary heating of the ore and other raw materials, can be reduced below 2,000 kw.-hours per short ton of metal. It will be shown in the final section of this article that power would have to be obtained at a very low cost to render competition with the ordinary blast furnace procedure practicable even on this basis.

The use of the electric furnace for iron ore reduction is, therefore, in the writer's opinion, not likely to undergo any industrial development at present, excepting under very special conditions. In some cases it may prove possible, by use of electric furnace methods, to manufacture iron or its alloys out of ore deposits which are otherwise unworkable, and in these cases the new methods of heating will, of course, find early application. The attempts to smelt New Zealand iron sand and the titaniferous ores of America are examples of this use. The trials of the Héroult furnace and process at Sainte Sault Marie in Canada are reported to have led to a similar result, for the plant which is to be erected as the outcome of these trials is to be used for the smelting of nickel-iron ores, and not for the production of ordinary pig-iron.

In countries like Norway and Switzerland, with abundance of water-power that can be developed at very low cost, it is possible, again, that a native iron smelting industry might be established, if iron ore and lime are found in the locality of the water-power. But here, again, special conditions will be required to render the industry a financial success, and it is unlikely that the iron will be able to compete in price with the product of the ordinary blast furnace in the open market. Until the coalfields of Europe and America are more nearly exhausted than at present, the electric furnace methods of iron smelting will therefore, in the writer's opinion, undergo little development. It is in the production of special steels and alloys in the electric refining furnace that the greatest progress is likely to occur within the next few years. That an electric iron smelting industry will some day be established the writer does not deny—but the conditions at the present time are not favourable to its early development—and they are hardly likely to be so for another 20 or 50 years.

Costs.

The figures for the costs of working the various electric furnaces and processes for iron and steel production are less reliable than those given in the preceding section of this article, since in practically all cases they are based on estimates rather than upon figures obtained from actual work.

The cost of ore, lime, coke and fluxes, and the cost of electric power can, of course, be obtained with exactitude for the

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various processes and localities, but such important items as electrodes, depreciation, repairs, interest on capital and management are largely unknown charges, and may be greater in the aggregate than is yet realised. The costs of electrodes and repairs are, of course, highest in the furnaces and processes using arc heating, and these processes are heavily handicapped by the expenditure upon these two items of running costs. The furnaces and processes using the induction methods of heating have a striking advantage here, since the outlay upon electrodes is nil, and the wear and tear of the furnace structure is small.

In the statement given below, the costs of production as given by the various furnace designers, and by others who have reported upon their working, are set down in the order followed in the first section of this article, but no attempt is made to institute comparisons between the various processes on the basis of these costs, since the variables are too numerous and conflicting. It is for this reason that the discussion upon the future of these electric iron and steel processes has been given at the end of the previous section, since the figures for power consumption are mostly based on actual trials, and possess a value lacking in those which are given below :—

I.—Heroult Furnace and Process.

(*a*) *Steel from Scrap.*—£2. 16s. per ton of 2,000 lb. exclusive of cost of scrap.
(Electric power at £2 per electrical horse-power-year.)

(*b*) *Pig Iron from Ores.*—£2 per ton.
(Ore at 5s. per ton.)

II.—Keller Furnace And Process.

(*a*) *Steel from Ores.*—£4 per ton of 2,000 lb.

(*b*) *Pig Iron from Ores.*—£2. 8s. per ton of 2,000 lb.
Electric power at £2 per electrical horse-power-year and ore at 6s. per ton.)

III.—The Kjellin Furnace and Process.

Steel from Scrap.—£6. 16s. per ton of 2,000 lb.
(Electric power at £2 per electrical horse-power-year.)

IV.—The Stassano Furnace and Process.

Pig iron from ore, £3. 15s. 3d. per ton of 1,000 kg. (electric power at £1. 16s. per electrical horse-power-year and ore at 14s. 5d. per ton).

V.—The Gin Furnace and Process.

Steel from molten pig, £3. 4s. per ton of 1,000 kg. (electric power at £2. 8s. per electrical horse-power-year and ore at 12s. per ton).

VI.—The Girod Furnace and Process.

Steel from scrap, £1. 3s. 3d. per ton of 1,000 kg.

VII.—The Conley Furnace and Process.

Steel from ore, £2. 7s. 3d. per ton.

VIII.—The Harmet Furnace and Process.

Steel from ore, £1. 2s. 5d. per ton.

The above figures show such wide variations that, even as estimates, they are misleading and unsatisfactory.

In attempting to form an opinion as to the comparative cost of working the electric iron and steel processes it is therefore better to rely upon the figures for the power consumption, given in the first section of this article. Taking the electrical h orse-power year at £2 and the average power consumptions in Table I. we have the following costs :—

1. Steel from molten scrap, 2s. 6d. (400 kw.-hours).
2. Steel from cold scrap and pig, 5s. (800 kw.-hours).
3. Pig iron from ore coke and lime, charged cold, 15s. 6d. (2,500 kw.-hours).
4. Pig iron from ore coke and lime, charged hot, 12s. 5d. (2,000 kw.-hours.)

In the manufacture of best crucible steel, however, it is customary to assume that between 2½ and 3 tons of coke are consumed per ton of steel produced. At the present market price of coke (17s.) the advantage is, therefore, on the side of the electric refining furnace.

As regards the electric smelting processes, it is necessary to remember that coke is still required to reduce the oxide of the iron ore to the metallic state, and that the only fuel saved is that used in the blast furnace for heating purposes. In the best modern smelting practice only 16 cwt. of coke are required per ton of pig iron produced, and of this total 6·5 cwt. are required to reduce the ore. The saving in coke by the electric furnace method of smelting cannot, therefore, exceed 9·5 cwt., or at the present price of coke 8s. 0d.

These considerations show that the prospects for the electric refining processes are much brighter than those for the electric smelting processes, since the saving of coke in the latter is too small to balance the large expenditure upon electric power. The horse-power-year would, in fact, have to be supplied at the extraordinary low cost of £1 in order to compete with the modern blast furnace, and the localities where it can be produced at this figure are certainly few in number. For the present, therefore, the application of the electric furnace in the iron and steel industries is likely to be restricted as a general rule to the refining processes, by which pig and scrap steel are converted into higher-priced products. In these branches it is likely to be very widely employed, and to have a most important effect upon the future development of the whole iron and steel industry.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO.

We give below an analysis of the accounts of the above company for the year 1906, showing the costs sub-divided under the various headings. The directors of this company make it a practice, in their annual reports, to keep the various details of their two undertakings, City and West End, separate, and the same plan has been followed in this analysis.

A comparative summary of the operating and financial results of the year's working is set forth below.

West End Undertaking.

	1906.		1905.
Gross earnings	£126,145 18 2	....	£130,733 9 4
Expenses, including depreciation	84,088 1 1	....	82,085 12 7
Net earnings	£42,057 17 1		£48,647 16 9

After bringing in a balance from last year and paying interest on the debenture stock, the directors are able to pay a final dividend of 5 per cent. for the second half-year. This, added to the first half-yearly dividend and the amount allotted to preference shareholders, absorbs a total of £51,919, leaving £4,574 to be carried forward. During the year an equivalent of 57,308 8 c.p. lamps were added, compared with 43,622 in 1905. The total now connected to the mains is equal to 510,589 8 c.p. lamps, of which 383,614 represent lighting and heating and 126,975 motors. The corresponding figures for last year were 453,285, 349,630 and 103,655.

City Undertaking.

	1906.		1905.
Gross earnings	£105,502 13 2	....	£95,340 8 3
Expenses	57,324 12 10	....	53,340 14 7
Net earnings	£48,178 0 4		£41,999 13 8

After paying interest on the debenture stock a credit balance of £490 is left, as compared with a deficit of £2,272 last year. This sum has been applied to reduce a debt to the West End undertaking. During the year an equivalent of 41,475 8 c.p. lamps was added to the mains, as compared with 70,128 last year. The total now connected is 412,684 8 c.p. lamps, of which 294,409 is lighting and heating and 118,275 motors. The corresponding figures for last year were 371,209, 274,509 and 96,700.

Both undertakings show an increase in the parochial rates owing to the recent quinquennial assessment. The amounts are £3,210 in the West End and £2,536 in the City. Almost all the other items of expenses are lower than last year. The decrease in the balance is due to an increase in the use of electricity for power purposes and the consequent decrease in the price per unit for energy used in this way.

The operating costs are set out below and the price per unit for each item obtained. Some explanation is needed to make clear how the figures in the column "*per unit sold to consumers*" are arrived at. In the case of both undertakings a portion of the electrical energy distributed is purchased "in bulk" from the other.

The West End buys 4,597,530 units from the City undertaking, which in its turn is a purchaser from the West End to the extent of 843,400 units. Thus each undertaking sells more than it generates and if we were to divide the several

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items of the works costs by the number of units sold in each case they would appear lower than they actually are. It is a simple matter to work out the costs of the combined undertakings, but in order that an idea may be gained of how the costs come out at the works we have proceeded as follows: The generating costs are first given per unit *generated* and this figure is, of course, exact. To estimate the equivalent figure per unit sold, we have split up the total units sold to consumers by the two undertakings in the proportion of the units generated at each station less the units used on the works. This gives figures on a basis fairly comparable with the ordinary analyses of costs of other undertakings, such as we publish from time to time.

It may be noticed that in this particular case the amounts used for determining the cost per unit *generated* (*excluding those used on works*) and *per unit sold to consumers* are not very different, and owing to this fact the price per unit is the same in the two cases, to two places of decimals.

The units generated, bought and sold are as follows :—

West End.		City.	
UNITS GENERATED	9,916,231	**UNITS GENERATED**	14,538,765
Units used on works ..	4,290,342	Units used on works ..	3,499,653
	5,625,889		11,039,112
Total units sold	10,222,919	Total units sold	11,882,512
Units sold to City	8,843,400	Units sold to West End	4,597,530
Units sold to consumers	9,379,519	Units sold to consumers	7,284,982

TOTAL UNITS SOLD TO CONSUMERS **16,664,501**
Proportion obtained from City..... 11,109,677
Proportion obtained from West End 5,554,824

The various items of expenditure, together with the capital account of each undertaking, are now given :—

West End Undertaking

Generating Costs.	Total.	Per unit (inc. units used on works).	Per unit (ex. units used on works).	Per unit sold to consumers
Coal or other fuel including carriage	£11,748 1 8	.. 0·28d.	.. 0·5d.	.. 0·5d.
Engine room and station expenses.....	752 2 3	.. 0·02d.	.. 0·03d.	.. 0·03d.
Proportion of salaries ..	1,267 11 6	.. 0·03d.	.. 0·05d.	.. 0·05d.
Wages	6,424 3 3	.. 0·15d.	.. 0·29d.	.. 0·29d.
Purchase of current	22,410 10 5	.. 0·55d.	.. 0·97d.	.. 0·97d.
Repairs and maintenance	4,842 2 7	.. 0·12d.	.. 0·21d.	.. 0·21d.
	£47,444 11 8	1·15d.	2·05d.	2·05d.

Distribution Costs.	Total.	Per unit sold to consumers.
Salaries, gratuities, &c.	£1,240 16 6	.... 0·05d.
Repairs and maintenance	5,337 18 9	.... 0·23d.
Wayleaves and licences.....	1,175 0 3	.... 0·05d.
Public lighting, maintenance	891 12 3	.... 0·04d.
	£8,609 7 9	0·37d.
Management Expenses.		
Rents, rates and insurances	£10,207 15 9	.... 0·44d.
Salaries and office expenses	5,998 14 7	.... 0·26d.
Law, Parliamentary & other expenses	827 11 4	.... 0·035d.
	£17,034 1 8	0·735d.
Depreciation for buildings, plant, machinery, &c.	£11,000 0 0	.... 0·47d.
TOTAL EXPENDITURE	**£84,088 1 1**	.... **3·625d.**
Balance.....	42,057 17 1	.... 1·8d.
TOTAL REVENUE	**£126,145 18 2**	**5·425d.**

Capital Account.

		£ per kw.	Per cent.
To purchase of generating station, mains, lands, buildings and law expenses connected therewith..	£110,744 14 10	.. 25·2	.. 11·1
Additional expenditure on :—			
Lands and buildings.....	167,687 6 3	.. 38·1	.. 17·7
Machinery	231,678 6 1	.. 52·6	.. 22·35
Accumulators.....	27,563 14 5	.. 6·3	.. 2·7
Mains	427,762 15 1	.. 97·2	.. 42·35
Meters.....	24,858 11 0	.. 5·6	.. 2·5
Electrical instruments	1,428 1 2	.. 0·3	.. 0·11
Provisional orders.....	5,104 19 4	.. 1·1	.. 0·43
Plant and tools	2,680 6 10	.. 0·6	.. 0·23
Artesian wells.....	2,523 0 6	.. 0·6	.. 0·23
Office furniture	3,276 3 7	.. 0·8	.. 0·30
Total	£1,005,307 19 1	.. 228·4	.. 100·00

The amount of capital still unexpended is £299,928. 0s. 11d.

City Undertaking.

Generating Costs.	Total	Per unit (inc. units used on works).	Per unit (ex. units used on works).	Per unit sold to consumers.
Coal or other fuel, including carriage.....	£14,977 3 9	.. 0·247d.	.. 0·31d.	.. 0·31d.
Engine room and station expenses	673 9 9	.. 0·01d.	.. 0·02d.	.. 0·02d.
Proportion of salaries ..	1,397 16 5	.. 0·023d.	.. 0·03d.	.. 0·03d.
Wages	7,141 17 3	.. 0·12d.	.. 0·15d.	.. 0·15d.
Purchase of current	4,111 11 6	.. 0·068d.	.. 0·09d.	.. 0·09d.
Repairs and maintenance	5,168 10 1	.. 0·085d.	.. 0·11d.	.. 0·11d.
	£33,470 8 9	0·553d.	0·71d.	0·71d.

Distribution Costs.	Total.	Per unit sold to consumers.
Salaries, gratuities, &c.	£1,082 5 3	.... 0·024d.
Repairs and maintenance	4,223 5 5	.... 0·09d.
Wayleaves and licences	197 18 0	.... 0·006d.
	£5,503 8 8	0·12d.
Management Expenses.		
Rents, rates and insurances £10,289 12 9		.... 0·22d.
Salaries and office expenses	6,954 1 6	.... 0·15d.
Law and Parliamentary expenses	1,107 0 0	.... 0·02d.
	£18,350 14 3	0·39d.
TOTAL EXPENDITURE	**£57,324 12 10**	.... **1·22d.**
Balance.....	£48,178 0 4	.... 1·07d.
TOTAL REVENUE £105,502 13 2		.... **2·29d.**

Capital Account.

		£ per kw.	Per cent.
Lands and buildings	£313,087 12 5	.. 19·0	.. 24·8
Machinery	350,091 16 1	.. 22·0	.. 27·1
Accumulators and accessories..	36,459 2 10	.. 2·1	.. 2·6
Mains	538,677 16 0	.. 33·2	.. 41·08
Meters	23,553 10 10	.. 1·0	.. 1·25
Electrical instruments	2,534 18 1	.. 0·1	.. 0·12
Provisional order, special Act.	5,521 11 8	.. 0·3	.. 0·37
Plant and tools	1,442 15 8	.. 0·09	.. 0·11
Artesian wells	3,327 7 11	.. 2·0	.. 2·5
Office furniture	925 14 0	.. 0·06	.. 0·07
	£1,275,622 6 4	79·85	100.00

Combined Undertakings.

Generating Costs.	Total.	Per unit sold to consumers.
Coal or other fuel, including carriage ..£26,725 5 5		.... 0·39d.
Engine room and station expenses	1,425 12 0	.... 0·02d.
Proportion of salaries	2,665 7 11	.... 0·04d.
Wages	13,566 0 6	.... 0·19d.
Purchase of current	26,522 1 11	.... 0·38d.
Repairs and maintenance	10,010 12 8	.... 0·14d.
	£80,915 0 5	1·16d.
Distribution Costs.		
Salaries, gratuities, &c.	£2,287 1 9	.... 0·03d.
Repairs and maintenance	9,561 4 2	.... 0·14d.
Wayleaves and licences.....	1,372 18 3	.... 0·02d.
Public lighting maintenance.....	891 12 3	.... 0·01d.
	£14,112 16 5	0·20d.
Management Expenses.		
Rents, rates and insurance.....	£20,497 8 6	.... 0·29d.
Salaries and office expenses	12,952 16 1	.... 0·19d.
Law, Parliamentary and other expenses	1,934 11 4	.... 0·03d.
	£35,384 15 11	0·51d.
Depreciation for plant, buildings, machinery, &c	£11,000 0 0	.... 0·16d.
TOTAL EXPENDITURE £141,412 13 11		.... **2·03d.**
Balance	90,235 17 5	.... 1·30d.
TOTAL REVENUE.....£231,648 11 4		.... **3·33d.**

The total maximum supply demanded was 5,353 kw. in the West End and 10,568 kw. in the City. There are 166 public lamps on the company's mains in the West End, which have used 453,993 units in the last year.

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THE BRENNAN MONO-RAILWAY.

Summary.—The Brennan mono-railway consists of cars having only one line of wheels and the centre of gravity considerably above the rail on which the car runs, balance being nevertheless maintained by electrically driven gyroscopes running at a very high speed.

In our last issue we referred briefly to the Brennan mono-railway which attracted so much attention last week at the conversazione of the Royal Society. We are now able to give some further particulars of this interesting system, which is due to Mr. Louis Brennan, C.B., already well known as the inventor of the Brennan torpedo. At present the mono-railway exists only as a model, which is just large enough to carry a man weighing 10 stone, but the experience so far gained is sufficient to demonstrate the practicability of the system.

The characteristic feature of this system of transport is that each vehicle is capable of maintaining its balance upon an ordinary rail laid upon sleepers on the ground, whether it is standing still or moving in either direction at any speed, notwithstanding that the centre of gravity is several feet above the rail, and that wind-pressure, shifting of load, centrifugal action or any combination of these forces may tend to upset it.

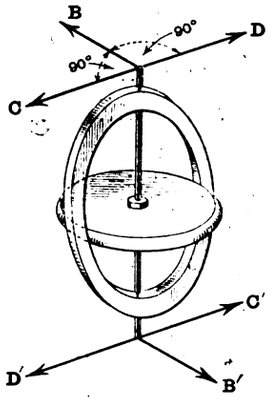

FIG. 1.—DIAGRAM ILLUSTRATING GYROSCOPIC ACTION.

Automatic stability mechanism of extreme simplicity, carried by the vehicle itself, endows it with this power. The mechanism consists essentially of two flywheels rotated directly by electric motors in opposite directions at very high speed, and mounted so that their gyrostatic action and stored up energy can be utilised. These flywheels are mounted on special bearings, and are placed in cases from which the air has been exhausted, so that both air and journal friction is reduced to a minimum, and consequently the power required to keep them in rapid motion is very small. It is stated that the stored up energy in the flywheels of the larger vehicles when revolving at full speed will be so great and the friction so small that if the driving current is cut off altogether they will run at sufficient velocity to impart stability to the vehicle for several hours, while it will take from two to three days before they come to rest.

In order to understand the principle on which these mono-rail cars are built it is necessary to remember that if we have a revolving gyroscope wheel, as indicated in Fig. 1, and we seek to give the axis a rotational movement by applying a couple in a direction such as B, B′, a couple at right angles to this direction will be set up as indicated by C, C′, or D, D′, depending on the direction of rotation of the wheel. The important point to notice is that the gyroscope does not give a couple in the direction BB′ in which it is sought to impress a movement upon it, but in a direction at right angles, giving rise to what may be termed a precessional movement.

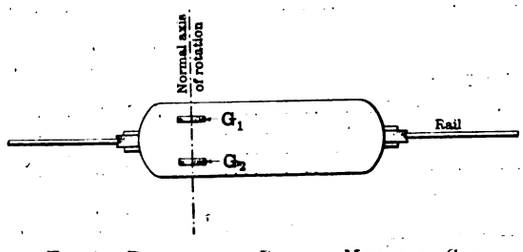

FIG. 2.—DIAGRAMMATIC PLAN OF MONO-RAIL CAR.
G_1, G_2 are the two Gyroscopes rotating in opposite directions.

Many attempts were made to use a single gyroscope to balance a car, but the results were unsatisfactory, the inclination of the vehicle being sometimes excessive, and not the same when running forward as when running backward. Two gyroscopes were, therefore, used, rotating in opposite directions, and by this device any bad effect of the kind just mentioned due to one of them is cancelled by the other. The two gyroscopes may be placed anywhere in the car, and separated if desired, provided they are, nevertheless, dependent upon each other, as will be seen later. Fig. 2 shows diagrammatically how they are placed in the model. The plane of each wheel is vertical, and normally its axis is at right angles to the length of the car—that is, to the track.

Fig. 3 shows diagrammatically the arrangement that is used. Looking at the plan, the two gyroscopes G_1, G_2, have the frames carrying them pivoted on trunnions, the upper ones of which are shown at T_1, T_2. The spindles of the gyroscope wheels are perpendicular to these frames, but are not shown, so as to avoid complication in the diagram. One of the gyroscope wheels is seen at W, in the elevation, surrounded by its circular frame. The two gyroscopes are together carried by a third trunnioned frame, partly indicated at F F, so that the whole arrangement is free to turn on the horizontal axis XY. Now, if either gyroscope is turned about the vertical axis through T_1 or T_2, it will exert a couple about a horizontal axis, as already explained. What happens when the car tends to roll over is that the frame F carrying the whole mechanism remains horizontal, but in doing so it alters its position with respect to the car body. It is, therefore, simple to arrange that the frame opens a valve, or closes a circuit, so that the gyroscope frames G_1, G_2, are acted upon mechanically. For example, a motor might be started up in this way to rotate the gyroscopes G_1, G_2, about the vertical axes through T_1, T_2, and this rotation at once creates a couple about a horizontal axis, tending to bring back the car to its normal position. The gyroscopes G_1, G_2, are connected together by toothed sectors, so that if one turns the other must turn also, but in the opposite direction, as is required owing to the rotation of the wheels being in opposite directions. In the model the turning of these sectors is effected by friction.

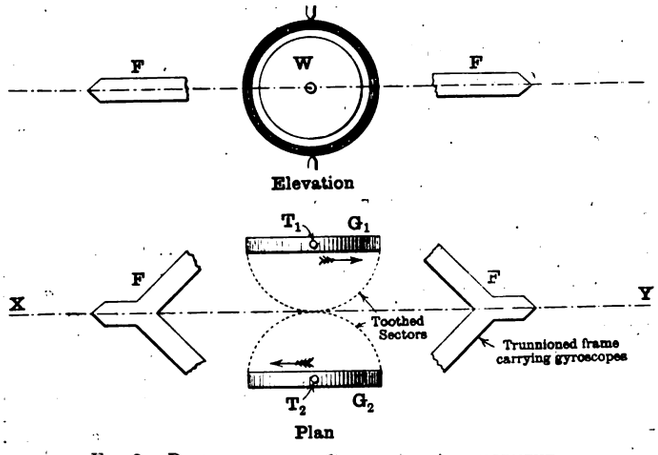

FIG. 3.—DIAGRAM OF THE GYROSCOPIC ARRANGEMENT.
(Direction of track is the same as the dotted centre line.)

It will be seen at once that if the gyroscopes turn so far as to be at right angles to the track they become useless. It is, therefore, necessary to so arrange matters that the gyroscopes return to their normal position parallel to the track after the required couple has been exerted. The means adopted for ensuring this have not been disclosed by Mr. Brennan as he is still at work on the subject.

The stability mechanism occupies but little space and is conveniently placed in the cab at one end of the vehicle. Its weight is also small, about 5 per cent. of the total load being considered an ample allowance for the first vehicle.

The road wheels are placed in a single row beneath the centre of the vehicles, instead of in two rows near the sides as usual, and are carried on bogies or compound bogies, which are not only pivoted to provide for horizontal curves on the track, but for vertical ones also. By this means the vehicles can run upon curves of even less radius than the length of the vehicle itself, or on crooked rails or rails laid over uneven ground without danger of derailment.

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The motive power may be either steam, petrol, oil, gas or electricity, as considered most suitable for local conditions. In the full-sized vehicle now being built, however, it has been decided to use a petrol-electric generating set, for the supply of current to the road wheel motors and to the stability mechanism. Such a vehicle will have the great advantage of being always ready for immediate use, the gyroscope wheels being kept constantly running by current from a small battery of accumulators while the engine is at rest.

In order that the vehicle may be able to ascend steep inclines the wheels will be power driven, and change gears provided for use in hilly country. It is also possible to run free wheel down hill at a high velocity, so that a good average speed can be maintained.

The system points to great economy resulting from making the vehicles wider in proportion to their length than on ordinary railways, and it has, therefore, been decided to make the experimental waggon 12 ft. wide, or one and a half times as wide as usual. For civil work in the colonies the vehicles will probably be two or three times as wide, if not more.

Brakes capable of being operated by pneumatic or manual power will be provided for all the wheels.

The rail, which is of ordinary section, only requires to be the same weight as one of the rails on an ordinary line in order to carry the same load on the same number of wheels in each case. The sleepers also only require to be one-half the length to give the same area of support to the vehicle.

Flying lines of railway can be laid with great rapidity over uneven ground with slight expenditure of labour, specially-designed building-vehicles, also on the mono-rail principle, equipped with electric gear for handling the rails, being kept at the rail head for the purpose. It is confidently anticipated that, working in this manner, it will be possible to keep up with an army on the march, and supply them with all their requirements.

For temporary work, bridges may be of the simplest possible construction, a single wire hawser stretched across a ravine or river being all that is necessary. These hawsers can be built up on the spot from separate wire rope strands, so that the transportation of them becomes an easy matter. It is stated that lateral swaying of the hawser will not disturb the balance of the vehicles, and that the strongest winds will not blow them off. In other cases of bridge building, a single row of piles with a rail on top will suffice, or a single girder carrying the rail may be conveniently used.

The expenditure of fuel is expected to be smaller than on ordinary lines, owing to the absence of flange friction on curves, and to the vehicles running without oscillation or jolting.

The speed may be from twice to thrice that of ordinary railways owing to the smoothness of running of the vehicles, and to the total absence of lateral oscillation.

Vehicles provided with their own motive power can go wherever a single rail is laid, and, besides carrying a substantial load themselves, are also capable, on tolerably level country, of supplying current to other vehicles unprovided with power-generating plant.

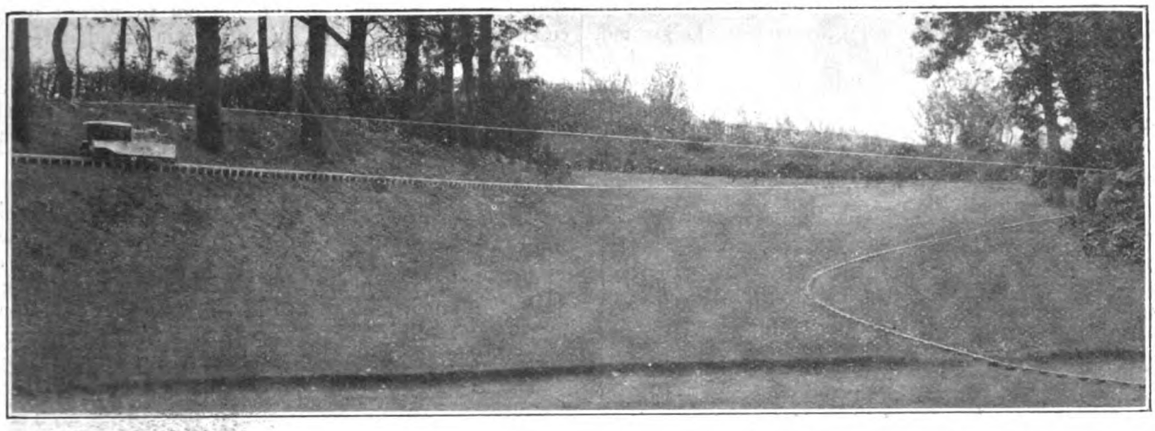

FIG. 4.—VIEW OF MODEL TRACK, INCLUDING WIRE ROPE "BRIDGE" (SEEN AS A LINE ACROSS THE PICTURE.)

The advantages claimed by the inventor for his system are:—

1. *High Speed.*—Almost incredible speeds are expected to be attained on high-class lines laid on this system, owing to the total absence of lateral oscillation caused on ordinary lines by the impossibility of laying two lines exactly level and parallel with each other. From twice to thrice ordinary railway speeds are to be expected.

2. *Capability of Vehicles taking Curves.*—The fact that the vehicles lean inwards to the correct angle when taking curves secures them from derailment at the highest speeds. They would, of course, have to be suitably approached to give the vehicle the time necessary to assume the proper inclination at the particular speed adopted and the line would have to be laid accordingly.

FIG. 5.—THE MODEL CAR, SEEN ALSO IN FIG. 4, WITH LOADS EQUIVALENT TO THE NUMBERS MARKED, AND CAPABLE OF CARRYING ONE MAN.

3. *Large Carrying Capacity of Vehicles.*—It is certain that for "high class" trans-continental lines, the vehicles will be very large, so large indeed that they will more resemble ships

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on shore, or travelling hotels, than vehicles as we know them now.

4. *Perfect Comfort in Travelling*, owing to there being no oscillation.

5. *Saving of Material* required for construction of line in the way of rails, bridges, sleepers, &c.

6. *Small First Cost, and Small Cost of Maintenance.*—This is obvious, as only one rail is required and the sleepers need be only half the length.

7. *Safety.*—Travelling will be much safer, owing to the absence of danger of derailment at high speeds.

Fig. 4 shows the model running along the side of a bank on longitudinal timbers placed upon piles driven into the ground, representing the application of the system to transport in mountainous country, especially country subject to landslips either in the form of boulders or slippery clay. This method avoids notching the sides of the hills, and does not interfere with natural drainage; it is also very easily repaired if injured, and allows great distortion through the slipping of the ground. On the right-hand side of the photograph is seen the rail, in this case made of gas pipe, but which, of course, would be of the ordinary section, turning through a corkscrew curve on to the wire rope bridge which the model traverses. It is an interesting fact that the model is even safer in the middle of this bridge than upon the rail. This is owing to the fact that, as the mechanism imparts a turning couple to the entire vehicle, it can move the rope laterally, and thereby save time in coming to a position of equilibrium.

Fig. 5 gives a more complete view of the model, which has propelling motors fore and aft. The gyroscopes are placed underneath the seat at the back of the cab. This model ascends slopes of 1 in 5 fully loaded with a load equivalent to 20 tons on the big machine which is to be built. It has two gears for driving the wheels, and also a free wheel. All the wheels are power driven, in order to enable the model to ascend steep inclines.

The gyroscope wheels are driven by armatures fixed direct on the shafts, the field magnets being carried in the casing, which is trunnioned top and bottom to permit of the precessional movement. Both pneumatic and hand brakes are provided. In the full size, this vehicle would be driven by two petrol engines placed in the cab, which would generate the current for the supply of the gyroscopes and the road wheel motors. It is proposed, in the first case, to use two 100 H.P. engines, and a small petrol-electric set will also be provided for keeping up the speed of the gyroscopes when the main engines are not working. When the main engines are running the current can, of course, be taken from them. This vehicle can thus run for warlike purposes in an enemy's country, wherever a single rail is laid.

We are much indebted to Mr. Brennan for supplying these particulars, and for his courtesy in showing us the model railway and explaining the many interesting details.

THE KENT ELECTRIC POWER COMPANY.

(*Concluded from page 133*).

Switchboard and Mains.

The high-tension switchboard, which has been designed and constructed by the Electrical Co., is extremely interesting and embodies several very valuable improvements on existing practice. It is seen in the upper part of Fig. 6 and also in Fig. 10.

In addition to each dynamo and feeder panel being entirely enclosed in a brick cell, the whole of the switchgear on each panel is mounted on a special carriage with an iron front. This front encloses the cell, which is thus entirely isolated. By an ingenious system this carriage is so arranged that it can be pulled forward and removed, if necessary, on a light trolley, thus entirely disconnecting the whole of the switchgear and apparatus from the 'bus bars.

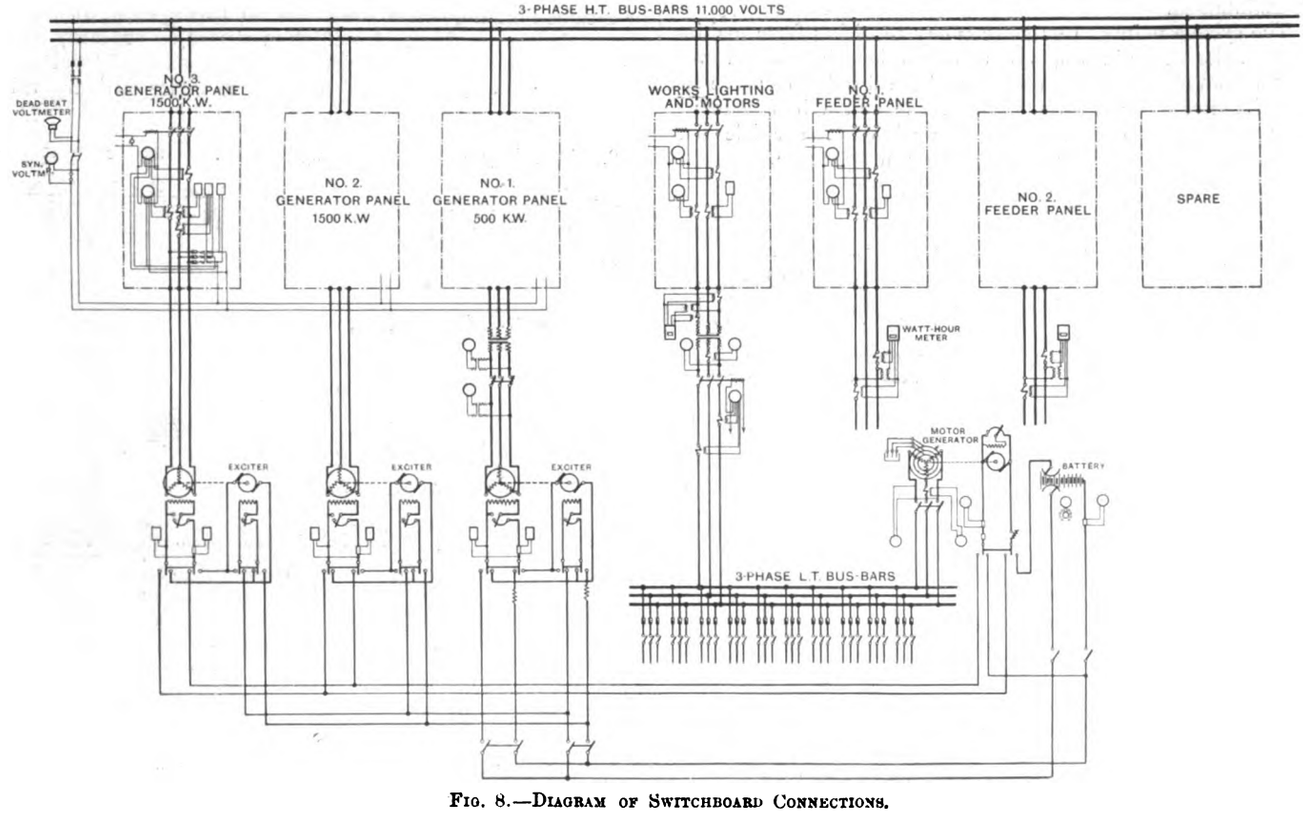

Fig. 8.—Diagram of Switchboard Connections.

The advantage of such a system is very obvious for high-tension work, since if it is necessary to clean the apparatus or carry out any repairs or adjustment, this is done when the carriage is entirely removed from the switchgear, thus prevent-

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ing any possibility of the attendants coming in contact with the high-tension circuits.

A further advantage of this system lies in the fact that, when any circuit or alternator is out of use, the carriage is drawn forward a certain distance, controlled by a stop provided for the purpose, which process disconnects the carriage from the 'bus bar, and, consequently, all the electrical apparatus belonging to the panel becomes dead.

In Fig. 9 is seen a spare feeder panel pulled forward on to a special trolley, which is used for supporting the panel, together with its carriage. The panel is drawn out with ease, as the carriage on which it is built moves forward on small wheels. Before the panel can be drawn forward it has to be released by the movement of a lever, which is interlocked with the switch mounted on the panel, so that the switch has first to be put into the "off" position before the lever can be moved. The connections with the 'bus bars are made by means of clip contacts. Each feeder panel contains one three-pole oil switch for 200 amperes, with the usual automatic release

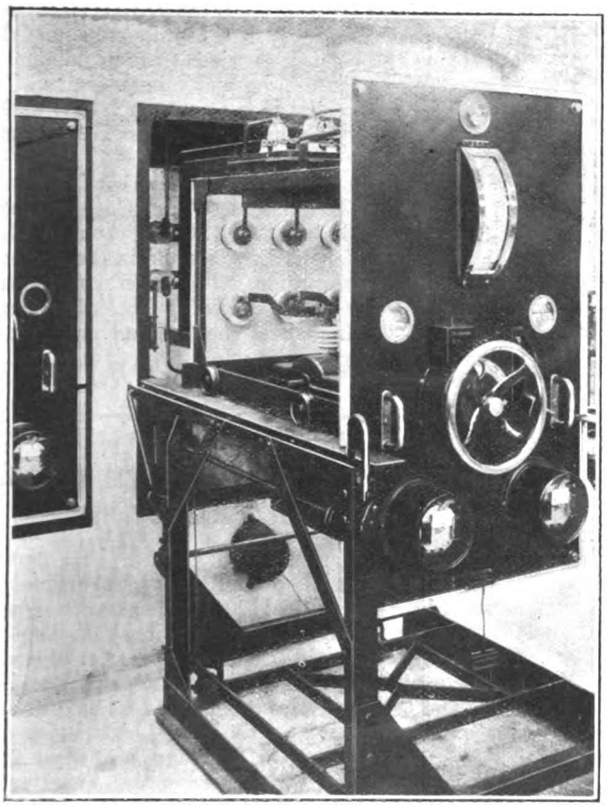

FIG. 9.—H.T. FEEDER PANEL DRAWN FORWARD ON TO TROLLEY.

coils; two maximum current time relays; two current transformers for the above relays; and one induction ammeter, profile form, with current transformer. Fig. 11 is a drawing showing an end view of the switchboards, and Fig. 8 is a diagram of the connections.

The 'bus bars themselves are entirely enclosed in brickwork chambers, and are thus fully protected from being a source of danger.

The alternator circuits are protected by automatic relays working with continuous current from an independent source, and are brought into operation by adjustable time-element relays.

Each alternator panel contains one three-pole oil switch for 200 amperes, with the usual automatic release coils; two combined maximum and reverse current relays; two current transformers for the above; one induction ammeter, profile form; one induction wattmeter, profile form; one dead-beat voltmeter, profile form; one three-phase potential transformer; and one two-pole plugging device for synchronising purposes.

The switchboard is so designed that, if in the future it is desired to connect overhead circuits, they can be easily added. At the present time the board is arranged to control three alternators and four feeder circuits.

There is an extremely compact arrangement for operating the two control rheostats, and for carrying the exciting cur-

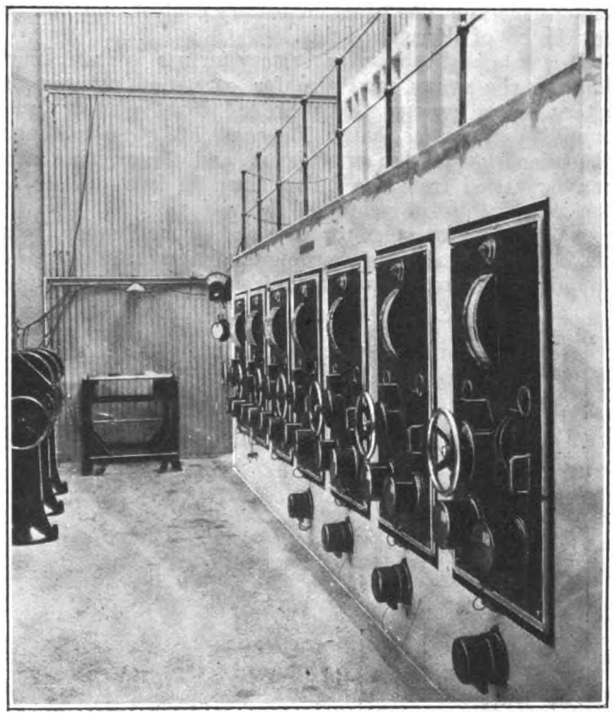

FIG. 10.—VIEW OF H.T. SWITCHBOARD AND ALTERNATOR FIELD CONTROL COLUMNS.

rent instruments, supplied in the form of a separate pillar, arranged in front of each of the dynamo panels. The resistances themselves are in a brick cellar beneath the high-

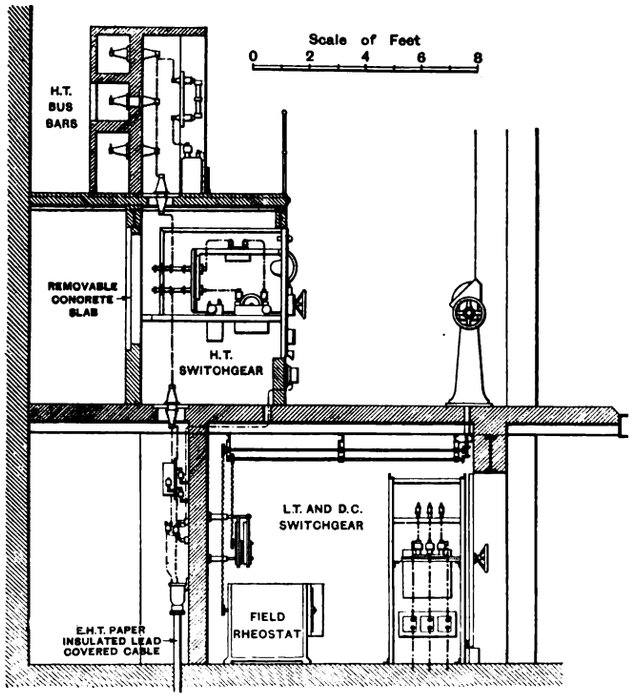

FIG. 11.—END ELEVATION OF SWITCHBOARDS.

tension gallery. On this lower gallery two low-tension switchboards are also erected. From one of these run the circuits for the works lighting and for the motors driving the circulating pumps, air pumps, stokers, &c.

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The two low-tension switchboards together comprise six panels; these are arranged as follows: one transformer panel, one panel for control of alternating current side of 50 kw. asynchronous motor-generator, one panel for works lighting and motors, one panel for control of continuous-current side of motor-generator, one panel for battery control, and one panel for control of alternator fields.

It is intended to install a battery for use in emergency for lighting the works, and also for excitation purposes, each alternator at present being excited from a small dynamo coupled on the same shaft. The control of these exciters is on the second low-tension switchboard, and the exciting current can be varied from the pillars fixed in front of the high-tension switchboard mentioned above.

A 50 kw. motor-generator, supplied by the Phœnix Dynamo Co. is being installed for charging the battery, the motor being supplied with three phase current from the low-tension 'bus bars.

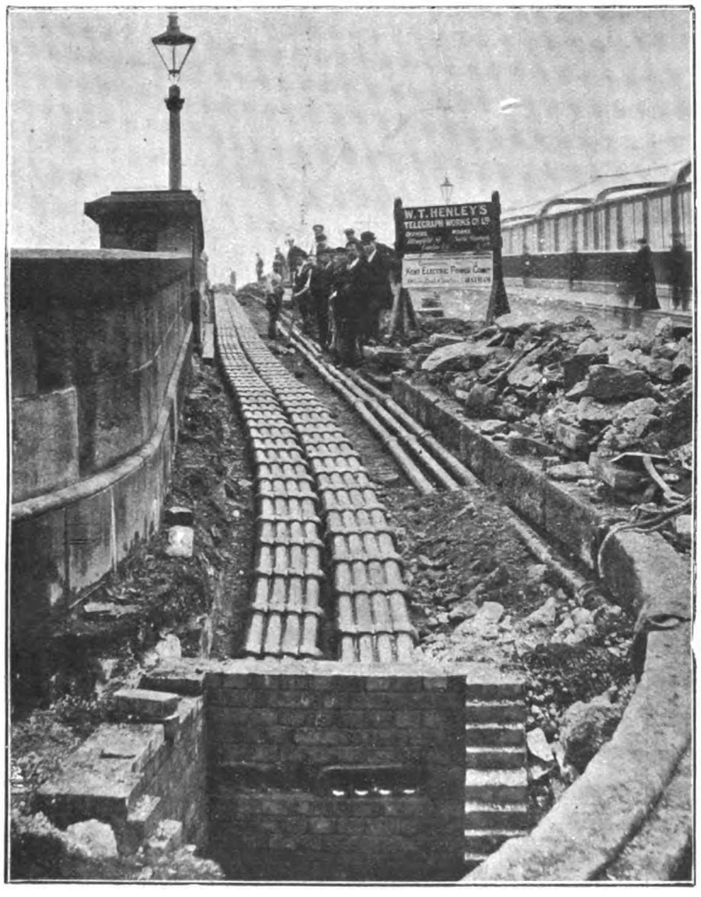

FIG. 12.—EIGHT-WAY CONDUIT BEING LAID OVER ROCHESTER BRIDGE.

At the present time, the arrangements are not quite complete for the 11,000 volts three-phase supply, so that a temporary supply is being given at 2,000 volts; this is obtained direct from the 500 kw. set and by the use of the transformer before mentioned, which is temporarily connected up to the larger sets.

The feeders running from the high-tension switchboard consist of Henley's three-core paper-insulated lead-covered cables drawn into Sykes conduits. An eight-way conduit (Fig. 12) is laid at present through Chatham. Three-phase current is to be supplied at 11,000 volts, and separate transformers are to be used for each large consumer. In the case of Messrs. Cory's works, where a supply of continuous current is required for crane work, &c., the 11,000 volts three-phase supply is taken to an induction motor coupled to a continuous-current generator of 500 kilowatts capacity. This motor generator is supplied by the Kent Electric Power Co., and a duplicate machine is also being fixed by Messrs. Cory, a throw-over switch enabling either plant to be used. It is worth noting that the current is metered on the continuous-current side of the motor-generator.

At the present time arrangements are being made for a four-core system of low-tension three-phase mains in Chatham and Rochester; these mains are being laid on the solid system. The Chatham and Rochester supply was originally on the single-phase system, but, owing to the temporary supply which was obtained from the Gillingham Corporation being three-phase, the mains had to be arranged in three circuits. During the change over of the consumers on to the new system the installations are to be converted from 110 to 230 volts.

The present generating station of the Kent Electric Power Co. provides room for the future installation of two more turbo-alternators, each of these to be of 3,000 kw. normal rating, and it is intended to erect a second chimney when the full complement of boilers is installed.

It is interesting to note that maximum demand indicators are being installed on the power circuits. These demand indicators are chiefly of the Electrical Company's and Reason Company's manufacture, and are fitted with Merz's attachment. In the former the attachment is driven electrically, and sums up the units consumed during every 15 minutes; in the latter the drive is mechanical, and the period over which the units are summed up is one hour. This latter period is, in our opinion, too long, but those giving the maximum average of the consumer's load reckoned over quarter hourly periods should prove very satisfactory both to the consumer and to the power company.

The consulting engineers who have carried out the scheme for the Kent Electric Power Co. are Messrs. G. L. Addenbrooke and A. A. C. Swinton, to whom we are indebted for the drawings and information contained in this description. The general manager of the Kent Electric Power Co. is Mr. H. E. M. Kensit, and Mr. C. T. Linney is the resident engineer, to whom our thanks are also due.

THE EXTENSION OF THE CITY & SOUTH LONDON RAILWAY.

The City & South London Railway, the first section of which was opened in 1890, has the credit of being the first underground electric railway in England. The original line only extended from the Monument to Stockwell, but in 1900 the extensions to Moorgate-street and Clapham were opened, and in 1901 the line was extended as far as the Angel, making a total length of 6¼ miles. On Saturday last, May 11th, the latest extension, which is from the Angel as far as Euston, was opened by Mr. H. P. Harris, Chairman of the London County Council.

It is expected that this latest addition to the line, about 1¼ miles in length, will bring a considerable increase of traffic, as it makes direct communication between the south of London and the Great Northern, Midland, and London & North-Western Railway termini. The new stations on the tube railway, which are situated at King's Cross and Euston, will prove very convenient for passengers travelling to or from the railways mentioned. The tube extension is of exactly the same character and dimensions as the existing line to the Angel, of which a detailed description was given in *The Electrician* of November 26, 1901, et seq., and also of December 18 and 25, 1903, when an abstract was given of Mr. McMahon's Paper read before the Institution of Electrical Engineers. It will be remembered that the railway is now worked on the three-wire continuous-current system with 1,000 volts pressure across the outers.

The new generating plant which is being installed in the power station at Stockwell, in order to satisfactorily deal with the increase in load due to the extension of the line to Euston, consists of two 300 kw. 500 volt E.C.C. generators, coupled to one Lentz engine. This latter is of German design and of

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standard type, but has been made by Messrs. Paxman, of Colchester.

A Richardson Westgarth condenser has also been installed. This is of Mr. Morrison's design, in which the water is passed through four times. It is capable of dealing with 50,000 lb.

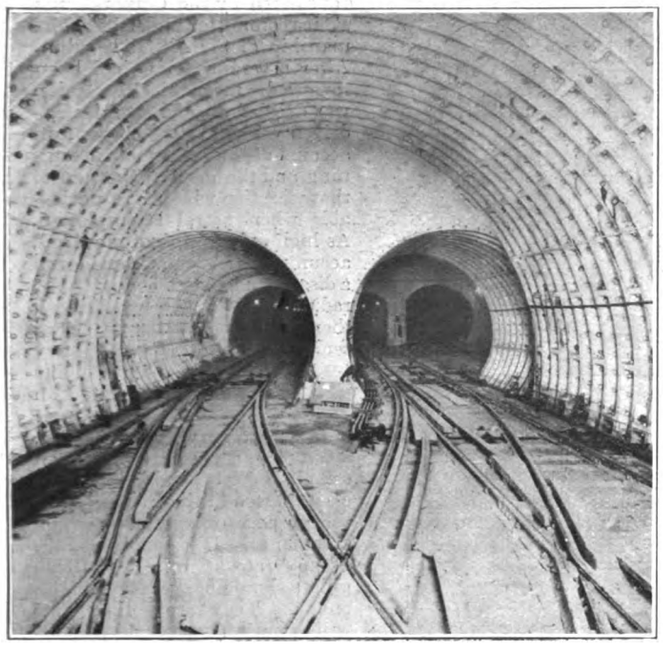

FIG. 1.—EUSTON CROSS-OVER AND SIDING.

of steam per hour. The vacuum which was usually obtained with the old condensing arrangements was only about 24 in. It is expected that better results will be obtained with the new condenser, which will also be of considerable use when it is necessary to shut the existing one down for cleaning and repairs.

In connection with the new condenser a Baker's oil separator is fitted. The previous arrangement for separating out the oil consisted of treating the hot well water with alumino-ferric solution for curdling the oil, the water being then taken to settling tubs and passed through a Wilson's patent automatic sand filter, and finally going through a feed water heater and Boby detartariser. Motor-driven air pumps and circulating water pumps have also been installed. Within the last 12 months an artesian well has been sunk adjacent to the power station, and the supply of water is now obtained from that source. The cost of the water taken from the artesian well works out at less than 1d. per 1,000 gallons. This means a very considerable saving on the previous price for water of 6d. per 1,000 gallons, which was paid for a supply of water from the public mains. Air at 60 lb. pressure is used for raising the water, and about 100,000 gallons of water are now taken per day from the well, the only disadvantage to set against this cheap source being that the water is rather hard.

No additional boilers are being installed, but six Sugden superheaters have been fitted, one on every second boiler. If these prove satisfactory, others will also be fitted to the remainder of the boilers. It is not intended to use many degrees of superheat, the object in installing the superheaters being to obtain dry steam at the engines.

The new extension of the track is of exactly the same construction as the rest of the line, of which particulars have previously been given in *The Electrician*.

Fig. 1 is a view of the tunnels at Euston station; the third tunnel on the right-hand side of the illustration is simply a siding and will accommodate two trains.

At the terminus at Euston a traverser (Fig. 2) is used for shifting the locomotive on to the return track.

Electric lifts of the Otis type have been installed at King's Cross and Euston, and at the latter station the gates of the lifts are worked by air pressure, similarly to those on the other tube railways, whilst the lift gates on the City & South London Railway have been previously only worked by hand.

The conductors are continuous throughout the whole of the tunnel, but section switches are fixed in each signal box, so that when necessary any section of line can be immediately isolated by the signalmen. This, of course, provides for safe and rapid isolation in the case of a breakdown.

An improvement, which also tends to increase the safety of the line, consists of two No. 12 gauge bare iron wires, which are run along the tunnel wall between the signal boxes. Each locomotive carries a battery telephone set, and by simply clipping a pair of leads on to the two bare wires mentioned the driver of the locomotive is immediately put into telephonic communication with the nearest signal cabin. These same iron wires are also used for local communication from one signal box to the next.

The electric lights in the tunnels are not used during the ordinary working of the trains, but each signalman has instructions that when a train has been a longer period than two minutes in any one section the tunnel lights are to be switched on. These tunnel lights are fed from the batteries at the sub-stations.

The signals are operated on Spagnoletti's electric interlocking principle.

The extension of the tunnel and the permanent way has been carried out by Messrs. Scott & Middleton, whilst the Electric Construction Co has fixed the third rail and done the bonding, &c., and the Lahmeyer Electrical Co. have supplied the new cables.

The only additional sub-station plant consists of an E.C.C. reversible booster in the London Bridge sub-station; this

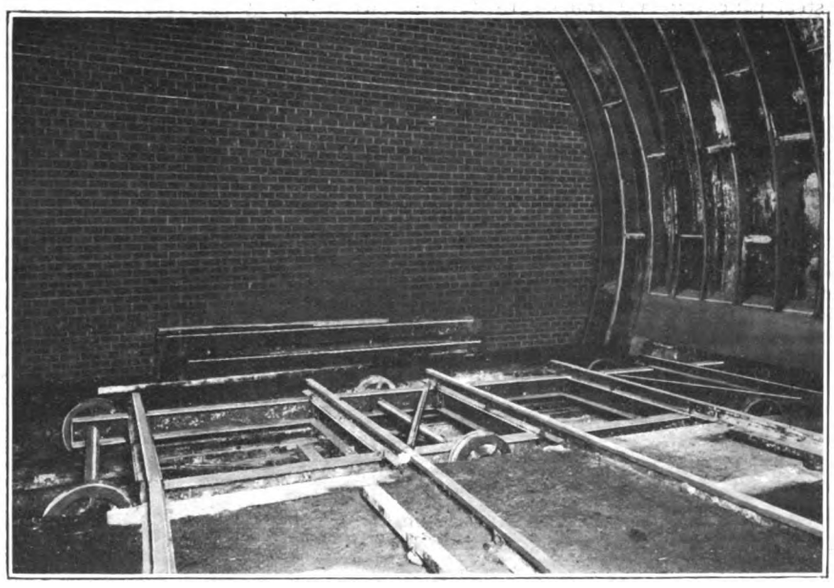

FIG. 2.—TRAVERSER FOR LOCOMOTIVES AT EUSTON.

booster is a modification of the well-known Highfield reversible booster.

Feeder cables have been run from the Angel sub-station to King's Cross, at which point the new section of the line will be fed, and the Angel sub-station will also continue to feed at the Angel as previously. It will be remembered that the other

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feeding points of the line are at London Bridge, where there is a sub-station. and at the Elephant and Castle and Stockwell, both of which latter places are fed direct from the generating station with low-tension current.

It is very interesting to note that the City & South London Railway has not been troubled with rail corrugations, and this notwithstanding that many of the rails have been in use for 17 years—that is, since the opening of the original line. A slight trace of corrugation is noticeable near Stockwell Station, probably due to the application of brakes, but nowhere else have any corrugations appeared. We believe that this fortunate experience is very largely due to the use of electric locomotives. The excessive wear of the rails on the District and other electrified lines probably arises from the use of motors at both ends of the trains, the motors at the end of the train causing the carriages to exert an excessive pressure on the rails at curves.

The new coaches which have been supplied by the Brush Electrical Engineering Co. have been designed to be as fire-proof as possible, and in this respect they are superior to those previously used.

The trailer coaches are constructed to give the same general appearance as the later type of existing stock, the main dimensions being kept the same. They are arranged to run in trains of five coaches, connected with four intermediate platforms carried on the bogies by rollers, and pivoted at each end to allow the cars to take curves readily. At each end of the train there is an end platform which is bolted to the bogie. The bogie frames are of pressed steel, the wheels and axles being of the City & South London Railway standard pattern.

Some of the chief dimensions are as follows: Length over car body, 26 ft.; width over car body, 6 ft. 10 in.; total height from rail, 8 ft. 4¾ in.; bogie wheel base, 5 ft.; bogie centres, 16 ft. 9 in.; length over bogies, 32 ft.; total length of train, 160 ft.; weight of train, 37½ tons; number of seats per car, 32; weight of car per seat, 0·25 tons; weight of train per foot-run, 0·284 tons.

The cars are constructed throughout of steel framework, the solebar being of plate flanged to form a deep channel, the longitudinal rails being of angle steel and the pillars and car-lines of light-section channel steel. The whole of the framework is well tied together with knees and gusset plates, while the steel panelling is arranged to take all wracking strains from the main connections. This gives great strength to the structure with a minimum weight of material.

The floor is made up of litosilo fire-resisting cement laid on corrugated plate, the corrugations being arranged to run cross-wise in the car.

The exterior of the car is moulded in teak, with teak window frames, and the panelling is painted and grained to match. This gives the cars the same general appearance as those previously constructed in teak throughout.

The interior of the car is arranged to give maximum room, no inside lining being provided for the roof or sides. The photo and mirror frames are in teak, the panelling painted and grained to suit, while the roof is enamelled white. Seats and backs are of the spring type with canvas-lined rattan, arranged longitudinally. Doors are provided at each end of the car, arranged to slide outside the end casing. The doors are framed in teak with steel panels. Ventilation is provided by means of perforated plates forming the clerestory sides, which gives a constant change of air.

The cars are equipped with Westinghouse brakes, the air piping being carried on the roof and the connections being made over the platform canopies.

We are indebted to Mr. P. V. McMahon, chief engineer to the line, and to the Brush Electrical Engineering Co., for the particulars here given.

NEW AMBULANCE SCHEME FOR THE CITY OF LONDON.

For some time past it has been felt that something better than the ordinary hand ambulance was needed in the City of London, and thus the question of improving this service has lately been considered by the Corporation's Police committee, under the chairmanship of Sir Alfred Newton. After several schemes had been reviewed, mechanical traction was decided on, and electrically-driven vehicles were chosen, on account of their quietness in running and the general absence of that vibration which is so noticeable when petrol is employed. As high speeds are not required, accumulators are not considered a disadvantage, and owing to the radius of action being limited there will be no difficulty about recharging, and a very heavy battery will not be needed. This new service was inaugurated on Monday last.

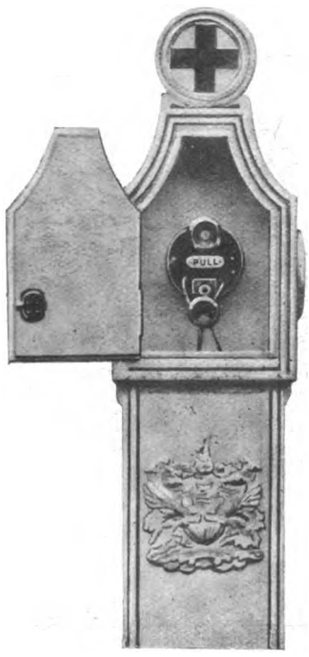

FIG. 1.—CALL BOX OPEN, SHOWING TELEPHONE.

In connection with the scheme, a complete call system has been established. Special pillars have been erected in the City area for the purpose of summoning the ambulance. It is not intended, at any rate at first, that these pillars should be accessible to the public. They are locked and will be entirely under the control of the City Police, who are provided with keys. This arrangement is really free from objection because the number of police in the City is very large, and, further, the pillars are, in general, placed at spots where a constable is on point duty, so there will be no injurious delay. All the pillars communicate with a special exchange at the head-quarters of the City Police in Old Jewry. When an accident occurs the constable will ring up this exchange, and the ambulance will be directed from it where to go. This is thought to be a better arrangement than having the pillars in direct communication with the

FIG. 2.—ELECTRIC AMBULANCE.

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district ambulance station, as in case of serious accidents several ambulances can be dispatched to one place. The whole of this calling system is under the control of Superintendent Fitzgerald of the City Police.

A view of one of the special call boxes is shown in Fig. 1. They are painted white with a red Geneva cross on the front. Their design is due to Messrs. W. B. Reynolds and they were manufactured by Messrs. A. C. Brown. The interior of the apparatus, as may be seen in the figure, consists of a "handle-grip" and an ordinary telephone instrument. When this handle is worked a distinctive call is made at Old Jewry, on receipt of which the ambulance is sent to the required spot without further delay. Should it be necessary to communicate any further message the telephone may be used by raising the receiver from the hook in the ordinary way. This telephone can also be used for purposes connected with the ordinary working of the police force without affecting the special ambulance call. The pillars themselves, of which there are at present 52 distributed over the City area, were erected by the Post Office for the Corporation. The wires, which connect them to the exchange, are for the most part laid in the same ducts as the Post Office telegraph cables and form part of a complete metallic circuit.

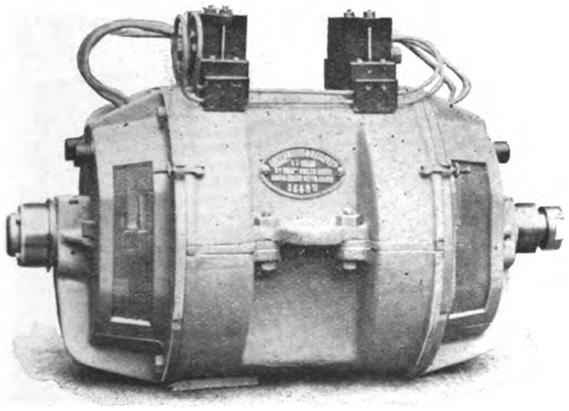

FIG. 3.—ELECTRIC MOTOR.

At present one electric ambulance has been completed and is to be housed in a temporary ambulance station in King Edward-street, near St. Bartholomew's Hospital. A general view of this car is given in Fig. 2. It has been built by the Electromobile Co., and its chassis embodies the usual details which are to be found in this firm's electric broughams and landaulettes (see *The Electrician*, Vol. LIV., p. 699). The bodies are similar to those of the ambulances used by the St. John's Ambulance Association. The stretchers can be easily removed, and there is room inside for a nurse to travel with the patients.

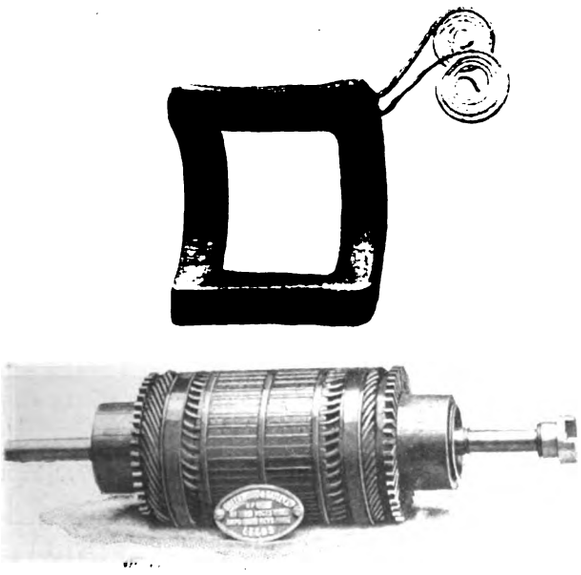

FIG. 4.—ARMATURE AND FIELD COIL.

The battery on the car consists of 45 E.P.S. cells of a special pasted type. The total weight is about 10 cwt. and the capacity is about 135 ampere hours. The positives have a life of 12 months or more according to the work done, and they can be easily replaced.

The ambulance is fitted with an 8 B.H.P. series motor by Greenwood & Batley (Ltd.), running at 1,500 revs. per min., but it can safely exert 16 H.P. for short periods. A general view of this motor is given in Fig. 3. It is of the ironclad type, bipolar and series-wound, having two separate commutators, connected to separate armature windings. The designers, MM. Costal and Gasnier, have introduced a very compact arrangement of field castings and bobbins by which magnetic joints are avoided, and the distortion of the field due to armature reaction is counteracted, resulting in a reduction of field ampere-turns and a total suppression of sparking. The controller gives five forward speeds ranging from 3 to 15 miles an hour, two electric brake contacts and one reverse contact. On the first forward contact both the armature windings and both the field windings are in series with each other and with a starting resistance. On the second contact, this resistance is cut out. On the third, the fields are placed in parallel, the armatures being as before in series. The fourth notch places the two armatures in parallel with the fields in series. The fifth and last speed is when both fields and both armatures are in parallel. The framework of the controller is an aluminium casting, bolted direct to two longitudinal angles of the chassis, which also carry the steering bracket. Its position is thus horizontal and immediately below the floor boards, in which is a trap-door exposing the brushes and terminals. It is enclosed from below by a sheet-metal casing, carried across the frame, so as to protect all the electrical fittings from mud and wet. The handle actuating the controller is immediately below the steering wheel and moves in a plane parallel to it. This has been found in practice to be the most convenient position, as it necessitates the least movement on the part of the driver. The handle is mounted on a tube concentric with a steering spindle, which actuates the controller by means of a bevel gear. The usual ratchet mechanism is provided to prevent any lingering between the positions of contact. An index plate, showing the positions for speeds, is mounted directly below the controller handle, on an external tube, which renders the whole steering column rigid.

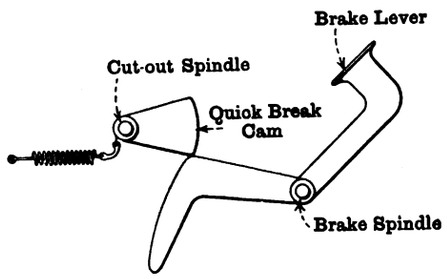

FIG. 5.—ARRANGEMENT OF BRAKE SWITCH.

In addition to the two electric brakes, a powerful double-acting expansion brake is fitted on the hubs of the rear wheels. The levers and connecting rods are so hung as to cause no vibration or rattling when the ambulance is running over uneven roads. A quick break switch is connected with the brake pedal so that the circuit is broken before the brake is applied. A slight movement of the brake spindle rotates a quick break, and the circuit is broken. Further movement of the spindle will not affect this mechanism, as it is still held off by the rounded part of the brake cam. On releasing the brake the quick break cam falls back, and the current is switched on quickly by the spring. A sketch of this arrangement is given in Fig. 5.

The motor drives through a double train of double helical gearing to the differential and thence to the hubs of the rear wheels by a live axle. The motor casing is continued into the gear-box, so that the entire driving mechanism is dust and waterproof, and can be entirely detached from the ambulance by removing the spring clips and the pin by which the motor is suspended from the frame. The gear runs in oil, which is thereby automatically circulated through the bearings and can only escape after reaching the road wheels.

For charging the batteries a special motor-generator, manufactured by the British Thomson-Houston Co., has been erected. It consists of a shunt-wound generator having an output of 34·8 amperes at 115 volts. This generator is direct-coupled to a 400 volt 6 H.P. shunt-wound motor running at a speed of 1,500 revolutions per minute. Current for driving this set is obtained from the mains of the City of London Electric Lighting Co. A switchboard is provided carrying the necessary regulating switches, instruments, &c.

In conclusion, we beg to tender our best thanks to Mr. A. A. Voysey, electrical engineer to the Corporation of London, under whose supervision this scheme was carried out for providing us with details of the various apparatus connected with it. We also wish to thank the Electromobile Co. and other firms mentioned in the above description for giving us information with regard to the special parts of the scheme with which they are connected.

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AN ELECTRICALLY-DRIVEN CEMENT WORKS.

The important works of Messrs. Casebourne & Co. (Ltd.), Portland cement manufacturers, are situated at Haverton Hill, West Hartlepool, and cover an area of about 5¼ acres. They are extremely compact, and are built almost entirely on foundations of reinforced concrete, owing to the marshy nature of the site.

Up to a few months ago the entire cement-making machinery was driven by oil engines, which have now been superseded by three-phase induction motors. The directors of the company first considered the subject of electrically driving their works at the beginning of last year, and after due deliberation were satisfied that the change would increase their output and cheapen their cost of production. A contract was therefore entered into for a generating plant, but this was subsequently cancelled in favour of an arrangement effected with the Cleveland & Durham Electric Power Co. for a supply of energy direct. Thus, motors and switchgear alone became necessary, and the contract for these was placed with the British Westinghouse Electric & Mfg. Co. (Ltd.). As the Cleveland & Durham Electric Power Co. generate and supply electricity at a price per unit which is, we understand, unequalled in Great Britain outside the Newcastle area, Messrs. Casebourne's choice of means

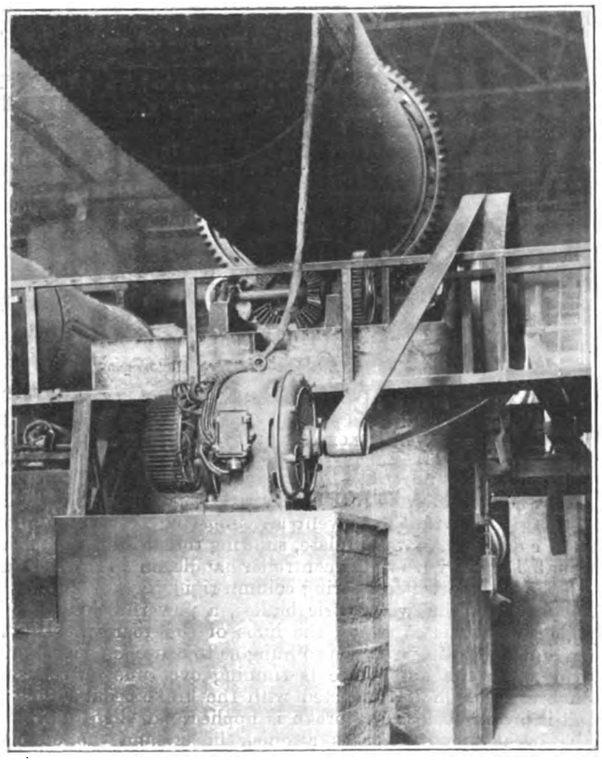

FIG. 1.—15 H.P. MOTOR DRIVING ROTARY KILN.

for obtaining a supply was fully justified. The installation is particularly interesting as being the first cement plant in this country to be electrically-driven throughout, and here, as elsewhere, the electric drive has met with remarkable success.

In operating modern cement-making machinery an absolute continuity of motive power is essential. The old system by which Messrs. Casebourne's machinery was driven cannot be said to have met this condition, as the oil engines had an unfortunate way of breaking down. Also, the practice of mechanically transmitting power from a central source is, of course, open to many objections, such as the loss in long lines of shafting, lack of flexibility and the necessity for large floor space conforming to engine requirements. Some idea of the conditions to be met in the modern manufacture of cement may be gained from the following description of the various processes through which the raw material—chalk and clay—passes before it emerges as the finished product.

In the first place, the chalk is brought by sea from Kent, up the river Tees, in steamers loading about 1,000 tons, to the side of Messrs. Casebourne's private jetty. Here it is hoisted from the boats by means of grabs and emptied into the hoppers of two large elevated crushers, through which it passes into a Hunt bucket conveyor made by Messrs. Babcock & Wilcox. This conveyor is driven by a 20 H.P. motor, and each bucket is swung on a centre pivot, and travels to the end of a raised gantry, where it is tipped. The chalk falls near the "wet mill," into which department it is run in bogies and emptied into "wash mills." The clay, which is dug locally, is brought in waggons and also emptied into the wash mills, the proportion of chalk to clay being approximately as three to one. These wash mills are octagonal in shape, and are fitted with harrows which are attached to radial arms and rotated by a central vertical shaft. Water is kept constantly flowing into them, and combines with the chalk and clay until the mixture is in a liquid form, technically termed "slurry." This slurry is then taken by a bucket elevator into what are known as the slurry-

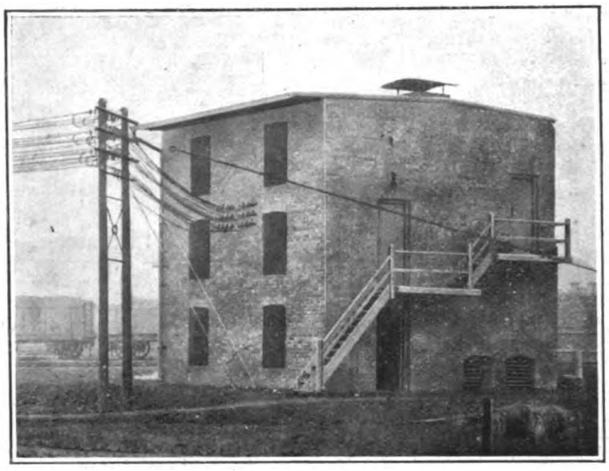

FIG. 2.—VIEW OF SUB-STATION.

grinding or tube mills, situated immediately behind the wash mills. This type of mill consists of a long hollow cylinder partially filled with flint cobbles, driven at a comparatively slow speed, and depending for its action upon a large rubbing surface. In passing through the tube mill the slurry is very finely ground, and it is recognised as one of the all-important points in cement manufacture that the finer the slurry the more reliable and constant in volume will be the cement. From the tube mills the slurry is pumped through underground pipes, by means of a three-throw 10 in. pump, into a large ferro-concrete mixer holding about 900

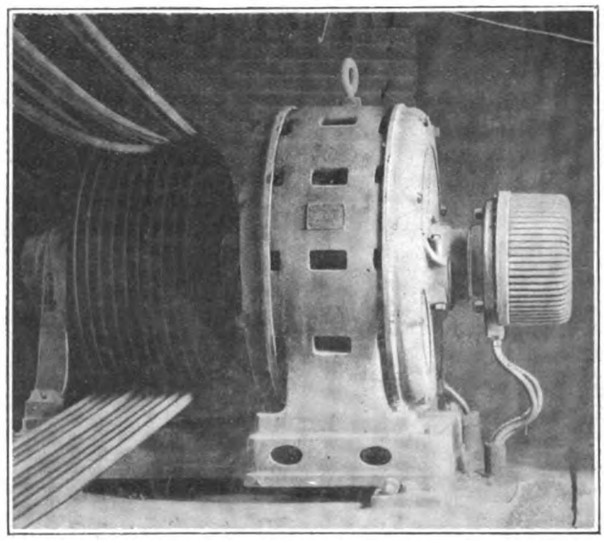

FIG. 3.—200 H.P. MOTOR DRIVING GRINDING PLANT.

tons. The continual rotation of large arms inside the mixer keeps the slurry at an even consistency before it enters the rotary kilns. It is next lifted, by a second pump, from the mixer up to the nose or entrance of each of the four rotary kilns.

This type of kiln, a view of which is given in Fig. 1, has completely revolutionised the system of cement manufacture in this country. It consists of an iron cylinder, about 100 ft. long by 6 ft. 6 in. in diameter, which rotates on its own axis at about one revolution per minute, and is lined with firebrick. The cylinder is slightly inclined downwards from the chimney, at which end the finely-ground slurry is fed in continuously. Into the further end

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the fuel, in the form of pulverised coal, is blown by means of a fan, and burns with an intense gas-like flame. The slurry, which passes steadily forward owing to the rotation of the kiln, gradually reaches the white-hot zone, and is converted into "clinker." The amount of slurry passing through the kiln can be regulated at the entrance or nose. The clinker then falls through a hood at the lower end of each kiln into a rotating clinker-cooler, in which it is cooled by cold air. Sliding down this cooler by gravity it next falls into a "shaker" conveyor, which transfers it to an inclined bucket-elevator, by which it is discharged into an elevated 300 ton ferro-concrete silo situated over the "dry mill." In this silo the clinker divides and drops down two shoots into a pair of No. 9 Krupp steel ball-mills for preliminary grinding, from which it proceeds by a bucket-elevator into an Avery automatic-weigher. The partially-ground material now passes by an inclined screw-conveyor into two 26 ft. 4 in. by 5 ft. Krupp tube-mills in which the final grinding is done. On emerging from the dry tube-mills the finished cement is taken—by means of a screw-conveyor, an elevator, and a second screw-conveyor—into the packing warehouse, where it falls through specially-designed chutes. The warehouse holds 6,000 tons of finished cement, which is sacked off for shipment by rail or water.

The coal-drying and crushing department is also worthy of notice. The coal is brought in wagons along a siding and tipped into a large, circular ferro-concrete coal pit, from which it is elevated into a rotary coal-dryer, heated by hot air. The coal, on leaving the dryer, should not contain more than about 1 per cent. of moisture, or it fails to grind perfectly, which operation is performed by two ball mills and two tube mills, similar in principle to those already referred to for grinding the clinker. The finely-ground coal is then transferred by a screw conveyor to four 5 ton hoppers at the end of the rotary-kiln house, where it next passes to the coal-feed fans, which blow it into the kilns, the amount of feed for each kiln being regulated by a Reeves variable-speed gear. A stream of hot air from the clinker coolers furnishes the supply of air for the fans and gives a still further drying effect to the fuel.

Ever since cement was first manufactured it has been subjected to a rigid system of testing. The chemical laboratory at Messrs. Casebourne's, where the tests are carried out, is a department no less important than large, and is equipped with a ½ H.P. motor. An "Eos" petrol gas plant, installed by Messrs. J. Powell & Sons, of Newcastle-on-Tyne, supplies the heat for the Bunsen burners, ovens and Muffle furnaces. Every known method is employed in the testing department to ensure a perfect and regular product, and that Messrs. Casebourne & Co. have succeeded in accomplishing this is proved by the remarkable specification to which they guarantee their "Pioneer" brand of Portland cement. This guarantees that the cement, if tested hot from the mouth of the mill. will stand the boiling test perfectly; and that, on the Le Chatelier tests, it will not give a greater expansion than 3 mm. to 5 mm., although 6 mm. is allowed by the British Standard Specification after seven days aeration. It also guarantees that the residue shall not exceed 14 per cent. on a sieve of 32,400 meshes per square inch.

The whole process, as seen at Messrs. Casebourne's works, is representative of the most up-to-date manufacture, and the new electrical scheme, together with certain mechanical improvements of considerable importance, have been carried out under the supervision of Mr. W. J. Coles, of Messrs. Maxted, Knott & Coles, of Hull, the consulting engineers, who, besides being a cement engineer, has a thorough knowledge of electrical work.

We now turn to the electrical equipment. The three phase 40 period high-tension transmission lines of the Cleveland & Durham Electric Power Co. are brought from Grangetown, a distance of 18 miles, into a sub-station at the works (Fig. 2). The cables are run underground, and it is the intention of the Power Company to lay a duplicate set to safeguard against accident. The current is then transformed down from 11,000 to 440 volts, the maximum variation of the pressure at the motor terminals being from 400 to 440 volts.

A Westinghouse low-tension switchboard is erected in the sub-station, and consists of six white Sicilian marble panels with fittings of copper. Each of the panels is of approximately 150 kw. capacity and is fitted with an ammeter, an oil-break switch, a lightning arrester, and an integrating wattmeter. The motors controlled from these panels are distributed in the six different sections of the works, and it is easy to calculate from the wattmeter readings the operating expenses of each section. A large integrating wattmeter fixed on the wall immediately facing the switchboard, gives the total consumption of electrical energy taken from the Power Company's mains.

The whole of the alternating-current motors are of the Westinghouse induction type, and, excepting three of 50 H.P. capacity, are provided with wound rotors and slip rings so that resistance can be introduced into the rotor circuits when starting. The wash mills and tube mill, in the wet mill department, are driven by a 200 H.P. variable-speed motor. The oil engine which previously drove them occupied practically 570 sq. ft., whilst the motor occupies 45 sq. ft. If we also include the water-cooling arrangement for the engine, which covers an area of roughly 855 sq. ft., we have a large balance in favour of the electric motor. There is another important advantage afforded by the electric drive in this department. Should the wash mills be shut down for an appreciable period, the slurry practically solidifies around the interior frame, which circumstance, together with the heavy nature of the machinery, makes a large torque at starting essential. As the 200 H.P. induction motor is designed for a starting torque of not less than twice the full-load running torque the advantage is obvious. This may also be said of all the motors to which reference is made. In the rotary-kiln house there are four 15 H.P. motors, each mounted on a concrete pedestal and driving a rotary kiln, as shown in Fig. 1, the method of rotating the kiln being by belt drive through spur-reduction gearing. The 15 H.P. motors are of the variable-speed type, and are capable of giving their full load torque at any speed between 400 and 800 revs. per min., the motor speed being varied to suit the amount of slurry passing through the kiln. The line shaft in the kiln house is driven by a 100 H.P. motor, and operates the slurry pumps—between the 900 ton mixer and the kilns—the clinker coolers and the Shaker conveyor. This latter feeds into an inclined bucket elevator, operated by a 15 H.P. induction motor, which leads into the dry mill, where the ball and tube-grinding plant is driven by two 200 H.P. motors, one of which is shown in Fig. 3. This mill was originally operated by two large oil engines, still to be seen; one of them is a good object-lesson of a severe crank-shaft "smash." The drum-type controller seen in Fig. 3 has nine starting notches, and the current-carrying portions are fitted with cheap copper tips which may be renewed when arc deterioration and wear render this necessary. The screw conveyors leading from the dry mill to the warehouse are operated by a 50 H.P. motor, and the coal-crushing plant is driven by a 150 H.P. motor.

Besides those already referred to there are two 50 H.P. motors driving direct-current generators. These latter are for lighting and for supplying direct current to the 20 H.P. motor operating the jetty conveyor, the small motor in the chemical laboratory and a 7½ H.P. motor driving the fitting shop, which were in use before the new electrical plant was installed.

All the alternating-current motors are of the Westinghouse semi-enclosed type, with open stator slots, and coils so arranged as to be readily interchangeable in case of accident; and the design of each stator and rotor is such as to produce a continuous flow of air through the internal parts while running. The guaranteed full-load efficiency of the 200 H.P. and 150 H.P. motors is 92 per cent., of the 100 H.P. motor 90 per cent., and of the 50 H.P. and 15 H.P. motors 87 and 85 per cent. respectively.

The aggregate capacity of the motors recently installed is nearly 1,100 H.P., and it may be of interest to note that from 3½ to 4½ million B.O.T. units will be required per annum, which amount should form a valuable load on the Cleveland Power Co.'s mains.

In electrifying their works Messrs. Casebourne looked for a substitute for the oil engine that would in the main eliminate many of the objectionable features before referred to, as well as provide a source of power immune from fire risk, and which could be subdivided and applied at the most advantageous points. The natural solution was the adoption of induction motors, and former troubles are now unknown, in spite of many adverse conditions against ideal motor operation. Of the many industrial applications of the electric motor there is probably none where the service demands are more exacting or the operating conditions more severe than in cement works. The heavy torque required to start the cement-making machinery, the nature of the load handled, the constant presence of dust, and the inflammability of pulverised coal bring problems into the electric drive which require the most experienced calculation. In the face of these facts, however, the advantages which have been afforded by its adoption have greatly extended the manufacturing limits of Messrs. Casebourne, who are now capable of dealing expeditiously with the largest contracts.

We are indebted to Mr. F. T. Tristram, the managing director of Messrs Casebourne & Co (Ltd.), to Mr. W. J. Coles, of Messrs. Maxted, Knott & Coles, and to the British Westinghouse Electric & Mfg. Co. for the information and illustrations contained in this article.

Extra-high Tension Generating Station.—According to *L'Eclairage Electrique* a generating station has just been erected near Mishawaka which contains four generators each of 1,000 kw. capacity. These machines generate three-phase current at 13,200 volts. They are direct-coupled to horizontal engines whose regulating apparatus is worked by auxiliary motors controlled from the switchboard. All the switchboard gear is low tension and is connected by relays on transformers to the principal switches, working at the generator voltage of 13,200. The transmission lines are supported by wooden poles not less than 40 ft. in height. The distance between the wires is 2 ft. 6 in. The voltage is stepped down to 110 volts for the lighting network, and 440 volts for power.

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TELEPHONIC TRANSMISSION MEASUREMENTS.*

(*Concluded from page 125.*)

BY B. S. COHEN AND G. M. SHEPHERD.

Summary.—In this Paper, the first part of which we gave in abstract in our last issue, the authors deal with the measurement of distortion and attenuation of the current waves in a telephone circuit, and also describe some preliminary tests for measuring the energy absorbed by telephonic apparatus.

Current Measurements.—The relationship between the currents C_s and C_r at the beginning and end respectively of different lengths of telephone line can be readily measured with two barretters. The relationship is complicated by the addition of terminal impedances at either end of the line. Fig. 6 shows this current relation plotted for various lengths of 20 lb. conductor cable equipped with ordinary telephone instruments at either end. It will be seen that up to nearly 6 miles the received current is greater than the sending current. At about 20 miles the sending end current, which has up to this length been mostly increasing, has practically reached a constant figure, and is after this very little affected by any further increase in the length of line.

Fig. 7 shows the relationship between the current at the sending end of the line when the receiving end is open and closed for various lengths of line. The cable line used in this case had 20 lb. conductors, and the line was terminated as before at either end by ordinary telephone instruments. It will be noticed that at about 20 miles and upwards the current flowing into the cable is practically unaffected by the opening and closing of the receiving end, and that this also happens at about 2 miles. The current used for the above tests was at 800 ∽, and practically sinusoidal in form.

Determination of Damping Constants on 20 lb. Cable.—This was done by actuating an ordinary telephone transmitting circuit by a

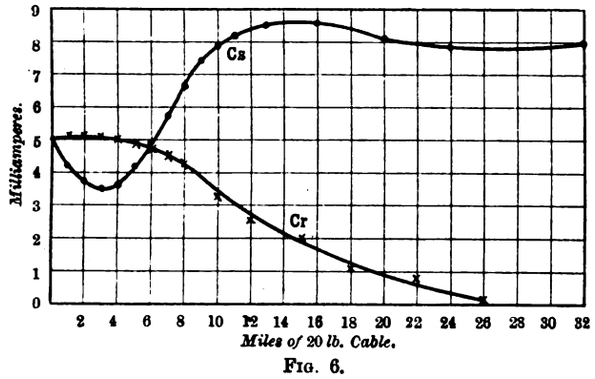

FIG. 6.

steady musical note, and then observing the ratio of sending and receiving currents on a varying length of cable, which could either be shorted at the far end, or closed through a known impedance. The appended table shows the relation found between the actual C_s/C_r, and the hyperbolic function cosh (la), which is the calculated ratio of C_s to C_r. (Where l is the length of line and a the complex attenuation constant.)

Miles.	C_s/C_r.	∽	Cosh (la).	Error.
		Far end short circuited.		
5	1·065	792	1·0287	−3·5 per cent.
10	1·385	783	1·3740	−0·8 ,,
15	2·310	763	2·3100	0·0 ,,
		Far end closed through impedance		22 ohms 0·15 henry.
10	1·302	792	1·2400†	−4·8 per cent.

Considering the irregularity in wave-form of a microphone produced current, the agreement between theory and practice is very fair.

Sinusoidal Current Producers.—Considerable difficulty has been experienced in obtaining a steady sinusoidal current of the frequencies required for telephone measurements. At present there appears to be no machine of a reasonably small size on the market for which the makers will give a sufficiently definite guarantee at the frequencies required. The machine used at present is a small inductor alternator, having an armature built up of ordinary slotted stampings, and gives a frequency of 800 ∽ at 960 revs. per min. The output is small, but the wave is a very fair one, considering that no special shaping of the teeth was attempted.

Wave Filter.—In order to purify the wave-form for very precise measurements the peculiar property of the periodic loaded line already referred to and mentioned by G. A. Campbell* in his Paper on loaded lines has been utilised. By building up an artificial line, consisting of four or five sections, each associated with a condenser, inductance and resistance coils, it is found possible to practically abolish all upper harmonics and to leave the fundamental frequency desired. A wave filter of this description requires no tuning, and is safe over a considerable range of frequency, but naturally introduces a certain amount of loss.

Power Measurements.

The amount of energy is frequently exceedingly small, perhaps a few microwatts only, and is always a very variable quantity. At the date of writing this Paper we are unaware of any instrument directly indicating small fractions of a watt, which could be included in the receiver circuit of a telephone without radically changing the circuit conditions. An ironless two-coil wattmeter of

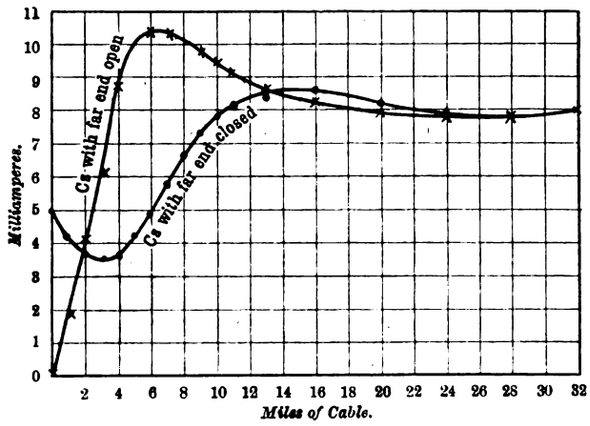

FIG. 7.

the requisite sensibility offers a series impedance of many thousand ohms, and is, of course, quite inadmissible on that account. A thermal method seems to be the only alternative, and the hot-wire voltmeter method, due, we believe, to Mr. M. B. Field, was employed with some success. The connections are shown in Fig. 8. The instrument used to indicate the vector sum and difference of potential was a Duddell thermo-galvanometer, operating with a 100-ohm heater. As only one such instrument happened to be available, it was necessary to employ a reversing switch to change the sense

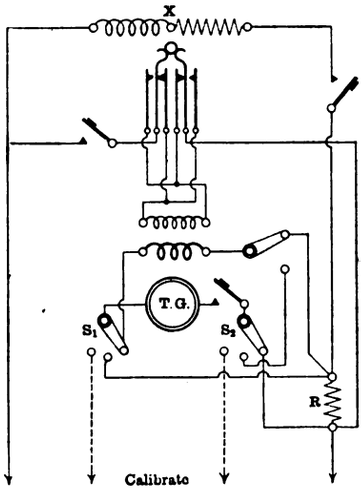

FIG. 8.

of the P.D. component. Switching arrangements were also provided to permit of current and P.D. measurements to be made independently, and to calibrate the galvanometer when required, by continuous current. Some difficulty was experienced in finding a suitable transformer for this work, presumably on account of complications occasioned by iron losses at the moderately high frequencies used to imitate speech currents, and also by variations of transformation ratio. An air-core transformer would probably have been a cumbrous and costly piece of apparatus, for it had to be borne in mind that, as the secondary winding was across the telephone circuit, a high inductance was imperative. A toroidal coil having a core composed of iron wire of about No. 40 S.W.G. was finally adopted. The dimensions of this core were approximately 11½ cm. external diameter, sectional area 7 sq. cm., depth 5 cm. The

* Abstract of a Paper read before the Institution of Electrical Engineers.
† This figure is the ratio of receiving end to sending end impedance.

* *Phil. Mag.*, Vol. V., 1903, p. 313.

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two windings had about 2,000 and 100 turns respectively, and the ratio of transformation experimentally determined ranged from 96·5 to 19·3, according to the number of secondary turns employed. A series of preliminary tests was made with the above-described combination, using artificial loads made up of known non inductive resistances, capacities and inductances; and the results, though not of a very high order of accuracy, were yet encouraging when the difficulties were considered. The thermo-galvanometer, as mentioned previously, when worked up to its greatest sensibility, was found to be extremely sensitive to outside disturbances of various kinds, and much trouble was experienced from leakage and capacity currents in the test circuit. When the frequency is even no higher than 800 ∽ the term "non-inductive," as usually applied to resistances, requires qualification; and unless care be taken very erroneous conclusions may be arrived at. Some results of using this apparatus are appended:—

Apparatus tested.	Current.	Actual watts.	Apparent watts.	Power factor.	Effective. L.	Effective. R.	∽
C.B. receiver	0·00695	0·00858	0·01435	0·600	0·0425	165	825
120 ohm receiver..	0·01160	0·02220	0·02930	0·760	0·0280	165	825
120 ohm receiver & induction coil	0·00220	0·00139	0·00247	0·562	0·0650	227	825
C.B. repeater, type 25 C., with 150 ohm subscribers' line	0·00208	0·00149	0·00218	0·685	0·0690	320	800

Test of sending end impedance of 80 miles of 20 lb. paper telephone cable, far end open:—

Current.	Watts.	Power factor.	Phase angle.	Impedance.	∽
0·00658	0·0163	0·71	48° 48′	552 ohms.	810

This is in good agreement with the theoretical estimate of the impedance of this class of cable—viz., 550 ohms and phase angle 45 deg. All the above-described tests were made with current supplied by the small inductor alternator previously referred to, using its natural wave-form.

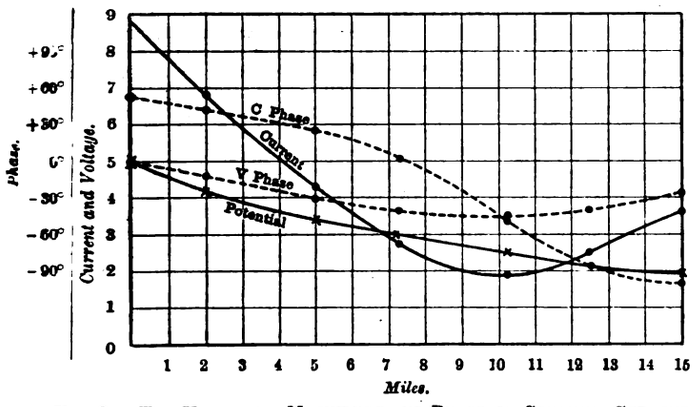

FIG. 9.—THE VARIATION, MAGNITUDE AND PHASE OF SPEAKING CURRENT ALONG A 15 MILE STANDARD CABLE LINE WITH TERMINAL INSTRUMENT OF 145 OHMS AND 0·1 HENRY.

The three-voltmeter method was found very convenient for certain measurements of the efficiency of induction and repeating coils. The instrument used was an Ayrton-Mather electrostatic voltmeter having a readable range of about 1-10 volts. By switching over quickly into the requisite positions on the circuit quite consistent readings could be obtained. An excellent point in favour of this voltmeter in connection with telephonic measurements is its negligible working current. We have also applied the three-voltmeter test to the determination of cable constants at working frequencies.

Cables of the ordinary telephone types are notable chiefly for their high copper resistance, very small inductance, and high insulation; consequently the evaluation of the inductance and leakage constants depends on the possibility of very accurate phase measurements correct to a few minutes. This is a matter of considerable difficulty, and the examples given below must be regarded as trial endeavours:—

Line.	Impedance. End open.	Impedance. End S.C.	R.	C.	S.	L.	∽
10m. 20lb. standard	495 – 54° 20′	657 – 29° 18′	82·4	0·0540	7·12 × 18⁻⁶	0·00145	750
10m. 20lb. artificial	498 – 51° 28′	644 – 36° 6′	94·0	0·0624	..	0·00020	750

Currents used were from 6 to 10 milliamperes with P.D.s of two or three volts. The figures for resistance and capacity differ very slightly from what would be obtained by direct-current measurements. The constants L and S in the case of the 20 lb. cable are possibly doubtful, owing to the phase-measuring difficulty referred to, but there is good reason to believe that there is a very considerable reduction in the effective insulation of paper cables at telephonic frequencies.

An appendix to the Paper contains the theory of transmission, and determination of line constants, &c.

Since this Paper was put together, the authors have seen some figures relating to the Einthoven string galvanometer used as a wattmeter, which look promising. This instrument, when used as a wattmeter, would appear to possess most of the desired qualities, though its sensitiveness might not meet all requirements.

A number of models were shown by the authors during the reading of the Paper. These represented the changes and phase relations of current and voltage along various types of circuits. In some cases a frequency of 800 ∽, and in others 1,440 ∽, was taken, and an initial impressed P.D. of 5 volts, and a piece of terminal apparatus at the far end having electrical constants, approximating to an ordinary telephone set, was allowed for. The amplitudes at the different distances were represented by the length of the radial wires, whilst the phase lag in regard to the initial P.D. (which was the datum point) was shown by the rotation in the direction of a left-handed screw.

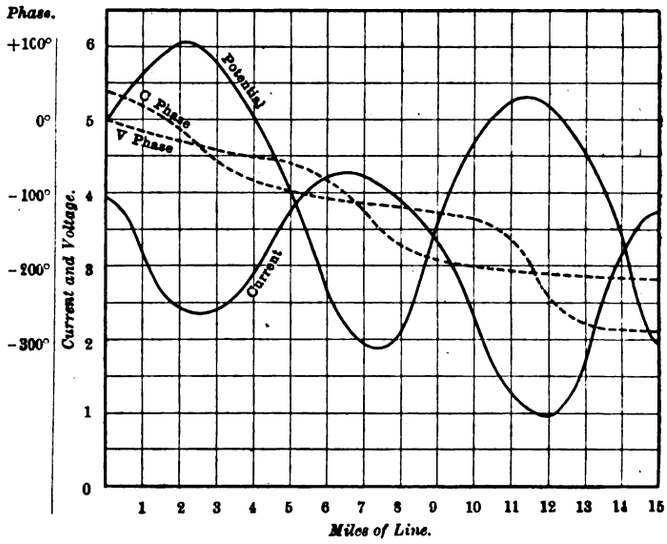

FIG. 10.—POTENTIAL AND CURRENT. LOADED LINE, 2 MILE POINTS 20 LB. CABLE.

Figs. 9 and 10 are two additional diagrams not included in the Paper but described by the authors at the Institution meeting. In Fig. 9 it will be noticed that the current which at first was leading becomes a lagging one, due to the effect of the receiving instrument. In Fig. 10, if a curve representing the watts were plotted, it would be found to have an almost constant downward slope.

We hope to give an abstract of the discussion on this Paper in our next issue.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

At the meeting of the Committee last week Dr. Fleming's statement was completed as follows:—

Dr. FLEMING: A good deal has been said by various witnesses before the Committee that if the Convention is not ratified by Great Britain there will be risk of a "wireless war," rendering all wireless telegraphy impossible. It is important to notice, however, that commercial organisations which exist for the purpose of making a return on invested capital do not indulge in unremunerative vindictive operations against their rivals. In the first place, it involves a large expenditure to erect and maintain a wireless telegraph station. If that station does not pay or serve some useful purpose it will, sooner or later, be closed. If two commercial organisations find that by some mutual arrangement they can do profitable work, but that without it neither of them can live, their respective interests will bring them together. Mr. Babington Smith has suggested that if England refuses to ratify the Convention, continental wireless telegraph Corporations may indulge in intentional disturbance. If they were to do so they would simply destroy their own field of operations. In common language, they would be cutting off their own noses to spite

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their faces. I regard this idea of a "wireless war" as entirely hypothetical. Even if we were to assume that none of the Powers agreed to ratify the Convention, it is ridiculous to suppose that every wireless station would set to work at once to churn up the æther and create such a disturbance in the universal medium that no one could utilise it. If, on the other hand, we assume that other nations ratify the Convention while England does not, England will be even in a better position for avoiding disturbances than if she ratified it, for the nations that ratify will be bound by the regulations of the Convention to use certain wave-lengths and not to use greater power than was necessary to effect communication. It will then be the simplest thing in the world for British stations to select other wave-lengths which do not interfere with Convention wave-lengths. Moreover, although it is conceivable that under some circumstances coast stations could deliberately interfere with each other, yet what is possible to the coast station or the power station is not possible to the ship. The ship is limited in the range of waves that it can send out and in the amount of power that can be employed by the antenna which can conveniently and safely be erected on the ship's mast. Hence the idea that a ship could "shout down" a particular coast station and effect its own desired communication with another one by sheer violence is also impracticable. If, for instance, a ship in the Channel was desirous of communicating with the Lizard, it would not be practicable for a coast station at Usbant to stop this communication, provided that the station at the Lizard was free to use the best known means to prevent this interference. The evidence of many witnesses given to the Committee on this matter is inconsistent. On the one hand, some witnesses, such as Sir Oliver Lodge, have claimed to have a perfect and exact method of tuning and isolation, and, on the other hand, he and others are advocating the adoption of the regulations of the Convention on the ground that this will prevent confusion and disturbance of one station by another. It has been suggested that the proposed regulation would induce an era of universal wireless peace. There is, however, a vast difference between the peace produced by bureaucratic regulation of a new and progressive industry, undertaken, so to speak, in advance of experience, and that spontaneous adjustment of respective interests, coupled with the inevitable survival of the fittest, which takes place when commercial organisations serving the public are left to work out their own purposes in their own way. The former is a thoroughly German, and the latter a characteristic British, mode of approaching the subject.

The case against ratification may, I think, be summarised as follows:—

1. The Berlin Conference has legislated far too much with a view to the immediate present and has neglected to consider the future of wireless telegraphy.

2. The Conference has treated the subject of electric wave telegraphy as if it had reached a mature condition, whereas it is only a growing child.

3. The Conference has held in view only the present simple methods of single-communication by fixed wave-lengths and wave-trains as used in spark telegraphy, and has ignored the possibilities of undamped waves and also the practical employment of electric wave telephony.

4. The effect of the Convention Regulations will most certainly be to cramp and restrict invention and to make it far more difficult to either try or introduce improvements.

5. The adoption of the Regulations of the Convention will remove that proper stimulus to making great improvements which arises from the pressure of necessity, by creating an artificial condition of affairs in which difficulties are covered up rather than removed.

6. These Regulations place the more efficient and progressive wireless telegraph methods on a level with the less efficient, and aim at a uniform mediocrity rather than the elimination of the unfit.

7. Our experience in the case of all previous great electrical inventions is that their premature subjection to official regulations has always in the long run proved to be a mistake.

8. The reliance on a network of bureaucratic regulations to bring about order and a certain minimum of efficiency rather than the promotion of progress and improvement by healthy competition, is a characteristic German mode of dealing with a subject, and is not in accord with British genius and enterprise.

At the conclusion of this statement, Dr. Fleming said, he desired to make an addition dealing with some of the points raised by other witnesses, and the Chairman thereupon gave Dr. Fleming permission to send in a supplementary statement, which, we understand, will be shortly presented.

At the meeting of the Committee on Tuesday this week Commander PAYNE was recalled, and said he studied the subject of wireless telegraphy from the point of view of British interests generally as well as from the naval point of view prior to the Berlin Conference. The organisation of the Marconi Co. would be of great value to Great Britain if it could be more fully extended. If Great Britain, being one of a number of Powers, had gone to the Conference with a determination to join the Convention she would have had to agree to the views of the majority, and, this being witness's feeling at the time of the Conference, he would have been inclined to oppose the Convention, but since studying the Convention and the views of the contracting parties his views had been modified. It would be an advantage to have communication under one general organisation, and he considered that the regulations had been framed in such manner as to remove the objections he had had to the Convention. The allowances that had now been made for free competition would tend to increase the development of the science throughout the world in a manner which could not have been provided for under the conditions of a British monopoly. If the majority of the other Governments had agreed to the Convention and Great Britain had stood out we should have had to compete against an organisation of Governments and this would have defeated one of the principal objects we had in view, because a number of British ships would have been unable to communicate with stations abroad. He considered intercommunication between various systems important. The question of intercommunication under one organisation was of vital importance and one must definitely settle that point before one could arrive at any conclusion with regard to the Convention being signed or otherwise. He did not consider there were any difficulties in the way of intercommunication that could not be overcome. Every system now in general use was, so far as he knew, capable of interchanging messages. In order to put before the Committee the improvements that had been made in spark telegraphy it would be necessary to touch upon the form of waves that had been used. At first strongly damped waves were used, and this had for its principal disadvantage that of interference, as it was difficult to design instruments which would be selective for different waves. Various other types of transmitting instruments were gradually introduced to transmit less damped or more persistent waves in order to obtain selectivity, so that different wave-lengths should not interfere with one another, and experiments were now being tried to make the waves still less damped to secure further selectivity. If these were successful further modification of receivers would be necessary. During the change to the less damped waves no difficulty was experienced in communication. He had said this to show there was no marked line of division between spark and so-called continuous wave wireless telegraphy and to remove from the Committee's mind any impression that the undamped wave system was unforeseen and entirely new. He had had practical experience of highly damped and mediumly damped systems working together and also of mediumly damped and continuous waves working together. If Great Britain was a party to the Convention the reservation of wave-lengths between 600 and 1,600 metres for the Navy would be beneficial and would enable the Navy to work out its organisation. Great Britain would derive great benefit in war time if the Convention were ratified, because all her commercial ships would be in a state to allow them to be used for naval purposes if desired, and this could only be done if the ships were capable of intercommunicating. This development was more likely to be obtained if all Governments were in agreement. From the naval point of view he considered intercommunication was of the utmost importance in war time, as it would provide for the mercantile marine being fitted with apparatus capable of communicating with the naval ships and having knowledge of the methods of signalling and the wave-lengths used. The benefit we should obtain, compared with other nationalities, was only a question of the number of ships fitted, and as we had the largest mercantile marine we should be at an advantage. To have at our disposal information from our traders as to the positions of other countries' ships would be an advantage, and it would mean that the number of our look-outs would be increased considerably, and this would also be of advantage to mercantile ships from the point of view of their own safety. If rival companies worked under different organisations it would complicate the signalling arrangements and make the working impracticable. He considered the organisation of wireless telegraphy for naval purposes was more difficult than for commercial purposes. Witness cited as an instance a naval station which, he said, received and tranmitted an average of over 2,000 coded words daily, and although there were at least 50 naval ships within range which were required to receive and send messages, and the number of messages sent and received by one of them was about the same as those dealt with by the shore station, and although other ships tried to interfere, only one message failed to get through. His point was that it was not a question of the skill of the operators, but of the naval organisation, which allowed the alterations to be made so as to continue the service.

Mr. GWYNN: Would such an organisation be impossible for other operators? Suppose instead of a naval station you had a Marconi station, would it be impossible for the Marconi Co. to carry on without interference?—I think it would be possible provided the wave-lengths were not limited.

Sir EDWARD SASSOON: Are you convinced that the regulations that have been drawn up provide efficiently for preventing interference with the service as at present constituted?—I am convinced that they will not interfere with naval working.

Are they capable of effective enforcement?—I think so.

Some of the shipping companies say that a universal service, under which they would be able to communicate with ships fitted with apparatus other than the Marconi, would be beneficial, and others, like the Cunard and the Allen Co., take an opposite view. Can you throw any light on this divergency of view?—I do not know the special requirements of different companies, but I imagine shipowners would take into consideration the points I have mentioned before purchasing sets of wireless telegraph instruments and the point as to their ability to communicate with naval ships in time of war. We can only make allowances for a general organisation of which we know the wave-lengths and the methods of signalling, and so on.

The POSTMASTER-GENERAL: I understood from your evidence that you were originally of opinion that it would be almost impossible, or impossible by the Convention, to obtain efficient regulations and security for their enforcement?—My principles have always been that it is necessary to have general communication between ships and shore stations under a fixed organisation.

You mean with intercommunication?—Yes. My idea originally was that it would be an advantage to have the control of wireless telegraphy in the hands of the British Government, because it would be more simple than having a number of Governments taking part.

You are satisfied now that the Convention will be an advantage both from the naval and commercial points of view?—Certainly, it is the only practical way that I can see of carrying out communication under one general organisation.

Capt. BETHELL was the next witness, and said that from April, 1903, to the end of December, 1906, one of his duties at the Admiralty was, in

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conjunction with the Director of Naval Intelligence, to advise the Board as to its policy in regard to wireless telegraphy. He was then practically the head of wireless telegraphy in the service. He was one of the delegates at the Wireless Telegraph Conference in 1906. He had read the evidence of his colleague, Col. Daniell, and he agreed with it. He had also read Mr. Cuthbert Hall's evidence. With regard to the allegation that a violent change had taken place on the part of the Admiralty in regard to the question of intercommunication, witness said that when he joined the Admiralty in 1903, and almost before he had got the threads of what was going on in the Department with regard to wireless telegraphy, the question of the attitude to be adopted by the delegates at the 1903 Conference was brought up, and he was asked to advise Lord Selborne, First Lord of the Admiralty at that time, with regard to the policy the Admiralty should pursue at that Conference. He could not say that he was against general intercommunication at that time, because he had hardly studied the question, but he was not prepared to undertake the responsibility of advising such a policy without having more time to study it than was then available, and the advice he gave was that there was no possible power in the hands of the British Government to enforce anything that was decided by a Convention with regard to intercommunication, and that the naval instruments at that time were of a very rough-and-ready sort. There was no system of tuning, they had only a few ships equipped, and the results they got were very indifferent and uncertain, and he did not consider they were ready for anything of that sort. He thought it was premature, and that the attitude the Admiralty delegates should take should be one of reserve, and certainly not to give the Conference any idea that they were going to accept a policy of intercommunication. When the question arose of another Conference, which it was thought would be held early in 1904, it was necessary that the Admiralty should decide something. By that time he had considered the question, and had made up his mind that general intercommunication was not a good thing. He was against it then and was against it at the present moment. What he called general intercommunication was compulsory intercommunication, with no exceptions at all. He advised then that the Admiralty should stick to what they had done before, and that they should go wholly for rejecting general intercommunication. Then the matter had to be considered from a general point of view. There were other departments concerned, and there was this question to be looked in the face—there had been a meeting of several of the nations (not all) who were interested in wireless telegraphy, and, with the exception of Italy, everybody was unanimous that there should be this general intercommunication, and they had to consider whether the English Government would be strong enough to take up a different policy. He meant that the other Governments were unanimous with regard to general intercommunication, without exceptions or exemptions. At a meeting on Feb. 24, 1904, of the three British Government departments concerned, witness was asked whether he could mention any conditions under which intercommunication should be accepted, and he then drew up conditions which he thought might be accepted, provided that, in the opinion of the Admiralty, there were suitable provisions for their enforcement. That might be said to have been the start of the Admiralty policy, and from that time till just before the delegates went to Berlin it was always the intention of the Admiralty to pursue that policy. In June, July and August, 1906, the delegates who were going to Berlin had meetings at the G.P.O. to consider the draft of the German Convention (which was absurd and could not possibly be accepted) to see how they could remodel it to enable them to agree to the signing of a Convention based on the principle of general compulsory intercommunication with no exceptions. A small sub-committee was appointed to consider the proposed regulations, upon which he did not sit. The policy adopted was the Admiralty policy, and though he was against it he was bound to carry it out. He was not satisfied with what the sub-committee was going to recommend, and he proposed to the delegates that they should go back to the *status quo ante* of 1904, but he did not lay great stress upon this as he proposed an alternative, which was fully discussed by the delegates, but the Admiralty came to the conclusion that, as they had laid down a policy, and as several countries had been communicated with and told of the attitude the British delegates would adopt at the Conference, they should accept the principle of intercommunication, but that they would insist upon being able to exempt any stations they liked. Witness placed great stress on that exemption clause, because he had a certain degree of sympathy with the Marconi Co.; he had watched their proceedings for many years, had had many dealings with them, and he had a great admiration not perhaps for the way in which they conducted their business, but for the plucky way in which they had fought everything that in any way tended to reduce their monopoly. He thought they had done a great deal for wireless telegraphy; they had built up an organisation which undoubtedly, in time of emergency, would be of great benefit to the Admiralty, and he did not wish to see anything done which would jeopardise that organisation. If you introduced general intercommunication without any exceptions you would have for a time a certain amount of dislocation. The Marconi Co. themselves feared this very much. No doubt they had other reasons for their policy, but that was one of the reasons they impressed upon him, and it was an opinion which appeared to him to be reasonable. He did not wish to enforce intercommunication at their important stations until they felt that they could come into this agreement without fear of their organisation being disturbed. His objections to general intercommunication were not that he thought it impracticable, as he believed it was perfectly practicable, and that what had been said about disorganisation had been very much exaggerated. He meant with regard to the physical difficulties of intercommunicating. It was a thing that would settle itself easily and quickly. He did not think it would jeopardise the company's position in any way, except that it might for a short time disorganise certain important stations of the company, and he did not want to see this happen. These stations were in an efficient state, and he looked upon them as an efficient reserve in case of sudden war.

The CHAIRMAN: Given the power to exempt stations, you withdraw your objection to intercommunication?—Decidedly. I am very much in favour of the exemption clauses.

All the points you insist upon were subsequently introduced into the Convention?—Yes.

The POSTMASTER-GENERAL: In a speech you made at the second sitting of the Conference you laid down propositions as to the exemption of stations. Can you tell us under what conditions that speech was made?—I knew there was a feeling in the Conference of suspicion against the British delegates and an idea that we had come there to criticise the whole thing and make it impossible and throw it aside and say we would have nothing to do with it. I wanted to remove that suspicion. I thought that unless we made the Conference believe we were going to act honestly, we should not get a proper hearing for the stringent regulations we were going to propose. I also wanted to make the Conference understand that it was not of such very great importance to England that we should have intercommunication because we had an organisation of our own, while others had not. It was to convince the Conference that Article 3 must be postponed until after the regulations had been made that I said what I did. We could not say whether we would agree to Article 3 until we knew what regulations were to be adopted by the Convention.

Mr. LAMBERT: Has there been any change of the general policy of the Admiralty?—None, unless you call a change of policy bringing in the stipulation as to exempted stations.

You had that in view, I assume, in 1904?—Not the exempted stations; that cropped up in 1906. Up to 1906 it was proposed to agree to general intercommunication without any exceptions whatever.

You are not expressing any opinions ordered by the Board of Admiralty?—No; I consider I am entirely free from the Admiralty now and am expressing my individual opinions.

Mr. LEE: It has been suggested to us in Mr. Cuthbert Hall's evidence that at the Conference in August last there were differences of opinion between the Admiralty and the Post Office delegates. Was the attitude of the Post Office at that time that intercommunication was desirable whether you could get exemption or not?—There was never any intention of getting any exemption; that was only my personal proposal. We should have agreed to intercommunication without exemptions if I had not raised the question. I think the British delegates were unanimous in agreeing to my proposals as soon as I put the matter before them.

The POSTMASTER-GENERAL: But the Post Office delegates, from the moment the principle of exemption was proposed, opposed it?—No, they adopted it at once. There was a little difference of opinion about how the exemptions should be carried out, but they agreed to the principle at once.

Do you think that under the Convention the majority of the stations should be exempted?—No, only those stations where traffic is congested.

With regard to the enforcement of the regulations, do you consider the provisions for their enforcement will be effective within a sufficiently short space of time to bring operators who are not complying with the regulations to book?—Yes. Of course, you must give all the Governments credit for wanting to work the Convention under the conditions upon which it has been framed, and we have a clause in the Convention under which, if we do not get redress, we can refuse to communicate with any ship which does not comply with the regulations.

In Mr. Cuthbert Hall's evidence he rather gave us to understand that the Marconi Co. were misled as to the attitude the Admiralty were going to take up, and that this affected their decision in a commercial matter and injured their business. Do you consider that the Marconi Co. have any grievance under that head?—I do not think so. I told Mr. Hall that the Admiralty would not agree to general intercommunication and would not accept the German Convention as it stood, but would modify it considerably, but I never discussed with him the principle of exempted stations.

You are satisfied that the regulations meet all your requirements, and that they can be enforced?—Yes, I was surprised that we got the regulations passed almost without discussion. We thought we had made them very stringent.

Sir EDWARD SASSOON: When you went to the Conference you had made up your mind that if you got the stipulations accepted reserving stations you would recommend the ratification of the Convention?—Yes. If I found there was a decided view amongst other nations that they would not have it I meant to propose to postpone the thing and not to come to an agreement, but we found everybody was thirsting for intercommunication except Italy, and I believe if the Italians had not been tied down they would have been glad to have it.

Let us take the case of a French and a German ship endeavouring to communicate, say, with the Lizard station at the same time, would there not be interference?—There should not be. The ship that calls up first informs the station of her position and other things, both ships inform the shore station how long they will be in the region of communication, and the shore station decides which shall communicate first. There would not be any difficulty unless it were created intentionally.

In replying to questions as to how a delinquent operator on a ship not complying with this practice could be brought to book and how long it would take, the Witness said the company working the shore station would notify the Government (the Board of Trade might take such matters in hand); it would then go through the Foreign Office, and the Ambassador in London, and through the ordinary diplomatic channels, and a reply would come in due course. If it were a case of a German ship, the German Government would go through their channels until they arrived at the operator and the German company would be ordered to deal with him.

(PARLIAMENTARY INTELLIGENCE *continued on page 192.*)

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THE RELATION OF SCIENCE TO PRACTICE.

The development of the mono-railway in the world of engineering has brought into great prominence a simple device which has been known for many years. The gyroscope is familiar to all of us. It has been sold in the streets as a twopenny toy, and it has enjoyed a popularity which is likely to increase owing to recent events. This popularity has been due to its apparent defiance of natural laws, which has caused it to appear somewhat mysterious, even to those who know something of mechanics.

But although the gyroscope has enjoyed a certain popularity, it has not received much attention in the average text book. Mathematicians no doubt appreciate what takes place, and can see very readily that its apparent mysterious disregard of the laws of Nature is only due to obeyance of other natural laws which are not so obvious. But, nevertheless, the subject of the gyroscope has seldom received simple treatment, and those who have understood it best have not sought to give it any useful application.

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Now, however, Mr. LOUIS BRENNAN has put the gyroscope to practical use in the way we describe in another column, with the result that he has obtained a vehicle capable of maintaining its balance on a single line of wheels, although the centre of mass of the system is considerably above the level of the rail. If such a vehicle begins to lose its balance, the force of gravity would, under ordinary circumstances, cause a rotation of the vehicle round the rail. It is therefore necessary to provide a counteracting couple to oppose this motion whenever there is a tendency to overbalance in one direction or the other. Such a couple is not obtainable directly from a gyroscope, because this does not oppose a couple impressed upon it; it gives a couple at right angles to the impressed couple. But by suitably arranging the direction of the impressed couple, another couple can be obtained in the desired direction, and the vehicle can be maintained in proper balance. This achievement must be described as a very beautiful result of applying a familiar principle in a suitable way, and we can only feel surprised (as, indeed, is generally so in such cases) that something of the kind has not been accomplished long before.

In this case, as in many others, the principle used is simple enough, but it has not been applied by those who are best acquainted with it. The science has been available for long enough past, but the practice has been wanting. There is, indeed, such a thing as being too familiar with a subject: although such familiarity may not breed the proverbial contempt, it may, nevertheless, so far blind us to possible applications that these are passed by without a thought, until finally someone with a much less extensive theoretical knowledge takes up the subject and applies it in an obvious way to fill a long-felt want. There is good reason, then, that Practice should receive full recognition from Science, and that both Science and Practice should be more sympathetic to each other than they are. Science has generally been more recognised by Practice than Practice by Science. Although science undoubtedly provides the raw material to be handled by practice, it is comparatively rare that the great industrial advances are made by those who are chiefly identified with science. The applications are made by other minds, and it is only fitting that those who effect great progress in a practical way should be duly recognised by those who are more concerned with science in its less practical bearings.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Central Station Electricity Supply. By ALBERT GAY and C. H. YEAMAN. 2nd Edition. (London: Whittaker & Co.) 10s. 6d.

This book might be more correctly styled "Central Station Electricity Supply with Special Reference to Non-condensing Single-phase Lighting Systems," as it is evident that the authors have barely considered any of the applications of electricity beyond that of lighting and have designed their power station and mains accordingly, the result being that the methods and apparatus described are nearly all out of date. Here and there, however, a piece of useful and modern information is to be found.

A large amount of space is taken up in descriptions of obsolete methods, apparatus and systems of no value to anyone but the historian and dangerous to the embryo station engineer, because in their intense desire to avoid partiality the authors have given no indication in the majority of cases as to what should be avoided. The major part of the book is too noncommittal to be of any real value. Parts of the book are very elementary and general, others advanced and special, making it difficult to comprehend for whose benefit it is really written. In many cases the same subject comes up several times in different chapters and apparently apropos of nothing; for instance, after having read the pros and cons (always pros and cons, nothing ever definite) of various methods of exciting alternators three times in three different places, one begins to wish that alternators were sufficiently accommodating to excite themselves.

The nomenclature adopted is old-fashioned and irritating; for instance, dynamotors, compensators (three-wire balancers) motor dynamos, automatic stoker, monophase, and so on.

The chapter on powers and regulations contains useful information as to the most important provisions of the Electric Lighting Acts, Board of Trade and Home Office regulations. The next chapter is taken up in discussing the pros and cons of direct and alternating single-phase current systems, called "direct" and "converted" supplies. Polyphase generation is given two lines. This part contains some bad examples of power station lay outs, and goes deeply into unimportant details, but practically ignores condensing and modern coal handling.

Chapter VI. contains valuable and up-to-date information on transformers, and a few pages are given to polyphase systems. The chapter on boilers describes several arrangements of pipe connections from boilers to engines, including our venerable friend the "ring." Out of the five arrangements given four are bad and one indifferent. The notes on condensing badly require bringing up to date.

Under smoke-consuming apparatus it is mentioned that underfeed stokers should answer the purpose of preventing smoke. But why should underfeed stokers be selected of all types of mechanical stokers? Under electrical equipment it is stated that compound-wound dynamos are rarely used on account of risk of reversals of polarity! In the chapter on switch gear, descriptions of apparatus for high and low tension, alternating and direct current are mixed up together, resulting in confusion.

Public lighting has more space allotted to it than its importance warrants, and the commercial development of an undertaking receives no attention.

Electric Wiring, Diagrams and Switchboards. By NEWTON HARRISON. (London: Crosby Lockwood & Son.) 5s.

According to a summary on the title page, this book is a practical guide for wiremen, contractors, engineers, and others interested in the application of electricity to illumination or power; it gives the important features found in all large power equipments, including the converting apparatus; further, the calculations and examples are all limited to the use of arithmetic. In the preface we learn that "the pages of this volume will prove of the utmost value to the student, wireman or contractor." Nevertheless, it is a little difficult really to see for whom the book is intended, for the treatment of the subjects included is so wanting in uniformity.

In some parts the author devotes much space to the simplest details. Thus there are numerous tables which are little else than multiplication tables; for example, there is a table comparing amperes with coulombs per second, starting with 1 ampere as equivalent to 1 coulomb per second and ending with 100 amperes equal to 100 coulombs per second. We think the most elementary reader might be expected to grasp the relation of amperes and coulombs per second without so much elaboration. On the other hand, statements frequently take the place of explanations, and there is often a want of clearness. Great stress is rightly laid on Ohm's law, but finally it is not clearly stated. The description of a Wheatstone Bridge as a "kite-shaped arrangement" does not strike us as very practical; and the definition of frequency as the term used to define the number of complete reversals of current per second, each complete reversal being due to the wire passing two poles, is an example of loose wording.

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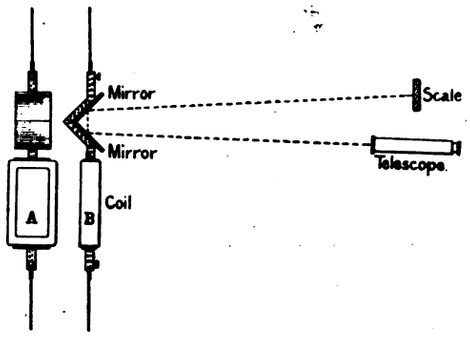
The author devotes about half the book to wiring, the chapter on drop showing clearly the advantage of the circular mil as a unit. Calculations of cables, and use of conduit on American lines, are fully treated, but practically nothing is said about accessories. A sketchy chapter on motors is included. The author then passes on to switchboards, giving a number of diagrams. Finally, losses with alternating currents is considered, and nine pages are devoted to induction motors and transforming plant, including rotaries, though it is difficult to see how the elementary reader will be able to benefit by this exceedingly brief treatment.

AN OPTICAL DEVICE FOR DEFLECTION INSTRUMENTS.*

BY EDWIN F. NORTHRUP.

The system of a suspended instrument, as a galvanometer, when subjected to vibrations will have a motion that is compounded of a rotation about a vertical axis and a rotation about a horizontal axis. If the system is held between an upper and a lower filament that are under tension, the horizontal component of the vibratory motion may be practically eliminated by accurately balancing the system about the line of the suspension. Sudden horizontal movements will then have little or no tendency to produce rotations.

Furthermore, in d'Arsonval galvanometers the electromagnetic damping forces quickly reduce to rest a system started into oscillation about a vertical axis. Oscillations of the system about a horizontal axis are not damped out by electromagnetic forces and are



more difficult to eliminate by balancing or weighing the system. The vertical movements of the image of the scale seen in a telescope blur the image, and often are so bad as to make it impossible to read the scale. To use suspended instruments in places subject to considerable vibration, the julius suspension is successfully employed, but this apparatus is both costly and cumbersome.

I give here an optical device which I have devised and employed that *entirely* eliminates the vertical component of the movement of the image of the scale. This device used in conjunction with a well-balanced system enables the scale to be easily read when the system itself is in violent vibration about a horizontal axis.

The device is clearly explained by reference to the diagram. Here B is a side elevation of a D'Arsonval coil fitted with two mirrors, their faces making an angle of 90 deg. with each other. A is a front elevation of the same.

The course of the ray from scale to mirrors and thence to telescope is shown in dotted line. It is easily seen that rotation of the 90 degree-mirror system about a horizontal axis does not change the direction of the light ray from scale to telescope. Furthermore, if the scale and telescope are vertically raised or lowered together in an arc of which the mirror is the centre the image of the scale continues visible in the telescope. It is therefore very easy "to find the scale" as the necessity for the up and down adjustment of telescope and scale when made to move together is dispensed with.

The loss of light by the double reflection is not noticeable and the double mirror system operates for deflections about a vertical axis in all respects like a single plane mirror.

If it is required to cast a spot of light on a scale this may be effected by placing a plano-convex lens of suitable focal length, in front of the mirror system.

* From the *Physical Review*.

PHYSICAL SOCIETY.

At a meeting held on April 26th, Prof. J. Perry, F.R.S., President, in the chair, a Paper on

"Electrical Conduction Produced by Heating Salts"

was read by Mr. A. E. GARRETT. The experiments described are divided into two series. The first, of a preliminary nature, consisted in testing a large number of inorganic compounds up to a temperature of 360°C. Several compounds, chiefly halogen salts, were found to produce easily-detected conductivity when heated. In the case of zinc iodide conductivity could be detected at the ordinary temperatures of the laboratory. The second series was confined to special cases in order to ascertain the causes of the increased conductivity. It was found that in all the cases tried a formula of the form $I = a\theta^{\frac{1}{2}} e^{-\frac{b}{\theta}}$, where I = saturation current, a and b constants, and θ the absolute temperature, represents with fair accuracy the connection between the saturation current and the absolute temperature. Saturation currents were obtained for both positive and negative ions. Moisture was found to be necessary in some cases in order that conductivity should occur; this was particularly the case with zinc iodide. The negative ions were shown to be true charged centres as they could be deflected by a magnetic field. The conductivity was stopped, when using zinc iodide, by a layer of aluminium foil 0·0008 cm. in thickness. The velocities at different temperatures and pressures were found for the positive ions produced by the iodides of zinc, lead, bismuth and cadmium. The positive ions from the zinc, lead and bismuth salts move with the same velocity under the same conditions; those from cadmium move about twice as quickly. These ions seem to undergo simplification as the temperature is raised. One of these simplifications occurs at 210°C. with pressures 10-25 mm. of mercury. These and other considerations point to the fact that the positive ions must be charged centres loaded with considerable amounts of the products due to the chemical changes which the heated salts undergo; in fact, ions similar to those observed in recently prepared gases, phosphorus, &c. The velocities of the negative ions, from iodides of calcium, barium and zinc, were obtained for temperature 215°C. at different pressures. The negative ions from all these compounds move with the same velocities under similar conditions of temperature and pressure. The rate of decay of zinc iodide at 25 mm. pressure and 260°C. was measured. For the first part of the heating it was found that the results could be represented by the sum of two exponential terms, but that after about 1½ hours no further decay took place.

Dr. R. S. WILLOWS expressed his interest in the Paper, and said that experiments similar to the author's had recently been described by J. J. Thomson in the Cambridge Phil. Soc. *Proc.* In the author's experiments there was a chance of chemical decomposition, but this had been guarded against by Prof. Thomson. Electrification could also be obtained by crushing salts in a mortar.

Mr. A. RUSSELL asked if cooling salts produced any electrification.

Dr. WILLOWS said the rate of leak increased with temperature, and he should therefore expect it to be very small at low temperatures.

Mr. W. B. CROFT exhibited some solenoids which will move under the action of the earth's magnetic field. In showing Ampère's experiments it is not very easy to complete the theory of magnetism by making a solenoid point to the north. Many years ago Ritchie made a solenoid with an iron core, which acted as a motor with the help of a mercury commutator. A copper solenoid without core was shown which had been made to rotate in this manner. The method is unsatisfactory and uncertain, owing to the rigidity assumed by the skin on the surface of mercury in certain conditions. The Ampère mercury contacts cause no difficulty when a wire rotates on its own axis, but there are strong hindering forces when the wire is pushed through the mercury, partly from the skin and partly from amalgamation.

The best pattern for a solenoid is suggested by the moving coil of an electro-dynamometer. Two of these were shown, which were conveniently worked by four dry cells in series. Each of them was hung with very thin metal strip by bifilar suspension, the threads about 5 in. long and $\frac{1}{10}$ in. apart. The bifilar control makes the movements manageable; it is convenient to set the coils N. and S., or the axis of the corresponding magnets E. and W., so as to make these swing up to the meridian when a current is sent through the coils. There were also shown some wire models of magnetic lines approximately made to scale so as to represent the horizontal, vertical and total lines of the earth.

There was also exhibited a thick copper wire of 6·28 cm. radius, which will give a unit magnetic field at the centre when 10 amperes is flowing. A long magnet was hung up at the side so as to show the effect of a magnetic pole being attracted to the centre of the coil, running right through and being repelled on the other side.

The CHAIRMAN bore testimony to the great rigidity of the surface of mercury after it had been exposed to the air.

Mr. A. CAMPBELL said this difficulty could be partly overcome by covering the surface of the mercury with amalgamating solution.

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Dr. CHREE believed that solenoids had been used in declinometers in Japan, but there did not appear to be any good reason for such an application.

Mr. W. S. TUCKER read a Paper on

"The Influence of Pressure upon Convection Currents, and a Criticism of J. Stark's Relation between Cathode Fall of Potential and Temperature."

Stark employed as cathode a wire mounted radially in a globe-shaped vessel. The wire was heated electrically and its resistance and hence its temperature determined. His relation for constant temperature was employed, viz. :—

$$K = K_n + \frac{k'}{pf^{\frac{1}{2}}}(i - x'pf)^{\frac{1}{2}},$$

where K and K_n refer to total and normal cathode fall, p the pressure, i the discharge current, f the area of cathode covered with negative glow, and k' and x' are constants. His results with the heated cathode suggest the modification

$$K = K_n + \frac{kT}{pf^{\frac{1}{2}}}\left(i - \frac{xpf}{T}\right)^{\frac{1}{2}},$$

where T is the absolute temperature of the air in the cathode dark space, supposed to be that of the cathode. He refers to the weaknesses of the method: (i.) the conduction of heat away from the wire by its leads causes the observed mean temperature to be too low; (ii.) the error made in assuming the cathode dark space temperature to be that of the heated cathode. The author's apparatus was devised to show how seriously these weaknesses affect Stark's results. A similar vessel, having approximately the same capacity, was taken and supplied with a similarly-mounted wire for a cathode. Its temperature was measured at the central part of the wire only, fine potentiometer wires being connected at points well removed from the junction with the leads. Within the same vessel a fine platinum wire was mounted parallel to the cathode and about 4 mm. distant. By means of this wire the heating effects of the cathode on the air in its neighbourhood could be measured. The part played by convection currents was determined from a series of curves connecting cathode and thermometer temperatures at different pressures. It was shown that convection losses varied sufficiently both with pressure and temperature to affect the curves from which Stark derived his equation. Observations were also taken when the distance between thermometer and cathode was varied, a low pressure being used so that convection effects were small. A great diminution of temperature with distance was observed, indicating a considerable error in Stark's assumption that the cathode dark space has a temperature approximating to that of the cathode. The heating effect of a sheet cathode was examined, and the observations showed it to be more reliable than a wire. The author's curves show very different convection effects to those obtained by Prof Bottomley, who employed a cylindrical vacuum tube. The cooling effect increases from pressures of about 15 cm. to those near 10 cm. then decreases, first gradually then rapidly. An approximate value of thermal emissivity for the bright wire was obtained which at 400°C. is near that of Schleirmacher. Reference is made to the observations of temperature in the discharge obtained by Prof. R. W. Wood, and the importance of the convection effects is suggested. Owing to convection Wood's values would probably be too high.

Mr. S. G. STARLING expressed his interest in the Paper, and said the curves showing the variation in the convection currents were very valuable.

Mr. A. CAMPBELL asked if the thermometer wire employed reached its steady state gradually or whether it overshot the mark and returned gradually to it.

Mr. DUDDELL pointed out that in some of his experiments he had found that the overshoot effect was due to flow of heat along the thermometer wire. A quick working instrument would approach the steady reading gradually.

Mr. J. A. TOMKINS exhibited a simple apparatus for mechanically illustrating the tangent and sine laws. Simple apparatus for mechanically testing the tangent and sine laws were described in 1887 in Ayrton's "Practical Electricity" and again in his more recent work published in 1897. Mr. Tomkins' apparatus, although inferior to some of Prof. Ayrton's, is extremely simple in construction and can be used equally well for illustrating the tangent or the sine law with good results. A weight is suspended by a fine thread from a hook, O. Attached to this thread at N there is a second thread passing over a pulley, P, and terminating in a scale pan for carrying weights. The pulley is fixed to an arm, capable of rotation about the centre C, which can be clamped in any desired position. Two scales are attached to the apparatus in such positions that the reading of one scale is proportional to the tangent of the angle made by the thread ON with the vertical, while the reading on the other is proportional to the sine of this angle. The thread ON represents the galvanometer needle, the tension in the vertical thread the controlling force, and that in the thread NP the variable deflecting force.

THERMIT RAIL WELDING.*

M. J. FRENCH.

The hardest proposition with which manufacturers of improved rail joint fastenings have to contend is to secure fair play for their devices. Many fastenings have features that mark a material advance over the old style of joint plates, but their application requires such care that its neglect would make the joints appear less desirable than those of older date, especially when the extra cost and consequent additional loss through failure is given due weight. All track engineers and superintendents concede the great advantage of a continuous rail, but the attempts to secure it have in some cases been so expensive and unsatisfactory that others have hesitated to recommend to their superiors the use of the latest and most scientific appliances.

On the Utica & Mohawk Valley Railway Co.'s system we have used only the thermit process of welding, and, with one exception, failures may be attributed either to carelessness in application or to lack of knowledge of requirements.

Although the details of the thermit welding process are familiar to track engineers generally, a brief description may help others to appreciate its advantages more fully. The process consists in pouring molten iron, or more correctly mild steel, from a crucible into sand and flour moulds placed around the rails at the joint. The rails having first been lined and surfaced, the joint is thoroughly cleaned with a sand blast or wire brush. Then the rails are heated by a gasoline or an oil blow-torch to expel all moisture, and by heating the rails to a dull red better results are insured, as the temperature of the molten steel is not reduced as much when coming into contact with the rails.

A pair of moulds made of an equal mixture of common clay and sand, or more preferably of sand and 10 per cent. of cheap rye flour, are then clamped firmly to the rails. The material of the moulds is held by wrought-iron framework provided with handles to facilitate carrying. The rail head is then painted with a watery solution of common red clay which the heated rail immediately dries up to a thin coating. This is to prevent the molten slag or steel from uniting with or burning the rail-head. After thoroughly luting all joints of the moulds with clay of the consistency of putty, common earth is packed around the outside of the moulds. The moulds and rails are then given a final warming with the blow torch, the flame being directed inside the moulds to expel any remaining moisture. The crucible on its tripod is placed with pouring hole directly over and about 2 in. above the gate in the mould. After placing the tapping pin, iron disc, asbestos disc and refractory sand in the bottom of the crucible to act as a plug for the opening, the thermit compound is poured in, and in the centre of the top is placed about one-third of a teaspoon of ignition powder. A storm match starts the chemical process.

The thermit compound is composed of aluminium and iron oxide, both in granular or flake form ; the ignition powder is composed of aluminium and barium peroxide in much finer form. When the match is applied the barium peroxide ignites and releases its oxygen to the aluminium very quickly. The heat produced is so intense that it causes the iron oxide to release its oxygen, which in turn is seized by the aluminium and almost instantly the entire contents of the crucible are a boiling and seething mass. By this reaction the pure steel is liberated and settles immediately to the bottom of the crucible. This wonderful chemical action is concluded within 30 seconds, the crucible is tapped by striking the tapping pin with a special iron spade, and the incandescent steel runs smoothly into the mould, the aluminium oxide or corundum slag following. In five minutes the mould can be removed for the passage of cars.

To go back to the beginning of the operations, our attempts to make moulds of half proportions of clay and sand resulted unsatisfactorily in that they shrunk badly in baking and required a great amount of careful luting to fill all irregularities at the joints. Also the clay was baked like a brick from the great heat of the welded joint and was quite hard to remove, adding somewhat to the expense. An old foundryman suggested to our foreman that he should try a mixture of clean, sharp sand with 10 per cent. of coarse rye flour, moistening the mixture sufficiently to retain its form when pressed in the hand. This mixture came away from the model without adhering, baked without shrinking a particle, and was hard enough to stand ordinary handling. I believe we were the first users of thermit to employ this mixture that has now become general. For baking the moulds we have found that a moderate heat of about the temperature required in baking bread proved most satisfactory, as a higher temperature burned the rye flour and destroyed its cementing property. By adding a teaspoonfull of turpentine for each pair of moulds the material was made as hard as concrete—unnecessarily hard for ordinary use but most desirable for special moulds for broken or combination joints.

* Abstract of a Paper read before the Street Railway Association of the State of New York, Buffalo, January 11, 1907.

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These special moulds we make solid, and then with cold chisel and file hollow out the space to form a welt of iron.

We first tried baking the moulds in a furnace with banked fire under a boiler, but the heat could not be regulated sufficiently, and we lost many moulds through burning. Our foreman then built an oven out at our Utica Park storeyard, using old bricks and building in a flat plate of iron above the firebox to baffle the heat. Above that two racks were placed to hold the moulds. This oven has a capacity of 12 sets of moulds, one man receiving 15 cents an hour, making and baking 12 sets in five hours. Thus we have a capacity of 24 sets per day at a cost of 6¼ cents a set for labour. Our moulds actually cost about 10 cents a set, as the workman was not constantly employed and we did not require the full output each day. Our oven is constructed with but one door for the moulds and fuel, but it is more desirable to have a separate door on the side of the baking chamber, as the oven is not then cooled off when fuel is placed in the firebox. We use old ties for fuel. We have made our own crucibles since using up the first six furnished by the Goldschmidt Thermit Co. We buy the magnesia tar and mix with it 25 per cent. of old crucible material finely powdered. These crucibles are very durable and last on an average for about 30 joints. We bake these in our oven with a higher temperature than that required for the moulds.

Results with Welding.—We have welded about 900 joints during the years 1905 and 1906. Of these 600 were made in 1905 on Lorain 95 lb., 9 in. tram-head rail. This work was subsequently paved in with vitrified blocks on concrete extending from the bottom of ties. The ties were 6 in. by 8 in. hewed southern pine, 8 ft. long, spaced 24 in. centre to centre on 8 in. of crushed stone. Ten of these joints proved faulty during the year, the break being generally elliptical in shape and extending from the end of the rail just underneath the head and above the weld, to the upper bolt hole; thence to the lower bolt hole and back to the base of rail near its end. This break is supposed to follow closely the line defining the extreme limit of recrystallisation of the rail that is produced as a result of the heat radiated from the weld itself. These rails had been drilled with 1¼ in. holes spaced 2½ in.—6 in.—6 in. in upper row and 3½ in.—6 in.—6 in. in lower row, for regular ribbed-girder joint plates, and the line of recrystallisation passed through the first holes in most instances. I understand that this recrystallisation is the cause of most of the breaks in both cast and electrically-welded rails. Nearly all of these joints that failed broke through contraction of the rails due to failure to protect them properly after welding continuously 500 ft. to 600 ft. of rail. Later we omitted the weld at every sixth joint until after the paving was finished on all joints but those left for contraction, when the latter were welded and the concreting and paving around them was finished. Thin sections sawed from the upper half of a rail were placed in the openings before welding.

Another kind of joint failure developed in the form of a slip joint, due to the iron of the weld failing to unite properly with the rail itself. We had about four of these slip joints during 1905. Later on we tested all welds immediately after cooling by striking them on both sides of the rail with a heavy spike maul, the labourer being instructed to break off the weld if possible. These defective joints were all repaired by making a special mould to enclose the old weld and by running another weld close against and at one side of the old one, over the break in the rail. This year we have had seven breaks in this total of 600 joints, all of them breaking through the bolt holes.

During 1906 we welded 200 joints on the same section of rail laid in 1902, where the 12-bolt ribbed plates had begun to show failure through working loose or the rail head had mashed down at the receiving end. In the latter case the receiving rail was shimmed up and, after welding, the head was ground true to a straight edge by means of a hand power emery-wheel grinder. Thus far but one of these joints has proved defective, as there was no expansion or contraction noticeable, the pavement being removed only at the joints

Some Precautions.—In one case when welding a 7 in. rail we found that we could sledge off the welds and that the iron from the thermit compound had not united with the rail; also that the iron came up to the top of the rail head. We subsequently found that the mould models had become mixed, and we had used one of too small horizontal cross-section, and consequently the rail chilled the small volume of molten iron coming in contact with it. Upon enlarging the mould model so that the thermit portion furnished only enough iron to come up under the rail head, we obtained welds that resisted the most vigorous sledging that could be given with a 10 lb. hammer. We were able to batter the weld out of shape, but could not separate it from the rail. This sledging test is now applied to all welds.

We found when welding in the morning with rising temperature that tightly-closed joints often humped up when welded. This proved to be due to the latent compression in the rails that did not manifest itself until the rail ends became soft. These humped joints were ground down with an emery wheel grinder. We had only a few of these joints when we realised the cause, and readily prevented such action by welding on cooler days or when the temperature was falling. We obtained the best results with joints open about $\frac{1}{16}$ in. to $\frac{3}{16}$ in., the expansion in welding closing tightly such an opening. We have made excellent combination welds between 80 lb. T-rail; 7 in. 70 lb. and 95 lb. T-rails and 9 in. girder rails. In making combination welds we found that it was essential to get a good body of metal between the upper side of the base of the deeper rail and the under side of the shallower section in order to secure the strongest type of weld.

Thus far there has been no appreciable excess wear in the head of the rails at the welds, and the heated portion seems to take the original temper, as it cools down slowly in about the same way as when coming from the rolls.

A few portions of thermit, not over six, have been lost through failure of the workman to tap the crucible properly, or lack of luting around the joints of the moulds. We have had but one explosion during our entire experience. That occurred after using the process 18 months, and was caused through carelessness in welding on a rainy day and in not thoroughly luting the moulds near the top. The slag came in contact with the wet earth around the mould, but no harm was done by the explosion, and the weld turned out to be a good one.

Cost.—The total cost per joint to weld the 9 in. girder rail on the 1905 construction, including all labour, materials, tools and patterns incident to the work, experimenting with mould materials and cost of oven, was $5.86 (£1. 3s. 5½d.). The total cost of welding old 9 in. girder work, including the removal of brick pavement and concrete at the joints and replacing the same, was $7.44 (£1. 9s. 9d.) per joint. The total cost of welding the 7 in. T-rail during 1906 was $5.81 (£1. 3s. 3d.) per joint.

Our track construction work has not been of such magnitude as to require continuous welding day after day, and we have used three men from a regular track gang for this work. In consequence the cost has not been so low as would have been the case under continuous operation. We have never exceeded 20 welds in any one day.

We tried welding at night for a short time, but, on account of increased expense and liability of accident, gave it up, as there was no real necessity for doing it at night so far as the operation of cars was concerned. The comparative simplicity and small cost of the outfit required, the facility of manipulation and the flexibility of the process in its application to various sections of rails and to other welding purposes serves, in our opinion, to make it altogether desirable.

We feel that our experience and the signal improvement of 1906 over the welding done in 1905 warrants us in continuing the use of the process. If our breakages do not exceed 2 per cent. a year, assuming the life of the rail to be 15 years, we shall have expended about $2.25 (9s.) per joint in paved streets in maintaining perfect stability and practically full electrical conductivity of the rails. Moreover, we have every reason to expect that the failures will materially decrease, as the weak joints should show themselves within the first year of service. We are also confident of reducing the breakage and loss of welding portions at the time of welding, because of the experience gained by our men.

CORRESPONDENCE.

CORRUGATIONS IN TRAM RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your paragraph on p. 82 you say: "Road Inspector" takes me to task for saying corrugations appear on straight rails. I may say I know of one instance in which corrugations exist on what apparently is a straight line. They are very slight, though quite sufficient to swear by; it is on a slight up grade, though I freely admit they are generally absent on straight lines.

He also mentions corrugations on the tube railways and Liverpool Overhead Railway, which are, I believe, both driven from the centre of the axle; with my theory as a basis I consider these are both easily explained, as I will endeavour to show.

As to the second point which he says needs elucidating—viz., "the absence of corrugations on the inner rail." Take the case of a pair of wheels and axles (not a driving axle for simplicity) rounding a curve of large radius, either the inner or outer wheel must slip a little, but the conditions as regards slipping are very different between the two wheels. If the outer wheel obtains the mastery in the contention which ensues, and retains its bite or hold on the rail, it compels the inner wheel to have a positive slip—that is, it must make its periphery

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travel faster than the wheel is travelling over the rail. Whereas if the inner wheel obtains the mastery (which I contend it does) it has not to compel the outer wheel to revolve quicker than its travel requires, but simply to retard it, which results in a negative slip or lag on the part of the outer wheel. Thus I contend it is this negative or positive slip which decides whether the inner or outer wheel gives way to the other and does the slipping, and the fact that only the outer rail suffers corrugation goes to prove that the outer wheel does all the slipping or lagging, which to my mind seems the most probable, the more so if brakes are being applied. Then, further, with regard to the question as to the slip taking place intermittently and forming or increasing corrugations, if the axle is strong enough to resist the torque it is subjected to, a strain is put upon the under carriage of the car, tending to thrust the axle box of the outer wheel backward and the inner one forward. If the outer rail surface is even, as when new or uncorrugated, this strain is continuous and not noticeable; but when it comes to a patch smoother than the rest of the rail, as in the hollow of a corrugation, the strain set up in the under carriage and twist in the axle are suddenly relieved by the outer wheel slipping, after which the strain is again renewed and so on. In curves of very large radius the relief necessary is very small, and takes the form of almost continuous slip, and is not so liable to form corrugations, or at least not so deep. In curves of shorter (but over 150 ft.) radius the slip and relief must take place at shorter intervals, which correspond in distance with the pitch of the corrugations it thus forms or increases.

Consequently, the shorter the radius the quicker the strain or tension accumulates, which necessarily reduces the pitch, and evidently the 150 ft. radius mentioned by "Road Inspector" in point No. 3 is a dividing line and a minimum, below which the pitch gets so short that even if corrugations existed, the wheel would bridge two and perhaps three waves at one time, and thus the tendency would be to grind out instead of forming corrugations. I think this theory as regards negative or positive slip will hold good in wheels either driven or otherwise, and that the end-driven axle is partly responsible for the trouble, and may accentuate or retard the effect produced by the negative slip. A couple of good diagonal stays between the four axle boxes, together with axles sufficiently strong, should go a long way towards reducing the trouble to a minimum by forcing the outer wheel to take a continuous slip.—Yours, &c.,

J. H. BRIGGS.

Leeds, May 13.

STENO-TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with care the description of the "Stenotelegraphic" system as described in *The Electrician* of May 10th, and have looked through the patent specification.

I do not wish to detract from the ingenuity of the invention, but in fairness to myself would like to point out that I invented this method of working in 1900, as will be seen from the description taken from p. 3 of the provisional of my patent No. 7,471, A.D. 1900, of which the following is an extract:—

There are other ways of receiving by variation in the strength of the arrival signalling current. For instance, the drum of the primary relay may be subdivided, say, into five or more divisions, the middle division, as heretofore, insulated, the outer divisions indicating respectively simple signals and compound signals, the compound signals being understood and split up by a recording or printing instrument operated thereby; that is to say, when a particular arrangement of signals which have to be transmitted and which have been provided for in the general adjustment of the system, they may be sent on as one signal only, with an increase of power, producing an increase of amplitude on the receiving relay, causing the pointer to rest on a particular division and thence operating the receiver to print or otherwise record the particular combination.

This is exactly what Mr. Baronio does with the stenocode. He proposes to use a relay with a 5 divisional drum or its equivalent, and he uses single and compound signals, indicating the compound signal by an increase of voltage, and he employs automatic apparatus to record or otherwise indicate the particular combination, exactly as I proposed. Although he could not in my opinion claim to have invented the system, he can claim, I believe, to be the first to have practically carried out such an idea. I did not follow up my proposal in this matter, although its possibilities were clear in my mind, because I considered and do now consider a new code objectionable for practical use, as it renders checking of the message well-nigh impossible.

In my opinion there are other and far better ways of accomplishing the same results—namely, by increasing the working speed—without departing from the present code.—Yours, &c.,

S. G. BROWN.

4, Great Winchester-street, E.C., May 14.

ELECTROLYTIC COPPER TUBES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a description in your paper of the proposed method of making tubes by electrodeposition by suspending in the solution some silicious matter such as sand or infusorial earths, which, it is claimed, enables tubes to be produced giving a high tensile strength.

Such a process cannot be of any commercial value, except in very exceptional cases, where cost is of little or no importance, as the resistance of the electrolyte is greatly increased.

I observe that the inventor claims he can deposit copper at the rate of 19 amperes per square foot at 2·5 volts, which is no improvement on the Elmore process. By the centrifugal copper process, copper can be deposited at 200 amperes per square foot at 0·75 volt, requiring only about one-third of the power and one tenth of the time claimed for the new process.—Yours, &c.,

SHERARD COWPER-COLES.

Westminster, May 14.

FUSE TESTS AT DEPTFORD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the report on the "Koolark" fuses tested at Deptford which appeared in your last week's issue, we wish to point out that the tests referred to were on 550 volt D.C. fuses. The statement that the London Electric Supply Corpn. had, previous to the "Koolark" tests, been unable to obtain a fuse which would stand a 500 kw. short-circuit referred only to D.C. 550 volt fuses and did not cover high-tension fuses, or in any way discredit the excellent results obtained by Mr. Partridge with his "Sparklet" fuse for high-voltage circuits.—Yours, &c.,

THE ELECTRICAL APPARATUS CO.
(per R. Amberton).

Caxton House, Westminster, May 15.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Die Forging and the Construction of Dies." By Joseph G. Horner. (London: "Engineering.") 14s. net.

"Machine Design." By Charles H. Benjamin. (London: Archibald Constable & Co.) 8s. net.

Proceedings of the Royal Society. Vol. LXXIX. No. B 530. Series B—Biological Sciences. (London: Harrison & Sons.) 3s. 6d.

Proceedings of the Royal Society. Vol. LXXIX. No. A 529. Series A. Mathematical and Physical Sciences. (London: Harrison & Sons.) 3s. 6d.

Annual Report of the Board of Regents of the Smithsonian Institution. Year ending June 30, 1905. (Washington: Government Printing Office.)

"Flying Machines." By A. W. Marshall and Henry Greenly. (London: Percival Marshall & Co.) 1s. net.

"Wireless Telegraphy for Amateurs." By R. P. Howgrave-Graham. (London: Percival Marshall & Co.) 2s. net.

"Heat Shadows." By Walter Jamieson. (London: Blackie & Son.) 6d. net.

"Elementary Electrical Engineering." By John H. Shaxby. (London: Blackie & Son.) 3s. net.

"Elektrische Fernphotographie und Ähnliches." By Dr. Arthur Korn. 2nd edition. (Leipzig: S. Hirzell.) 2m.

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PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

(Continued from page 185 of the present issue.)

How would they know the ship?—It has its code number and could always be identified.

Suppose a French ship were communicating with the English coast and a German ship and an American ship were communicating with each other at the same time, might there not be difficulty in receiving the message of the French ship?—It depends on whether they are working on the same wave-length. A communication between ships must be on the 300 metre wave-length, but the French steamer communicating with the English coast might be on the 600 metre wave-length, and in that case there would be no confusion. Further, there is a clause in the Convention which states that ship-to-ship communication is to give way to ship to shore communication.

Mr. LEE: What objects had certain countries in refusing to avail themselves of the privilege of exemption?—I think they did not like to go back on what they had previously proposed.

You do not think it contains the germ of a plot for a future Convention to enforce general intercommunication?—No, but I think before the need occurs for another Convention we may see that they have been right, although we have not been wrong. We are getting all the advantages of intercommunication with none of the risks.

The POSTMASTER-GENERAL: You think that when the time for another Convention arrives it will not be necessary to exempt stations?—Yes.

Sir EDWARD SASSOON: Could the spark system and the continuous-wave system be made to intercommunicate?—Yes, I think they will come together.

Mr. ADKINS: It has been suggested that we should be at an advantage if we did not ratify and other nations did, as we should be able to use any wave-length. Do you think we should have an advantage?—No, I do not think other nations will tie themselves down and let us do as we please. The Convention was drawn up by Germany, and we, and no one else, cut the whole thing to pieces. There is not a point in it of any value that was not proposed by Great Britain.

Are the Admiralty in favour of the ratification of the Convention as now proposed in its entirety?—I cannot speak for the Admiralty now, but I am in favour of it.

The CHAIRMAN: Do you not think you have rather overstated the case with regard to the difficulty of tracing and punishing the operator who disobeys the provisions of the Convention?—I have put the case in the worst possible light. The Admiralty might, of course, communicate with the foreign Admiralty concerned, as in the case of the International Telegraph Convention. What I meant was that we must be prepared to accept such procedure if necessary.

Mr. H. BABINGTON SMITH, C.B., C.S.I., secretary to the General Post Office, was recalled and said he wished to offer some evidence with regard to certain statements made by Mr. Cuthbert Hall concerning the attitude of certain foreign delegates. Mr. Hall made certain statements as to remarks made to him by the French delegate M. Bordelongue, and he (Mr. Babington Smith) had asked the latter whether he wished to make any rectification. The witness then read questions which had been put to Mr. Hall and his answers to them and also a letter received by witness from M. Bordelongue on the subject. M. Bordelongue, in effect, entirely controverted the evidence of Mr. Cuthbert Hall as to his (M. Bordelongue's) views on intercommunication. Mr. Babington Smith referred to the views of some of the other delegates to the Conference on this point with a view to controverting the evidence of Mr. Cuthbert Hall.

The CHAIRMAN: Have you anything to say with regard to the use of stations other than Marconi stations for public service?—We have received information that during the six months ended April 30, 1907, the coast stations of the United States transmitted from shore to ship 32,887 messages, and received from ships 46,182. The total number of messages transmitted and received by the Marconi shore stations in the United Kingdom (leaving out the new service from Poldhu) was 16,035 messages. Mr. Cuthbert Hall stated that the total amount of traffic transmitted and received in the year by the Marconi stations (I understand this means in other countries as well as Great Britain) was 1½ million words. The traffic transmitted by the American stations (if each telegram were 15 words) was 2,370,000 words. These figures are given by the various companies, and I have no means of checking them any more than those of the Marconi Co. The figures I gave regarding the Marconi Co.'s messages relate to messages transmitted over the Post Office wires, which would cover a very large majority of the messages sent, but the figures may be a little under the mark. We are officially informed by the Netherlands administration that 2,700 messages were sent and received in 1906 at the Scheveningen Telefunken station, which is more than the number sent and received over the Post Office wires at any Marconi station in this country, except Brow Head and the Lizard. With regard to intercommunication, Art. 3 (relating to general intercommunication) does not lay down that every station must use apparatus which can intercommunicate, but only that intercommunication must not be refused on account of difference of systems. If physical intercommunication cannot take place there is no obligation to adopt or adapt apparatus so that it can take place. With regard to the restriction as to wave-lengths, it is only stations open to general correspondence which are restricted to the two wave-lengths of 300 and 600 metres. Other stations can be authorised to employ any wave-length their own Government may approve, provided it is not between 600 and 1,600 metres.

The Committee then rose.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

In our last issue (p. 149) we were able to give a short report of the debate on the order for the second reading of this bill. Mr. Courthope moved that the second reading be taken that day six months, while Mr. McKinnon Wood supported the second reading, and the gist of the remarks of both members appeared in our last issue. Mr. W. F. D. Smith also supported the measure, arguing that the present County Council might be safely entrusted to look after the ratepayers' interests.

Mr. CHIOZZA-MONEY asked the House to reject the bill because it contained the leasing clause. In these days of successful municipal electrical undertakings there was no reason for treating electricity supply as experimental, and showing lack of confidence in the managing ability of the people of London.

Mr. PICKERSGILL considered it would be better to give the monopoly of electricity supply to London County Council, even though the Council proposed to hand over the undertaking to a private company, than to grant the monopoly directly to a private company.

Mr. BOWERMAN (Deptford) said the Labour Party would strongly oppose the second reading, because they objected to the undertaking being handed over to private enterprise instead of being worked by the County Council. If there were such risks as had been alleged, how was it so many keen company promoters were desirous of securing the undertaking?

Mr. WATERLOW supported the bill because he believed that London required cheap electricity for power. All the small industries in London depended upon cheap power, and to that extent upon cheap electricity. In the area covered by the bill there were 45 public authorities and 27 companies supplying electricity, but they could not supply it as cheaply as the County Council would be able to supply it under the bill, because they could not get the necessary equality of load throughout the 24 hours. In the event of leasing he attached the greatest importance to the date of 1931, when the powers of almost all the existing companies would be purchasable by the borough councils. Leasing must not extend beyond that date, or, alternatively, the whole question of electric power for London must come up for review in 1931. He would vote for the second reading, but he wanted to see the details of the measure carefully safeguarded.

Mr. BONAR LAW said this was a subject that had occupied the attention of the Board of Trade two years ago. He did not think it was the business of the House to go into the merits or demerits of private trading as against municipal enterprise. If he believed that municipalities as a whole would manage their business as well as private enterprise he would be much more in favour of municipal enterprise. The County Council were pledged to have the business conducted by private enterprise, if possible.

Mr. LLOYD-GEORGE said that the bill was framed on the recommendations of the Special Committee which considered the whole matter of electric supply in London last year, and on that ground he supported its second reading. The question as to terms and conditions was not to be settled on a second reading; it was a matter for Committee. He recommended that they consider the suggestion that they direct their minds to a limitation of the power of the Council to part with its franchise in point of time. It should be so limited that the County Council, in 1931, would be able to deal with the question of purchase as a whole, as that was the date when most of the private enterprises might be purchased by the municipalities. Ten out of 12 municipal electrical undertakings in London showed a profit on a lower charge for current. He found on investigation that the difference between the charge for electric energy made by London municipalities and that of the companies was something like 1d. per unit (or about 30 per cent.) lower by the former than by the latter. And still the municipalities made a very considerable profit on their reduced charges. It was the same in the provinces. The gross profit made by the provincial local authorities upon a capital expenditure of £28,000,000 for the supply of electricity was over £2,000,000, with £1,265,000 set aside for purposes of sinking funds. This seemed to be the only country in the world where there existed a terror of municipal enterprise. If they went to Germany they would find the municipalities supplying docks, electricity, water, gas, houses and land.

Mr. CROOKS said the leasing clause in the present bill practically meant that they would be compelled to lease, and then exactly the same thing would happen as they had experienced in the case of tramway leases, under which the County Council had been unable to improve the hours of labour or rates of wages, or reduce the fares. What would happen would be that there would be an amalgamation of the electrical companies in London, who would arrange the price before they went to the County Council. Many of the local authorities had already got electrical plant. Were they going to allow a great trust to come in and practically scrap that plant, leaving the authorities to bear the burden of the rates? They had just heard from the President of the Board of Trade the same old official arguments. There had been no change of Government; there had only been a change of representation in the House of Commons. The permanent officials were against the proposal. But he urged the House not to give away the inheritance that belonged to the people of London. The Council ought to have full power to supply the electricity.

Mr. DICKINSON believed it could be shown that work carried on by municipalities was more efficacious and cheaper than work carried on by private companies. On an average municipalities had laid down tramlines at a cheaper rate per mile than companies, had worked with a smaller percentage of working expenses to gross receipts, net revenue showed a greater percentage return on capital expended, net revenue per mile was larger and the average fare charged was smaller than by the companies.

The bill was still under consideration at 11 o'clock when the debate stood adjourned.

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ABERDEEN CORPORATION BILL.

On Monday a Select Committee of the House of Lords (Lord Ludlow presiding, and Lords Seton, Sinclair, Howard de Walden and Clements) considered this bill, which confers powers to supply electricity to several parishes adjoining the City of Aberdeen; but in the area of the County Council.

Mr. LLOYD, K.C., said that Aberdeen municipal electricity works had been in operation over 12½ years, and during that period had paid 30 per cent. of its cost towards depreciation, sinking fund, &c. In desiring to supply outlying parts, the Corporation were actuated by the desire to supply the needs of these districts. The people in these parishes wanted electricity and the Corporation were willing to supply the County Council with everything if they would take over the control. A clause gave the County Council the right of purchase up to 1912.

After hearing evidence, the Committee allowed the bill to proceed.

London United Tramways.—On Tuesday a House of Commons committee passed the preamble of the Bill promoted by the London United Tramways (1901), Ltd., for an extension of two years for the construction of authorised lines and for the purchase of land, &c.

North-East London Rly.—A House of Lords Committee, presided over by Lord Balfour of Burleigh, approved on Tuesday the preamble of this Bill, for an extension of time for acquiring lands and for the construction of railways authorised by the North-East London Railway Acts, 1905 and 1906, &c.

STORES AND COST-KEEPING FOR ELECTRICITY SUPPLY UNDERTAKINGS.*

BY D. DENHOLM.

The importance of having a properly organised and efficient system of handling the stores and keeping the costs of electricity supply undertakings is now generally admitted, and while it is impossible to devise a system which would apply in all working details to every undertaking, there are certain general arrangements applicable to all. In organising a stores and costing system, consideration has to be given to what is required from these departments. The accountant requires that the records must be kept so that he can get the results, and all information as to the working of the whole of the department at any time promptly and accurately. The engineer's department requires to some extent the same information, but in addition it is stipulated that work must not be delayed owing to any rigid system which will prevent the getting of material promptly and as it is required.

In the electricity department of the city of Glasgow, the work carried on includes everything that can possibly be required in connection with the supply of electricity. In addition to the routine work of the generating stations and the distribution of supply to consumers, the department employs its own workmen for most of the work in connection with the extensions which are more or less continually going on. All this involves a corresponding increase and variety in the work of the stores and costing departments, and necessitates a properly organised system if endless confusion is to be avoided. The stores arrangement described below is based on the system in use in the electricity department of the Glasgow Corporation. The costing arrangement is, however, different, some of the points on which there has been trouble in working being improved upon.

Stores.

General.—In the stores department, a complete and accurate system of requisitioning, purchasing, receiving, storing, distributing and accounting for all stores is required. There should be a general store, with a thoroughly experienced storekeeper in charge. At this store all records will be made up, not only for goods received and issued from the store, but for material which is delivered direct on to jobs. At the sub-stations it will not, as a rule, be necessary to keep more than small supplies of running materials, and these materials, issued from the general store, can always be charged direct to the proper job number, as hereafter explained. The storekeeper would see that the stocks are kept up, goods properly checked and inspected on receipt, and material issued against proper orders. He would be required to keep a keen eye on scrap (a very important item), and generally take an intelligent interest in the work of the department. If the work of the stores is efficiently carried out, it assists and makes for accuracy in all the work which follows, and of which the storekeeping is the basis.

Requisitioning of Material.

A requisition form in duplicate should be used: (*a*) by the storekeeper for stock renewals, (*b*) by engineers or other responsible persons for requisitioning material which is not regularly stocked The first copy being sent to the stores superintendent, second copy retained in the book. On the requisition form would be stated full particulars of the goods required, general allocation number, when wanted, and where the goods are to be delivered. The stores superintendent, having satisfied himself as to the correctness of all the details on the requisition, issues an official order on the firm which is to supply the goods.

Order Form.—The orders should be typewritten, and press-copied into a book, the leaves of which are numbered according to the numbers on the forms. The order should be signed by the chief engineer or his departmental assistants, who have authority to sign for him. When the official order is issued for the goods the number of the order and date of issue will be marked on the requisition, which should be sent to the storekeeper. The storekeeper would have it filed on file No. 1, so that when the goods have been delivered he may mark them off on the requisition. The completed requisition would then be filed on file No. 2. The storekeeper has thus two files with requisitions, No. 1 showing all goods on order still to deliver, and file No. 2 with completed requisitions, and showing date of delivery of the goods.

Purchasing.

For goods being supplied under a yearly contract it is simply a matter of clerical routine, but where there is no contract competitive offers should, as a rule, be taken. An inquiry form should be used, and unaccepted offers acknowledged and declined on a special form.

Specification and Tender Form.—Special attention should be given to the specification and contract form issued for general stores. The author has seen some hundreds of these documents, and in very few instances were they properly drawn up. In drawing up a specification and tender form foolscap paper of a good quality should be used. On the front page state clearly the general conditions and specification under which the material is to be supplied. On the second page detail the material in the form of a price list, leaving ample space for filling in prices. In the price list state as clearly as possible what is required, giving the usual trade description if at all possible. Do not state "best quality, to sample," and then show a third or fourth quality sample. Rather let the offerer send in a sample if there is any doubt as to the quality wanted. On the third page state the letter of offer. A record of all quotations accepted should be kept on cards or in a loose-leaf book. Unaccepted quotations should be filed for reference.

Goods Received.

These should be recorded in triplicate books, printed in red: First copy to accountant, second copy to stock clerk, third copy retained in the book. All goods received would be checked on receipt, and a goods received note would be made out and signed by the storekeeper, giving full particulars of the goods received, weight or quantity, and remarks as to breakages, shortages, &c., also full particulars of (*a*) packing, (*b*) carrier, (*c*) whether carriage paid, (*d*) amount of carriage. These apparently minor details should be carefully given, as they save a great deal of trouble later on, when railway accounts, &c., come to be checked. Goods received notes would be further dealt with as follows: (*a*) Goods received from outside firms. The first copy, with the sender's receive note, is passed to the accountant. The second copy would be passed to the stock clerk for entry of the material into the stock sheets. (*b*) Material returned as unused on the job for which issued should be entered on a separate receive note, and not along with scrap material. The first copy would be sent to the accountant. The second copy would be passed to the stock clerk, who would make the entries in the stock sheets, and price the items on the receive note. The receive note would then be passed to the cost clerk. (*c*) Special allowances for scrap. Joint boxes, fittings, &c, returned from jobs, which would be worth full value if cleaned up or slightly repaired, would be treated as scrap on the receive note, but the word "good" in brackets would be written against the item, and due allowance made for same in pricing. This means that such boxes or fittings are debited to "Scrap Account," but when they have been overhauled a receive note receiving from "Scrap Account" is made out taking them into stock. (*d*) Material from the workshop would be dealt with as in (*a*) above. (*e*) Material delivered (by the supplier) direct to a job on the streets. The foreman in charge of the work would send the supplier's receive note to the stores, and the storekeeper would make out a goods received note for the material, marking it "Delivered direct to ——," *i.e.*, the place where the job is. (*f*) Material delivered by the supplier direct to sub-stations. The engineer in charge would send the supplier's receive note to the stores, and a goods received note would be made out and marked "Delivered direct to ——," giving name of sub-station.

Storing of Goods.

Accommodation required for Stores.—There is one absolutely essential point in store-keeping, and that is plenty of accommodation for keeping the material properly. It is impossible to keep stock accurately if it is all jumbled together and crowded on shelves and bins. There should be ample ranges of shelves, pigeon-holes, drawers and racks, as well as a margin of floor place.

Labelling of Places containing Stock.—Prominently on the outside of each place containing material there should be a card or a label fixed stating: (*a*) Standard list number; (*b*) description of

* Abstract of a Paper read before the Glasgow Local Section of the Institution of Electrical Engineers.

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material; (*c*) minimum stock; (*d*) location number. The standard list number will be found of assistance where the turnover is at all large. In Glasgow, with a stock of something over 10,000 items and an enormous turnover, it was found that confusion arose owing to the same material appearing under two or three different descriptions. To meet this difficulty the stock has been standardised, and every item has a list number, which is used on all orders received, and despatch notes and other forms. The stock is divided into sections A to Z. The list number consists of the section letter, a numeral and, where necessary to give a size or a further description, a small alphabetical letter, thus: 1 sq. in. T.C. V.B.S. Callender cable. The section letter is "A." The number as per list is "1." And, as the different makers' cable has to be kept separate, the small letter "*a*" is for the maker's name. The complete list number is, therefore, "A 1 *a*"; or, 2 in. cast-iron pipes, S. and F.; the section letter is "B"; the number as per list is "80"; the complete list number would be "B 80."

The location number is the number of the rack, bin or drawer, as the case may be, and is useful if marked on the stock sheets.

There should be, in addition to the annual stocktaking, a continual checking of the stock against the balances shown on the stock sheets. This can be done by having so many of the items checked weekly by the accountant and the result shown on the stock sheets.

Distribution of Material.

A goods despatch note is required in triplicate, printed in black: First copy to the accountant, second copy to the cost office, third copy retained in the book.

A despatch note would be made out for all goods sent out from the stores, or for material delivered direct to the jobs or sub-stations. Material would be supplied against written orders only, the latter made out on the proper form by the foreman or tradesman. The despatches would be dealt with as follows: (*a*) For material to tradesmen and others within the department, the first copy of the despatch note, signed by the receiver of the goods and accompanied by the order issued on the store, would be sent to the accountant. The second copy would be passed to the stores clerk, who would enter the quantities into the stock sheets, price the items on the despatch note, and pass it to the cost clerk. (*b*) For material delivered direct to jobs on the street by the supplier, the storekeeper would make out a despatch note, marking on it, "Delivered direct by ——," and giving the name of the firm supplying the goods. The copies of the despatch note would be dealt with as in section *a* (*c*) For material delivered direct to sub-stations, as in section *b*. (*d*) For material to the workshop, a despatch note would be made out as in section *a*, except when any box, fitting or other article is sent for repair or alteration. An order to the workshop on a special form would be sufficient. (*e*) For goods sent to persons or firms outside of the department, or for returned empties, &c., despatch notes would be made out as in section *a*, but in addition it is necessary to have an "advice form" to be sent with the goods, or posted to the firm, advising the despatch. (*f*) When material out of stock is to be scrapped, a despatch note would be made out as in section *a*. No material would be scrapped out of stock without the authority in writing of the departmental engineer and the stores superintendent. (*g*) A separate stock account would be kept for all movable plant and tools. A monthly return of tools, &c., condemned as useless would be made up and a despatch note made out for them, debiting to scrap account.

Costing.

The costing comes under two general headings:—(*a*) Generating department. (*b*) Mains department. The generating department costs should include all the work done at the generating stations and sub-stations, as well as the purely generating costs. If the job numbers are properly stated by the engineers and foremen in giving their instructions to workmen to begin with, and the work in the stores department is efficiently carried out, the getting out of the costs is much simplified. Capital and revenue items would be each designated by a number, and the numbers applicable to capital and to revenue are never used twice, so that there is no difficulty in discriminating as to the number denoting what is chargeable to capital and what is chargeable to revenue. A running cost number, fixed by the cost clerk, would be placed under the principal number thus: An instruction form would be issued to lay a distributor in district "X." The sub-division number for distributors under capital account is 801, say; therefore the job number would be $\frac{\text{X.801}}{\text{R.C.N.}}$.

In the generating department it would not, as a rule, be necesary to issue written instructions to workmen for work to be done. The engineers and foremen only would order material from the stores on an "Order to Stores," form. In the mains department the work is of a different nature. Jointers, branchmen, &c., are working over large areas, and it is better that each tradesman should have his instructions in writing. The superintendent would issue an instruction form (filling in the workman's name) to do the work, marking thereon the general allocation number, the running cost number being fixed by the cost clerk. This complete number would be used on all subsequent forms issued for work to be done on the same job. The first and second copies of the instruction form would be passed to the cost clerk, who would at once fix the running cost number and hand the first copy to the workman when he reports himself at the time office for starting on his job. On the back of the form the workman would mark the time spent on the job, and give a note of the material he had used. This list of material would be compared with the amount he had drawn from the stores for the job, as shown by the dispatch notes. Any serious difference would be inquired into and reported to the superintendent in charge. In the case of a large amount of work being carried out to one instruction, the workman would make a weekly return of time and material on a special sheet supplied by the cost clerk, his instruction form being retained until the completion of the job. From the second copy the full particulars of the place and job would be entered into the "instruction form register."

Job Number Register.—In this register would be recorded all the job numbers fixed for work done in the generating department. It is of the utmost importance that this book should be kept up-to-date and carefully indexed.

Instruction Form Register.—This is the job number book in the case of the mains department. The size of book or books required depends on the amount of work being done. The important point is that the book or books must be cross indexed, and be carefully kept.

Binding Receive and Despatch Notes.—As already explained, the second copy of the goods received and the goods despatch notes are passed to the cost clerk, after having been priced in the stores and had the job numbers stated on them. These notes are now bound into loose binders or files, one binder or file being used for each general allocation number. From the binders the notes for each running cost number—that is, for each job—are taken and pinned together with sheet for labour, sheet for cartage, abstract sheet.

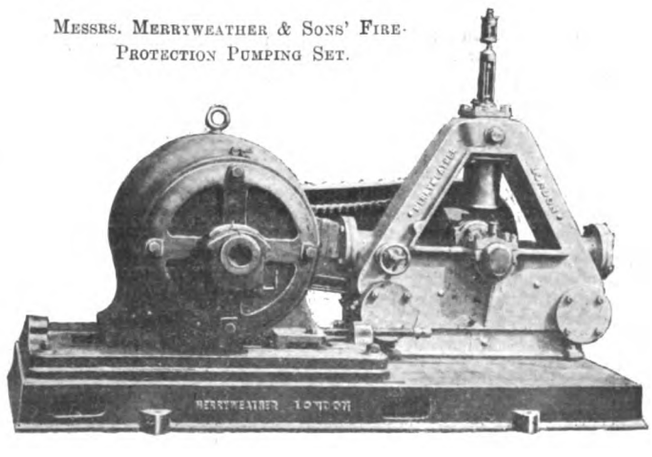
Abstract Sheet.—On the abstract sheet would be shown the amount of each class of material used and the totals of the items for cartage and labour. From the abstract sheets the monthly summaries would be made up and copies supplied to the chief engineer and to all the engineers responsible for the work carried out. Should details of any particular job be required, they would be quickly got at from the bound notes, which would be pigeon-holded and kept for, say, two years.

In the foregoing Paper the author is fully aware that he has by no means exhausted the subject. The handling of the fuel supplies and the time-keeping arrangements have not been touched upon, and much remains to be said of the filing of prices and records, the care of movable plant and tools, the economic handling of scrap, &c. The aim of the Paper is not so much to put forward any cut-and-dried system, as to call the attention of the members to the need for some kind of system if the electrical supply undertakings are to be built up on those sound commercial principles which have been found so indispensable in the commercial development of other great industries.

Included with the Paper were copies of all the forms and notes to which reference has been made.

ELECTRIC FIRE PROTECTION.

The installation of the electric light in country houses has provided a most convenient power for the driving of machinery for fire protection. The current can be easily conveyed to a motor driving



Messrs. Merryweather & Sons' Fire-Protection Pumping Set.

a pump placed close to any available water supply, and mains laid to serve hydrants in and around the whole of the premises to be protected. A good example of such a system has just been installed by Messrs. Merryweather & Sons at Ponsbourne Park, near

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Hertford, the residence of E. Hildred Carlile, Esq., M.P. Here one of the firm's treble-barrel "Hatfield" pumps of a capacity of 200 gallons per minute has been fixed and is arranged to draw water from two independent sources alternatively and deliver into a high-pressure fire-main pipe, on which a number of hydrants are fixed. The pump is driven by an electric motor of 15 H.P. at 200 revs. per min. on a 200 volt circuit. A silent chain is used for the drive. The current, which is also used for lighting the premises, is provided by an oil engine and dynamo.

LEGAL INTELLIGENCE.

Bosch v. Simms Mfg. Co. (Ltd.)

Last week Mr. Justice Neville heard this action for an injunction to restrain defendants from applying privately by letter or circular or by a traveller to any person, firm or company who was, before the sale of the Simms-Bosch magneto department of the business of defendants to plaintiff, a customer of defendants in respect of the business carried on by that department, asking such customer to continue after such sale to deal with defendants in respect of the business carried on by that department, or not to deal with plaintiff. It appeared that defendants (manufacturers of motor cars) had a magneto department for the manufacture and sale of magneto machines for motor cars made under the Simms-Bosch patents, in which plaintiff and defendants were jointly interested. Disputes having arisen between plaintiff and defendants, in relation to Simms-Bosch magneto machines, an agreement was entered into between them whereby defendants agreed to sell to plaintiff that portion of the Simms Co.'s business for £20,000. Plaintiff covenanted that he would not grant to anyone except defendants any licence to manufacture magnetos under the Simms-Bosch letters patent, but reserved to himself the right to manufacture, and he further agreed, in consideration of £3,000, to grant defendants a licence. The sale was completed and the licence granted by Feb. 22. On Feb. 15 defendants sent a circular to all their customers to the effect that they had made the sale to plaintiff, but notifying that they hoped, in less than six months' time, to be able to supply magnetos of British make, to be placed on the market as "Simms magnetos," and which would be found of equal, if not superior, quality to those they had hitherto supplied. Plaintiff at once notified defendants that this circular was a breach of the agreement, but defendants denied this. Thereupon plaintiff issued a writ claiming an injunction, and now moved for an interim order.

After hearing legal arguments, Mr. Justice NEVILLE said he thought plaintiff was entitled to an injunction to restrain defendants from issuing circulars to their old customers soliciting orders for magneto machines. There was in the sale of the goodwill an implied condition that the vendor would not solicit the old customers of the business for orders. Plaintiff bought the "Simms-Bosch magneto department of defendants and the goodwill attached thereto." Surely the goodwill was the hope of getting further orders from those who had bought these magneto machines, and it was contrary to the principle of "Trego *v.* Hunt" for defendants to go to the same customers and ask them to buy magneto machines. Therefore, defendants must be restrained from soliciting or offering for sale to the old customers magneto machines separately. Defendants, however, were manufacturers of motor cars, and he thought that in offering motor cars, although containing magneto machines, to their old customers they would not be committing a breach of the agreement.

Greenberg v. New Leader Motors (Ltd.)

Last week a Divisional Court (Mr. Justice Phillimore and Mr. Justice Bray) heard this appeal of defendants from the judgment of the Common Sergeant given in the Lord Mayor's Court, London. In the original action plaintiffs sued defendant company for £73. 10s. for 30 four-cylinder coils, alleged to have been sold and delivered, and the Common Serjeant entered judgment for plaintiffs for £61. 5s. beyond the amount paid into court, with costs.

According to appellants, the goods were supplied to the company of Binks & Co., motor manufacturers, on the order of the manager (Mr. Chas. Binks) in August, 1905. About five of the coils were used by the company. A fire took place at the company's premises, and the company went into liquidation, the coils, which were not burned, remaining on the premises, which were taken over by the Leader Motors on formation in Oct. 1905. Mr. Binks was managing the Leader Motors Co., and Mr. Godwin was the liquidator of Chas. Binks (Ltd.) The New Leader Motors (Ltd.) was subsequently formed to take over the assets and liabilities of the Leader Motors (Ltd.), and Mr. Binks was appointed works manager. Defendants alleged that he played a double part. He was the chief debenture-holder in Binks (Ltd.), and it was to his interest to get rid of all their liabilities.

Their LORDSHIPS, without calling on counsel for respondent, held that there was evidence on which the Common Serjeant could act, and the appeal was dismissed.

Roberts v. Reliance Lift & Engineering Co.

At Bradford County Court last week plantiff sought to recover balance of price of goods supplied and work done in connection with two electric lifts at Bradford Workhouse Infirmary. The claim was for £56. 10*s.* 11½d., but only £18. 10s. 5½d. was in dispute. For plaintiff it was stated that in 1905 defendants contracted to supply two lifts to Bradford Workhouse Infirmary, and they contracted with plaintiff to do the wiring work. Shortly after one of the lifts was put in it was found not to work, and defendants communicated with the London firm, from whom they bought the electrical apparatus, in order to ascertain the reason. Plaintiff contended that defendants were at fault in not getting an expert to see that the apparatus was properly connected. Finally, an expert was summoned and found several defects in defendants' work, and only one small defect in plaintiff's wiring work. It was alleged that that defect was caused by defendants' workmen in their endeavours to make the lift work. The lift was put into working order, and worked satisfactorily for a time, but subsequently defects were found, and defendants made several unsuccessful attempts to put these right. They called in plaintiff from time to time, and gave orders for certain things to be done, and it was in connection with those items that the amount in dispute was incurred.

Evidence for plaintiff having been taken, his HONOUR said the question with regard to the two defects was whether those had existed from the beginning, or whether they were caused by changes that took place afterwards.

For the defence it was contended that plaintiff's work had not been done as it ought to have been done, and defendants had been put to considerable loss by the negligence or carelessness of plaintiff.

Judgment was reserved.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Birmingham Corporation require for their Summer-lane electric generating station a shift engineer, over 25 years of age and with sound mechanical and electrical engineering training. Commencing salary £150, rising to £250 per annum. Also a power-house foreman, over 30 years of age (commencing wages £2. 5s., rising to £3. 5s. per week). Applications to the city electrical engineer and manager (Mr. R. A. Chattock), 14, Dale-end, Birmingham, by 28th inst. See an advertisement.

A draughtsman is required with general experience of electric construction details and capable of calculating windings of continuous current apparatus. Wages 42s. per week. See advertisement.

Messrs. A. Reyrolle & Co. (Ltd.), Hebburn-on-Tyne, require at once a draughtsman, experienced in design of controllers, motor starters and resistance work. See an advertisement.

A working foreman electrician is wanted by Dublin & Lucan Electric Railway Co., Conyngham-road, Dublin. See an advertisement.

The Governing Body of the Battersea Polytechnic (London) invite applications for the position of principal, to date from September next. Commencing salary £800 per annum, increasing to £1,000. Particulars from the Clerk. Applications by May 25.

For the Indian State Railway service two signal inspectors are wanted, one of whom must have a knowledge of electrical instruments used in signalling and interlocking installations. Salary in each case 300 rupees per month. Applications to Director-General of Stores, India Office, London, S.W., by May 25.

Mr. Thomas Wm. Bloxam, A.M.I.E.E., acting city electrical engineer at Belfast, has now been appointed permanently to the position recently vacated by Mr. Victor A. H. McCowen.

Mr. Bloxam was educated at Cheltenham College. In 1888 he was elected to an open scholarship at the City and Guilds Central Technical College, where he obtained the diploma of the college. He was then employed at the works of the P. & O. Steam Navigation Co., at Albert Docks, London, subsequently making voyages to India and Australia as electrician on the company's steamers. In 1893 Mr. Bloxam was appointed engineer-in-charge at the G.E. Railway Co.'s electricity works. On leaving the latter company's service in 1897 he was appointed chief assistant engineer at the County of London Electric Supply Co.'s works at Wandsworth, and in 1899 became chief assistant engineer at Dover. In July, 1899, he was appointed chief assistant at Belfast.

Mr. J. H. Bolam, M.Sc., station superintendent at Bristol, has been appointed borough electrical engineer at Weymouth. There were 154 applicants, but these were reduced to 3, viz., Messrs. J. H. Bolam, M.Sc., H. A. Howie (chief assistant at Wolverhampton), and John Williams (chief assistant at Rotherham). The choice of the electric lighting committee fell upon Mr. Bolam.

Mr. W. B. Morgan has been promoted to the position of station superintendent at Bristol (in succession to Mr. J. H. Bolam) at £225, increasing to £250 per annum on Dec. 1 next, and Mr. A. E. Wilson has been made mains superintendent in place of Mr. Morgan at a salary of £175, increasing to £200 in 12 months.

Mr. W. Y. Anderson, of the Lancashire Electric Power Co., has been appointed junior assistant in the business development department of Birmingham Corporation electricity works.

Mr. E. Williamson, who has been district manager of the National Telephone Co. at Nottingham for eight years, has been promoted to a similar position at Birmingham. Mr. C. H. Sibley, of Dublin, succeeds Mr. Williamson at Nottingham.

Mr. R. Withycombe, who until recently held the position of chief assistant engineer in the West Ham Corporation tramways department, has been appointed engineer and manager of the Zanzibar Lighting, Railway & Telephone Co. Mr. Withycombe left London on May 2 to take up his new appointment.

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Association of Teachers in Technical Institutions.—The first annual conference of the members of this Association will be held in Leeds on May 23, 24 and 25.

The presidential address will be delivered on May 23 by the president, Mr. V. A. Mundella, M.A., B.Sc. There will be a meeting at 10 a.m. on the 24th for the reading and discussion of Papers at the Leeds Institute, and after luncheon visits will be paid to certain works, &c. The annual dinner takes place at 7 p.m. on the 24th inst.

Communications regarding the conference should be addressed to the hon. sec. of the Conference committee (Mr. Jas. C. Edwards), 21, Sefton-avenue, Beeston Hill, Leeds.

Australasia.—The "Australian Mining Standard" states that it is expected that electricity supply will be available in Deloraine (Tasmania) in July.

Clark & Co. (Melbourne) have entered into a provisional agreement with Launceston (Tasmania) Council for constructing an electric tramway in the town, and have deposited £1,000. The firm will form a company to construct and work the tramways, and the Council will supply three-phase alternating current at a pressure of 5,000 volts at ½d. per unit. The undertaking is to be exempt from rates for the first three years, and in assessing the rates to be subsequently paid the basis will be taken of £100 per route-mile. The Council have the right to purchase at the end of 25 or any subsequent seven years.

Auckland (N.Z.) City Council received seven tenders for supply of electric lighting plant and at first decided to accept that of the Australian General Electric Co., but as the company declined to recognise the special conditions in regard to bonus and penalties, the tender of Turnbull & Jones, Auckland, was accepted at £11,808.

The Napier (N.Z.) Gas Co. have amended their articles of association to enable them to supply electrical energy.

The working of the Victorian Government's electric railway between St. Kilda and Brighton (the rolling stock of which was recently destroyed by fire) has been re-commenced by means of cars borrowed from the N.S.W. Government tramway department.

Electric cranes supplied by the Glasgow Electric Crane Co. (recently amalgamated with Jessop & Appleby Bros. under the title of Applebys Ltd.) have been installed and put into operation at Fremantle (W. Australia) Harbour. The cranes are of the gantry pedestal type with 50 ft. jib and lifting 70 ft., and run on a pair of rails 23 ft. apart, so that two railway trains can pass beneath. Current is taken from Fremantle power station at 2,200 volts two phase and transformed to 400 volts three phase.

At Carningham (Victoria) recently a banquet was held to celebrate the inauguration of the new electro-hydraulic sluicing plant of the Electro-Hydraulic Dredging Co. Plant of 180 H.P. to 200 H.P. is installed at the power house, and Mr. J. A. Dawson, electrical engineer and managing director of the company, stated that the use of electricity did not make the cost of the installation more expensive than the cost of three or four dredges worked by the different mining companies concerned would have been, and the number of men required was reduced by the use of electricity from 90 to nine.

Ayr.—Extensions of the electric lighting mains, estimated to cost £2,250, have been authorised.

Barnsley.—The charge for electric current has been reduced from 4d. to 3¾d. per unit on the flat rate and from 7d. per unit for the first hour and 2d. after to 7d. and 1½d.

The chairman of the Electricity committee said that during the past year the gross profit was £6,770. 13s. 8d., and, with £1,560 from last year, the disposable balance was £8,361. Payments of principal, interest, &c., amounted to £5,049. 5s. 3d., leaving £3,311. 15s. 9d. This was lessened by the £550 paid to the rates last year and also the £500 lent to public lighting account (to be repaid in five years), leaving £2,261. 15s. 9d., from which they proposed to take £500 for relief of rates, carrying £1,000 to reserve and the remainder forward.

Birchington (Kent).—There is a proposal before the Council for the supply of electricity by a local company to be formed in the district.

Bolton-Bury Tramways.—Through communication between the tramway systems of Bolton and Bury Corporations will be inaugurated to-day.

Bradford.—The Tramways committee have been authorised to construct the Brownroyd-hill tramway route at a cost of £12,000 for the permanent way and £1,300 for overhead electrical equipment.

Conciliation in the Engineering Trade.—Representatives of the Engineering Employers' Association in North-east Coast yards and of the Ironfounders' Association have agreed to establish a conciliation board for the regulation of wages and the settlement of trade disputes. In the event of failure to arrange any dispute through the medium of the board the matter is to be referred to arbitration.

Croydon.—The L.G. Board have sanctioned the following loans for extensions of the electricity undertaking—viz., £9,973 for mains, house services and sub-stations, repayable in 20 years; £708 for tranformers repayable in 15 years, £1,504 for meters, repayable in five years; £9,627 for excess expenditure and new works, repayable in 15 years.

Customs Duties.—The following import duties under the Roumanian tariff have been declared by recent decisions: Ammeters and voltmeters 100 lei per 100 kilogs.—£2. 0s. 8d. per cwt; watt-meters, 1·50 lei per kilog.—£3. 1s. per cwt.; steam, gas, &c., engines (not including machines driven by the engines, nor boilers), 25 lei per 100 kilog.—10s. 2d. per cwt.

Since the new Japanese tariff came into force in October last it has been decided that earthenware insulators are dutiable (under sec. 408) at 40 per cent. ad val.

Dundee.—The negotiations between the Town Council and the Harbour Board have now been satisfactorily concluded with regard to the site for the new power station, the Harbour Board having accepted the terms of the Council at 12s. 6d. per pole. With this difficulty settled, it will be possible to proceed with the erection of the new station immediately, although it is hardly probable that it will be ready to meet next winter's demand.

The Council, on the recommendation of the city electrical engineer (Mr. Richardson) has decided to abolish the minimum charge for meters for lighting in the case of all residential tenements. It has also been decided to include powers for the supply on hire or sale of motors, lamps, electrical apparatus, &c., in the forthcoming provisional order to be promoted by the Council.

The Dundee Shipbuilding Co. have decided to abandon steam and to substitute electric driving at their Panmure shipyard. There will be 25 motors of about 30 H.P., and the contract has already been placed with the British Westinghouse Co. Negotiations have been opened with the Corporation for a supply of electricity for power and lighting at the yard.

Dunfermline.—The question of electricity supply was again discussed by the Council on Monday, when it was decided to continue negotiations with the Fife Electric Power Co. for a supply in bulk.

East Ham.—The Electric Lighting committee have approved an estimate of £1,599 for two additional cooling towers at the electricity works.

Electrical Contractors' Association.—At the annual meeting of the West Yorkshire branch last week the secretary (Mr. E. C. Wallis, Leeds) presented the annual report.

During the year ended April 30 the membership of the branch increased by 17, and includes members from Leeds, Bradford, Harrogate, Dewsbury, Huddersfield and Hull.

At the annual dinner the toast of "The Electrical Contractors' Association" was proposed by Mr. T. Roles, city electrical engineer of Bradford, and responded to by Mr. Robson, of Newcastle. The toast of the "West Yorkshire Branch" was proposed by Mr. Harford, of Liverpool, and responded to by Mr. Steinthal, of Bradford.

Electrical Engineers Volunteers.—Second-Lieut. C. F. Smith, A.M.I.E.E., has resigned his commission.

Electro-culture.—In the "Fortnightly Review" for April Mr. Clarke-Nuttall writes interestingly on the subject of "Some Recent Developments in Plant Growing." He mentions the good work of Lemström and refers to the later experiments (with ether) of Johannsen, of Copenhagen. The Paper does not carry us any further in our knowledge of the effect of the electric treatment of plants or as to how much we may expect from the application of ether, but it serves a useful purpose in collating the more recent particulars concerning both methods of plant production.

Finchley.—The Electricity committee recommend application being made for sanction to borrow £16,830 for additional generating plant, &c.

The electrical engineer (Mr. E. Calvert) reports that the proposed extensions have become imperative in order to meet the increasing demands for electric current in the district.

It is also recommended that a sub-committee (Messrs. Todd, Gorringe and Gough) be appointed to ascertain the lowest terms upon which a supply in bulk can be obtained from the North Metropolitan Electric Power Supply Co.

Gravesend.—The borough electrical engineer (Mr. McInnes) has been voted £50 for extra work in connection with the extension of the electricity works.

Hammersmith (London).—The stables and mess rooms at the depot and Chancellor's Wharf are to be wired. It is estimated that electric lighting will be one-third cheaper than gas.

Harrogate.—The chairman of the Electric Lighting committee (Mr. Stott) states that there are now 1,350 consumers of electricity and the revenue for the past year was £16,905, the estimated net profit being £2,000.

Home Railways.—An interesting pamphlet on "Home Rails" has been compiled by Messrs. Wise, Speke & Co., of Newcastle-on-Tyne, who review the financial position of 15 of the main lines. The authors take a hopeful view of the future of home railways.

In regard to electrification, it is stated that "As far as home rails are concerned, there appears to be no immediate prospect that electricity will generally take the place of steam on the main lines, although for suburban services electricity is eminently suitable. The results obtained on the North-Eastern Railway and Lancashire & Yorkshire Railway are very satisfactory. The North-Eastern Railway has had to contend with the severest tramway competition along their whole electrified route, and notwithstanding this have considerably increased their receipts. The substitution of electricity for steam has enabled them t greatly increase

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their receipts over those which they formerly obtained when working by steam, and before the days of tramway competition."

Imperial Cables.—At the recent Colonial Conference the following resolution proposed by Cape Colony on the subject of Imperial cable communication was approved;—

(1) In the opinion of this Conference the provision of alternative routes of cable communication is desirable, but in deciding upon such routes the question of the strategic advantages should receive the fullest consideration; (2) that landing licenses should not operate for a longer period than 20 years, and that when subsidies are agreed to be paid they should be arranged on the standard revenue principle—*i.e.*, half the receipts after a fixed gross revenue has been earned to be utilised for the extinguishment of the subsidy and by agreement for the reduction of rates.

London-Brighton Trunk Telephone.—The Postmaster-General has decided to erect four additional trunk lines between London and Brighton.

London County Council.—At Tuesday's meeting it was agreed to lend Stepney £10,000 for electric lighting.

Estimates.—On the consideration of the estimates of the Highways committee Sir J. W. Benn criticised the proposal of the committee to expend £8,000 on the renewal of special track work at the Elephant and Castle out of the renewals reserve fund. He contended that this fund ought to be kept intact, and moved that the work be paid for out of revenue.

Mr. Shirley Benn said the track was laid four years ago, and had now to be renewed. The renewals fund was the place from which the cost should come.

Mr. Whittaker Thompson (chairman of the Highways committee) said the conditions were new. That was a piece of the line which, owing to great wear and tear, had worn out sooner than expected, and the officers said the renewals fund was established for the purpose of meeting such expenditure.

The vote was eventually allowed on the understanding that it should be without prejudice to the question whether it should be charged to the renewals fund.

Tramcar Bodies.—The adjourned report of the Highways committee recommending expenditure of £23,400 on the provision of 50 electric car bodies to be carried out under the management of the committee was agreed to.

Lowestoft.—The Council have decided to enter into a contract with Cain & Cartwright, of Birmingham, in connection with an express parcel delivery system. The firm will pay £45 per annum for the right of using the tramcars free in conjunction with their scheme, on the basis of a three years' contract.

Luton.—An unopposed inquiry was held here last week into the application of the Council for sanction to borrow £17,000 for extensions of the electricity undertaking.

Mexico.—The "Diario" contains a law authorising the Compañia Limitada de Tranvias Eléctricos de Mexico to construct and work an electric tramway in Mexico City between the Interoceanic railway station and San Lázaro.

Middlesex Tramways.—The electric tramway route between Wood Green and New Southgate was opened for traffic on Saturday last. The Wood Green-Palmer's Green line will be opened in a few days.

Newport (Mon.)—An inquiry was held here on Tuesday into the application of the Corporation for sanction to borrow £30,000 for electricity supply extensions.

The town clerk (Mr. Newman) said that £20,000 was for general extensions of mains to meet expanding business of the electricity department and £10,000 for additional plant.

Norway.—It is announced that Mr. Hiorth, of Christiania, has invented a system of treating low grade iron ores in an electric smelter, with graphite as a reducing medium instead of coal, and he has been awarded a prize for his invention by the Iron and Steel Institute.

Porto Rico.—This American colony is being rapidly developed, and telegraphs and telephones and other modern developments are being introduced. 65 additional miles of telegraph line were built in 1906, and telephonic communication has been established right across the island to Ponce. A private telephone undertaking is in process of organisation to connect up all the more important business centres.

Provisional Order Revocation.—The Board of Trade have revoked the Burgess Hill Electric Lighting Order, 1901, as from May 7.

Ravensthorpe (Yorks.)—Sanction has been received to a loan of £2,425 for electricity supply.

Stepney (London).—At the last meeting of the Council a discussion arose on the recommendations in regard to the scheme for the extension of the electricity undertaking, particulars of which were given in our last issue.

In regard to the estimate of £54,000 for the Blyth's Wharf scheme, of which £36,900 is to be spent to deal with the load anticipated at Christmas, 1908, the chairman of the Electricity committee (Councillor Gordon) said they were preparing plans and estimates in order to have everything in readiness for the autumn. Then they would ask the Council to authorise the committee to let the contract if they were to go on with the work.

Consideration of this estimate was adjourned, but the portion instructing the committee to prepare detailed plans for submission was carried.

The recommendation that Mr. Tapper be entrusted with the whole of the work in connection with the new generating station was referred back.

In regard to the annual accounts of the electricity undertaking, a summary of which appeared in our last issue, Councillor Gordon claimed that they were supplying electricity at the cheapest rate in London, and he thought the fact that they were able to make so substantial a surplus as £15,657 reflected credit on the way the undertaking was managed. The business was perfectly satisfactory; it had been established on commercial lines and had from the commencement been a success. The average amounts paid by the London borough councils for the electric lighting of the streets was 1·94d. per unit; the average charge made by the companies for the electric lighting of the streets was 2·02d; in Stepney the charge was only 1½d. All the indications point to a prosperous future.

The abstract of accounts and balance sheet were adopted.

Switzerland.—The "Feuille Fédérale Suisse" of April 17 contains a copy of a law respecting concessions of water power in Switzerland which provides that the utilisation of water power is to be supervised by the Federal Government, which will enact laws regarding the granting and holding of concessions, as well as the transmission and distribution of electric power. The Cantonal Governments may grant concessions, and fix and levy the dues payable for the use of water power, but the taxes must not be of such a nature as to render the utilisation of water power too onerous. The use of water power from "abroad" shall not be allowed without the authority of the Federal Government. Allowing for exceptions that may be provided for by Federal legislation, the provisions of this law are applicable to existing water-power concessions.

The "Feuille Fédérale Suisse" also contains a law authorising a company, presided over by Dr. C. Spahn, mayor of Schaffhausen, to construct a steam or electric railway from Schaffhausen to the frontier, near Ober-Bargen. Capital expenditure is estimated at 5,500,000fr. (£220,000).

Uffculme (Devon).—The Parish Council are in negotiation with a local firm (Messrs. Fox) in regard to public electric lighting. Messrs. Fox offer to supply electricity from their station for public lighting, provided the Council lay the necessary cables, at an estimated cost of about £250. A committee has been appointed to deal with the matter.

West Ham.—On the advice of the borough electrical engineer (Mr. Seabrook) tenders are to be obtained for an ash conveyor.

The Anglo-Continental Guano Co. have decided to take a large supply of current (night and day) on a five years' agreement.

The Electricity committee have been considering a suggestion by Mr. Seabrook for giving a supply of current to premises off the route of the existing mains which involve extensions of cable not warranted by the income to be derived at the moment. Mr. Seabrook suggests the laying of a pipe and, for the time being, using small rubber or bitumen covered wires to meet immediate requirements, and as the load increases to remove these wires and replace by permanent lead-covered cables. The adoption of this system would make many extensions feasible which are impracticable at present owing to the cost of laying permanent cables. Estimates having been submitted showing the saving to be effected, Mr. Seabrook has been authorised to carry out extensions approved by the committee on this system.

The tramways manager (Mr. Blain) reports that owing to the through running arrangements now taking place, practically in the whole of the eastern Metropolitan area, it has grown increasingly inconvenient for the different authorities to have separate sets of bye-laws. He has, therefore, been endeavouring for some time past to secure the adoption of a standard set, and as a result of conferences on the subject he has submitted a set for adoption. The existing West Ham bye-laws had been practically adopted as a model, the variations being very small. The bye-laws drawn up by the conference are to be adopted.

The Home Secretary has written in reply to representations made by a deputation which attended at the Home Office, in July last, stating that there are grave objections to the transfer of the licensing of tramcars and of tram-drivers and conductors to the local authorities. It is important, he urges, that in an area like the metropolis there should be one standard of fitness for all vehicles and all drivers and conductors. The question as to whether it is desirable to allow trams to carry excess passengers is a matter for Parliament to deal with. With regard to the power of the police to require the re-painting of cars, that power would not be exercised in an arbitrary manner. The police, as licensing authorities, would be satisfied if tramcars go through the depot once a year to be touched up and varnished, re-painting to be done when necessary. The proposal to issue temporary licences to drivers, &c., had nothing to recommend it.

Willesden.—Mains are to be extended at an estimated cost of £411. A draft agreement with the owners and occupiers of houses to be wired and supplied with fittings on the hire-purchase system has been drawn up by the electrical engineer, Mr. J. G. Bruce.

Wolverhampton.—On Monday the Council accepted tenders for the extension of the electricity works, and it was decided to apply for sanction to a loan of £35,000.

The borough electrical engineer (Mr. C. E. C. Shawfield) reported that though it was possible to accommodate a certain amount of additional

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generating plant in the engine room there was no more space available in the boiler house. Further boiler power was absolutely necessary. It would also be necessary to provide for a new chimney stack. The extension would provide sufficient room for four boilers and four generating sets of a total capacity of 4,000 kw., but it is only proposed at present to instal two boilers and two generating sets of 2,000 kw., of which 1,000 kw. would be immediately required by Messrs. Bayliss, Jones & Bayliss.

The capital expenditure of the extensions is put at £30,000, and, in addition, £15,000 will be required for extensions to mains.

Warwick.—The Council have entered into an agreement with Leamington & Warwick Electrical Co. for the supply of electric current to the county buildings.

Wireless Telegraphy.—We have received from the A.E.G foreign department a copy of a very interesting pamphlet on "Undamped Oscillations in Wireless Telegraphy," by Herr Otto Nairz, issued by the Gesellschaft für Drahtlose Telegraphie (Telefunken System).

Workers in the Iron and Steel Trades.—The Home Secretary has appointed a Departmental Committee to consider and report as to what would be the best method of securing to workers in the iron and steel trades, who are paid by weight, the means of checking the correctness of the wages they receive. The committee is composed as follows: Messrs. E. F. G. Hatch (*chairman*), Geo. Ainsworth, H. Eccles, John Hodge, M.P., John Lloyd Morgan, K.C., M.P., Ald. P. Walls and H. J. Wilson (one of H.M. inspectors of factories). The secretary is Mr. A. Maxwell, of the Home Office.

Workmen's Compensation Schemes.—The Chief Registrar of Friendly Societies has given notice that he has made draft regulations under the Workmen's Compensation Act, 1906, respecting the certification, &c., of contracting-out schemes. Copies of the draft regulations may be obtained from the Chief Registrar, 28, Abingdon-street, London, S.W., on payment of 1s.

Yarmouth.—The tramway route to Caister was opened for traffic on Tuesday.

The proposal to authorise the borough electrical engineer (Mr. G. Bryant) to supply outside arc lamps on a maintenance scheme (the wiring and fixing to be sublet to local contractors) has been referred to the General Purposes committee.

Electricity Supply Football League.—A meeting was held at the offices of the St. James' & Pall Mall Co. on May 2 with a view to forming an Associated Footba'l League among the various electric supply undertakings of London. It was decided to have a further meeting on May 28 at Carnaby-street, Golden-square, W. (at 6:30 p.m.) when, it is hoped, representatives of companies and boroughs within a 15 mile radius of Charing Cross will endeavour to attend. Mr. S. Green, hon. sec. (pro. tem.), 19, Carnaby-street, London, W., will be pleased to furnish further information.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Bolton.—The Corporation electricity department has had a successful year, the net profit being larger than it has ever before been. The total revenue was £51,500. 2s. 3d., an increase of £9,124 over 1905-6, and the total costs £18,174. 1s. 9d., increase £2,363, leaving gross profit £32,837. 11s. 9d., increase £6,272. After providing for interest on mortgage debt, &c. (£7,186. 15s. 1d.), and allowing for depreciation on machinery, mains, transformers, accumulators, motors and instruments (£14,033), the net profit was £11,617. 6s. 8d., out of which £6,000 has been voted to relief of rates, and £3,204 applied in replacing engines, &c., and in writing off cost of storage battery which has been displaced, leaving £3,100. 18s. 2d. to be carried forward. At the end of the year there were 2,074 consumers, representing an equivalent of 292,397 8 c.p. lamps connected, the average number of lamps per consumer being 141, compared with 116 in 1906. 9,505,925 units were generated (compared with 7,107,144); 1,457,547 units were supplied for private lighting, 9,291 for public lighting, 3,619,390 for traction, and 3,065,824 (compared with 1,423,759) for motors, and the average price per unit was 1·45d. There are 278 power consumers (against 226) and 536 motors (with an aggregate of 6,134½ H.P.) connected, compared with 418 motors and 3,535¾ H.P. The works cost was 0·438d. and the total cost 0·535d. (against 0·512d. and 0·626d. in 1906), the inclusive cost being 1 159d., compared with 1·437d. The net capital expenditure is £210,697, and the plant installed represents a capacity of 6,800 kw.

The borough electrical engineer and manager (Mr. A. A. Day) is to be congratulated upon the year's record. Altogether the accounts show the advisability of adopting a low price for motor supply, and also the advantage to be derived from keeping the capital account (which is very moderate at Bolton) at a low figure.

Chesterfield.—The second annual report of the engineer and manager of the tramways (Mr. R. L. Acland) states that the capital expended during the year was only £107, the total being £68,528. 11s. 2d.

Traffic receipts were £10,988. 12s., and other receipts made the total £11,492. 3s. 7d. Traffic expenses were £2,690. 9s. 9d., general expenses £768. 1s. 7d., power expenses £1,882. 8s. 3d. (1·640d. per car-mile) and repairs and maintenance £769. 6s. 10d. Gross profit was £5,381. 17s. 2d. and net profit £1,322, compared with £1,466. 2,302,097 passengers were carried and 275,417 car-miles run. The drop in net profit is due to increased rates and taxes, increased cost of current and repairs.

Grimsby.—The total revenue of the electricity department for the year ended March 31 was £13,049. 2s. 6d., including £7,614. 5s. 8d. from sale of current by meter, £3,247. 8s. 9d. from sale of current under contract (to Tramway Co. and G.C. Railway Co.) and £1,620. 6s. from public lighting.

The total expenditure was £6,279. 17s., and after allowing £59. 18s. 2d. for bad debts, the gross profit was £6,754. 7s. 4d. Interest absorbed £3,202. 12s., and instalments of principal repaid £2,212. 6s. 1d; £500 was transferred to local rate account against £504. 10s. 8d. to net revenue appropriation account, and, after paying interest and bank charges (£67. 18s. 2d.), the net profit for the year was £1,261. 11s. 1d., against £1,004 in 1906. The total capital expenditure is £91,358. 4s. 10d., the amount expended during the year being £9,464. 3s. 3d. 1,491,687 units were generated, 649,967 were sold to private consumers, 448,832 supplied for traction, and 121,939 for public lighting, while 85,990 units were sold to the G.C.R. Co.

In his sixth annual report the borough electrical engineer (Mr. W. A. Vignoles) thinks the result of the year's working is very satisfactory, seeing that the revenue obtained from the sale of electricity to the G.C.R. Co. has not been as much as was anticipated, and that during the last six months the price of current to private consumers was 4d. per unit, against 4½d. during the preceding year. There are 527 consumers with the equivalent of 65,144 8 c.p. lamps connected (against 503 and 53,543 8 c.p.). There are 112 motors with an aggregate of 787 H.P. connected (against 91 motors and 513 H.P.), and 226,382 units were sold for power, compared with 149,877 in the previous year. The time-switch system is appreciated by consumers, 21 motors being supplied on this system, aggregating 227 H.P. Total management costs were 0·320d. per unit sold (a decrease of 0·019d.); the total works costs were 0·762d., and 0·805d., and the total costs 1·062d., against 1·124d. During the year a new 500 kw. steam dynamo and a new boiler were installed. As the L.G. Board only allow five years to repay loans for meters, the Electric Light committee have decided to purchase these out of revenue, and about £150 will be provided each year for new meters and about £150 for payment of permanent employés of the department engaged on work chargeable to capital account.

Llandudno.—Out of the net profit (about (£1,000) on the past year's working of the electricity undertaking £300 is to be contributed to relief of rates.

Rotherham.—The receipts of the electricity undertaking during the year ended March 31 were £11,381, against £10,524 in 1905-6. After deducting working expenses the gross profit was £6,315. Interest on loans and sinking fund instalments absorb £3,983, leaving a net profit of £2,332, out of which £1,924 has been transferred to depreciation. After adding amount from last year, the net balance is £562, which is to be appropriated for relief of rates. The depreciation and renewals fund amounts to £7,201, or nearly 14 per cent of the capital. The equivalent of 6,971 33 watt lamps was connected to the mains during the year. The demand for current for power is rapidly increasing.

The capital expended on the tramways is £123,914. During the year ended March 5,743,298 passengers were carried and 618,211 car-miles run, the receipts per car-mile being 10·45d., against 9·80d. in 1905-6. The gross profit was £8,712, and the net profit £4,201 (against £1,646) has been carried to depreciation.

St. Anne's-on-the-Sea.—The electrical engineer (Mr. J. H. Clothier) states in his annual report that 717,599 units of electrical energy were sold during the past year, an increase of 101,000 over 1905-6. There are 534 consumers, an increase of 116, and applications are in hand from 16 new consumers. Mr. Clothier states that there is a steady increase all round; the demand for heating and motors is particularly notable.

Shipley.—The accounts of the Electricity department show a deficit of £703 for the past year. In future a flat rate of 4½d. per unit will be charged for current, the maximum demand system having been abolished.

Southport.—There is a profit of nearly £200 on the past year's working of the electric tramways, compared with a deficit of £600 in 1905-6.

West Bromwich.—The gross profit on the past year's working of the electricity department was £6,248, against £5,673 in 1906, and the net profit £2,624, compared with £1,931. The total net capital expenditure was £60,793, an increase of £4,933.

"The Electrician" in Canada.—The circulation of *The Electrician* in Canada has for many years past included a considerable number of the leading electrical engineers in the country, and most, if not all, of the principal manufacturing and supply houses. The recent changes in the postal arrangements, under which *The Electrician* can be posted to Canada for 1d. per copy, will enable us to cover a wider field in that country, and we have made arrangements by which all persons and firms engaged professionally and industrially in electrical engineering in Canada will receive copies of *The Electrician*.

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TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

The Higher Education committee of *Portsmouth* Corporation invite tenders for (1) supply and fixture of switchboards and wiring, (2) electric light fittings, and (3) special electric light fittings in the new Technical Institute. Specifications, &c., from the Principal of the Institute. Tenders, addressed to the Chairman of the Higher Education committee, Technical Institute, Arundel-road, Portsmouth, by May 28. See an advertisement.

Hull Electric Lighting Committee invite tenders for supply and erection of one 500 kw. high-tension continuous-current dynamo, coupled direct to a Belliss engine. Forms of tender and specifications from the city treasurer, Mr. T. G. Milner. Tenders to the Chairman of the committee, Town Hall, Hull, by noon May 23. See also an advertisement.

Belfast Tramways and Electricity Committee invite tenders for a lighting switchboard to control 2,000 kw. and one motor generator for their East Bridge-street electric station. Specifications from the city electrical engineer, Mr. Thos. W. Bloxam. Tenders to the town clerk (Sir Samuel Black), City Hall, Belfast, by noon, June 1. See also an advertisement.

Derby Corporation invite tenders for supply and delivery of bitumen insulated cable. Particulars and forms of tender from the borough electrical engineer (Mr. T. P. Wilmshurst), 16, Full-street, Derby. See also an advertisement.

Derby Tramways committee want tenders for supply of materials and construction of works in connection with permanent way and electrical equipment of a portion of the Corporation's electric tramways. Further information relating to the permanent way from the Borough Surveyor and Engineer, and with regard to the electrical equipment from the Borough Electrical Engineer.

Lanark County Council require tenders from manufacturers of electrical generating machinery and from manufacturers of secondary batteries, for the construction and erection of one 70 kw. motor-generator, alternating and direct-current switchgear, one battery charging booster, and one battery of 282 cells. Tenders to the county clerk (Mr. Thos. Munro), County Offices, Hamilton, N.B., by May 22.

Edinburgh Corporation require tenders by 10 a.m. May 27 for steam, exhaust and circulating water pipe-work at M'Donald-road electricity station. Specifications, &c., from the City Electrical Engineer or from Sir Alex. B. W. Kennedy, 17, Victoria-street, London, S.W.

Edinburgh Corporation also want tenders by 10 a.m. June 3 for constructing sewer shaft and laying iron pipe line for condensing water for M'Donald-road station. Specification, &c., from the City Electrical Engineer or from Sir Alex. Kennedy.

Glasgow Corporation want tenders by May 23 for supply of about 85,000 tons of coal (washed or dry screened singles) for the electricity department. Specification, &c., from the City Electrical Engineer, 75, Waterloo-street, Glasgow.

Goole District Council is prepared to receive competitive schemes for the erection of electricity supply plant and the necessary distributing mains to supply electricity within the compulsory area of supply. Particulars from the clerk to the Council, Mr. James Wm. Johnson. Schemes by Friday, May 31.

Sheffield Electric Lighting committee invite tenders for steam turbine, alternator, exciter, condenser and other accessories. Specifications from the general manager and engineer (Mr. S. E. Fedden), Corporation Electricity Supply Dept., Commercial-street, Sheffield. Tenders by 10 a.m. May 27.

Bedford Corporation invite tenders for supply of high and low-tension cables for 12 months. Specifications from the borough electrical engineer (Mr. R. W. L. Phillips), Cauldwell-road, Bedford. Tenders by noon 25th inst.

Southwark (London) Council want tenders by 4 p.m. May 29 for wiring a branch library. Specifications, &c., at the Town Clerk's office, Walworth-road, S.E.

Dartford District Council want tenders by 4 p.m. June 11 for stores for 12 months, including meters, cut-outs, cables, jointing materials, oil, coal, &c.

The Clyde Navigation Trustees, *Glasgow*, want tenders by 10 a.m. June 1 for 12 months' supply of stores, including electrical stores, iron and steel, ironmongery, steam tubing, oils, paints, varnishes, &c.

Radcliffe Library committee want tenders by 10 a.m., 18th inst., for wiring and fitting new library. Specification from Mr. H. Lord, 42, Deansgate, Manchester.

Limerick Electrical committee require tenders by noon June 11 for stores for the electricity department, including cable, accumulator and mains accessories, &c.

Knaresborough Water Carnival committee want tenders for search-light and telephone required at the carnival to be held on Aug. 15.

The Deputy Postmaster-General, Adelaide, *South Australia*, wants tenders by July 10 for supply of two telephone switchboards, lightning arrester board, 1,000 fuses, 500 Leclanché cells, 100 mechanical registers, 12 differential galvanometers, 15 electromagnetic transmitters, 6 resistance boxes, 5 miles copper wire, 5,000 copper tapes and 5,000 copper binders. Forms at the General Post Offices, Adelaide, Melbourne, Sydney and Brisbane.

TENDERS RECEIVED AND ACCEPTED.

The following tenders were received for generating plant, &c., required for the electric lighting scheme of the Ascot Gas & Electricity Co. The consulting engineers are Messrs. Handcock & Dykes:—

Two Gas Dynamos and Producer Plant.

Bilbie, Hobson & Co. (Hornsby engines and J. & P. dynamos) (*accepted*)	£2,669 14 0
Electric Construction Co. (Hornsby engines)	2,981 0 0
Johnson & Phillips (Campbell engines)	2,952 0 0
Farringdon Engineering Co. (Davey Paxman engines, Newton dynamos)	2,950 0 0
Schultz & Co. (Stockport engines, Crompton dynamos)	2,919 0 0
Mawdsleys Limited (Stockport engines)	2,907 0 0
Siemens Bros. Dynamo Works (Hornsby engines)	2,901 0 0
Phoenix Dynamo Co. (Stockport engines)	2,823 0 0
Johnson & Phillips (Hornsby engines and producers)	2,807 0 0
Farringdon Engineering Co. (Hornsby engines, Newton dynamos)	2,806 0 0
Rawlings Bros. (Hornsby engines)	2,742 18 10
Johnson & Phillips (Premier engines and Daniel producers)	2,729 0 0
Ditto (Hornsby engines and Mersey producers)	2,557 0 0

Overhead Traveller.

Herbert Morris & Bastert (*accepted*)	£157 0 0		
Schultz & Co. £225. 5s. and £260 10		G. A. Musker & Co.	235 0
Carrick & Ritchie	249 0		

Switchboard and Booster.

Electric Construction Co. (*accepted*)	£832 10 0		
Prestwich & Burt	£1,250 0 0	Nalder Bros. & Thompson	963 5 0
Johnson & Phillips	1,012 0 0	Farringdon Eng. Co.	948 0 0
Schultz & Co.	999 5 0	Hamilton Bros.	933 10 0
India Rubber Co.	993 5 0	Rawlings Bros.	*888 12 6
Siemens Bros. & Co.	974 0 0	Edison & Swan Co.	†878 12 6

* Plus £23. 12s. 6d. for specification work.
† Plus £23. 12s. 6d. for specified instruments.

Storage Battery.

Tudor Accumulator Co. (*accepted*)	£931 0 0*
Chloride Electrical Storage Co.	1,019 10 0†
D.P. Battery Co.	998 0 0‡
Rawlings Bros. (Pritchetts & Gold battery)	927 0 0§

Maintenance per annum: *£71. †£70. ‡£65. §£91. 15s.

Cables.

Siemens Bros. & Co. (*accepted*)	£9,444 6 0		
W. T. Henley's Co.	£9,943 0 0	British Insulated & Helsby Cables	£9,616 10 0
St. Helens Co.	9,923 19 3	Johnson & Phillips	9,551 10 6
Callender's Co.	9,781 3 9	Rawlings Bros.	9,467 10 7
Schultz & Co.	9,718 0 3		

Govan Corporation have accepted the following tenders for annual stores for the electricity department:

Alex. Macqueen & Co., crank chamber oil; Henry Wells Oil Co., cylinder oil; Dempster, Moore & Co., packings and gauge glasses; R

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Flinn & Co., washed cloths; British Insulated & Helsby Cables, lead-covered and armoured and vulcanised bitumen cables and cable accessories; J. A. Rudd & Co., rubber-covered cables; Craig, Sharp (Ltd.), bitumen, compound, &c.; Ferranti Limited and Chamberlain & Hookham, meters; Keighley Electrical Engineering Co., fuse boxes; David Richmond & Co., wrought-iron tubes; M'Dowell, Steven & Co., c.i. pipes; Scott & Rae, cement; W. Morrier, brushes; J. Duncan, ironmongery, drysalteries, white and coloured waste; J. Storer & Co., caustic soda and sulph. alumina; Robinson, Dunn & Co., timber; Sloan Electrical Co., Arc lamp carbons; Cruikshank & Co., joint boxes; Electromotors Limited, motors (½ H.P. to 4 H.P.); Lancashire Dynamo & Motor Co., motors (5 H.P. to 30 H.P.); Adams Mfg. Co. and Brook, Hirst & Co., motor starters; E. P. Allam & Co., d.p. switches.

London County Council received five tenders for supply of six fuel economisers for the second portion of the Greenwich generating station:—

E. Green & Son (*acc.*)..	£3,805 14	Roberts Bros.....	£3,967 10
Goodbrand & Co.....	4,050 0	A. Lowcock (Ltd.).....	3,910 0
Clay Cross Co.....	4,033 0		

Messrs. Green & Son are allowed to sub-let to the British Thomson-Houston Co. the supply of induction motors; to Llewellin's Machine Co., worm gears; to British Westinghouse Co., starting switchboards; and to R. Wagner, pyrometers.

Wolverhampton Council have accepted the following tenders:—Babcock & Wilcox, boilers, economiser and feed pumps, £5,622; John Thompson, steel chimney and feed water tank, £765; Willans & Robinson, turbo-alternators and condensing plant, £1,214; H. Gough & Sons, extension of station buildings, £2,900.

The Metropolitan Asylums Board received three tenders for alterations and additions to the electric light plant at the Brook Hospital:—J. H. Holmes & Co. (*accepted*), £367; Electrical Power Storage Co., £385. 10s.; Siemens Bros. & Co., £436.

The following tenders have been accepted by Croydon Corporation: E. Green & Son, economiser, £658. 8s.; W. Smith & Sons, foundations for flue and economiser, £519; Babcock & Wilcox, boiler feed piping, £145.

Lowestoft Electric Lighting committee have accepted the tender of the Lahmeyer Electrical Co. for feeder cable and pilot wires at £1,451. 11s. 9d. and that of the British Insulated & Helsby Cables for one feeder pillar and two disconnecting boxes.

The Barrow Hæmatite Steel & Iron Co. have placed with Veritys Limited an order for a large swithboard for controlling 3,000 kw. generators and power circuits.

Isle of Wight Education committee have accepted the tender of the local electric light and power company for wiring the new secondary school at Newport at £39. 15s.

East Ham Council have accepted the tender of W. R Reynolds (out of 13 tenders submitted) for wiring the Central Carnegie Library at £271. 12s. 6d.

The Oxford Electric Co. have placed with Bruce Peebles & Co., of Edinburgh and London, a further order for a motor converter, making the third order for this type of plant.

Dublin United Tramway Co. have an order with Willans & Robinson for a 1,000 kw. steam turbine set, including alternator and electrically-driven surface condensing plant.

For wiring the Hornsey Rise fire station, London County Council received eight tenders (ranging from £140 to £195), and the lowest (that of W. J. Fryer & Co.) was accepted.

The tender of Wm. Cory & Son has been accepted by London County Council for the supply of 25,000 tons of coal for Greenwich generating station at 14s. 5d. per ton.

London County Council have accepted the tender of the Alldays & Onions Pneumatic Engineering Co. for supply of electrically-driven fans for the School of Arts and Crafts at £693.

Bristol Watch committee have accepted the tender of the Post Office for the installation of 50 fire-alarm boxes of the Gamewell type at £878 per annum for 10 years, and £384 per annum after.

Hull Electric Lighting committee have accepted the tender of Siemens Bros. & Co. for cables (there were nine tenders); that of Hedley, Brown & Co. for oils; and that of E. M. Parsons for wiring No. 8 sub-station.

Kettering Council have accepted the tender of W. T. Glover & Co. for ½-mile of cable at £300.

Bristol Electrical committee have placed an order with Siemens Bros. Dynamo works for a steam turbo-alternator at £800.

Worcester Council have accepted the tender of Morris & Co. for wiring the sewage works at £74. 10s.

Yarmouth Electricity committee have provisionally accepted the tender of Down & Co. for 6,500 tons Scotch anthracite peas coal.

Whitby Guardians have accepted the tender of Walker & Hutton for wiring work at the workhouse.

The Electric Cable Co., of New York City, have received an order from the N.Y. City Interborough for a large quantity of flexible mesh rail bonds, which, we are informed, are to be hereafter used exclusively by the Interborough Co. To meet the growing demand for this product the Electric Cable Co. are making extensive additions to their plant at Bridgeport, Conn.

BUSINESS NOTICES.

Mr. W. Duddell has taken offices at 56, Victoria-street, Westminster, S.W., to which address all business communications should in future be addressed.

Mr. J. Erskine-Murray, D.Sc., M.I.E.E., consulting electrical engineer and wireless telegraphist, will remove on May 22 from Glasgow to Oswaldestre House, Norfolk-street, Strand, London, W.C.

The Consolidated Accessories Co. have removed from Craven House, Kingsway, W.C., to 27, Clements-lane, London, E.C. The business of the company has been under the control of Mr. J. McI. Cater since November last, in place of Mr. H. C. King, whose connection with the company then ceased.

E. P. Allam & Co. have appointed J. Parkinson & Co., Post Office-chambers, St. Nicholas-street, Newcastle-upon-Tyne, as their sole selling agents in the Northumberland and Durham districts.

BANKRUPTCIES, LIQUIDATIONS, &c.

Meetings of the creditors and shareholders of the British Electric Equipment Co. (Ltd.) were held on Tuesday.

The Official Receiver (Mr. Winearls) reported that the company was formed in Nov., 1904, with a nominal capital of £40,000, to acquire from Mr. H. G. Nicholson, as a going concern, the business of electrical engineers and contractors, carried on under the style of the British Electric Equipment Co. The consideration was £15,215, divided into £7,215 cash and £8,000 ordinary shares. The company also took over the liabilities of the business, and agreed to pay Mr. Nicholson £200 for commission previously earned. That gentleman was also appointed managing director at £1,000 a year. The total issued capital was £14,017. It appeared that out of £15,215 paid for the business by the company £10,000 was represented by goodwill. The business consisted of carrying out engineering contracts in connection with electric tramways for various town and district councils. It had been financed throughout by Mrs. Nicholson, who held charges amounting to over £12,000 over the debts due from the various councils. Those charges being upon book debts did not require to be registered under Sec. 14 of the Companies Act, 1900, and consequently the creditors had no opportunity of knowing the exact position before giving credit to the company. A further fact to be noted was that until a month or two ago no register of mortgages was kept by the company. The circumstances under which those charges were given to Mrs. Nicholson would be investigated with a view to testing their validity. In addition to those charges £2,000 5 per cent. debentures covering the whole of the company's assets had been issued to Mrs. Nicholson to secure a present advance of £500 and past advances of £1,500, and the validity of these bonds would also be questioned. An approximate statement of affairs showed total liabilities £25,493, of which £9,836 was unsecured; the assets (valued at £2,000) were entirely absorbed by the claims of debenture holders, and there would be nothing for the unsecured creditors or shareholders.

The liquidation was left in the hands of the Official Receiver and a committee.

The discharge of Arthur Blackburn, electrical and mechanical engineer (trading with James Walker as Blackburn, Walker & Co.), Upper Lane Mills, Cleckheaton, has been granted, subject to debtor's consent to a judgment for £20.

Edwin Jas. Muddle, electrical fitter, &c., 69, Cromwell-road, and 86 & 87, Western-road, Hove, has been adjudicated bankrupt. First meeting of creditors at 4, Pavilion-buildings, Brighton, on May 23, and public examination at the Court House, Brighton, June 6.

The Court has approved the payment of a composition of 10s. in the £ by Ernest C. Holt (trading as Holt & Co.), electrical engineer, Queen's-arcade, Rhyl. The receiving order has been discharged and the adjudication annulled.

Claims against McPhail & Simpson's Dry Steam Patents Co. (Ltd.) by May 28, to Mr. J. W. Close, North British & Mercantile-buildings, Leeds.

A meeting will be held at 70A, Basinghall-street, London, E.C., on June 17, to receive an account of the winding up of the Electro-Medical Supply Co. (Ltd.).

R. W. Vicarey (Ltd.) is being wound up voluntarily. Mr. F. J Harper, County-chambers, Shrewsbury, is liquidator.

A meeting will be held at Town Hall-square, Bradford, on June 18 to receive an account of the winding-up of the Land & Water Electric Power Synd. (Ltd.)

Sale by Auction.—Messrs. Horne & Co., 8, Delahay-street, Storey's Gate, Westminster, S.W., will sell by public auction on Wednesday, May 22 (at 11 a.m.), obsolete and unservicable stores, including quantities of founders' and lead ashes, crucibles, copper, brass, lead, iron and steel, zinc, aluminium and other metals,

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electric light carbons, electric cable, telegraph instruments, galvanometers, ebonite, lathes and tools, weighing machines, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on Friday and Tuesday previous to and on morning of sale. Catalogues at the War Office, Whitehall, the Ordnance Office, Tower, and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Plant for Sale.—Mr. V. Newport advertises for sale a 1 B.H.P. Morton gas engine, a 50 volt 10 ampere compound-wound dynamo, belting, main switchboard and instruments, Luna arc lamps, &c.

Plant Wanted.—Mr. Thomas Johnson, Prescott-street, Wigan, is advertising for a steam turbine, or other compact engine, either direct, rope or belt-driven.

Agents Wanted.—An advertiser requires agents to sell electric light (wooden) casing on commission.

Telephone Installation for Sale.—An advertiser has for disposal a second-hand private telephone installation, comprising 25 hole switchboard with indicators, five pairs of cords and plugs, micro-telephone, seven table instruments, eight wall sets, battery boxes, &c.

City of London Directory.—We have received a copy of the 1907 (37th annual) edition of this very useful directory and official guide to the City of London from the publishers, Messrs. W. H. & L. Collingridge, "City Press" offices, Aldersgate-street, London, E.C. The new edition has been carefully revised and brought up to date. The usual information concerning the City Corporation, the committees, the City officials, the Livery Companies, &c., which form a special feature of the directory, is again included. The names of the members of the new London County Council and of the various committees of the Council are also given. The directory should prove most useful to business men and all having commercial relations with the City of London. The volume is divided into sections, "Official" and "Educational," Livery Companies Guide, streets section, alphabetical section (containing the name, address and trade or profession of every person or firm in the City), and a Trades Guide. An interesting Biographical section contains sketches (with portraits in some cases) of leading City men, and there is a good coloured map of the city, showing ward boundaries, &c. Much of the information given could not have been obtained before March, and therefore could not have been earlier published without detracting from the utility of the directory. The published price is 12s. 6d.

CATALOGUES, &c.

Telegraph Condensers.—The Telegraph Condenser Co., Peckham Park-road, London, S.E., send us a copy of a handsome publication, which deals with their standard patterns of condensers for all classes of telegraph works.

Station Publicity.—"Words of Wisdom" is the title of a brochure just issued by the borough electrical engineer of Grimsby (Mr. W. A. Vignoles), directing attention to the advantages of electric lighting.

Gib Cranes.—Another useful catalogue is to hand from Applebys Limited, which gives very full details of steam and electric gib cranes. The catalogue is of convenient size for carrying, and at the end a number of pages of squared paper are provided for draughting purposes. Almost every type of this class of crane is described and illustrated.

Electro-Medical Apparatus.—A fully-illustrated list of electro-medical apparatus has just been issued by Krupka & Jacoby, London. The list gives details and prices of accumulators, transformers, surgical lamps, induction coils, small motors and electrical surgical instruments. An interesting item is the hydro-electric four-cell bath, by which currents can be made to traverse various parts of the body.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during April, 1907, and (*b*) during the current year from Jan. 1 to April 30, with the increases or decreases compared with the corresponding periods of 1906:—

Electrical machinery, (*a*) £50,177 (increase £12,960), (*b*) £194,370 (decrease £7,860); telegraph and telephone cables, (*a*) £44,948 (increase £32,856), (*b*) £121,670 (increase £67,950); telegraph and telephone apparatus, (*a*) £21,248 (decrease £8,892), (*b*) £83,057 (decrease £30,085); other electrical wires and cables: rubber insulated, (*a*) £12,174 (increase £8,783), (*b*) £35,428 (increase £6,948); with other insulations, (*a*) £3,579 (decrease £5,658), (*b*) £31,450 (decrease £719); other electrical goods and apparatus, (*a*) £42,722 (increase £6,825), (*b*) £177,871 (increase £6,144). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £124,671 (increase £33,914), (*b*) £449,476 (increase £50,238).

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from May 7 to 13, with the ports of destination:—

Aden—£84 (telegraph material). *Africa*—Alexandria, £67; Beira, £109; Benguela, £60 (telegraph material); Cape Town, £380 (including £25 telegraph material); Delagoa Bay, £43; Durban, £1,339 (including £1,284 telegraph material); Port Elizabeth, £23. *Argentina*—Buenos Ayres, £2,313 (including £1,759 telegraph material). *Australasia*—Adelaide, £83; Auckland, £214 (including £82 telegraph material); Fremantle, £229; Hobart, £50; Lyttelton, £73; Melbourne, £587 (including £273 telegraph material); Otago, £40; Perth, £619; Wellington, £38. *Belgium*—Brussels, £253; Ghent, £73; Ostend, £86. *Brazil*—Rio Janeiro, £298; Santos, £871. *British Guiana*—Demerara, £64. *British North Borneo*—Labuan, £20 (telegraph material). *Burma*—Rangoon, £60. *Canada*—St. John's (N.F.), £43 (telegraph material). *Ceylon*—Colombo, £382. *China*—Hankow, £142; Shanghai, £384 (including £59 telegraph material); Tientsin, £153. *Cochin China*—Saigon, £25. *Corea*—Chemulpo, £40. *France*—Boulogne, £14. *Germany*—Bremen, £32; Cologne, £17. *Holland*—Amsterdam, £105 (including £23 telegraph material); Flushing, £166. *Hong Kong*, £490. *India*—Bombay, £2,489 (including £1,989 telegraph material); Calcutta, £2,586 (including £933 telegraph material). *Japan*—Nagasaki, £37; Yokohama, £27. *Madeira*, £17 (telegraph material). *Mauritius*, £122. *North Atlantic*—£21,620 (telegraph material). *Portugal*—Oporto, £43. *Russia*—St. Petersburg, £46. *St. Helena*, £61 (including £37 telegraph material). *Siam*—Bangkok, £50. *Straits Settlements*—Penang, £73 (including £14 telegraph material); Singapore, £98. *Sweden*—Stockholm, £560 (telegraph material). *Uruguay*—Monte Video, £32 (telegraph material). *West Indies*—St. Thomas, £15,000 (telegraph material). Total, £52,930, against £18,493 in the corresponding week last year (May 9 to 15).

According to official returns for April, 1907, the value of electrical goods and apparatus (other than machinery and telegraph and telephone wire) exported from the United Kingdom was £122,908, compared with £103,285 in the corresponding month of 1906 and with £272,707 for April, 1905, an increase of £19,623 compared with 1906 and a decrease of £149,799 compared with 1905. For the four months of 1907 the total value of these goods was £638,645, compared with £828,020 for 1906 and with £650,474 in 1905, showing decreases of £189,375 and £11,829 compared with 1906 and 1905 respectively. The value of electrical machinery exported in April, 1907, was £97,368, compared with £67,531 in April, 1906, and £33,061 in April, 1905, increases of £29,837 and £64,307 respectively. The total value of electrical machinery for the four months ended April 30, 1907, was £302,981, compared with £271,594 in 1906 and £201,825 in 1905, increases of £31,837 and £101,156 respectively.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

February 28, 1907.

8,345A/06 DE MARÇAY. Accumulators. (Date applied for, 6/4/06.)
4,842 PHILPOTT & ALDERTON. Liquid switch for control of electric motors.
4,844 WEST. Storage batteries.
4,846 SKIDMORE. Joints of railway and tramway rails.
4,854 BAMBER. Production of electric current.
4,865 LOCKWOOD. Holders for incandescent lamps.
4,867 WALSH. Axle boxes for railway and tramway vehicles.
4,927 CHAPLET & SOCIÉTÉ LA NEO METALLURGIE. Electric furnaces. (Date applied for, 25/9/06.)*†
4,930 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for conductors.
4,931 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.

March 1, 1907.

19,219A/06 WATKINSON & PAYNE. Electrical resistance device. (Date applied for, 28/8/06.)*†
4,937 GILLON. Insulating composition.
4,950 BISSET. Lifeguard for electric tramways, &c.
4,986 ELLWOOD. Reversible turbine.
4,988 HEYLAND & KORDA. Rotary transformers. (Date applied for, 20/6/06.)*†
4,995 FORTESQUE-REDMAN & SMITH. Fuses and fuse carriers.
5,012 COOK. Electrical protective apparatus.*
5,025 GRIFFITHS & BEDELL. Current collector. (Date applied for, 3/3/06.)*†
5,036 UZAC. Manufacture of tubular articles by electrolysis. (Date applied for, 3/3/06.)*†
5,037 B.T.-H. Co. (G.E. Co., U.S.) Regulating electric lighting systems.

March 2, 1907.

5,066 HANN & INGLE. Earth return connections.
5,100 CÔTE & PIERRON. Electric furnaces for the continuous extraction of zinc from its ores.
5,116 MCALPINE. Switches.*
5,120 JOHNSON. Automatically cutting off current from overhead cranes or any electrical machine.
5,133 LEITNER. Compound electric motors.
19,951A/06 SEFTON-JONES. (Decker Electrical Mfg. Co., U.S.) Batteries. (Date applied for, 7/9/06.)*†
19,951B/06 SEFTON-JONES. (Decker Electrical Mfg. Co., U.S.) Plates and connectors for batteries. (Date applied for, 7/9/06.)*†
19,951C/06 SEFTON-JONES. (Decker Electrical Mfg. Co., U.S.) Batteries. (Date applied for, 7/9/06.)*

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SPECIFICATIONS PUBLISHED.

1905 SPECIFICATION.

25,134 CAYLEY & EDWARDS. Fluid pressure turbines.

1906 SPECIFICATIONS.

3,316 VOELKER & SULSER. Resistances for heating vessels and the like by electricity.
4,649 TOURTEL & JOHNS. Coin-freed electric supply apparatus.
4,838 LAKE. (Smith.) Electric motors.
4,849 RAVENSHAW, MIDDLETON & TOWNSEND. Magnetic clutches.
4,939 LAKE. (Lentz.) Safety guards or fenders for tramways.
4,961 LEA. Measuring and recording the flow of electrical forces.
4,995 HETTINGER. Selective or multiplex wireless signalling, signalling with connecting wires by alternating currents, and construction of wave meters.
5,037 HOWARTH. (Maschinenfabrik Oerlikon.) Synchronous alternating current generators.
5,136 CREEDY. Single-phase dynamo-electric machines.
5,167 MORGAN CRUCIBLE CO. & SPIERS. Pneumatic holders for commutator brushes.
5,261 B.T.-H. Co. & HOPPS. Self-regulating dynamo-electric generators.
5,262 B.T.-H. Co. & HOPPS. Suspension of the motors in electric vehicles.
5,450 WALKER. Collection of current from direct-current dynamo.
5,493 FIEDLER. Secondary batteries.
5,555 BROCKIE. Regulating mechanism for arc lamps.
5,952 FIELD & FERRANTI. Electro-magnetic switches.
6,006 B.T.-H. Co. (G.E. Co., U.S.) Switches.
6,010 WOODHOUSE. Conduit for electric conductors.
7,232 HEWER. Distribution boxes or section pillars.
7,627 B.T.-H. Co. (G.E. Co., U.S.) Electric railway systems.
7,916 TOURTEL & JOHNS. Electric time switches.
7,997 YATES & ALBROW. Coin-freed apparatus.
8,235 LÖWENHERZ. Automatic switch for portable incandescent lamps.
9,146 HALL. Terminal for use with electric conductors.
9,859 JACOBY. Electric motor starting and regulating switches.
10,016 B.T.-H. Co. (G.E. Co., U.S.) Starting devices for electric motors.
11,639 BLOXAM. (Lux.) Metallic filaments for glow lamps.
11,690 RECORD & BEVIS. Switches.
12,024 ELECTRICAL IMPROVEMENTS (Ltd.) & HACKING. Electrically lighting up gas lamps.
12,386 KREINSEN. Contact devices with a swinging plug.
12,896 BRECKNELL, MUNRO & ROGERS & MUNRO. Bow trolleys.
13,207 WISE. Incandescent lamps.
13,391 SMITH. Electric cooking stoves.
15,021 CONSORTIUM FÜR ELEKTROCHEMISCHE INDUSTRIE GES. Bodies of tungsten filaments for incandescent lamps. (Date applied for 5/7/05.)
15,022 SCHNEIDER & WESENFELD GES. Electrical winding apparatus for clocks. (Date applied for, 7/3/06.)
15,107 NASMITH. (Carbone.) Three-phase arc lamps.
15,281 BROOKES. (Cushman Electric Co.) Electric controllers for variable speed motors.
15,500 BINKO & PHŒNIX ELECTRIC HEATING CO. Electric radiators.
15,727 JUNGNER. Primary galvanic elements. (Date applied for, 12/7/05.)
15,784 ROUNSEVILL & BILMS. Time measuring device for telephone conversations.
16,343 KORN. Measuring the exposure of a selenium cell.
16,568 JANDUS ARC LAMP & ELECTRIC CO. & JONES. Arc lamps.
16,597 STORER & COOPER. Systems of control for electric motors. (Date applied for, 24/7/05.)†
16,702 MILLS. (Hale and Kilburn Mfg. Co.) Car seats.
16,823 RUTLEDGE. Steam turbines. (Date applied for, 25/7/05.)†
16,905 BASSETT. Thermo-chemical generator of electricity. (Date applied for, 27/7/05.)
17,419 HAHNER. Switches or line selectors for telephones. (Date applied for, 14/11/05.)†
17,513 BUTCHER, BUTCHER & BROWN. Arc lamps.
17,560 STEINMETZ. Dynamo electric machines. (Date applied for 7/8/05.)
17,589 ELLIS. Securing shades of silk or like materials to electric lamps.
18,255 KLEINSTEUBER. High-tension section-insulator for electric tramways or railways. (Rights under Patents, &c., Act, 1901, not granted.)
18,290 JUSTICE. (Melms & Pfenninger Ges.) Turbines.
18,317 JUSTICE. (Melms & Pfenninger Ges.) Elastic fluid turbines.
18,876 DARLINGTON. Cooling of electric transformers. (Date applied for, 5/9/05.)†
19,249 HAYDEN. Electrical sparking devices.
19,387 KAFFERLE. Electro-magnetically operated temperature regulating apparatus.
19,482 EISEMANN. Electrical ignition arrangements.
19,593 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckert-Werke.) Control of speed of motors or other machines.
19,717 FELTEN & GUILLEAUME-LAHMEYERWERKE A.-G. Alternating current machines. (Date applied for, 4/9/05.)
19,878 DE FOREST WIRELESS TELEGRAPH SYND. (De Forest). Apparatus for signalling by electromagnetic waves.
20,130 HADDAN. (Caldwell.) Current-collecting trolleys.
20,235 AUDIBERT. Mercury vapour or like electric lamps. (Date applied for, 20/9/05.)
21,003 NAEGGERATH. Collector rings for dynamo electric machines. (Date applied for, 22/9/05.)
21,050 VERITYS LIMITED & ROGERS. Brush Holders.
21,159 ALLGEMEINE ELEK.-GES. Regulation of single-phase dynamo electric machines of the commutator type. (Date applied for, 15/9/05.)†
21,638 KIELL. Regulating electrically heated incubators.

COMPANIES' MEETINGS AND REPORTS.

Eastern Telegraph Co. (Ltd.)

The seventieth ordinary general meeting of this Company was held on Tuesday, at Electra House, London, E.C., under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The ASSISTANT SECRETARY (Mr. H. St. L. Smith) read the notice calling the meeting and the auditors' report.

The CHAIRMAN then said: Gentlemen, on the occasion of our last general meeting authority was given to alter the date of the Company's financial year, and to give effect to this resolution accounts have been prepared for the three months to Dec. 31, 1906, which are now submitted for confirmation. Before moving the usual resolution for the adoption of the report and accounts, it has been customary in the past to enter with some detail into the relative items of receipts and expenditure, with the object of explaining any important variations therein, but, as the accounts now before us are for a broken period, it would be somewhat difficult, and possibly misleading, to attempt any such comparison with any previous accounts. I have the pleasure to state that in the aggregate our receipts show an improvement of about £9,000 compared with the corresponding quarter of 1905. At our last meeting I referred to the decrease in the message receipts on the correspondence exchanged with India, China and Japan, Egypt and South Africa. The receipts from traffic with China and Japan still show a falling off as compared with the corresponding period of 1905. This is owing to the general decrease of traffic coming after the inflation caused by the Russo-Japanese war, but there are signs that this last-named traffic is on the road to recovery. To a large extent our South African traffic has always depended on mining business, and I am afraid that, judging from the present state of that industry, it will be some time before we are likely to regain our former amount of traffic. I am in hopes, however, that in course of time the general commercial business of South Africa will gradually increase so as to make up what we have lost through the falling off in the Stock Exchange business of the mines. Our receipts from correspondence exchanged with India, South America and Egypt show substantial increases, but against this we have had, in respect of Egypt, to carry 25 per cent. more work for the same money, and the same remark, to a less extent, is true with respect to India.

With regard to the expenditure, it is, as I have stated, somewhat difficult to draw any comparisons, but I may mention that the accounts for the period under review contain no variations of an important character. Working expenses have increased during the quarter for the reasons stated at our last meeting—viz., in consequence of the augmentation of our staff abroad, rendered necessary by the larger volume of work to be handled consequent upon the important reductions which have from time to time been made in the tariff, and to the automatic increases in the salaries, but apart from the increase under the heading of salaries and wages, expenses have remained normal during the quarter. The laying of the new cable between Porthcurnow–Fayal and St. Vincent to which I have before referred, has occasioned an increase in our contributions towards the expenses of other companies' stations where our cables are joined up. As a set-off against these items of increased expenditure, the expenses in respect of the maintenance of our cables are a good deal below the average, the reason being that the amounts received for charter of our repairing steamers by other companies is larger than usual. The net result of working for the nine months to Dec. 31, 1906, is that we have an available balance of £284,752, and, after making suitable provision for our reserve funds, we are able to propose the payment of a final dividend of 1¼ per cent. and a bonus of 2 per cent., making, with the previous distributions, a total payment of 5¾ per cent. for the nine months. This is equivalent to our customary distribution at the rate of 7 per cent. per annum including dividend and bonus. I am pleased to be able to inform you that, as the result of protracted negotiations with the Portuguese Government, the concession which this company held, conveying the sole right for landing cables between Great Britain and Portugal and between Portugal and Gibraltar and Malta, has been extended for a further term of 15 years. I now move the adoption of the report and accounts, and the declaration of the dividend and bonus.

The VICE-CHAIRMAN and MANAGING DIRECTOR (Sir John Denison-Pender, K.C.M.G.) seconded the motion, which was carried unanimously.

A resolution was passed approving the payment to the auditors of an additional fee for the extra audit necessitated by the alteration in the period for the termination of the company's financial year, and a cordial vote of thanks to the chairman, directors and staff for their services terminated the proceedings.

Eastern Extension Australasia & China Telegraph Co. (Ltd.)

The sixty-seventh half-yearly general meeting was held on Wednesday, at Electra House, London, E.C., under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The GENERAL MANAGER and SECRETARY (Mr. F. E. Hesse) read the notice calling the meeting and the auditors' report.

The CHAIRMAN then said: Gentlemen, the gross revenue for the half-year under review amounted, in round numbers, to £296,000, against £317,000 for the corresponding period of 1905, showing a decrease of £21,000, which is mainly due to the abnormal traffic created by the Russo-Japanese war having ceased to exist. The traffics which were not affected by the war continue to show a steady improvement, and I am happy to say we are still holding our own in the keen com-

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petition that is being carried on between the Government Pacific Cable and our system for the Australasian traffic. The working and other expenses amounted, in round numbers, to £139,000, against £135,000 for the corresponding period of 1905, showing an increase of £4,000. This is accounted for by the supplemental allowances which it was found necessary to make to the staff to meet the rise in exchange in the value of the dollar in the Straits Settlements and China, and the exchange differences affecting expenditure due to the same cause (as shown in Abstracts B and C of the printed accounts). The items referred to are £4,223, £2,876 and £1,057, aggregating £8,156, and, in order to appreciate the detrimental effect which the recent substantial rise in exchange had upon the European staff serving in the Far East it is necessary to bear in mind that their salaries and allowances are fixed in sterling and converted into currency at a rate regulated by the rate of exchange of the day. Consequently, when the value of the dollar rose from 1s. 9d. in 1904 to 2s. 4d. at the beginning of last year, while the purchasing power of the dollar had by no means increased correspondingly with the rise in exchange, your Directors felt bound to give suitable relief under such unfavourable circumstances. But for this special expenditure, the working expenses would have shown a decrease of, roundly, £4,000, in consequence of the cost of repairs to cables having been exceptionally light during the past half-year.

The net profit for the half-year amounted to £138,385, and, after adding £88,958 brought forward from the previous half-year, there remained an available balance of £227,000. The usual quarterly interim dividends of 2s. 6d. per share were paid during the past year, and it is now proposed to distribute a final dividend for the year of like amount, making a total dividend of 5 per cent. In addition a bonus of 4s. per share will be paid, making a total distribution of 7 per cent. for 1906. The usual additions have been made during the past year to the maintenance ships, insurance, and depreciation funds, and, after adding £75,000 of the revenue balance to the general reserve fund, the sum of £17,344 is carried forward.

During the past year our two New Zealand cables, the Hong Kong–Foochow and Foochow–Shanghai cables, as well as the Saigon–Singapore cable, have been partially renewed. The lengths of new cable inserted in these lines aggregate 464 nautical miles, and the cost of the renewals, amounting to £44,160, has been debited to the general reserve fund. You will have learned from the printed report that, with a view to further improving telegraphic communication with the Far East, we have obtained a concession from the Dutch Government for the laying and working of a submarine cable been Java and the Cocos Islands. The length of cable involved is about 820 nautical miles, and is estimated to cost about £80,000. A portion of the cable will be supplied from our stock at Singapore, and the remainder will be manufactured and sent out from this side. The new communication is expected to be opened towards the end of the current year, and will provide a useful alternative route for our Far East traffic. I now move the adoption of the report and accounts, and the declaration of the dividend and bonus set out therein.

The MARQUESS OF TWEEDDALE seconded the motion, which was carried unanimously.

The retiring Directors (Sir John Wolfe Barry and Mr. Francis A. Bevan) were then re-elected, as were the retiring auditors, Messrs. Deloitte, Plender, Griffiths & Co., and Welton, Jones & Co.

Mr. J. NEWTON then proposed a vote of thanks to the Chairman, the Directors and the staff. He observed that the dividends paid by the Company seemed to be as secure as Consols, and they were paid almost as regularly to the day. The shareholders could not be too thankful that they had such an able administration of their affairs. He often attended the meetings and was surprised that no shareholders asked any questions—a fact which he regarded as positive evidence of the satisfaction prevailing among their entire body. He did not think that a dividend of 7 per cent., although satisfactory and paid very regularly, was too much in the case of submarine cable property. The Company had rendered the world greater services than it was possible to estimate in figures, and therefore a dividend of 7 per cent. ought not to be begrudged, and there ought not to be the outcry they sometimes read in the newspapers about cheaper submarine telegraph communication. What with codes, &c., telegraphic communication was, he said, as cheap now as letter writing used to be 70 or 80 years ago.

Mr. O'BEIRNE seconded the motion, which was carried unanimously.

The CHAIRMAN: On behalf of the Directors, the staff, and myself, I wish to give you my hearty thanks for the renewed vote of confidence which you have expressed in us. I assure you that no Board could, I think, give greater application to the interests of their shareholders than the Board of the Eastern Extension Company, and we hope that we shall continue to be as successful in the future as we have been in the past.

The proceedings then terminated.

Western Telegraph Co. (Ltd.)

The sixty-seventh ordinary general meeting was held at Electra House, Finsbury-pavement, on Wednesday, under the presidency of Sir JOHN WOLFE BARRY, K.C.B.

The SECRETARY (Mr. E. Steer Hodson) read the notice calling the meeting,

The CHAIRMAN: It is a source of gratification to the Board that we are again able to submit to the shareholders a very satisfactory report and statement of accounts, although a large proportion of the increased message revenue was due to a very exceptional and regrettable cause—namely, the lamentable earthquake which devasted the city of Valparaiso in August last year. This disaster was responsible for the interruption of a competing route and the diversion to our system of the whole of the traffic with that district, which was naturally of abnormal volume during the period immediately succeeding the catastrophe. Apart from this especial circumstance there was, however, considerable commercial activity in the several countries of South America which are served by the Company, and traffic with Brazil and the River Plate exhibits small but steady progress. The revenue for the period since January 1 last is only slightly below that for the corresponding period in 1906. Reverting to the accounts for the half-year under review, the general expenses in London, compared with the corresponding period in 1905, show an increase of £294, which calls for no special comment. Those at our stations were more by £5,642. This amount includes an increase in salaries and wages of £2,065, due to annual promotions, overtime, and additional staff engaged during the half-year. Maintenance of land lines, electrical expenses, &c., caused an increased expenditure of £941. Repairs to buildings cost £531 more, and furniture for additional staff quarters accounts for an extra expense of £1,048. There are several other items of augmented and a few of decreased expenditure. There is one special item of expenditure—namely, that of expenses in connection with negotiations. This represents this Company's proportion of the expenses and payments connected with the concessions recently granted for the new cables from England to the Azores and St. Vincent, Cape Verde Islands. We have considered it better to debit this amount against the revenue account for this half-year instead of spreading it over a period. Expenses attending maintenance of cables, amounting to £40,928, show on balance a decrease of £11,287. The expenses in connection with our cable steamer "Norseman" were more, in consequence of the cost of her survey and consequent repairs, being £1,713 more than in the December half-year of 1905. On the other hand, there was a decrease in the ordinary working expenses of this vessel, and in the result this ship has cost £993 more than in the corresponding half-year of 1905. The steamship "Norse" was laid up for the whole of the period under review; consequently the insurance of the hull and machinery, depreciation and consumption of stores, harbour wages, &c., were borne by the Company in place of the charterers by whom she was employed in 1905. This accounts for an increase of £911. As you know, we are anxious to dispose of this ship. The old "Cormorant" was only in commission for four months this half-year, and the expenses were less by £1,507. The new boat "Cormorant II." accounts for £3,460, which did not appear in the corresponding half-year's accounts. The expenses of the store ship "Norna" show a small increase of £87. Chartered steamers cost us less by £8,080, and 113 knots less cable was expended in repairs than in 1905, representing a saving of £12,229. Sundry expenses at stations, &c., in connection with repairs were more by £475, representing the cost of cable repairing outfits and gear supplied to various stations. Our stock of spare cable was larger in this than in the corresponding half-year, and the insurance and amount written off for depreciation was, therefore, more by £510. The amount received for the charter of the Company's cable steamers was less by £4,090, as the c.s. "Norse" was hired by the Eastern Telegraph Co. for 172 days in the latter half-year of 1905. The result of all these increases and diminutions is, as I have said, a saving of £11,287 under abstract C. After providing £16,000 for debenture stock interest and £3,415 for income tax, there remains a balance of £193,176, to which is added the sum of £2,663 brought forward from June 30 last, making a total of £195,839. First and second interim dividends, amounting to £62,379, have been paid, and after transferring £100,000 to the general reserve fund, £5,000 to the maintenance ships' reserve fund, £10,000 to the marine insurance fund and £10,000 to the land and buildings depreciation fund, there remains a balance of £8,460, which is carried forward to the next account. Although the sum of £100,000 has been transferred to the general reserve fund the proprietors will observe that the fund has been depleted during the half-year by no less than £74,315, being the balance of the cost of the new St. Vincent–Fayal cable, so that the net amount by which the fund has been increased was less than £26,000. Furthermore, our reserves, nominally amounting to somewhat over a million and a quarter, are not entirely represented by liquid assets. For example, the capital expended exceeds that issued by nearly £18,000, spare cable and stores in hand stand at nearly £60,000, and the investments at the present market price show a depreciation of something between £70,000 and £80,000. Part also of our reserves are of necessity employed as working capital. The shareholders have consistently endorsed the policy of the Directors in building up and maintaining substantial reserves, which we still consider absolutely imperative. In our extensive system there are at least 4,000 knots of submarine cable which have been submerged for over 30 years, and almost the whole of this is in very deep water. Another factor which is constantly before the Board, and the consideration of which I earnestly submit to the shareholders, is that our prosperous condition is apparently exciting envy, so that further competiton is threatened from several quarters. In these circumstances we feel sure of the continued support of the proprietors in fortifying our general reserve fund. I now move the adoption of the report and accounts.

The DEPUTY-CHAIRMAN (Sir John Denison-Pender, K.C.M.G.) seconded the motion.

Mr. GEORGE ENNIS said he felt that the Directors deserved the highest commendation for the report submitted on that occasion. The Chairman had pointed out that although the amount placed to the reserve fund, £100,000, was large, yet it must be considered depleted by the amount taken from it in connection with the St. Vincent–Fayal cable; but he presumed that that cable was a valuable asset and not a bad investment. He was sure that the shareholders would continue to support the Directors' policy of maintaining the reserve fund, although he hoped that when another half million had been added to it the shareholders might expect to receive an increase in the dividend.

The CHAIRMAN: I did not wish for a moment to suggest in what I said before that the expenditure upon the new St. Vincent–Fayal cable

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was not a good investment; on the contrary, I think it is a very fine investment indeed. The shareholders, however, will realise that unless we had had the reserve fund, we should have been obliged to raise fresh capital in order to provide that cable, which was necessary for our system. It was, therefore, perfectly legitimate to take the money required for it out of our reserve fund, which really exists for the very purpose. As to the distribution of a larger dividend, I am bound to say that I do not think that that is very probable in the immediate future. I have always said that in such an enterprise as a submarine cable it is most desirable to keep the dividend to a normal figure as far as possible, so long as we do not get too rich, and at present, and for some time to come, I do not think we shall be in that position.

The resolution was carried unanimously.

A cordial vote of thanks to the Chairman, the Directors and the Staff terminated the proceedings.

West Coast of America Telegraph Co. (Ltd.)

The tenth ordinary general meeting was held on Tuesday under the presidency of Sir JOHN DENISON-PENDER, K.C.M.G.

The SECRETARY (Mr. Fred. L. Robinson) having read the notice convening the meeting and the auditors' report,

The CHAIRMAN said: Gentlemen, you will notice from the report that the gross revenue for 1906 was £68,048, compared with £50,808 last year, showing an increase of £17,240. The expenses for 1906 were £34,173, compared with £31,114 in the previous year, thus also exhibiting an increase of £3,059. The chief items in the increase in the expenses are salaries £1,358, and you will understand that this is not an amount which we can really control to any very great extent, because, as men remain year after year with you, we are bound, of course, to do something for them. In this Company I am sorry to say that we have not been able to do very much, and when you consider that there is no pension fund to look forward to I think that you may regard the increase in the item of salaries as small. Rents show an advance of £329, travelling expenses are £404 more, and on maintenance of cables there is an increase of £483. The cables maintenance is, of course, always a variable item, depending entirely on the number of breaks in the year. The expenses connected with the maintenance of land lines were £203 more, and the earthquake at Valparaiso cost us £212. The only decrease in the expenses is in electrical instruments, and these were £125 less in 1906 than they were in the previous year. I am glad to say that the satisfactory revenue we have earned (and the various increases have not been large) has not been owing to any special cause, but is really attributable to good sound trade with the West Coast; and there is no reason to suppose that this will not be maintained, and even increased possibly. The disastrous earthquake at Valparaiso we are all aware of. It broke both our cables, and I think that our staff there and all those working for us are to be congratulated on the way they got things through again. One cable was repaired, I think, within about six days, and the other cable within a fortnight. I am thankful to say that none of our staff were injured by that awful catastrophe. This is the first time for many years that your Directors have been able to appear before you in a position to pay a dividend. You will remember that at the time this Company (it is a good many years ago now) was in a very prosperous state it was working in conjunction with another company, and those who were responsible for the management and the direction at that time did everything they could, I think, to maintain the position; but those who were acting as friends, and who might have been looked upon as such, were really, I think, only waiting until they saw a chance of turning round, depreciating the value of your property, and then trying to buy it up at their own price. However, just at that time the Western Company stepped in and assisted the West Coast of America Co. in the position the latter were then in, with the result that, slowly I am bound to admit, but surely, year by year, we have improved the position, and we are at last now enabled to again enter the list of dividend-paying companies. Some shareholders might say that a dividend of 2½ per cent. is not a very large one, but I ask you just for a moment to consider the position of the Company. You have cables which are 30 years old, your ship is about 30 years old too, and your Directors will have to accumulate a strong reserve fund. The policy of your Directors, however, is not to inflate the value of your shares by paying a big dividend because we made a considerable profit this year, but to increase the value of your capital by putting aside a strong reserve, without which I do not regard any cable company as being in anything like a secure position. I now move the adoption of the report and accounts.

Sir ALBERT J. LEPPOC CAPPEL, K.C.I.E., seconded the motion, which was carried unanimously.

The CHAIRMAN then moved approval of the dividend of 2½ per cent. (tax free) for the year 1906, which was seconded by Mr. F. WALTERS, and carried unanimously.

The retiring director and auditors having been re-elected, a cordial vote of thanks to the chairman terminated the proceedings.

West India & Panama Telegraph Co. (Ltd.)

The sixtieth ordinary general meeting was held on Wednesday, Mr. WALTER BISHOP KINGSFORD presiding.

The MANAGER and SECRETARY (Mr. R. T. Brown) read the notice calling the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, the total amount for the half-year to credit of revenue is £34,203. 9s. 7d., compared with £28,031. 13s. 9d. for the corresponding half-year, an increase of £6,171. 15s. 10d. It may be of interest, in passing, to mention that the half-year under review has yielded the largest receipts for any December half-year since the year 1893 (excluding, of course, the half-year of Dec., 1898, when we derived an abnormal receipt from the Spanish-American war traffic). The greater part of the above-mentioned increase of £6,171 arises from traffic the receipts from which, as mentioned in the report, showed a satisfactory increase of £5,460 over the results for the corresponding period. In analysing the figures, however, we find that approximately 70 per cent. of this increase was yielded by the foreign group of stations, the British section accounting for the remainder. We are thus once again indebted to the foreign stations for the greater part of an increased revenue derived from our message receipts. The expenses for the half-year are £21,612, against £23,231—showing a reduction of £1,619 on our expenditure for the corresponding period. Apart from a few minor savings in certain other items of expenditure, this reduction of £1,619 is attributable to our ship having been engaged on cable repairing work for only 78 days as compared with 159 days in the same period of 1905. Considering the very extensive area over which our cables operate, the earnings of the Company, as you know, have always been, and still are, very small. It is, therefore, encouraging to be able to report that the present balance of revenue of £12,951 is the best that we have had in any half-year ending either in June or December during the last eight years, even if we exclude from it the £1,000 transferred from income tax account. As to this item, gentlemen, I ought just to explain that we recently succeeded in making more satisfactory arrangements with the Income Tax Commissioners as to the basis of the Company's assessment for income tax, which has enabled us to release that amount. To sum up the figures, our receipts are £34,203. 9s. 7d., and our expenses £21,611. 19s. 7d., leaving a balance of £12,591. 10s.; to which is added £1,547. 10s. 6d. interest on investments, and £312. 16s. 8d. brought forward from last half-year, making a total to be dealt with of £14,451. 17s. 2d. The Directors accordingly recommend the payment of 8s. per share on the first preference shares, being 2s. balance of arrears and 6s. dividend in full for the six months to Dec. 31, 1906, together amounting to £13,825. 4s., carrying forward a balance of £626. 13s. 2d. The Board have much satisfaction in thus being able to recommend a dividend which finally clears the first preference shares of the arrears of dividend which began to accrue 6½ years ago. I now move the adoption of the report and accounts, and the declaration of the dividend set out therein.

Mr. HENRY HOLMES seconded the motion, which was unanimously adopted.

The Directors were authorised by resolution to expend a sum of £346 in reimbursing the Kingston staff of the Company for their losses caused in the recent earthquake. The Chairman explained that the earthquake which destroyed Kingston, the capital of Jamaica, had done some damage to the Company's premises there, but, fortunately, no loss of life occurred amongst the Company's staff. Some injury had, however, been caused to several members of the staff, one old servant of the Company—a messenger—having been badly injured. Several miles of landlines connecting up the Company's cables had been destroyed. He was glad to be able to state that Mr. MacLeod, their clerk-in-charge at Kingston, had, at great personal risk, succeeded in digging one instrument out of the ruins, and with it had established a temporary office a few miles from Kingston. In this way telegraphic communication with the outside world had been promptly opened, and this means of communication was the only one available for several weeks, and enabled full tidings of the terrible disaster to be published. The staff had partially lost their homes and effects, and the amount of £346 was the estimated loss. The Chairman read a letter from Mr. Hamar Greenwood, M.P., who happened to be in Kingston at the time of the earthquake, eulogizing Mr. Macleod's services, as well as those of the Company's staff generally.

The retiring director, Mr. Henry Holmes, was then re-elected, and in returning thanks for his re-election said that he was bordering upon 90 years of age, and had been a Director of the Company for 34 years. He felt as capable as ever of doing his duty to the shareholders. He referred to the volcanic nature of the bottom of the sea where the Company's cables were laid, and said that at both ends of their system they met with serious difficulties, which for many years they had overcome, and which he hoped they would still overcome and go on and prosper.

The retiring auditors having been reappointed, and a hearty vote of thanks to the Chairman, Directors and staff of the Company having been adopted unanimously, the proceedings terminated.

West African Telegraph Co. (Ltd.)

The twenty-second ordinary general meeting was held yesterday, the Marquess of TWEEDDALE, K.T., presiding.

The SECRETARY (Mr. John Cambrook) read the notice convening the meeting, and the auditors' report.

The CHAIRMAN said: The gross income for the year under review amounted to £66,158, as against, for 1905, £65,846, showing a small increase of £312. This Company's proportion of the receipts from the South African Joint Purse shows a reduction of about £1,500 when compared with the preceding year. There is also a slight diminution, as compared with 1905, in the sum received on account of the diversion of traffic over our lines, owing to the interruption of the cables of other telegraph companies. On the other hand, the Portuguese traffic shows a small increase, and the amount received for interest on reserve fund investments is nearly £1,000 more than in the previous year. Further, in consequence of the continued improvement in the value of the Portuguese currency, there has been a profit on exchange of £965 as compared with a loss in 1905 of £1,308, the revenue account thus benefiting, by this item alone, to the extent of £2,273. The ordinary expenses amounted to £15,500, against, for the previous year, £15,700, or a decrease of £200. The expenditure in connection with the

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maintenance of our cables shows a very satisfactory reduction of £4,000 as compared with 1905, the result being that our total expenses for 1906 are £4,200 less than they were in the previous year. I am glad to state that we have now come to a satisfactory arrragement with the income tax authorities regarding the vexed question of the amount of depreciation on our cables to be allowed when assessing the Company for income tax. Under it we have obtained a refund of £738. 17s. 7d., and as this was in respect of back years the amount has been placed to the credit of the general reserve fund. A proportionate saving also appears under the heading of income tax in the accounts for the year now before you. I take this opportunity of mentioning that, owing to its defective condition, it is proposed to renew, in the autumn, a not inconsiderable portion of our Sao Thome-Loanda section. This renewal will involve a large expenditure, and shows the necessity for the policy which your Directors have always followed of strengthening the Company by placing substantial sums to the reserve fund. After putting aside the sum of £30,000 to the reserve fund, and allowing for the interim dividend of 2 per cent. paid in December last, your Directors are able to recommend the payment of a final dividend of 2 per cent., making 4 per cent. for the year, leaving £2,155 to be carried forward.

I now move the adoption of the report and accounts.

Sir JOHN DENISON-PENDER, K.C.M.G. seconded the motion, which was carried unanimously.

The retiring Director and the retiring auditors having been re-elected, a vote of thanks to the Chairman and Directors terminated the proceedings.

Submarine Cables Trust.

The thirty-sixth ordinary annual meeting was held on Tuesday, under the presidency of the MARQUIS OF TWEEDDALE.

The SECRETARY (Mr. Sidney Collett) having read the notice convening the meeting,

The CHAIRMAN said: The revenue for the year—which, in addition to dividends received on the stocks and shares we hold, includes also interest on deposits—amounted to £25,278, or £220 more than last year. This increase is small, but as our total receipts represent a net return of over 8 per cent. on our investments, there is little scope for any great improvement in that direction. Such as it is, it is due in a measure to larger dividends being received from our investment in the Mackay Companies. Last year those companies paid 2 per cent. on their common shares, while this year they have paid 4 per cent.—that is, at the same rate as they are paying on the preferred. I should like, however, to say with regard to the increase of £220 in our receipts, that this is not exactly what it would have been under normal circumstances. The difference is easily explained. The Eastern Telegraph Co. decided some little time ago to alter the date of their financial year, under which arrangement the date of the payment of their dividend, which usually came within our financial year, was, in consequence deferred; and as we had already absorbed the estimated surplus funds of the Trust by the acquisition of a number of certificates, it became necessary for us to make up the amount of the Eastern Telegraph Co.'s dividend in these accounts, by including a dividend on the Anglo-American Telegraph Co.'s shares, which, though not actually paid within our financial year, was declared before the year closed. This dividend, which we included, was slightly larger than the Eastern Company's dividend which was excluded—the Eastern dividend being £1,351, while the Anglo dividend was £1,414. With this explanation you will understand why our accounts only include three-quarters' dividend on the Eastern Company, and five quarters on the Anglo Company. This increase of £220, together with the fact that we carried forward a somewhat larger amount than we did in the previous year, and also that the 6 per cent. interest we have paid to our certificate holders was less this year by about £350 owing to the number of certificates we acquired and cancelled last year, has enabled us to buy forty-three certificates, as against forty-one in the previous year. So that we have now acquired and cancelled 1,117 certificates out of the original 4,200, leaving 3,083 certificates outstanding, and we carry forward a sum of £454 to next account. I believe, gentlemen, this will be considered a satisfactory condition of things, and you may be interested to know that the market value of the securities held by the trust shows an appreciation over cost of nearly £182,000. I now move the adoption of the report and accounts.

Sir JOHN DENISON-PENDER, K.C.M.G., seconded the motion, which was carried unanimously.

The retiring auditors were then re-appointed and a vote of thanks to the Chairman brought the proceedings to a close.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—The gross profit for 1906 was £73,710. 13s. 7d. General charges, maintenance, debenture stock interest and £6,500 carried to depreciation reserve absorb £49,526. 7s. 2d., leaving net profit £24,184. 6s. 5d. General reserve has been reduced by £6,890. 11s. 5d., being losses accumulated since Oct. 31, 1904, in connection with the Australasian branch, and part of the expenses of closing that branch. The business has now been placed on a different footing by the appointment of agents. The fund has also been debited with £13,593. 2s. 11d. for preliminary expenses, experiments and excess cost of work carried out during the year on new lines of manufacture (principally main line rolling stock and commercial motor vehicles) entered upon in consequence of a diminution in the demand for tramway rolling stock. In view of the depreciation in the value of the company's investments the directors recommend that out of the profits of the year £21,483. 14s. 4d. be appropriated to general reserve, leaving £2,700. 12s. 1d. to be carried forward. £22,822. 19s. 2d. has been expended on additions to plant and buildings during the year. The directors report that while the works have been fully occupied during the year on important contracts, the amount of net profit has been seriously affected by the continued strenuous competition, by the strike of workmen in the car-building shops, and by the onerous terms upon which money has had to be borrowed to provide additional capital required for the increasing business which the company now commands. A lease of the works and business of the British Automobile Development Co. has been acquired.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The chairman (Col. A. J. Filgate) stated at the meeting last week that the advance in the proportion of working expenses to gross earnings from 40·4 per cent. in 1905 to 43·7 per cent. was due to heavier outlays on renewals and to the fact that two of the new stations had not come into full working. Difficulty had arisen in connection with the maintenance of the underground feeders, and it had been decided to re-lay the faulty feeders in iron troughing and that work was progressing.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—The directors' report for 1906 states that the balance profit on the year's working (after providing for income tax) was £80,773, added to £38,921 brought forward. Deducting interest and preference dividend, appropriation for depreciation (£12,866) and on office furniture (£356), the available balance was £82,972. The directors propose a dividend on the ordinary shares at the rate of 10 per cent. (tax free) or 10s. per share, whereof 5s. was paid on Nov. 1, and 5s. will be paid on 31st inst., a bonus of 5s. per share to be paid also on 31st inst. The carry forward is £56,722. The results must be considered satisfactory, as showing an advance on the excellent figures of 1905. In the early part of the year there was a large demand for cables and other materials manufactured by the company; but during its concluding months sales were restricted, owing to the unusually high prices of metals, and especially of copper. As a result, few important contracts for new mains have been entered into during the past six months, and a waiting policy has been adopted by many of the company's customers. The possibility of legislation affecting electrical supply has also had its effect in postponing new undertakings. The company's business in this country has, therefore, for the present, being chiefly confined to extensions of existing networks. On the other hand, the foreign connection has been enlarged and increased. Further contracts of considerable magnitude have been carried out in various parts of India, in Hong Kong, Shanghai and other places in the Far East. Important contracts have been secured in South America and Mexico, the company's engineers having carried out the laying of cables in Brazil and in the Argentine. The business on the Continent has been vigorously pushed, and orders have been secured (amongst other places) for the tramways of St. Petersburg and the lighting of Christiania. The company has recently turned its attention to Canada, and arrangements have been made there which have already resulted in satisfactory orders, with every prospect of excellent business being secured in the future. The difficulties which have attended the operations of some of the companies supplying electricity in bulk have caused disappointment to the directors, and have naturally affected this branch of the business. The directors are, however, of opinion that power supply over wide areas will, at no distant date, again require large quantities of underground mains. The securities which the company holds in several of the power undertakings have already been much written down, but before arriving at the profits for last year a further large sum has been written off to meet possible losses in South Wales and elsewhere, and to provide against further depreciation. The directors consider that they have made ample provision in this respect. The reorganisation of the Anchor Co.'s factory at Leigh and its business generally is now completed. The amount at which the company's interest stands has been amply written down. The working of the Anchor Co. is satisfactory, and is at a profit, its trade in rubber wires having been considerably extended. The machinery, plant and equipment at the factory at Erith and on outside contracts have been maintained in a thoroughly efficient condition, and the cost thereof has been charged against the year's profits. Circumstances arose which rendered it possible for the directors to acquire a share in the business of the St. Helens Cable & Rubber Co., thereby putting an end to troublesome competition and assisting the company in other directions. The participation in the St. Helens business has already proved of considerable benefit to the company.

CHISWICK ELECTRICITY SUPPLY CORPN. (LTD.)—The report for 1906 states that during the year £6,112 was expended on machinery, mains, "free" wiring, &c. The total number of lamps, motors, &c., fed from the corporation's mains at Chiswick and Aberystwyth is equivalent to 60,351 8 c.p. The number of consumers was 1,378, and extensions are now in progress both at Chiswick and Aberystwyth to meet the increasing demand for current. The maximum power sent through the mains in 1906 was: Chiswick, 874 B.H.P. on Dec. 31; Aberystwyth, 280 B.H.P. on Aug. 18. The profit for the year was £6,126. The directors propose to pay a dividend on the ordinary shares of 6 per cent. for the year.

SMITHFIELD MARKETS ELECTRIC SUPPLY CO. (LTD.)—At the adjourned meeting on Friday Mr. H. Leon explained that the meeting held on Feb. 15 last was adjourned to enable the board to discuss with two of the shareholders the question of the payment of a cash dividend. They had consulted another counsel (Mr. Palmer), and his opinion, even more strongly expressed than that of the former counsel (Mr. Cane), was that, under the circumstances, they would not be justified in paying a cash dividend. The directors' report was then adopted.

SOUTH STAFFORDSHIRE TRAMWAYS (LESSEE) CO. (LTD.)—The total revenue for 1906 was £43,741. 10s. 1d., against £39,208. 16s. 2d. in 1905, and the expenditure was £41,209. 4s. 8d., compared with £41,433. 16s. 1d. From the profit of £2,532. 5s. 5d. has to be deducted the loss incurred in 1905 (£920. 12s. 9d.), leaving £1,611. 12s. 8d. Expenditure on capital account during the year amounted to £33,900. 9s. 11d. 8,625,745 passengers were carried, against 7,782,261 in 1905.

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URBAN ELECTRIC SUPPLY CO. (LTD.)—At the meeting last week Mr. F. E. Gripper stated that notwithstanding severe competition they had been able to make considerable progress. They had connected the equivalent of 54,000 additional 8 c.p. lamps, and the profits had increased from £28,000 to £33,000, an increase of 18 per cent. The increase in capital expenditure had been only a little over 4 per cent. During the year about £15,000 had been spent on additional generating plant and about £25,000 on mains and connections. The net profit was £31,439. After deducting debenture interest (£9,000) the balance was £22,439. The amount required for the 5 per cent. guaranteed dividend on the preference and ordinary shares was £32,500, leaving £10,060, which had been paid by Edmundson's Electricity Corpn., under the terms of their contract. An issue of £75,000 debenture stock had just been made to pay off the amount due to their contractors.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

ANGLO-SOUTH AMERICAN PUBLIC WORKS CO. (LTD.) (93,296.)—Reg. May 9, capital £10,010 in 10,000 ordinary shares of £1 each and 200 founders' shares of 1s. each, to acquire the connection in South America of Kirby, Son & Brown and G. J. H. Hooghwinkel, to acquire contracts, concessions, rights and privileges relating to the construction, equipment and management of railways, tramways, docks, harbours, &c. First directors, W. G. Brown and G. J. H. Hooghwinkel.

JOHN STIRK & SONS (LTD.)—Reg. May 4, capital £20,000 in £1 shares, to acquire works, premises and business carried on by John Stirk & Sons and the Northern Engineering Co. (1900), Ltd., and to carry on the business of mechanical and electrical engineers, tool makers, manufacturers of dynamos, motors, motor carriages, &c. First directors, G. Stirk, E. Stirk, R. Stirk and J. G. Stirk. Reg. office, 7, Turney-street, Halifax.

STATUTORY RETURNS.

BRITISH COLUMBIA ELECTRIC RAILWAY CO. (LTD.)—In return to Nov. 20 capital is £1,500,000 in £300,000 5 per cent. cumulative perpetual preference stock, £309,000 preferred ordinary stock, £400,000 deferred ordinary stock and 500,000 shares of £1 each, of which £300,000 5 per cent. cumulative perpetual preference stock, £300,000 preferred ordinary stock and £400,000 deferred ordinary stock has been taken up. £200,000 deferred ordinary stock is considered as paid, and £837,088. 13s. 2d. has been paid on the remainder. Mortgages and charges at date of return, £458,000. Trust deed to secure perpetual consolidated debentures not exceeding amount of paid-up capital created Feb. 14, subsequent reg.

BRITISH POWER CO. (LTD.)—Return to Dec. 31 gives capital as £250,000 in £10 shares, of which 6,265 have been taken up. £62,650 has been received. Mortgages and charges, £35,900.

H. J. CASH & CO. (LTD.)—According to return to March 5 capital is £10,000 in £1 shares, of which 6,000 have been taken up. 12s. 6d. per share has been called up, and £3,750 has been received. Mortgages and charges nil.

CHISWICK ELECTRICITY SUPPLY CORPN. (LTD.)—Return to April 13 (filed April 9) gives capital as £100,000 in 99,900 ordinary and 100 founders' shares of £1 each, of which 60,900 have been taken up and paid for in full. Mortgages and charges, £50,000.

COUNTY OF DURHAM ELECTRICAL POWER DISTRIBUTION CO. (LTD.)—Return to March 28 gives capital as £500,000 in 50,000 preference and 50,000 ordinary shares of £5 each, all of which have been taken up. £5 per share has been called up and £473,958 has been received, leaving £26,042 (being balance of final call due April 22) unpaid. Mortgages and charges, nil.

CYCLE ELECTRIC LAMP CO. (LTD.)—The capital in return to May 1, 1906 (filed April 12, 1907), is £30,000 in £10 shares, all of which have been taken up. £10 per share has been called up on 275 and £2,350 has been received, leaving £400 in arrears. £27,250 is considered as paid on 2,725 shares. Mortgages and charges, nil.

DYNAMOTOR LIMITED.—The capital in return to March 1 is £6,000 in £1 shares, of which 5,530 have been taken up. £1 per share has been called up on 530 and £524 has been received. 5,000 shares are considered as fully paid. Mortgages and charges, nil.

MELTON MOWBRAY ELECTRIC LIGHT CO. (LTD.)—In return to March 27 capital is £25,000 in £5 shares, of which 4,000 have been taken up and paid for in full. Mortgages and charges, £20,000.

MINERS' LAMP ELECTRIC LIGHTING CO. (LTD.)—In return to Aug. 20, 1906 (filed Feb. 26, 1907), capital is £3,000 in £5 shares, of which 300 have been taken up. £5 per share has been called up on 110, and £550 has been received. £950 is considered as paid on 190. Mortgages and charges, nil.

NORTHALLERTON ELECTRIC LIGHT & POWER (LTD.)—According to return to March 13 capital is £6,500 in 2,900 preference shares of £1 each and 12,000 ordinary shares of 6s. each, of which 1,151 preference and 4,561 ordinary have been taken up. £2,519. 6s. has been received. Mortgages and charges, £5,140.

NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)—Return to March 14 gives capital as £100,000 in £1 shares, of which 36,614 ordinary and 25,040 preference have been taken up. £61,654 has been received. Mortgages and charges, £47,800.

SANITAS ELECTRICAL CO. (LTD.)—The capital in return to Feb. 1 is £5,000 in £1 shares, of which 4,250 have been taken up. £2,250 has been received, leaving £2,000 in arrears. Mortgages and charges nil.

SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)—In return to March 13 capital is £300,000 in 150,000 ordinary and 150,000 preference shares of £1 each, of which 120,000 ordinary and 117,968 preference have been taken up. £1 per share has been called up on 117,500 ordinary and 112,600 preference, and £230,100 has been received. £7,868 is considered as paid on 2,500 ordinary and 5,368 preference. Mortgages and charges, £237,968.

TYNESIDE ELECTRICAL DEVELOPMENT CO. (LTD.)—In return to Feb. 27 capital is £100,000 in 100 shares of £1,000 each, all of which have been taken up. £100 per share has been called up and £10,000 has been received. Mortgages and charges nil.

YORKSHIRE (WEST RIDING) ELECTRIC RAILWAYS CO. (LTD.)—Return to March 8 gives capital as £600,000 in 70,000 preference and 50,000 ordinary shares of £5 each, of which 46,261 preference and 40,000 ordinary have been taken up. £431,305 is considered as paid. Mortgages and charges, £275,000 4½ per cent. debenture stock.

MORTGAGES AND CHARGES.

CRYSELCO (LTD.)—Issue on May 1 of £300 4½ per cent. debentures, part of series created June 26, 1905, to secure £10,000, charged on company's undertaking and property, present and future, including uncalled capital and the Kempton Works, Kempton, Beds. Trustees, A. Baker and H. S. Deacon. Previously issued of same series, £8,200.

CITY NOTES.

MEMORANDA (May 16).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 30 5/16d. per oz. Consols 84 13/16—84 15/16 for money, 84 13/16—85 1/16 for account; 2½ per cent. annuities 83¼—83¾. Consols Pay Day, June 3; Stocks and Shares Continuation Days, May 28 and June 11, Ticket Days, May 29 and June 12; Pay Days, May 30 and June 13; Mining Share Carry-over Day, May 27.

CASTNER-KELLNER ALKALI CO. (LTD.)—The directors have declared an interim dividend for the six months ended March 31 at the rate of 8 per cent.

CENTRAL & SOUTH AMERICAN TELEGRAPH CO.—The Central News Agency announces that it has been decided to increase the capital of this company from $8,000,000 to $12,000,000. $2,000,000 is to be distributed among the shareholders in the form of a dividend.

CENTRAL ELECTRIC SUPPLY CO. (LTD.)—The 4 per cent. guaranteed debenture stock transfer books will be closed from 18th to 31st inst., inclusive, preparatory to payment of interest due June 1.

COMPANIES STRUCK OFF THE REGISTER.—The following were removed from the Register of Joint Stock Companies on May 7: Anti-Vibrator, Electric Battery Case and Fittings Synd., Electric Dänite Synd., Electric Lamp Renovating Co., Electric Vehicle Co. of Great Britain, Freshwater and Totland (I.W.) Electricity Supply Co., Northern Engineering Co., Torquay Electro-therapeutic Institute, Tramway Traction Co. of South America.

The following will be struck off the register unless cause is shown to the contrary before Aug. 10: Albert Electric Lighting Co., Birmingham Art Metal Co., British Electric Installation Contractors, Carboid Oilless Bearing Co., City of Bath Electric Lighting and Engineering Co., Collier Audible Telephone Synd., Epstein Electric Accumulator Co., Fowler Insulator Synd., Home Telephone Co., International Electric Synd., Lithanode & General Electric Co., Lodge Electric Lighting & Power Co., New British Electric and Installation Contractors.

GENERAL ELECTRIC CO. (U.S.A.)—The directors have decided to offer to stockholders $13,000,000 5 per cent. 10 year debenture bonds, which will be convertible after June 1, 1911.

JAMES HINKS & SON (LTD.)—The directors propose to pay a final dividend for the past half-year at the rate of 12½ per cent., tax free (making 10 per cent. for the year).

KALGOORLIE ELECTRIC POWER & LIGHTING CORP. (LTD.)—The directors have declared a dividend on the preference shares at the rate of 6 per cent. for the three months ending March 31.

REUTER'S TELEGRAM CO. (LTD.)—The balance for distribution for the year ended Dec. 31 amounts to £4,844. 1s. 7d., including £81. 9s. 10d. from last account. An interim dividend of 2½ per cent. was paid in October, and the directors now declare a dividend of 4s. per share, equal to 2½ per cent., making a total distribution (tax free) of 5 per cent. for the year, leaving £108. 9s. 7d. to be carried forward.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The amount of electricity sold for the quarter ended Lady Day is returned at 2,687,005 units, estimated to produce £36,886. 8s. 2d., against 2,377,044 units which produced £34,519. 11s. 11d. for the corresponding period of last year.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed May 23 a special settling day in 625,000 £1 fully and partly (10s.) paid shares of the *Victoria Falls Power Co. (Ltd.)*, and have granted quotations to a further issue of £83,000 4½ per cent. first mortgage debenture stock of *Edmundson's Electricity Corpn. (Ltd.)*, and a further issue of 2,000 £5 fully-paid ordinary shares of the *Hove Electric Lighting Co. (Ltd.)* The committee have been asked to grant quotations to 413,804 common and 500,000 preferred $100 shares of the *Mackay Companies*.

WILLANS & ROBINSON (LIMITED AND REDUCED.)—A petition for confirming the resolution reducing the capital of this company from £750,000 to £483,336 will be heard by Mr. Justice Joyce on June 4. Creditors and shareholders may obtain copies of the petition from Messrs. Farrar, Porter & Co., 2, Wardrobe-place, Doctor's Common, London, E.C.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 8	1,385	− 41	49	67,365	+ 1,715
Airdrie	,, 3	218	+ 1	17	3,803	− 6
Anglo-Argentine	,, 13	17,447	+ 1,312	19	313,072	+ 26,685
Ashton-under-Lyne Corp	,, 11	391	+ 52	7	2,713	+ 392
Ayr Corporation	,, 11	222	− 9	52	14,548	− 55
Baker St. & Waterloo Ry.	,, 11	2,390	+ 1,049	9	20,975	+ 7,745
Barnsley	,, 3	153	+ 7	17	2,732	− 63
Barrow	,, 3	232	+ 11	17	3,809	− 2
Bath Electric Trams, Ltd.	,, 8	790	+ 40	19	12,993	− 21
Birkenhead Corporation	...	...	...	...	...	...
Birmingham Corporation	,, 11	6,190	...	6	34,175	...
Birmingham & Mid.	April 26	707	...	16	12,268	...
Blackburn Corporation	May 8	1,062	+ 127	§6	7,187	+ 638
Blackpool Corporation	,, 9	812	+ 9	5	3,678	− 817
Blackpool and Fleetwood	,, 11	305	+ 9	6	2,582	− 143
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 12	2 245	+ 150	6	12,813	− 167
Bournemouth Corporation	,, 8	1,654	+ 141	¶5	9 235	+ 7
Bradford Corporation	,, 11	4,669	+ 241	6	27,158	+ 379
Brighton Corporation	,, 12	911	− 9	6	5,074	− 466
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 10	4,943	+ 8	13	61,409	− 233
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 11	1,257	+ 114	6	5,847	− 151
Burton Corporation	,, 12	283	− 4	6	1,645	− 169
Bury Corporation	,, 5	988	...	5	4,794	...
Calcutta Tramways Co.	,, 13	R15,174	+ R3,221	18	R255,189	+ R7,775
Camborne-Redruth	,, 11	103	− 3	19	2,067	+ 54
Cardiff Corporation	,, 11	1,972	+ 49	6	11,910	+ 24
Cavehill	,, 3	59	+ 9	17	1,205	+ 31
Central London Railway	,, 11	5,924	− 579	19	117,464	− 11,860
Chatham & Dist. Lt. Rys.	,, 9	700	+ 36	¶18	12,099	+ 864
City & South London Rly.	,, 12	2,691	+ 185	19	50,841	+ 1,042
City of Birmingham	,, 3	2,702	...	17	46,283	...
Colchester Corporation	,, 8	195	...	...	...	...
Cork Electric Trams Co.	,, 9	419	− 6	19	7,822	− 148
Croydon Corporation	,, 10	1,428	+ 3	16	7,985	− 531
Devonport & Dist. Trams.	,, 3	435	+ 18	17	7,546	+ 126
Dover Corporation	,, 11	229	− 3	6	1,274	− 117
Dublin & Lucan Railway	,, 10	147	+ 1	19	1,843	− 15
Dublin United	,, 10	6,000	+ 794	†19	90,461	+ 3,637
Dudley Stourbridge	,, 3	768	+ 30	17	13,693	− 129
Dundee Corporation	,, 8	1,104	+ 101	53	55,790	+ 7,354
East Ham Council	,, 11	943	+ 63	6	5,286	− 161
Exeter Corporation	,, 10	296	+ 38	16	1,780	+ 155
Falkirk and District	,, 8	200	...	6	1,759	...
Gateshead & Dist. Trams.	,, 3	982	+ 86	17	16,837	+ 573
Glasgow Corporation	,, 11	18,402	+ 1,712	49	836,510	+ 67,649
Glossop	,, 11	150	+ 4	19	2,514	+ 67
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	,, 3	219	+ 9	17	3,801	+ 113
Great Northern & City Rly.	,, 11	1,760	+ 70	19	34,895	+ 123
Gt. Northern, Piccadilly, &c.	,, 11	4,050	...	19	72,639	...
Greenock & Port Glasgow	,, 3	667	+ 70	17	10,629	+ 133
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 3	258	+ 3	17	4,365	− 249
Hastings Elec. Trams Co.	,, 9	510	+ 226	19	15,236	...
Hong Kong	...	...	...	...	...	...
Huddersfield	,, 11	1,585	+ 106	6	9,335	+ 527
Hull Corporation	,, 11	2,403	+ 258	6	13,813	+ 594
Ilford District Council	,, 11	500	+ 37	6	2,884	− 117
Ilkeston District Council	,, 8	137	+ 14	6	816	+ 103
Ipswich Corporation	,, 11	391	+ 6	6	2,203	− 132
Isle of Thanet Co.	,, 11	428	+ 26	32	9,417	+ 168
Jarrow	,, 3	120	...	17	1,910	...
Keighley Corporation	,, 9	166	+ 18	45	6,768	+ 553
Kidderminster & District	,, 3	93	+ 2	17	1,653	− 71
Kilmarnock Corporation	,, 11	152	− 35	52	8,136	+ 113
Kirkaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 9	1,203	+ 356	19	19,831	+ 4,001
Lancashire United	,, 8	1,238	+ 423	§19	21,189	+ 5,858
Leamington	,, 3	129	− 6	17	2,390	− 122
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	,, 11	2,398	+ 145	19	39,985	+ 355
Leith Corporation	,, 11	527	+ 27	†52	26,186	+ 6,369
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 12	1,475	+ 18	19	26,723	+ 178
Liverpool Corporation	,, 4	10,801	+ 538	18	187,009	+ 2,821
*London County Council	,, 4	29,745	+ 4,669	5	141,741	+ 13,311
London United	,, 10	6,547	+ 656	†19	103,518	+ 3,299
Lowestoft	,, 11	186	+ 34	32	4,880	+ 644
Maidstone Corporation	,, 11	113	+ 4	6	634	− 6
Manchester Corporation	,, 11	14,629	+ 1,529	6	82,675	+ 7,321
Mersey Railway	,, 11	1,856	+ 113	19	34,803	+ 1,530
Merthyr	,, 3	197	+ 10	17	3,466	+ 201
Metropolitan Dist. Railway	,, 12	7,678	− 376	19	148,671	− 2,918
Metropolitan Elec. Trams.	,, 3	4,170	+ 1,141	17	69 119	+ 15,773
Middleton	,, 3	307	+ 33	17	5,192	+ 92
Nelson Corporation	...	...	...	...	...	...
Newcastle-on-Tyne Corp.	,, 11	4,120	+ 272	6	24,099	+ 442
Newport (Mon.)	,, 11	653	+ 58	6	3,850	+ 198
Northampton Corporation	,, 10	450	+ 15	16	2,115	− 48
Oldham, Ashton & Hyde	,, 3	570	+ 62	17	10,024	+ 673
Oldham Corporation	,, 12	1,960	+ 147	7	13,610	+ 1,351
Perth (N.B.) Corporation	,, 8	140	+ 3	51	7,338	...
Perth (W.A.) Elec. Trams.	,, 10	1,359	− 191	19	28,228	− 660
Peterborough	,, 3	108	+ 7	17	1,896	+ 17
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 12	1,866	+ 103	6	10,993	− 122
Potteries	,, 3	1,874	+ 113	17	31,465	+ 369
Preston Corporation	,, 8	728	+ 39	6	4,371	+ 200
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 9	577	+ 116	†6	3,211	+ 457
Rothesay	,, 3	85	− 30	17	1,468	+ 10
Salford Corporation	,, 13	4,582	+ 175	6	27,631	+ 323
Sheerness	,, 1	54	+ 4	17	860	− 17
Sheffield Corporation	,, 12	5,699	+ 457	7	37,933	+ 2,076
Singapore Trams.	,, 11	$9,615	+ $811	6	$59,942	+ $10,650

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	May 8	933	+ 48	...	...	...
Southend Corporation	,, 8	395	...	6	1,742	− 139
South Metropolitan	,, 3	657	...	17	12,021	...
Southport Tramways	,, 3	237	− 35	17	4,098	− 402
South Staffs	,, 3	846	+ 98	17	15,017	+ 1,128
Stalyb'dge, Hyde, &c., Jt. Bd	,, 11	811	+ 45	6	4,607	+ 173
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	...	...	...	...	...	...
Sunderland and District	,, 8	432	+ 95	19	7,760	+ 1,007
Swansea Trams	,, 3	807	+ 48	17	13,822	+ 377
Swindon Corporation	,, 8	158	− 15	6	1,009	− 130
Taunton	,, 3	43	...	17	689	− 50
Tynemouth and District	,, 3	169	− 14	17	2,891	− 343
Tyneside Trams Co.	,, 8	423	+ 50	19	7,620	+ 660
Victoria, Elec. Supply Co. of	April 7	1,532	+ 784	2	2,602	+ 1,003
Wallasey District Council	May 11	778	+ 49	6	4,652	+ 116
Walsall Corporation	,, 11	495	− 6	19	8,840	− 451
Warrington Corporation	,, 9	379	+ 20	6	2,263	+ 101
West Ham Corporation	,, 9	2,298	+ 130	6	14,133	+ 660
Weston-super-Mare	,, 1	60	− 14	17	774	− 42
Wolverhampton Co.	,, 3	416	+ 37	17	7,175	+ 122
Wolverhampton Corpn.	,, 8	840	+ 28	17	14,199	...
*Worcester	,, 3	258	+ 5	17	4,239	− 96
Wrexham	,, 3	94	− 2	17	1,652	− 26
Yorkshire W.R. Trams	,, 12	1,288	+ 447	19	20,539	...
Yorkshire Woollen District	,, 3	935	+ 118	17	15,881	+ 1,059

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shares	Last Dividend	Name.	Price Wed., May 15.	Rate % Yielded.	Dividend Due.	Business Week to May 15. Highest.	Business Week to May 15. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	7⅜—7⅝	5 2 0	Ap, Oct	7¼	7⅛
£	2/9	Do. 5½ per Cent. Cum Pref.	6¼—6	4 12 0	..	6⅝	6½
St.	6/	Do. Permanent 6% Deb. Stock	135 —136	4 8 3	..	..	..
St.	5/	Auckland Elec. Trams. 5% Deb. (red.)	101 —107	4 13 6	..	105	..
£	..	Brisbane Electric Trams. Invest. Ord.	2¾—3	3 15 0	..	2⅞	2⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅛—5¼	4 18 9	..	5	..
St	4½%	Do. 4½ per Cent. Db. Prov. Certs.	93 —102	4 8 0	..	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	1 3 —127	4 14 3	..	..	..
St.	5%	Do. Pref. Ord. Stock	106 —111	4 10 0	..	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	102 —1 6	4 14 3	..	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	99 —102	4 8 0	..	..	..
100	4½%	Do. Vancouver Power Debs.	1 01—1 4	4 6 0	..	..	..
5	3/0	†Buenos Ayres & Belgrano Ord.	3⅛—3¾	4 0 0	..	3 11	3⅜
5	3/0	† Do. 6 per Cent. "A" Cum. Pref	4⅛— 4	5 11 6	..	5⅛	5
5	3/0	† Do. "B"	4¾—5¼	5 14 0	..	5⅛	5
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	..	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	..	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	98 —101	4 19 0	..	..	..
10	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	100 —104	5 5 9	..	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 —105	5 14 0	..	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7½—8	5 0 0	..	7⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5¼	4 7 0	..	5⅛	5⅛
1	4½%	Do. 4½% 1st Deb. Stock (red.)	103 —108	4 3 3	..	103	..
S	..	Cape Electric Tram Shares	⅜ ½	..	..	½	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db	96 —100	5 0 0	..	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 —90%	5 11 0	..	..	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 —95	5 5 0	..	..	..
5	6%	Do. 6 per Cent. "B" Ditto	80 —84	7 2 6	..	8⅜	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅞—1⅞	3 9 6	..	..	..
100	0 7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	5 1 0	..	..	..
St	5%	Do. 5 per Cent. Reg. Mort. Deb.	98 —101	4 19 0	..	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —101	4 19 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 —101	4 6 6	..	..	..
St	4%	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	..	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	125 - 130	3 1 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	£5¾—£7¾	5 3 0	..	96	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¼ - 5¼	5 11 0	..	..	..
10	3/1¼	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8⅛	5 15 0	..	8¼	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	90 —90	4 11 0	..	90	..
£	5/3	†Calcutta Elec. Supply Ord.	7½ - 8¼	5 2 0	..	8⅛	8
5	2/3	† Do. £4 paid	6 —7	..	..	8¼	..
5t	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	..	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2½	..	..	..	..
St.	5%	Do. 5 per Cent. Deb Stock	88 —92	5 8 6	..	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 — 98	5 2 0	..	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 —109	5 10 0	..	..	..
1	0/7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	⅞ - 1	..	..	1	1
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94⅛—97½	5 2 6	..	..	..
1	1/6	Raud Electric	1⅛ - 1⅛	..	..	..	..
1	0/6	†River Plate Electricity Co. Ord.	⅝ - ¾	..	..	¾	..
1	1 2½	† Do. 6 per Cent. non-Cum. Pref.	1⅛ - 1⅜	6 8 0	..	1⅜	..
St.	5%	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	..	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	..	5⅛	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	98 —100⅝	5 0 0	..	99⅛	98⅞

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., May 15.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO MAY 15. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	9¼–10¼	6 16 6	..	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½–10	4 10 0	..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10½–10¾	5 11 8	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	101 –104	4 6 6	..	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅞–5⅛	5 5 0	..	..	..
St.	4½	† Do. Do. 1st Debs.	97 –99	4 11 0	..	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 – 9	5 11 0	..	..	..
5	3/6	Do. 7 per Cent. Pref.	7½– ¼	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	100 –103	3 17 6	..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅞– 4⅛	5 18 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	4 – 4⅛	5 0 0	Feb, Aug	4⅛	4⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	99 – 99	4 1 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅞–4⅛	5 9 0	..	..	..
5	2/3	Chelsea Electric Supply Ord.	3¾–4⅛	5 6 0	March ..	9⅛	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	104 –107	4 4 0	June, Dec	106	105
10	7/0	City of London Electric Lighting Ord.	10 –10½	5 14 0	Feb, Aug	10⅜	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11½–12½	4 16 0	Jan, July	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 –124	4 0 9	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	..	..	..
5	5%	County of Durham Elec. P.D. Ord.....	4¼–4⅜	4 7 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4¾–5	5 4 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅜–8⅛	5 17 6	..	7⅞	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10⅛–11⅛	5 4 0	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	1 6 –1 9	4 2 6	..	106	..
St.	4½%	Do. Second Deb. Stock Prov. Certs,...	95 –98	4 12 0	..	97	95
5	3/6	Folkestone Electricity Supply Co. Ord	4⅜–5⅛	5 2 0	..	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	5 –5⅛	4 11 0	..	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	97 –100	4 10 0	..	..	..
5	5.0	Hove Electric Lighting Ord.	7 – 7½	6 0 0	..	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼–9½	5 5 0	..	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜–7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 –100	4 0 0	..	..	..
St.	4%	Kensingtn. & Kugtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 –1 2	3 13 0	..	..	..
3	2 4½	London Electric Supply Ord.	1⅞–2⅛	5 13 0	..	..	..
5	3.0	Do. 6 per Cent. Pref.	4⅝–5½	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	£5 – 98	4 2 0	Mr,Jn,S,D	..	..
5	4/0	Metropolitan Electric Sup. Ord.	6 – 6⅜	6 3 0	April, Oct	..	..
5	2.3	Do. 4½ per Cent. Cum. Pref.	5 –5⅛	4 5 6	Jan, July	5⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 6 –109	4 2 9	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	92 – 94	3 14 6	..	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98⅞	4 12 0	..	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅝–8¾	5 8 1	Feb, Aug	..	..
100	4½	Do. 4½ per Cent. Deb.	99 –101	4 10 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7¼–7⅝	5 8 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛–5⅜	4 7 9	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 –100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 –1 1/16	2 16 6	Mar, Aug	..	..
100	4½	Do. 4½ per Cent. Deb.	100 –101	4 10 0	Jan, July	..	..
10	9.0	Notting Hill Electric Ord.....	12 –13	5 15 0	March ..	..	..
5	4 6	Oxford Electric Ord.	6 –6½	5 8 0	March ..	6⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 –98	4 1 6	..	..	..
5	5.0	St. James' & Pall Mall Elec. Ord.	7⅜–7⅝	6 1 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾–7⅛	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	91 –94	3 14 6	..	..	..
5	..	Smithfield Markets Electric Stp. Ord...	1⅛–2⅛	.. ..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 –77	5 4 0	..	..	..
5	3.0	South London Electric Supply Ord.....	2⅛–2⅝	6 8 0	..	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅞–1	3 6 9	..	..	..
1	0.8⅜	Do. 7 per Cent. Cum. Pref.....	1⅛–1⅜	4 15 0	..	..	..
St.	4½	Do. 4½ 1st Db. Stk. Red.....	100 –103	4 7 6	..	..	..
5	2/6	Urban Electric Supply Ord.	1¼–2½	10 0 0	..	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	3 –4	6 5 0	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	95 –98	4 12 0	..	..	..
5	6 6	Westminster Elec. Sup. Ord.	9⅛–9⅜	6 3 0	Mar, Sept	9⅛	..
5	2.3	Do. 4½ per Cent. Cum. Pref.	5⅛–5⅜	3 14 8	..	5⅛	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 –95	4 4 0	..	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜–⅞	5 14 0	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅜–½	5 0 0	..	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	..	95⅜	..
St.	4½	B'ham & Midland Trams 4½ 1st Db Stk.	96 – 99	4 11 0	..	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14¼–14⅝	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 –9⅛	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	99 –103	3 17 6	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2 –2⅛	12 0 0	..	2⅛	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6¼–6⅜	8 13 0	Feb, Aug	6⅜	6⅜
St.	5%	Do. 5 per Cent. Perpetual Debs.	99 –103	4 17 0	..	10 ⅜	100
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	79 –82	5 9 6	..	£0½	..
St.	4%	Central London Ordinary Stock	71 –73	5 10 0	June, Dec	75	71
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	..	..	..
St.	4%	Do. Deferred Stock	52 – 55	7 5 0	..	..	..
100	4%	Do. 4 per Cent. Debs.	103 –106	3 15 6	..	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	88 –86	4 13 0	..	83½	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½–5	5 0 0	..	4½	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 –101	3 19 0	..	..	..
St.	2½	City & South London Rly. Con. Ord. ...	41 –43	4 19 0	Feb, Aug	42½	4 ½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 –121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 –118	4 4 9	..	117½	..
St.	5%	Do. (1901)	115 –118	4 4 9	..	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 –105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd, Ord...	14¼–15½	8 18 6	..	..	..
10	6/0	Do. 6 per Cent. Pref.....	13¼–14½	4 2 9	..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2½–3	.. ..	..	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 – 88	4 11 0	..	86	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	93 –101	4 9 0	..	9½	..
10	9%	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11½	5 6 6	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	100 –102	4 8 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 –2	.. ..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 –73	5 9 6	..	..	..
St.	47/6	Lancs. Utd. Trams 5 · Prior Lien Db. St.	95 –93	.. ..	..	..	..
10	..	Liverpool Overhead Railway Ord.....	1⅜–1⅝	.. ..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 –90	4 9 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	7⅜–7⅝	5 14 3	..	7¼	7⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	85 – 89	4 10 0	..	85½	£5
St.	..	Mersey Con. Ord. Stock	3 – 5	—	..	..	..
St.	..	Do. 3 per Cent. Perp Pref.	7 –10	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	1/16–3/16	—	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	5/32–7/32	5 3 0	..	5/32	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0	..	97	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾–1⅛	.. ..	May	..	..
10	8/0	Potteries Electric Traction Ord.	8⅜–6⅛	6 8 0	..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	6 –7½	6 13 5	Feb, Aug	6⅜	..
St.	4½%	† Do. 4½ per Cent. Deb. Stock	96½–99½	1 10 6	..	..	..
1	3/56d	St. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	1/16–1 1/16	5 16 6	..	..	..
St.	3⅝ 3½	Do. 4 per Cent. Deb. Stock	82 – 86	4 13 0	..	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	86 –90	5 11 0	..	..	..
..	5%	Underground Elec. Rys. Co. of London...	74 –77	6 10 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 –1⅛	—	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3¼–3⅝	—	..	..	..
St.	4½%	† Do. 4½ per Cent. 1st Debs.	90 – 93	4 16 9	..	..	..

SHARE.	LAST DIVIDEND	NAME.	Price Wed., May 15.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO MAY 15. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	¼–½	.. ..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	5/16–⅜	7 16 0	..	..	..
1	2/4½	Babcock & Wilcox Ord.....	3¾–4	5 0 0	..	3⅞	3⅞
1	0/7½	Do. Pref.....	1⅛–1⅜	3 17 0	..	1⅛	..
5	6/0	British Insulated & Helsby Cables Ord.	6¼–7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅞– 6⅛	4 16 0	Jan, July	..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 –1 5	4 5 9	..	103¾	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3	..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 –1⅛	.. ..	..	1⅛	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£4 –£8	5 18 0	..	..	..
2	1/0	Brush Electrical Engineering	½–⅝	—	March ..	..	..
2	2/1⅝	Do. 6 per Cent. Pref. non-Cum.	1 –1⅛	8 0 0	Mar, Sept	1⅛	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 –92	4 13 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 –78	5 14 6	Jan, July	..	..
5	5.0	Callender's Cable Con. Ord.....	10 –11	6 13 0	Jan, July	10⅜	10⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛–5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs (red.)	106⅛–108½	4 8 0	Nov, May	..	..
1	0/9⅜	†Castner-Kellner Alkali Co.	1 1/16–1 5/16	5 14 0	..	1 1/16	1 1/32
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	..	..	..
1	0/9⅜	Chadburn's (Ship) Telegraph Ord.	1⅜–1⅝	7 5 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16–1 3/16	5 4 0	..	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 54,000).....	1¼–2⅛	3 10 8	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96%–99⅝	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1 5/16–1 7/16	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 –105	4 5 6	..	101½	104¾
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1 –1⅛	10 2 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼–2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	85 – 87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 –92	5 8 6	..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	¾–1⅛	10 0 0	H'lf-yearly	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅝–2⅛	11 0 0	..	2⅛	2⅛
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	87 – 90	5 0 0	..	..	..
2	..	Electric Construction Co.....	⅛–7/16	.. ..	July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅝–2	7 0 0	July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8¾–9⅛	5 7 0	..	9 1/16	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	..	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅛–12⅜	5 17 6	Feb, Aug	11⅞	11⅞
5	2/3	Do. 4½ per Cent. Pref.	5⅛–5⅜	3 18 8	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 –109	4 2 6	..	..	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15½–16½	6 2 6	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 –100	4 0 0	..	..	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	2 –1⅞	7 6 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 –100	4 10 0	..	..	..
1	..	Simplex Conduits Ord.	1⅛	.. ..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	.. ..	..	..	..
12	24/0	Telegraph Construction & Maintenance	31 –32	5 12 6	Mar, July	31½	..
100	4%	Do. 4 per Cent. Deb. Bonds (1900) ...	100⅜–103⅛	3 17 0	Jan, July	102	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛–2 1/16	5 19 0	..	2⅛	2 1/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅝–1⅞	4 1 0	..	1⅝	1 1/16
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 –117	4 5 6	..	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 –104	3 17 0	..	105	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 –107	4 4 0	..	106¾	105¾
10	6.0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½–10	5 0 0	..	..	..
5	..	Willans & Robinson Ord.....	1¼–1⅜	.. ..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅞–4¼	.. ..	Apr, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	79 –83	4 16 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 –91	5 10 0	..	..	..
St.	15/0	Anglo-American	61¼–64½	6 0 6	F,My,Ag,N	63	61¾
St.	30/0	Do. Preferred	106¾–107¾	5 12 0	F,My,Ag,N	107⅜	106¼
St.	13%	Do. Deferred	20⅛ – 20⅜	4 4 0	F,My,Ag,N	21	2 ⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92¼–94½	4 4 6	Jn,Ap,Jy,O	93⅜	93
10	5 0	Cuba Submarine Ord.....	8 –8½	5 13 0	Feb, Aug	8	..
10	10/0	Do. Preference 10 per Cent.....	16 –17	5 19 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜–3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅜–9⅛	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100%–103⅜	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	15⅜–15⅞	5 17 6	Ja,Ap,Jy,O	15⅞	15½
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	..	..
St.	65/0	†Eastern Ordinary ..... xd & bonus	137 –139	5 0 6	Ja,Ap,Jy,O	142½	141
St.	17/6	† Do. 3½ per Cent. Pref. Stock	88⅛–90½	3 17 3	Ja,Ap,Jy,O	90⅛	89⅞
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104⅛–106⅛	3 15 0	May, Nov	106⅛	..
10	2/6	Eastern Extension	13½–14	5 0 0	Ja,Ap,Jy,O	13⅞	13⅝
St.	4%	Do. 4 per Cent. Deb. Stock	104½–106⅛	3 15 0	Feb, Aug	104¾	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	£8¾–100⅜	4 0 0	May, Nov	..	..
10	3%	G.N. (of Copenhagen), ex Coupon 69 ...	84 –86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 –102	4 8 0	June, Dec	..	..
25	52/6	†Indo-European ..... ex all	56⅛ – 58⅜	5 11 0	May, Nov	59	58
100	4%	Mackay Companies Common	70 1/16–72 1/16	5 10 0	Jan, July	..	..
100	4%	Do. Preference	71 1/16–72	5 11 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞–1	.. ..	..	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99⅛–100⅞	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 –10⅛	3 16 0	..	..	..
2	1/3	†West Coast of America	1⅛–1⅜	3 12 9	..	1⅛	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1/16–1/8	.. ..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	8 – 8½	7 1 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6¾–7½	.. ..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	103 –103	4 17 0	Jan, July	102	..
10	3/0	Western Telegraph	13⅞ 14⅛	4 19 0	Mr,Jn,O,D	14⅛	13⅞
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 –105	3 16 0	..	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 –94	4 5 0	..	93	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 –101	4 19 0	..	..	..
5	3 0	Chili Telephone	6⅜–7½	5 11 0	August ..	6 1/16	..
1	0/4½	Monte Video Telephone Ord.	1 1/16–1 1/16	4 14 0	..	1	..
1	0/6	Do. 5 per Cent. Pref.	⅞–1	5 0 0	..	..	..
St.	6%	National Co. Pref. Stock	108 –110	5 9 0	..	109⅜	108⅜
St.	5½%	Do. Def. Stock.....	104⅛–106½	5 3 0	..	106	105¼
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11¼–13⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	11	10⅜
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅝–5 1/16	4 10 0	Feb, Aug	5⅞	5 1/16
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	95⅛–97⅞	3 11 9	June, Dec	96⅛	9 1/16
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –102	3 18 0	..	101¼	100 1/16
1	0/9⅜	Oriental	1⅝–1 11/16	4 17 6	April, Oct	..	..
1	0 7½	Do. 6 per Cent. Cum. Pref.	1¼–1⅜	4 16 0	..	1⅜	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 –98	4 2 0	..	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	99 –102	4 7 0	..	97⅛	£5
5	3 0	United River Plate.....	6¾–7½	5 9 6	July	7⅛	7
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 11 0	June, Dec	5½	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	103 –142	4 9 3	June, Dec	1 9½	..
		FINANCIAL, INVESTMENT, &c.					
5	3 0	Elec. & Gen. Investment 6% Cum. Pref.	4 –5	6 0 0	..	..	..
10	2 0	Globe Telegraph & Trust.....	10¾–11	5 0 0	Ja,Ap,Jy,O	11	10¾
10	3.0	Do. 6 per Cent. Pref.....	14 –14½	4 4 0	Ja,Ap,Jy,O	14½	14
10	6/	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	125	127½

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

The Imperial College of Science and Technology.

IN commenting last week upon the draft charter of the Imperial College of Science and Technology we omitted to draw attention to the fact that the Central Technical College, although forming part of the complete scheme, will still retain a very independent position. At present this college is what is known as a School of the University, and this means that it possesses certain privileges for its students; for example, the examination for the diploma of the college is accepted as an intermediate examination of the University. Moreover, the work carried out at the college is taken into account if a student enters for a degree examination of the University, and it is, therefore, of value quite apart from any result obtained by it at the college. These are privileges which are undoubtedly of advantage in some respects, but, nevertheless, they may have the disadvantage that a student going up for a University degree is apt to pay more attention to such subjects as are included in the University syllabus than to other subjects of equal or greater importance. So far as the present scheme is concerned, the Central Technical College still holds this position, for it practically retains the management of its own affairs, and will continue to award the diplomas of Associate and Fellow of the City and Guilds of London Institute.

WHETHER this independent position will be changed later on when the whole question is considered by a Royal Commission remains to be seen, but we doubt very much if the advantages gained by independence are likely to be put on one side. In his letter of February 19th last, to Sir FRANCIS MOWATT, Mr. MCKENNA was evidently not much in favour of University control. As a rule a University syllabus is not frequently revised, and for that reason it is apt to be out of date. In some branches of work this may not be a matter of great importance; as, for example, in civil and mechanical engineering, in which progress, although constantly being made, is not very rapid. But in electrical engineering and its allied subjects, progress is apt to be made with startling rapidity, and for that reason hard-and-fast lines cannot be adopted without serious disadvantage. University bodies are proverbially academic and disinclined to move, except with considerable lag. Moreover, if a technical college is carrying on investigations of any great value, its staff are certainly much more likely to know what kind of a syllabus is desirable than the members of the University Senate, who probably know little of the work or methods of the college in question. We, therefore, hope that nothing will be done to saddle the Central Technical College, or the other colleges at South Kensington, with a University syllabus, the aim of which is generally to enable students to pass examinations.

Life of Frosted Lamps.

NOTWITHSTANDING the fact that frosted incandescent lamps have a more pleasing appearance than those made of clear glass, and that they are generally favoured by consumers, yet electricity supply authorities hesitate to recommend their general adoption owing to one serious disadvantage which they possess, namely, the rapid falling off in the light emitted, and consequently in efficiency, which takes place after only a short life as compared with that in the case of a clear bulb lamp. This great falling off in light has frequently been attributed to either the outside blackening by dust on the frosted surface, or else to the effect of the higher tem-

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perature reached by the lamp through greater absorption. In another column we publish a communication by Mr. E. P. HYDE, received from the Bureau of Standards at Washington, in which is put forward a further explanation of this falling off in light. In the case of the lamp with the clear glass bulb a very large percentage of the light passes straight through the glass, whilst in the case of the frosted bulb a much smaller percentage of the light passes straight through, and a considerable portion of the light only passes through after several reflections inside the bulb. As at each reflection the light has to pass through the film of black deposit inside the bulb, it is evident that a much larger absorption of light must take place when a frosted bulb is used.

Leading-in Wires for Incandescent Lamps.

THE majority of electricity consumers will probably at one time or another have had an unsatisfactory experience of cheap glow lamps, which are usually of foreign manufacture. One cause of the trouble is probably the use of alloys for leading-in wires in place of platinum. In a Paper recently read before the Glasgow Local Section of the Institution, and of which we give an abstract in this issue, Mr. BASTIAN describes a method by which copper may be used for these leading-in wires, with corresponding advantage in the cost of manufacture of the lamp. If this method proves as satisfactory in practice as in Mr. BASTIAN'S experiments, it should be of considerable advantage to manufacturers of carbon lamps, though the advent of the metallic filament lamp may make such a substitute comparatively less important.

Bulk Supply for Middlesbrough.

WE have on a previous occasion drawn attention to the energetic policy adopted by the Newcastle-on-Tyne Electric Supply Co. conjointly with the Cleveland & Durham Electric Power Co. in competing with local authorities. The latter company has for some time past caused considerable anxiety to the Middlesbrough Corporation. It will be remembered that the borough electrical engineer (Mr. H. M. TAYLOR) some time ago reported on the advisability of erecting a new power station in order to satisfactorily compete with the Power Company within the Corporation's area. Now, however, we learn that the Corporation has definitely entered into an agreement to take a bulk supply of electrical energy from the Cleveland & Durham Electric Power Co. This supply will, of course, be used in conjunction with that generated by the municipality's existing electricity works, and, presumably, any extensions of the latter will not now be proceeded with. An arrangement of this kind offers considerable advantages to a municipal authority, who are thus relieved to some extent from further capital expenditure, though meters, services and mains have still to be provided for. In the particular agreement which has been entered into by the Middlesbrough Corporation extensions of mains will presumably be considerably curtailed, for the Power Company are to be allowed to supply electrical energy direct to consumers outside a specified area, which is already supplied by the municipal mains. The developments resulting from this agreement, which is to continue in force for 15 years, will be watched with great interest, perhaps not unmixed with anxiety in a number of cases, by municipal electrical engineers throughout the country. We do not doubt that similar agreements could be entered into, in the case of many small electrical undertakings, with considerable benefit both to the power companies and to the municipal authorities themselves.

Institution of Electrical Engineers' Benevolent Fund.—The ninth annual general meeting of the contributors to this fund will be held to-day (Friday), May 24th, at the offices of the Institution of Electrical Engineers, at 4:45 p.m., to receive the report of the committee of management and the statement of accounts and balance-sheet to December 31, 1906.

Application of Electricity to Mines.—We find that our note in last week's issue on "Application of Electricity to Mines" was somewhat incomplete. At Manton Colliery, in addition to the current being used for the main shaft pumps, all the machinery for the screens and surface work is electrically driven and the haulage machinery is now being converted. The installations at both collieries mentioned were carried out by Messrs. Ernest Scott & Mountain.

Pocket Test Lamp.—The *Street Railway Journal* describes a pocket test lamp which has lately been put on the market. It is especially designed to overcome the difficulty and annoyance of determining whether enclosed fuses have blown, but is useful in all cases where it is desirable to find out whether or not a circuit is alive. It is made up of a specially-designed incandescent lamp enclosed in a fibre casing. The casing has ferrules and knurled binding posts on either end, while at the middle a fair-sized hole through both walls of the casing allows the illumination of the lamp to be plainly seen. For the majority of switches and fuses the metal ends of the test lamp will bridge parts of opposite polarity, but for work where the distance is greater than the length of the test lamp the binding posts afford a convenient means of clamping leads of sufficient length. The device is not designed for continuous service, and should be used only for flashing, as the small enclosed casing will soon become too hot if left long in circuit.

The Bunsen Gesellschaft.—The fourteenth annual meeting of this German Society of Electro-Chemists was held at Hamburg, on May 9th to 12th, about 200 members, accompanied by 40 ladies, attending the meeting. Among those present were Professors Nernst, Landolt, Richards, Abegg, Bodenstein, Will, Danneel, Förster, Haber, Le Blanc, Lepsius, Löb, Luther, Marckwald, Schenck, and Tammann. The most notable absentees were Messrs. van't Hoff and von Böttinger, who were indisposed, and Ostwald. The papers and discussion upon "Radio-activity and the Theory of Atomic Dissociation," were placed first upon the programme, and on that account attracted the largest audience. The contributions of Marckwald, Meyer and of Landolt proved the most interesting. It was announced to the meeting that von Böttinger had provided the funds for a Bunsen Medal, which is to be presented every two years by the Council of the Bunsen Society. The medal will be of gold and worth £25 to £30. The first presentation is to be made in 1908. The meeting of the society next year will be held at Vienna, but the date is not yet fixed.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tarifa—Tangier	Jan. 18, 1904 ..	—
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
New Brunswick—Prince Edward Island	Jan. 9, 1907 ..	May 17, 1907
Panama—Buenaventura	Feb. 28, 1907 ..	—
Buenaventura—Santa Elena..	Feb. 28, 1907 ..	—
Dakar—Konakry	April 24, 1907 ..	May 22, 1907

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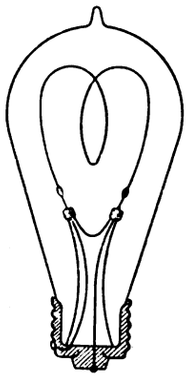
Manchester Students' Section of the Institution of Electrical Engineers.—At the last committee meeting of this section Mr. J. Roberts, jun., and Mr. J. Lawton Lovell were respectively elected vice-chairman and honorary secretary of this section. The former played a large part in the formation of this section and held the above post until his removal from Manchester, to which city he has lately returned.

The Employment of Mercury Vapour Lamps in Damp Places.—The *Elektrotechnik und Maschinenbau* states that mercury vapour lamps lend themselves very advantageously to the lighting of places where the atmosphere is damp and charged with vapour, and in which the operation of arc lamps is not sufficiently reliable. The case is cited of a factory having a floor area of about 7,100 sq. ft. and 14 ft. high, in which 12 Cooper-Hewitt lamps are employed for lighting. They are fed two in series off a continuous-current supply at 220 volts. The tube of each lamp is 3 ft. 9in. long and 1 in. in diameter. By means of an appropriate reflector the light produced is distributed with an intensity of 955 c.p. at an angle of 45 deg. below the horizontal, of 1,100 c.p. at 60 deg. and of 1,200 c.p. at 90 deg. The consumption is about 385 watts per lamp, giving a total consumption of 4,620 watts, or 0·65 watt per square foot of surface lighted. Formerly 24 arc lamps, each consuming 660 watts, or a total of 15,480 watts, were used; the power consumed was then equal to 2·2 watts per square foot of surface lighted.

Leading-in Device for Incandescent Electric Lamps.—The *Electrical World* gives an account of a lamp in which platinum is entirely dispensed with and copper or iron is used as the material for the leading-in device. The upper end of the central glass tube is provided with separate tubular extensions, the open ends of which are hermetically sealed in the following manner. Over each extension is placed a cap of copper or iron, as shown in the figure. The parts are then heated in the ordinary glassblower's gas-jets to a temperature sufficient to soften the glass. A gentle air-pressure is then exerted, so as to bring the glass into intimate contact with the sides of the cap. Upon cooling, the cap shrinks tightly about the glass and forms a perfect vacuum-tight joint about the same. This arrangement is due to Mr. W. R. Whitney, who states that the joint is probably assisted by some combination between the oxidised surfaces of the metal and the parts of the glass in contact therewith. The metal is sufficiently thin to stretch and will thus not exert such a pressure upon the glass as to shear or break it. A thickness of metal $\frac{1}{100}$ in. or less has been found to be satisfactory.



Whitney Lamp.

Merchant Venturers' Technical College, Bristol.—The plans for the restoration of the main building of this college have now been approved by the Society of Merchant Venturers, and involve very considerable changes in the arrangements of the original building. The engineering workshop and forge will still be located in the basement, as will the electrical engineering laboratory and the hydraulic laboratory; both will, however, be much larger. An extensive workshop for motor car engineering will be provided. A portion of the yard at the back of the college will be covered over, and in it will be placed the experimental engine, dynamos and central electric light and power station, now situated in the Rosemary-street branch building of the college, as well as testing machines of various kinds. On the ground floor the great hall will be retained in its original position. On the first floor there will be the gallery of the great hall, a large mechanical laboratory, engineering lecture room and drawing office. On the second floor will be found the lesser hall, physical laboratory, optical laboratory, photographic laboratory, physical lecture theatre, two science lecture rooms, two ordinary class rooms, library, research laboratory, &c., while on the new third floor provision is made for a chemical department, which will include a chemical lecture theatre, preparation room, elementary chemical laboratory, advanced chemical laboratory, balance room, combustion room, professors' room and stores. The fume closets will be built outside the main laboratories, as will also the store for dangerous chemicals. It is confidently expected that the whole of the work of restoring and refitting the building will be completed in time for the students to return to Unity-street in September, 1908.

American Electro-chemical Society.—The eleventh general meeting of this society was held at Philadelphia from May 2nd to 4th, and turned out to be one of the most successful gatherings held during its existence. A large number of Papers dealing with electric furnaces and other phenomena in high-temperature chemistry were read, among them being "Carbon for Electrometallurgy," by Mr. F. A. J. Fitzgerald and J. Forssell, and "A Closed Electric Furnace for Reducing and Distilling Metals from their Ores," by Mr. E. R. Taylor. Dr. C. P. Steinmetz gave an experimental lecture on "Conduction," in which he divided all materials into classes depending on whether they conduct metallically, electrolytically, as an arc, or as a vapour. After describing the characteristics of each class he showed that there is no distinct division in certain substances, which seem to belong to two or even three classes. The principal difference between arc conductance and vapour conductance is that the former is continuous and the latter intermittent. The specific resistance of an arc is about the same as that of a good electrolytic conductor—*i.e.*, from 1 to 4 ohms per cubic centimetre. Dr. Steinmetz showed that the generally accepted theory, that the conducting carbon vapour is obtained from the positive carbon, is erroneous, and that the arc material, which makes conduction possible, comes from the negative carbon. This explains the operation of the arc rectifier and also the fact that it is impossible to maintain an arc with an alternating voltage of 1,000 or even more between certain conductors, while with a much lower continuous voltage this is easily done. The following Papers were among those read on electrolytic phenomena:—"The Electrolytic Pickling of Steel," by Mr. C. J. Read, and "The Electrolytic Corrosion of Brass," by Prof. A. T. Lincoln. The cost of power for electrochemical industries was very fully discussed in connection with Papers read by Messrs. E. A. Sperry and C. E. Lucke on this subject.

Comparison of the Costs of Three-phase and Continuous current Transmission.—*L'Electricien* gives an account of some results obtained by Prof. Motta, of the University of Milan, who studied the above problem for a particular case. It was required to supply a town with 28,000 kw. and to utilise a waterfall 95 miles away. The transmission line had to cross mountainous regions. The three-phase system at 60,000 volts and the continuous-current system at 150,000 volts were compared, as these two voltages were the most economical for the case considered. Ten machine groups were required on the Thury system, each group consisting of four generators, driven by a water turbine. The limiting voltage per group was 15,000. The transmission line consisted of two insulated conductors. The three-phase generators were, as usual, worked in parallel, and operation with a frequency of 42 was considered. The calculations and tests of Prof. Motta led to the following conclusions, which are in favour of the use of the three-phase system in this particular case. The line drop is 3 per cent. less in the case of three-phase working when both systems are fully loaded—*i.e.*, 28,000 kw. The first cost is 1·6 per cent. less in the case of continuous current (£400,000 and £406,400). This covers the cost of machines, switchboards, insulators, poles and transmission lines; transformers for the three-phase and motor-generators for the Thury system. In the Thury system the line cost is low (£120,000) but the machine cost is high (£280,000). In the three-phase system the position is reversed, the line costs £256,400 and the machines £150,000. The sub-stations cost £144,000 (continuous) £31,800 (three-phase). The transmission line for the

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three-phase system consisted of three wires, each 0·372 sq. in., while for the continuous current four wires, each 0·22 sq. in., were required. The number of commutators in series (104) demanded by the continuous-current system greatly contributed to its rejection.

Oscillation-Generator for Wireless Telegraphy.—In a recent number (April 7th) of the *Elektrotechnik und Maschinenbau*, Dr. J. Sahulka, prompted by the present activity in the designing of oscillation-generators, calls attention to an apparatus he patented in 1904. Before sketching the design as patented he describes the primitive form that led to the final one, and this primitive form is superficially very similar to the generator proposed and patented by S. G. Brown. It consists of a toothed wheel, a slip-ring and two brushes, one brush bearing on the slip-ring and one touching the teeth of the wheel, arranged as a shunt to a circuit comprising a source of E.M.F., a condenser, and the primary of a Tesla transformer (with an air-wire as secondary). When a tooth of the rotating wheel touches the brush the charged condenser discharges itself in an oscillatory manner through the primary of the oscillation transformer. In Brown's arrangement, it will be remembered, a copper block bears on a rapidly rotating aluminium wheel; the copper block is analogous to the brush of Sahulka's arrangement, and, no doubt, the rattle of the block on the aluminium wheel has an effect similar in kind to that just described. The final form of Sahulka's arrangement consists of a pair of equal toothed wheels, each with a slip ring, on the same axle but insulated one from the other, and with the teeth staggered in angular position. A brush connected with the source of E.M.F. touches all the teeth of both wheels in turn as the axle rotates and charges two condensers alternately through the corresponding slip ring. The condensers have a common pole permanently connected to the other pole of the source of E.M.F. For the discharge there is a second brush, which leads through the primary of the oscillation transformer to the common pole of the condensers, and this brush as it touches each tooth soon after the charging brush has left it, allows the condensers, in turn, to discharge in an oscillatory manner through the primary of the oscillation transformer. The result is that, according to the inventor, some 10,000 wave-trains can be excited per second, the constituent waves of each train having of course a period determined by the inductance and capacity in circuit.

The Institution of Electrical Engineers.—The Council has decided to award premiums for Papers read before the Institution during 1906-7 as follows: The Institution Premium to Mr. C. C. Paterson, for his Paper, "Investigations on Light Standards and the Present Condition of the High-voltage Glow Lamp"; the Paris Electrical Exhibition Premium to Prof. J. Epstein, for his Paper, "Testing of Electric Machinery and of Materials for Its Construction"; an Extra Premium to Prof. A. Schwartz, for his Paper, "Flexibles, with Notes on the Testing of Rubber"; an Extra Premium to Mr. C. Wade, for his Paper, "The Use of Wooden Poles for Overhead Power Transmission"; an Extra Premium to Mr. W. Cramp (Manchester), for his Paper, "Magnetic Leakage and Its Effect on Electrical Design"; an Extra Premium to Mr. T. H. Schoepf (Manchester), for his Paper, "Single-phase Railway Motors and Methods of Controlling Them"; an Extra Premium to Dr. W. M. Thornton (Newcastle), for his Paper, "The Distribution of Magnetic Induction and Hysteresis Loss in Armatures"; the Fahie Premium to Messrs. B. S. Cohen and G. M. Shepherd, for their Paper, "Telephonic Transmission Measurements"; an Original Communication Premium to Messrs. A. Baker and J. T. Irwin, for their Paper, "The Analysis of the Magnetic Leakages in Induction Motors." Students' Premiums.—A First Students' Premium to Mr. W. Browning (Manchester), for his Paper, "Further Notes on Conductivity"; a First Students' Premium to Mr. E. A. Watson (Birmingham), for his Paper, "A Simple Method of Measuring Sparking Voltages"; a Second Students' Premium to Mr. E. W. Moss (London), for his Paper, "Electric Valves"; a Second Premium to Mr. R. Rankin (Glasgow), for his Paper, "An Elementary Paper on the Induction Motor"; a Second Premium to Mr. R. J. Kaula (London), for his Paper, "The Equipment of Steam Turbine Generating Stations." Award of Scholarships.—The Council have awarded scholarships for the year 1907-8 as follows: Mr. R. E. Neale, Central Technical College, one Salomons Scholarship; Mr. P. E. Péronne, Finsbury Technical College, one Salomons Scholarship; Mr. E. M. Mallett, University College, one David Hughes Scholarship.

Generating Station worked by Diesel Engines.—A description of the central station at Friedenau, which is worked by Diesel engines, is given by M. Max Müller in *L'Industrie Electrique*. As Friedenau is one of the most aristocratic suburbs of Berlin, the municipality preferred to employ oil instead of steam engines with their attendant smoke, and to design the exterior of the station so that it had the appearance of an ordinary middle-class house. Current is distributed on the three-wire system at 440 volts across the outers. The basement of the station contains a battery of 264 cells with a total capacity of 600 ampere-hours at a two hours discharge rate. It also contains the petroleum tank, with a capacity of 400 cubic ft. The oil is pumped up from this into two other reservoirs, each of 66 cubic ft., on the ground floor, whence it is distributed to the engines through filters. On this floor there are also two reservoirs, each of 132 cubic ft., containing cooling water. In the engine room are two 185 kw. Diesel engines, working at a speed of 155 revs. per min. They each have two vertical cylinders with a stroke of 2 ft. 6 in. and a diameter of 20 in., and are fitted with two flywheels 13 ft. 9 in. in diameter, weighing 15 tons. The combustible liquid is delivered to the admission valve by a pump worked by the main shaft. The valves of this pump are controlled by the governor, so that the amount the valves open depends on the load. This method of regulation works very well. The oil has a calorific value of from 4,320 to 4,545 calories per pound and costs £36 per ton. After combustion this oil leaves no residue in the cylinders, and, although the engines have been working for nearly two years, they have not yet been cleaned. The consumption guaranteed by the makers for a combustible with a calorific value of 4,545 calories per lb. and the results actually obtained on a five hours' test at the station are indicated in the following table:—

Load per cent.	Consumption in lbs. per H.P. hour. Guaranteed.	Obtained.
100	0·37	0·35
75	0·39	0·36
50	0·45	0·42
33	0·60	0·48

The calorific value of the oil used was 4,500 calories per lb.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 24th (to-day).

INSTITUTION OF ELECTRICAL ENGINEERS.

5 p.m. Annual General Meeting at 92, Victoria-street.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Physics Laboratory, Royal College of Science, Imperial Institute-road, South Kensington. Papers on "The Measurement of Mutual Inductance by the Aid of a Vibration Galvanometer," by Mr. A. Campbell and on "Note on the Rate of Decay of Active Deposit from Radium," by Messrs. W. Wilson and W. Makower. An exhibition of an "Apparatus for Relay Working of Long Submarine Cables" will be given by Mr. S. G. Brown.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:30 p.m. Meeting at the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Paper on "Some Experiments on the Magnetic Character of Vessels," by Capt. W. Bartling.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street. Lecture on "Recent Contributions to Electric Wave Telegraphy," by Prof. J. A. Fleming, F.R.S.

TUESDAY, May 28th.

SOCIETY OF ARTS.

8 p.m. Meeting at John-street, Adelphi. Paper on "Sheffield Plate and Electro-Plate," by Mr. Sherard Cowper-Coles.

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ELECTROLYTIC CORROSION OF IRON AND STEEL IN CONCRETE.*

BY A. A. KNUDSON.

It has sometimes been supposed, since concrete is effective in preserving ironwork from corrosion when placed in water, whether salt or fresh, that it would similarly act as a protection against electrolysis. In this Paper the author shows the fallacy of this assumption. Not only does a current cause corrosion of the iron, but disintegration of the concrete. In tests which he carried out, the electrical resistance of the concrete fell rapidly, and the concrete cracked and softened.

In these days of wide and rapidly-growing use of reinforced concrete and hydraulic cements in all kinds of structures, the question often comes up as to whether concrete will afford to iron and steel the same protection from stray currents of electricity that it does from ordinary corrosion or rust. In the practice of investigating movements and results of currents upon underground pipes and other structures, several instances have come to our notice where damage has been caused by electrolytic action upon metals covered or encased in concrete or Portland cement. In view of the importance of this question, therefore, we have thought it would be of service to those who are interested in the subject if more light were thrown on the true value of concrete as a supposed insulator. Blocks of concrete containing iron tubes were prepared of equal parts of Portland cement and sand. They were made in ordinary metal pails, slightly larger at the top than at the bottom. In the centre of each block was placed a 2 in. wrought-iron pipe, as shown in Fig. 1. Block 1 was immersed in fresh water and block 3 in sea water. These were connected in series, with 0·1 ampere continuously flowing through them. Block 2 was also immersed in sea water, but no current was sent through it. This was for the purpose of comparison after the blocks were broken open. These tests were carried out at the Electrical Testing Laboratories, New York. The results of importance upon this first group of blocks were found in the gradual disruption of the concrete, as shown by the cracks as time went on and the appearance of electrolysis and loss in weight of the iron tubes of both Nos. 1 and 3 when the tests were concluded. The report furnished by the laboratory on this first set of experiments concludes as follows:—

After the conclusion of this test, which extended over 30 days time, the blocks were removed, and after allowing them to dry the were broken open. It was found to be quite easy to break opey blocks Nos. 1 and 3, which had already become cracked. Block No. 2, which had not been subjected to electrolysis, was broken with the greatest difficulty. Blocks Nos. 1 and 3 showed on their interior strong evidences of electrolytic action in the form of what was apparently a deposit of iron rust extending from the pipe toward the outside of the block. Along certain lines which acted like lines of cleavage, the cement was found to be softened so that it could readily be cut or scraped with a knife. The pipes enclosed in Nos. 1 and 3 were found to be considerably corroded. A portion of the scale on the corroded parts of these pipes was removed and the pipes were weighed. The pipe in block No. 2 was as bright as a new pipe. The concrete showed no evidences of a deposit of iron rust.

Weighing of the pipes had been made by Mr. Knudson before casting them in the blocks Weighings made at the conclusion of the experiment, together with these initial weighings, are given in the following table:—

	No. 1 fresh water.		No. 3 salt water.
Initial	3 lb. 12·50 oz.	.....	3 lb. 7·5 oz.
Final	3 lb. 10·95 oz.	.....	3 lb. 6·4 oz.
Loss	1·55 oz.	.....	1·1 oz.

As has been said above, the scale was not entirely cleaned off from pipes Nos. 1 and 3 before the final weighing was made, so that the loss in weight does not represent the entire amount of the electrolysis which had occurred.

The results of these experiments seemed so important that it was thought best before drawing conclusions to have the tests repeated, and, therefore, another set of experiments, similar to the first, was made to see how the data would compare.

Second Set of Experiments.

In this case two blocks of concrete were prepared, numbered 4 and 5. These were made the same as the others except that Rosendale cement was used, called in the trade "Brooklyn Bridge Brand." The object of using a different cement was to see if there was any change in the results that could be attributed to the use of a different brand of cement. In these tests two readings every 24 hours were made through the entire 30 days, and the appearance of the blocks was closely watched. The source of current, as in the first test, was from a storage battery, and the pressure was increased or decreased according to the resistance, in order to maintain a constant current of 0·1 ampere.

The variation of resistance in both blocks during the test of 30 days is important. Such changes are graphically represented in curve sheet Fig. 2; the figures showing ohms are given as relative, as they may not quite accurately represent the true values. They were obtained by simply dividing the volts by the 0·1 ampere. It was found in the preliminary trials that resistance measurements by the usual methods, such as the Wheatstone bridge, were not accurate, owing to strong polarising effects. For this reason the resistances as shown by these curves, while not considered absolutely accurate in every case, are sufficiently so for our purpose of examination and study. The curve in Fig. 3 represents the sudden fall or practical breakdown of concrete as insulation in 48 hours. The measurements in this test were made by the Wheatstone bridge, using alternating current and a telephone receiver. They are considered fairly accurate.

Quoting parts of the report on this second series of tests:—

It appears from these observations that, before the ninth day, the process of electrolysis had arrived at quite an advanced stage on

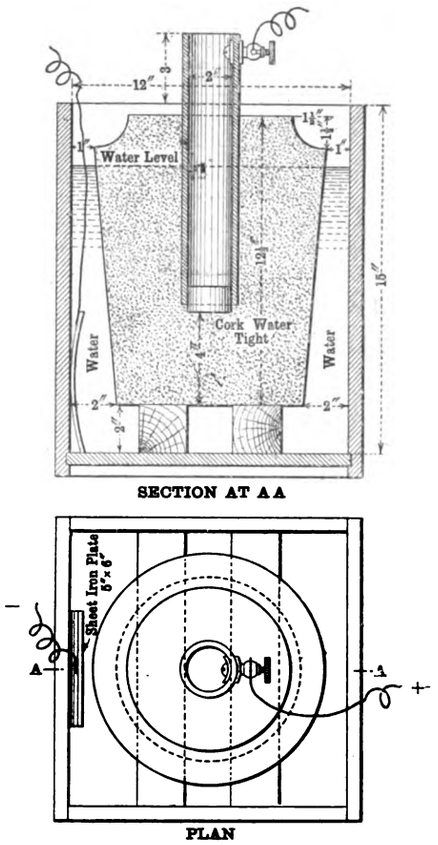

Fig. 1.—Plan and Section of Iron Pipe Incased in Block of Concrete in Water.

both blocks, and before the rise in resistance took place, which afterwards in fresh water reached 300 to 400 ohms, requiring some 30 to 40 volts to maintain the 0·1 ampere. We should not, therefore, conclude that because such high readings are not found in practice it is a sign that there can be no electrolysis. In the salt water block it was observed that, even to the eleventh day of the test, 5·5 volts only was required to pass the 0·1 ampere, and at that time the record states the cracks in both samples have increased in prominence. After the conclusion of the test, which continued over 30 days' time, the concrete blocks were removed from the water and allowed to dry. They were then broken open. Block No. 4, which had been under test in the salt water, was found to have a rust-coloured deposit extending along the sides of a crack from the external surface to the pipe. The rust-coloured deposit in sample No. 5 was only about the pipe.

The weights of the pipes before and after the tests are given in the following table:—

	No. 4, salt water.		No. 5, fresh water.
Initial	3 lb. 7·1 oz.	....	3 lb. 6·6 oz.
Final	3 lb. 5·5 oz.	....	3 lb. 5·5 oz.
Loss	1·6 oz.		1·1 oz.

This second series of tests show results very similar to the first, only more pronounced; and we believe they also show that the

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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results would be practically the same with concrete made up with any of the different brands of cement found in the market, or made with different proportions of sand, or made of brick or stone masonry.

These tests and experiments go to show that only a small fraction of an ampere is necessary to cause electrolytic action. The element of time being always with us, it is only necessary, where electric currents are present of sufficient voltage in the proper direction, to cause even a very small amount of current to pass that will in time cause corrosion upon interior steel structures, whether placed in concrete, brick or in granite masonry. It is not expected, however, that large granite piers would develop cracks, but electrolysis to

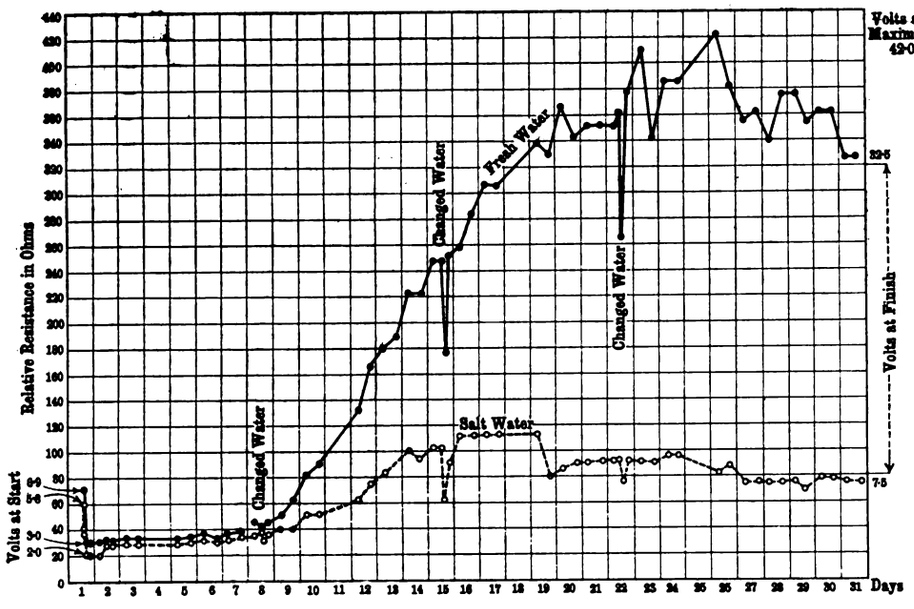

FIG. 2.—CURVES SHOWING RESISTANCE OF TWO BLOCKS OF CONCRETE, ONE IMMERSED IN SEA WATER AND ONE IN FRESH WATER FOR 30 DAYS WITH STEADY CURRENT OF 0·1 AMPERE MAINTAINED UPON AN IRON PIPE PLACED IN CENTRE OF EACH.

interior steel work and to bridge anchorages may go on just the same. Cracks may develop, however, in concrete piers of small bridges, such as those which cross creeks or canals.

By way of a practical illustration the author referred to a bridge over the Gowanus Canal, South Brooklyn, at Hamilton Avenue. His observations and tests pointed strongly to electrolytic action from trolley currents as being the true cause of the cracks which had appeared in the concrete. Ordinary care would suggest that costly structures of this kind should be periodically inspected for evidence of electrolytic action upon the interior steel work, especially if located contiguous to water, or in the vicinity of electric railways or railway power stations as in the case just cited. Furthermore, this question should be carefully considered when such structures are planned, and tests made at locations of proposed bridges or other structures, to ascertain the electrical conditions and the possibilities of injury due to electrolysis from stray currents.

This question of electrolytic corrosion of interior steel in the construction of high buildings, however, has not been entirely neglected. There is at least one case, that of the *New York Times* Building, where provision has been made in advance as a protection. In the "Building Supplement," issued by that Paper, dated January 1, 1905, an interesting description is given in detail of the entire construction of that building. The following extract, referring to electrolysis, will be of interest:—

"The danger that in the case of the steel frame, rust and the disintegration of electrolysis would hasten the process of dissolution so much as to make structures of this kind prematurely unsafe through the destruction of their supports, was recognised in time to permit of ample safeguarding in the case of the steel frame of the Times Building. It is axiomatic that columns to which moisture has no access will not be impaired by rusting, and that those effectually insulated from vagrant electrical currents will not be affected by electrolysis. The first consideration was to keep the basements dry. Hence the thorough waterproofing and draining of the retaining walls which were carried under the floor of the press room, occupying the great area of the sub-basement. As a further safeguard, all the steel members up to the street level are encased in Portland cement mortar, to the minimum thickness of ¾ in. This is effectual protection against rust deterioration. Under these conditions electrolytic disintegration is deemed impossible, but the probability of its occurrence in even microscopic degree is rendered still further remote by as perfect insulation as can be provided. There is sufficient earthing to relieve any electrical tension which may exist in any part of the steel frame by drawing off the current at points where electrolytic action cannot be set up."

This is the first instance we have noticed where a large corporation has recognised this danger and has taken steps beforehand to avoid it. The protection of steel structures already constructed, however, is a different matter. While plans may be made to provide insulating methods and water proofings, before construction, it is not easy to prevent corrosive action, when the conditions are favourable, after construction.

Another point which may have an important bearing on this subject, is the great pressure upon pillow blocks, and upon piers supporting as they do enormous weights, which serve to make excellent electrical contact with concrete or masonry on which they stand, and, therefore, offer further opportunity for inviting stray currents.

Photographs were shown by the author of the underside of two water meters which were practically destroyed by electrolysis while in service in the cellars of dwellings in a distant city. They were shown as an illustration of how railway currents will follow a service pipe for a considerable distance from the tracks, enter a building, and find an outlet to ground on the damp soil of a cellar.

REMEDIES.

Coatings of various kinds of paints or varnishes will be of little use as an insulation, for it must be borne in mind that not only a moisture resistant is required, but an insulation that will resist continual moisture, and also that will stand the pressure of great weights.

From these laboratory experiments, as well as observations in practice, we draw the following conclusions:—

1. Steel structures are well preserved from ordinary corrosion by concrete if placed either in salt or fresh water. This, however, has long been known.

2. If but a small fraction of an ampere of electricity passes from an interior metallic column or structure into concrete or masonry as usually made, there will be corrosion of the metal and disintegration of the concrete or masonry.

3. Structures of steel in concrete that are subject to sea water are in more danger from electrolytic action than those in fresh water, by reason of the lower resistance of concrete in sea water, as shown by the laboratory experiments.

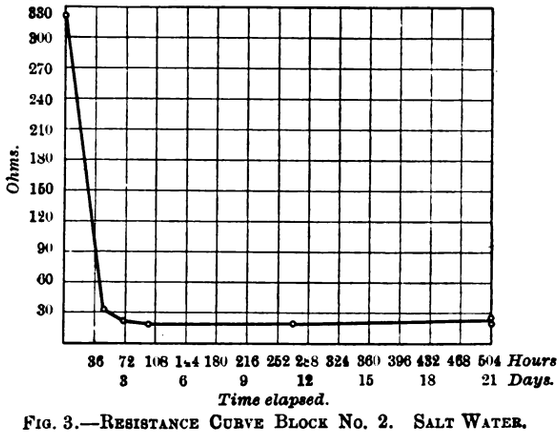

FIG. 3.—RESISTANCE CURVE BLOCK NO. 2. SALT WATER.

4. In no sense can concrete be considered an insulator, and, as shown, it is, from all appearances, just as good an electrolyte as any of the soils found in the earth.

It is therefore to be expected that so long as the single trolley with its grounded return is in general use, just so long may we look for electrolytic action in some form upon various underground structures; and reinforced concrete is no exception to the rule. It is not at all surprising that such currents are busy at steel work of bridge-anchorages. Whether enclosed in concrete or masonry, these materials, as we have endeavoured to show, are no protection from the straying railway current when the conditions are favourable for electrolytic action. It would seem that this question should receive due consideration by those who have to do with planning and constructing important public works and buildings, as well as those who are entrusted with the care and safety of such structures.

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SIMPLE ZERO METHODS FOR THE DIRECT DETERMINATION OF LEAKAGE FACTORS.

BY DR. R. POHL.

Summary.—The Author considers simple direct methods of determining leakage factors. After referring to R. Goldschmidt's, which is simple though somewhat troublesome, the Author describes two such methods which give accurate results, and can be used with ordinary testing instruments.

The magnetic leakage in electrical machines has of late been the object of renewed interest, as proved by several papers and discussions on the subject. This is mainly due to its great importance in direct current machines of the interpole type. In machines without commutating poles, the leakage, which amounts to from 10 per cent. to 20 per cent. of the useful flux (leakage factor 1·1 to 1·2), merely necessitates a corresponding increase of pole and yoke section without in any way interfering with the performance of the armature. In machines with commutating poles, however, we have to distinguish between the leakage of the main poles and that of the commutating poles; whilst the former has the same effect as before and a similar relative proportion to the main flux, the latter may, even in the best designs, amount to from 50 per cent. to 100 per cent. of the commutating flux (leakage factor, 1·5 to 2), and is in some constructions many times as large as the useful flux. In consequence thereof, if great care be not taken in designing, it may lead to unsatisfactory performance and sparking owing to excessive magnetic densities in the commutating poles.

Under the circumstances it is desirable to have simple methods for the experimental determination of the leakage

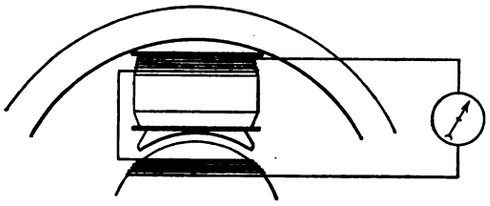

FIG. 1.—GOLDSCHMIDT'S METHOD OF DETERMINING THE LEAKAGE COEFFICIENT.

factor of both the main and auxiliary poles which enable the designer to check his calculations. Such methods should only require instruments which are at hand in the test room of every manufacturing firm, and which are easily portable, so as to allow also of the test being carried out on installed machines.

The method mostly adopted for the determination of the leakage factor—*i.e.*, the ballistic measurement of the flux in the armature and in the poles—can only be considered a laboratory experiment, seeing that it requires the use of a ballistic galvanometer, which most probably will not form part of an average test room equipment. Another method, the only one published, which allows a direct determination of the leakage coefficient, is that by R. Goldschmidt.* A coil of t_{pole} turns of thin wire is wound round one pole, and a similar one, containing $t_{arm.}$ turns, round the armature, so that the total flux, $N_{pole} = N_{arm} + N_{leakage}$, passes through the former coil, while the useful flux, $N_{arm.}$, only passes through the latter (see Fig. 1). Both coils are connected in series with each other and with a millivoltmeter. If now the excitation of the machine is broken, E.M.Fs., e_{pole} and $e_{arm.}$ will be induced in the test coils, which are proportional to $N_{pole} \times t_{pole}$ and $N_{arm.} \times t_{arm.}$ respectively. If the connections be made so that these E.M.Fs. are opposing each other, there will be no deflection of the millivoltmeter for equal induced E.M.Fs.—that is, for $N_{pole} \times t_{pole} = N_{arm.} \times t_{arm.}$, or

$$\frac{t_{arm.}}{t_{pole}} = \frac{N_{pole}}{N_{arm.}} = \sigma.$$

Thus, by altering the number of turns of one of the coils until no deflection is obtained when opening the excitation, we immediately arrive at the required leakage coefficient.

Goldschmidt's method is of striking simplicity, and, in principle, far superior to the ballistic test for practical purposes. It is, however, not free from disadvantages.

In order to obtain results which are accurate within 1 per cent., the number of turns to be wound round the field poles and armature must be very high, the more so because it is not advisable to work with fractions of a turn, owing to the uncertainty as to what ratio the E.M.F. induced in this fraction of a turn bears to that induced in a complete turn. The trouble of winding so large a number of turns and of adjusting them, considerably detracts from the practical value of the method.

In the following, further zero methods for the direct measurement of the leakage coefficient, σ, are given. They require the use of resistances of known value, as contained, for instance, in a post-office box, and of a sensitive galvanometer always at hand in connection with the Wheatstone Bridge. They require only a very small number of turns, in many cases even a single turn being sufficient, and they also lead to very accurate results.

One turn of wire is wound round one field pole near to the yoke, and another turn round the armature as before. The two turns are connected in series across the outer terminals of the Wheatstone Bridge (Fig. 2), and the galvanometer is joined to the middle terminal and to the point where the two turns are joined together. The coils are so connected that their induced E.M.Fs. e_{pole} and $e_{arm.}$ act in the same direction, and are consumed in the resistances unplugged in the Wheatstone bridge. If these resistances are unplugged in such a way that, when opening or closing the excitation, no deflection is obtained in the galvanometer, then e_{pole} will just equal the drop in the resistance R_{pole}, and $e_{arm.}$ equal the drop in $R_{arm.}$ (see Fig. 2), and we thus obtain immediately the leakage coefficient

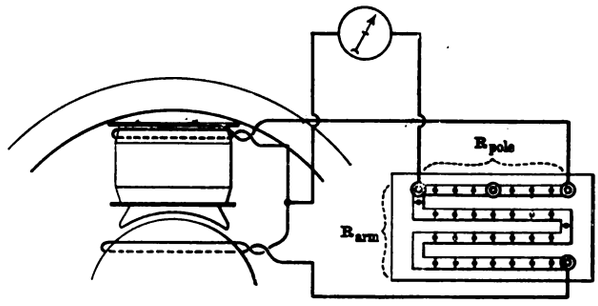

FIG. 2.—ZERO METHOD WITH FIXED NUMBER OF TURNS.

$$\sigma = \frac{e_{pole}}{e_{arm}} = \frac{R_{pole}}{R_{arm}}.$$

In carrying out the experiment we may insert 1,000 ohms in $R_{arm.}$ and increase R_{pole}, beginning with 1,000 ohms, until no deflection is obtained when opening the exciting circuit If, for instance, this is the case for R_{pole} equal to 1,150, σ will be equal to $\frac{1,150}{1,000} = 1{\cdot}15$.

The resistance of the turns will always be practically negligible.

Another form of the test, which is superior to the above on account of its higher sensitiveness, is as follows: The number of field and armature turns are again made alike. The ends of the field turns are now connected across the outer terminals of the Wheatstone bridge, whilst the armature turns are connected in series with a galvanometer or milli-voltmeter to one outer terminal and one middle terminal of the bridge, the arrangement being so that $e_{arm.}$ becomes balanced by a portion of e_{pole} equal to it, in potentiometer fashion (Fig. 3). Assuming the same leakage coefficient, 1·15, as before, we shall now have, for instance, $R_{arm.} = 1{,}000$ ohms, $R_{pole} - R_{arm.} = 150$ ohms; whereby, again, the galvanometer will show no deflection when the circuit is opened or closed. This method allows of very

* See *Elektrotechnische Zeitschrift*, 1902, p. 314.

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accurate determination of σ, and the time required for it is not more than a few minutes.

In testing it was found that, even for small machines, a satisfactory result could be obtained with only one turn each round field pole and armature. The galvanometer was of the moving coil type of high sensitiveness. If an ordinary millivoltmeter is used it will be necessary to have more than one turn; but, in most cases, three or four turns should suffice.

The method described above may also be used for quickly determining the distribution of the leakage. For this purpose the experiment may be carried out for a number of different positions of the field turn, which can easily be moved along the pole, and may also be wound round the yoke while the armature turn remains in its first position.

It need scarcely be mentioned that the leakage coefficient determined for low excitation will not be the same for higher magnetic saturations and loads; and that it is not possible, in this way, to find the value under normal magnetic conditions owing to the danger arising from the sudden breaking of the full excitation. As is well known, however, the leakage coefficient corresponding to any flux density and load may be easily calculated from the leakage factor at low saturation by means of the no-load characteristic and armature reaction curve of the respective machines.

As a third alternative the use of a differential galvanometer with additional non-inductive resistance in the circuit of the pole test coil may be suggested. This alternative is less practicable, as a good instrument of the type in question will only rarely be found in test-rooms.

If, now, the determination of the leakage coefficient of the auxiliary poles is to be executed, this may be done by one of

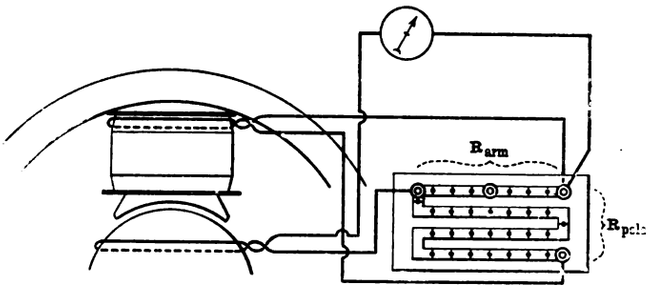

FIG. 3.—A MORE SENSITIVE ARRANGEMENT OF THE METHOD SHOWN IN FIG. 2.

the methods above described, preferably by the second one. In carrying out the experiment, the main field will have constant and normal excitation, while no current flows in the armature. The current in the auxiliary pole winding may be of such a strength that the ampere-turns of the auxiliary poles are equal to that portion of their full-load ampere-turns, which, under normal conditions, forms the magneto-motive force for the commutating flux. A coil of a series of turns is lying on the armature underneath the commutating pole, and another round the commutating pole as near as possible to the iron of the same, each coil having the same number of turns. The excitation of the auxiliary poles will then be broken and the resistance adjusted so that the deflection becomes zero. The experiment may again be repeated for different positions of the coil on the auxiliary pole. In order to obtain the leakage factor of the auxiliary poles under normal working conditions for full load, the relative value of the leakage flux found by the above experiment must be multiplied by the ratio of the ampere turns existing on the auxiliary pole at the respective load to the ampere-turns employed at the test. A further correction will be required should the auxiliary poles be unsymmetrically arranged between the main poles—*i.e.*, nearer to one main pole than to the other.

It will be found in practice that instead of adjusting the resistances carefully until no deflection is obtained, the result will sometimes be more accurately arrived at by plotting one or two positive and negative deflections of the galvanometer as functions of the respective values of $R_{pole}/R_{arm.}$, and connecting the points by a line, the intersection of which, with the zero line, corresponds to the desired value of σ.

A PERMANENT-LEAK WATER LIGHTNING ARRESTER.

BY LEWIS W. DIXON.

Owing to the importance of providing for lightning discharges on overhead networks, the following description of a water lightning arrester, recently erected at the Treforest power station of the South Wales Electrical Power Distribution Co., near Pontypridd, will be of interest.

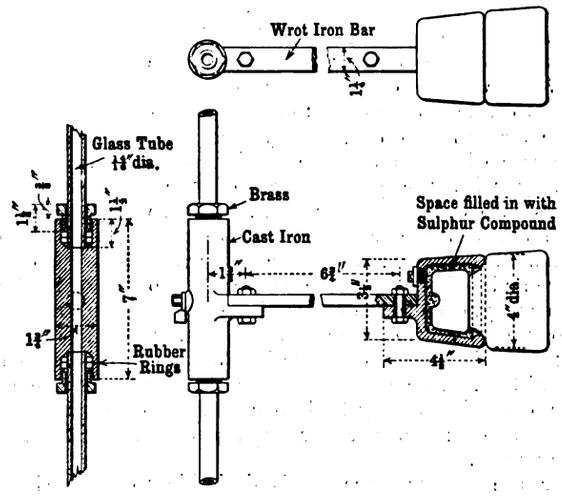

FIG. 1.—DETAILS OF INSULATED BRACKETS FOR CARRYING SOCKETS.

Before proceeding with the description I should like to mention that a somewhat similar type of arrester was seen at work by two of our engineers some 2½ years ago at the D'Avignonnet power station of the Société Grenobloise de Force et Lumière in the South of France, the working

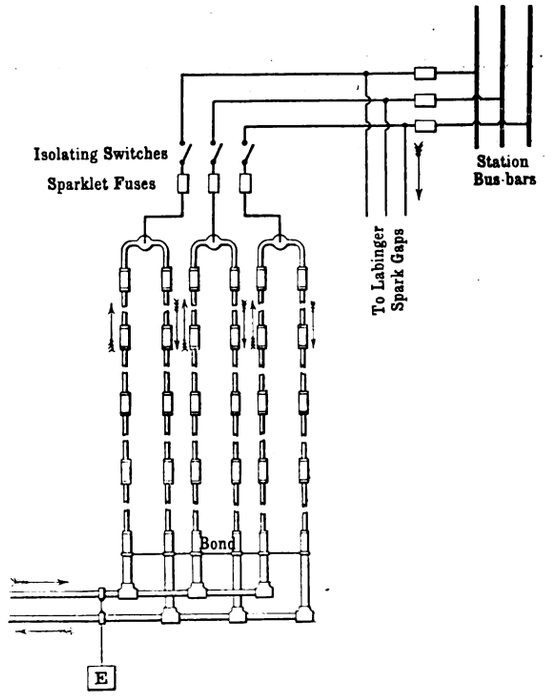

FIG. 2.—DIAGRAM OF CONNECTIONS.

pressure between phases being 26,000 volts. On hearing of this the writer designed a piece of apparatus on the same principle—but with several improvements—to cope not only with static charges and disturbances, but, if possible, with atmospheric discharges, which have caused a great deal of trouble

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at one time and another on the South Wales Company's extensive distribution system.

Two horizontal water pipes are provided, flow and return, efficiently connected with the neutral of the generators and the station earth plate. To the "flow" and "return," vertical pipes of glass tube are connected, jointed at the top to a special piece of glass tubing shaped like an inverted "U" having a glass bulb in the centre, into which the point of the line wire dips, being made water-tight at this point by a conical plug of indiarubber.

The 'flow' and 'return'

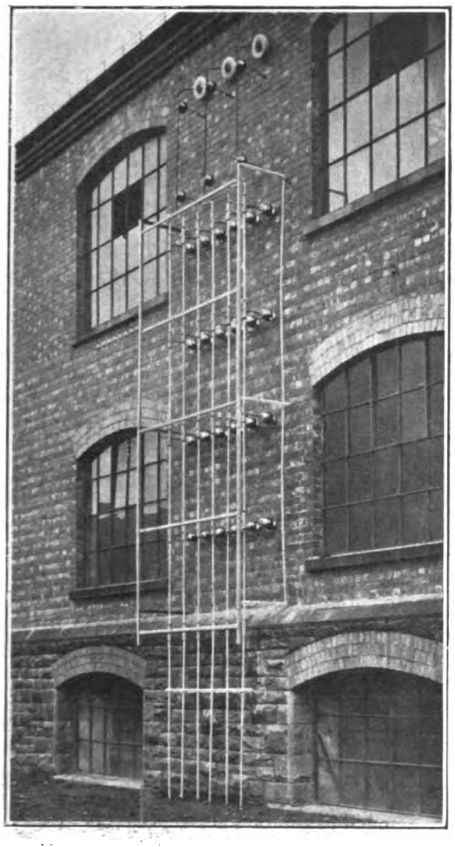

Fig. 3.—General Arrangement of Tubing.

The lines above referred to are protected by Wurtz spark-gaps, which, from all accounts, failed to act, as most of the energy went to earth from the "primary" to "earth shield" of one of the transformers at the Cambrian; but the fact of the spark-gaps having acted in the power station goes to show that the whole of the system was considerably disturbed thereby.

Another discharge occurred in the same district about two months ago, but this time the Wurtz arrester acted well, and we are inclined to think that the lines were not actually struck, but were affected by a discharge occurring in the immediate neighbourhood of the conductors, there being so little damage done.

It seems, therefore, that the use of permanent resistances will, at any rate, help to level off the usual surging and resonance phenomena one gets in underground and overhead mains, and we have every confidence, although we have only

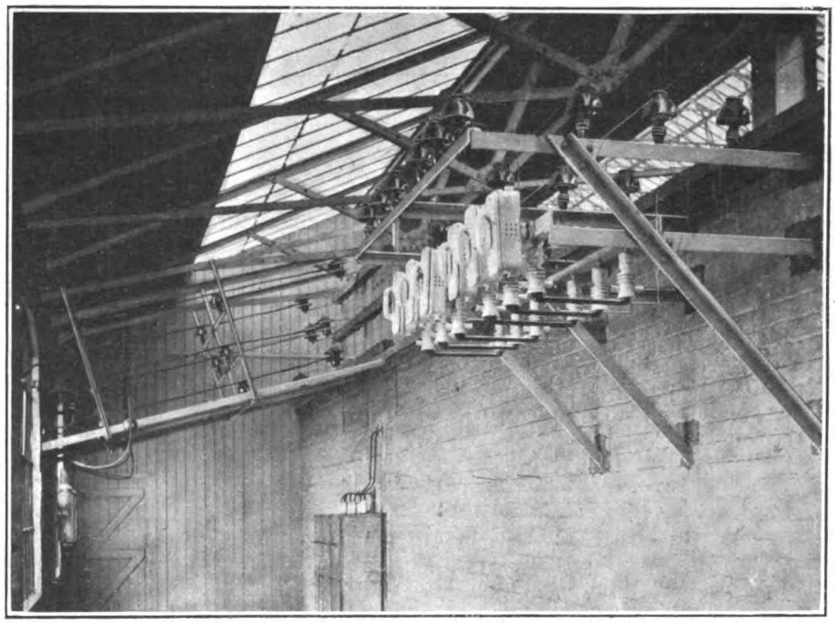

Fig. 4.—Arrangement of E.H.T. Switch and Fuse Gear, behind Main Switchboard.

through this loop of glass tubing represents the maximum resistance for one of the three lines, being approximately 700,000 ohms, which at the nominal pressure of, say, 6,800 volts that exists on the system, between line and earth, will give a leakage of about $\frac{1}{100}$ ampere.

The resistance in the three sets can be conveniently altered if necessary by connecting up any one of the rows of metal sockets to earth, which form the joints of the glass tubing. The sockets themselves are provided with gun-metal stuffing boxes with rubber insertion, with the addition of a 0·05 sq. in. cable connector; a leakage can thus be obtained if desired of about $\frac{1}{25}$, $\frac{1}{50}$, $\frac{1}{75}$ or $\frac{1}{100}$ ampere (the lengths of tubing below can be short-circuited for safety as well).

These sockets are firmly fixed to iron brackets supported on Locke insulators tested to 50,000 volts, which are cemented into the wall of the power house, as indicated in Fig. 1.

Fig. 2 shows the diagram of connections to the station 'bus bars (it being proposed to erect another set to act as a duplicate to the present one). It will be extremely interesting to know if it will relieve matters to any extent in the event of any of the overhead lines being directly struck by lightning, or by the action due to an atmospheric discharge in the neighbourhood, as on one occasion last winter, during a severe thunderstorm, all the Lahmeyer spark-gaps connected to the various feeders and 'bus bars in the power station were seen to act vigorously, an atmospheric discharge having apparently struck the company's 11,000 volt overhead lines between Ystrad Rhondda and the Cambrian Colliery, Clydach Vale, some 12 miles away from the power station.

allowed for the passage of a small current, that the effects from lightning discharges will be considerably lessened.

The two accompanying photographs show the general arrangement of the apparatus, Fig. 3 showing the glass tubing, &c., outside the building, and Fig. 4 the arrangement of the switch and fuse gear fixed to the wall behind the main switchboard.

THE PUPIN TELEPHONE CABLE ACROSS LAKE CONSTANCE.

Summary.—In this article an account is given of the difficulties experienced in manufacturing and laying a cable with Pupin coils, and the results obtained are compared with those obtained on ordinary telephone cables.

Two types of cable have up to the present been used in telephone work for crossing short arms of the sea. The first type consists of a gutta-percha covered cable, in which the influence of the self-induction on the speaking power is not noticeable. Endeavours have been made with this kind of cable to keep down the resistance and the capacity. A decrease in resistance is obtained by an increase in the size of the copper conductor, and the simplest way of lowering the capacity is by increasing the thickness of the gutta-percha covering. An example of this simple arrangement is the four-core telephone cable laid between England and Belgium. A large decrease in

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the charging capacity can be obtained for the same dimensions if the four conductors in a cable of this kind are provided with a common gutta-percha covering. This method has been employed on the telephone cable between London and Paris.

In the second type of cable, self-induction is used for decreasing the damping of speech. The self-induction is distributed equally over the conductors, by giving the cable a covering of iron wire. This method has been employed both on gutta-percha and lead-covered cables. Two cables of this kind were laid by the Felten & Guilleaume A.-G. between Refsnaes and Soelvig. The first had a simple gutta-percha insulation, the second was lead-covered. The largest number of cores that can be laid up in these cables is four, or two complete speaking circuits, the two opposite conductors making up one circuit. As each conductor lies symmetrically with regard to both con-

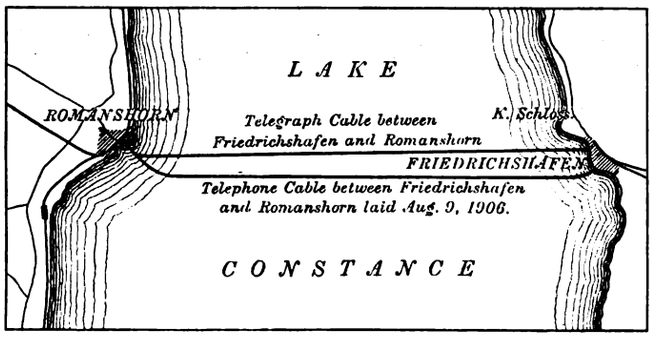

FIG. 1.—MAP OF THE ROUTE FOLLOWED BY THE TWO CABLES ACROSS LAKE CONSTANCE.

ductors of the other circuit, there is no cross-talking between the two. All these cables are laid in comparatively shallow water in the Baltic and North seas at a maximum depth of not more than 27 fathoms. An increase of the self-induction by the use of an iron-wire covering is only possible up to certain limits, and the capacity is also greatly increased by this method, if the diameter of the cores—*i.e.*, of the insulating covering, is not increased at the same time, so that a cable of this kind is very expensive.

The self-induction can also be raised and the damping at the same time considerably decreased without any capacity being added, by the use of the Pupin system, although the resistance is increased by an amount equal to that of the coils. A Pupin cable is, of course, considerably cheaper than a cable with distributed self-induction. There is no difficulty about connecting the coils in cables laid underground, and a large amount of work has already been done on this system. In submarine work, the employment of these coils gives rise to great difficulties, as they must be placed in circuit before the cable is laid. In order that these difficulties might be overcome and put to a practical test, Messrs. Siemens & Halske were desirous that the length of the first cable laid should, if possible, not be too great, and the requirements of the Generaldirektion der Königlich Württembergischen Posten und Telegraphen for a telephone communication between Friederichshafen and

FIG. 2.—DIAGRAM SHOWING THE PROFILE OF THE LAKE BOTTOM.

Romanshorn for the states of Bavaria, Wurtemberg and Switzerland seemed to be a suitable object for the first trial of a Pupin submarine cable, as the distance is only about 9½ miles. As it turned out, certain circumstances arose which rendered the matter far from easy. Thus, the maximum depth of Lake Constance by the route by which the cable was laid is relatively great, the number of speaking circuits was fixed at seven, and the cable could not be brought to the locality for laying by ship, but had to be transported by rail.

As a telegraph cable was already in existence between Friedrichshafen and Romanshorn, the new cable had to be kept at a certain distance from it. The general route is shown on the map (Fig. 1), and the profile of the lake bottom is shown in Fig. 2. Although the contour is different on the two sides, yet it gradually falls to a deep channel which traverses the whole length of the lake. The maximum depth of this channel is 138 fathoms, which depth is almost reached by the cable, the difference being only a few fathoms. The cable had to be capable of standing the water pressure, which at this depth is about 25 atmos. Tests made on this point show that a longer time under a pressure of 25 atmos. is the same as

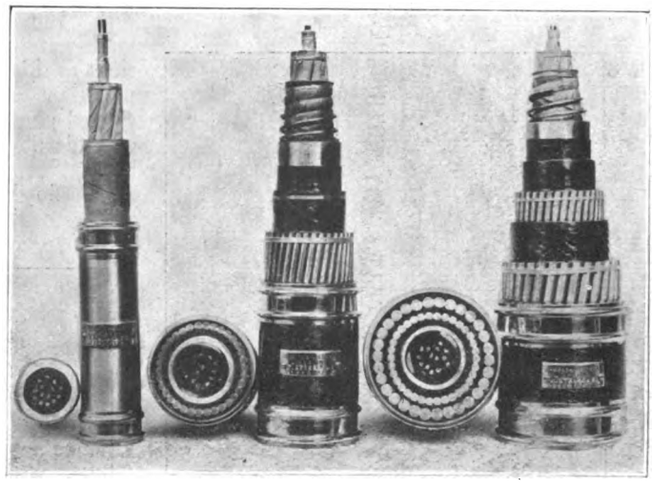

FIG. 3.—TYPES OF CABLES.

a shorter time under higher pressures, and, as the preliminary investigations could not be very extended, the lower pressure could not be taken as a standard. A factor of safety of six was considered to be sufficient, and therefore all standard tests were carried out for short periods at 150 atmos. In this case only a lead-covered cable having seven circuits was tested.

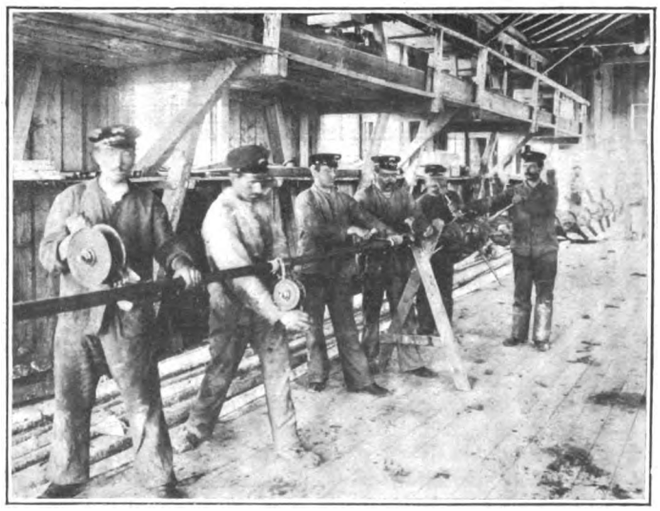

FIG. 4.—OPERATION OF CONNECTING THE PUPIN COILS IN THE ALREADY ARMOURED CABLE.

The cores could not be allowed to sustain the pressure, and the capacity had to be kept down. The lead sheath had therefore to be given sufficient strength to prevent the conductors being pressed together. To obtain this strength by increasing the thickness of the lead sheath would have been too expensive, for tests showed that even a sheath 5 mm. thick was not sufficient protection against the maximum water pressure. The diameter of the core, which was about 25 mm., had a considerable influence in these tests. A hollow tube of pure lead offered the least resistance to pressure, and tinned lead was only slightly better. When the lead tube contained a core the resistance was only increased very little. If the pressure was made great enough the lead tube and cable core were pressed together. The deformation occurred at the place where the

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resistance was least, and thence spread along the whole length of the test piece. Time was also a factor, as a piece which stood a certain pressure for half an hour was pressed flat after two hours. At a pressure of 50 atmos. all the test pieces of the above kind were forced out of shape, and as a result all ordinary cables were excluded. That the core did not hinder the deformation was clear, but it influenced its shape. A means had to be found for providing the cable with sufficient artificial stiffness and resistance, without prejudicing its flexibility. The problem was solved, in this case, by covering the core with

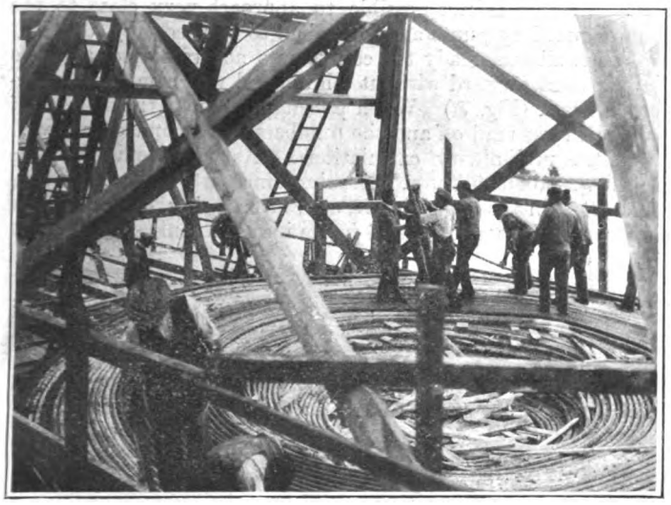

FIG. 5.—LOADING THE CABLE ON BOARD THE LAYING SHIP FROM THE RAILWAY TRUCKS.

steel wire spirals, over which the lead covering was pressed on. The diameter of the steel wire chosen was 2 mm. A length tested under a pressure of 150 atmos. showed no deformation. Different thicknesses of wire might have been used for different depths, but for simplicity, and owing to the fact that there was no time for further tests, the same wire was employed throughout the submarine portion and for the shore ends. The land cable only was manufactured in the usual way without the protecting wire. Fig. 3 shows the types of cable used, the land, submarine and shore ends. In the middle is the submarine cable. It is armoured with 32 iron wires 3·75 mm. in diameter. On the right-hand side is the double-armoured shore end. The inner armour is the same as in the submarine cable; over this is a jute covering, and the second armouring consists of 30 wires 5·4 mm. in diameter. The land cable, which is an ordinary lead-covered cable, is shown on the left-hand side.

It was specified that the whole of the submarine cable should be fitted, every 600 yds., with arrangements for preventing water which might be forced in through a fault from getting over the dividing piece. This problem was solved at the same time as that of connecting the Pupin coils in circuit. As the coils have a larger diameter than the cable cores, the leadsheath at the coils must necessarily be thickened. These places had, of course, also to withstand a pressure of 25 atmos., and they were therefore exposed for a longer time to a continuous pressure of 150 atmos.

The coils are circular, and are connected in circuit with one conductor. Through their centre passes one of the conductors, with which they are *not* connected. They are separated by dividing pieces. The connection between the cylindrical coil and the cylindrical cable is made by a conical piece which serves as the division and prevents the advance of water in case of a fault. There are two of these conical pieces to each coil, and it is provided on both sides with a watertight joint. This joint is made by replacing the hygroscopic paper insulation by an indiarubber sheath and winding over it a conical steel wire spiral. Tests have shown that this arrangement works very well. With a pressure of 75 atmos. some drops only were admitted after a very long time, while at lower pressures no water at all got through. The coils are connected into the double wire circuits every 1,100 yds. They were inserted in the already armoured cable every 550 yds., the core being stretched at the place by a pull of about 2 tons while the operation was carried out by hand (Fig. 4).

Although the submarine cable was only about 9⅓ miles long, the laying had to be done with a proper machine, such as is used for deep sea work. The weight of the cable was not inconsiderable, and when paying out at the deepest places a pull of about 2 tons had to be taken into account, an amount which might have become unruly. A pull of this kind could not be regulated with an ordinary friction brake. In order to erect a suitable machine certain minimum dimensions were requisite on the cable ship. The cable was loaded from the railway wagons on to a ship, which was capable of carrying the necessary machinery comfortably, as well as 110 tons of cable. It was laid in a ring on deck at the fore end of the ship, while the laying machine was built aft.

At the first unsuccessful attempt, which took place in the autumn of 1905, an old laying machine belonging to the well-known cable ship "Faraday," the property of Messrs. Siemens Bros. & Co., was used. The diameter of its drum was only 5 ft. 8 in. and the cable with its thickened coil sections had to be wound over it, for which purpose it was rather small. For the work in the summer of 1906 a specially built laying machine with a larger drum diameter (8 ft.) was used. This was designed by Herr Weiss, a specialist at this work, and was built by the firm of Fr. Gebauer, in Berlin. The machine worked very well. It was substantially of the same form as those used on ordinary cable ships, but was specially noteworthy for the fact that the size of the sheave over which the cable ran out was not greatly increased. As the coils were distributed over the cables there might be irregularities in laying, owing to the unevenness

FIG. 6.—COMMENCEMENT OF LAYING, AUGUST 8, 1906, SHOWING THE TWO SHIPS.

in the running out, and during the first laying this unevenness caused the cable to spring off the roller. In order to avoid this, guides were provided in front of the wheel. The dynamometer, which served the purpose of checking the amount of pull, was also made larger, as was the run-over roller at the bow of the ship.

As the laying of this cable was really deep sea work, in which it is necessary that cable should not be paid out too quickly, all necessary arrangements were made to provide for smooth operation. For this to be done the cable had to be under control until it reached the water, and to ensure this a wooden staging was used. On the top of this staging above

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the cable ring was fixed the guiding roller, and the cable ran in a slot from this roller to the bow of the ship. The cable was loaded on to the ship so that it could be unwound smoothly, for the laying speed must not be too slow. The loading of the cable on to the ship was carried out by the laying machine, the needful steam being supplied from a small boiler. Fig. 5 shows this being done. On the completion of the loading the cable ship was bound broadside on to the laying ship, the "Württembergischer Salondampfer König Wilhelm." Manœuvres undertaken by the combined ship (Fig. 6) gave good results even in a high wind and heavy sea. The weather during laying was not very clear. In order to keep as good a course as possible with the double ship, which was rather hard to steer, buoys were fixed on both sides of the 138 fathom channel, and in this way the route between Friedrichshafen and Romanshorn was divided into three sections of about 3 miles each. Determinations of the right course were made by the sextant and checked by sounding. For this latter a very simple apparatus was used, which combined the functions of a paying out and a measuring machine as well as a dynamometer. A lead weight was let down at the end of a thin steel wire and the amount let out measured by passing the wire over a small dynamometer drum, which indicated the moment the lake bottom was reached, as the pull was then taken up.

The buoys were set out in the usual way. Before the proper laying a preliminary laying, to test the certainty of action, was undertaken at different depths and in the deepest place with a short length of cable in which were several coils. One end of the cable was anchored and the rest paid out at a high speed. The cable was laid and relaid several times, and was also dragged along the lake bottom for some distance. The results showed that success might be relied upon, and although the jute serving was completely torn off, the coils themselves were undamaged.

The laying was begun on the morning of August 8, 1906. After about 1½ miles had been laid a fault developed and the cable had to be drawn out. A test showed that the fault was in the shore end and in the neighbourhood of the first coil. As it was suspected to be in the coil itself this was cut out. However, it was not there, but a short distance from it in the lead sheath. It was satisfactorily shown that a principal fault—*i.e.*, a fault which occurred from connecting in the coils—was not present, and the laying was begun afresh the next morning, the damage having meanwhile been repaired. The "König Wilhelm" towed the cable ship as near as possible to the shore, the cable end was taken out and drawn into the measuring room, which was a room in a private house primitively adapted for the purpose. The cable was fastened to the shore so that it could not be damaged by anything passing, and was buried in a trench which had been previously dredged out. As it was not possible to approach very close to the shore, auxiliary punts and boats had to be used (Fig. 6).

When all was ready the course was accurately set and the laying went forward without a hitch and was completed without a break (Fig. 7.) When passing the buoys the amount of cable laid was read off and the numbers corresponded very well with the preliminary calculations. As the average laying speed was about 5 knots, the submarine part of the cable was completed in about two hours, and, after laying, the cable was kept under inspection for 24 hours in case a fault should make its appearance. The ship then returned to Friedrichshafen, taking up the buoys on the way. The next day the splice between the submarine cable and the shore end at Romanshorn was made. This shore end had been laid some days previously and its end fastened to a buoy. After the splice was made on the ship a coil was connected in circuit and the cable sunk in the lake. The shore end was then jointed to the land cable, which completed the laying proper.

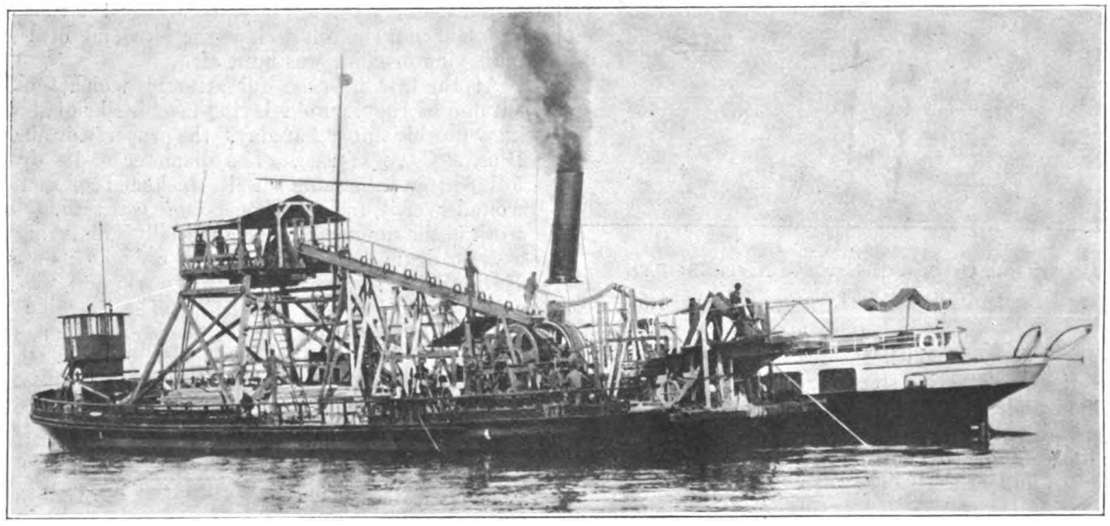

Fig. 7.—Laying of the Cable in Progress.

From the foregoing description it follows that the laying of the first Pupin submarine cable solved a mechanical problem. The peculiar conditions were fortuitously arduous, and probably as a consequence an earth occurred on one of the cores, about a month later, at a place where the water pressure was greatest. There was a coil in the faulty section, but not in circuit with the conductor on which the fault occurred. It is admitted that this was due to a mistake

Table.—*Comparison of the Details of Some Modern Telephone Cables.*

Cable.	Construction.	Capacity. Mfd.	Self-induction. Henries.	Resistance. Ohms.	Damping factor.	Cross-section. Sq. mm.	Diameter. Mm.	Total range. Km.
1. Refsnaes–Soelvig	Gutta-percha. Three iron wires, each 0·2 mm. diameter	0·12	0 0087	4·55	0·0084	8·6	3·3	300
2. Fehmarn-Laaland	Lead-covered. Iron wire, each 0·3 mm. diameter	0·082	0·0050	5·34	0 0105	10·0	3·6	238
3. Cuxhaven–Heligoland	Lead-covered, Iron wire, each 0·3 mm. diameter	0·044	0·0043	3·80	0·0065	12·6	4·0	385
4. Friedrichshafen–Romanshorn	Pupin cable.	0 039	0·21	3·35	0·0072	1·77	1·5	347

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in laying, which is quite conceivable considering the attendant circumstances. All the other cores were unaffected and remained well insulated. In connection with the working of the Pupin system, it is only necessary to point out that in all cases where these coils have been fitted the operation has been good.

However, some remarks on the speaking power of the Lake Constance cable are here put forward. The operation of a cable circuit depends on the values of the resistance, self-induction and capacity. The damping factor is taken as a basis of comparison. For cables with high self-induction, as in the Pupin system, the relation is

$$B=\frac{R}{2}\sqrt{\frac{C}{L}}\cdot 10^{-3},$$

where R is the working resistance in ohms for the double circuit, L is the self-induction in henrys, C is the capacity in micro-farads per kilometre. The resistance is the sum of that of the conductors and the coils. The stranded copper conductors have a cross-section of 1·77 sq. mm. The guaranteed resistance was 20 ohms per kilometre of double wire. The resistance of the coils was guaranteed to be 20 ohms, so that the total guaranteed resistance per kilometre was 40 ohms, while the actual resistance worked out at 33·5 ohms per kilometre. The guaranteed capacity was 0·05 mf. per kilometre; the actual value was 0.038 mf. per kilometre. The guaranteed self-induction was 0·20 henry, while the actual was 0·21 henry. The alternating current used had a frequency of 900. B is thus equal to 0·01 guaranteed or 0·0072 actual value. Prof. Breisig, in the *Elektrotechnische Zeitschrift*, 1905, p. 385, gives a summary of the values for submarine telephone cables with constant self-induction.

In the above table the three most recent of these cables are shown with their best results. The first is a guttapercha cable with a covering of three iron wires, each 0·22 mm. in diameter. The second and third are lead-covered with an iron wire covering. The fourth is the Lake Constance cable. The damping factor in all four cables is about the same. The Lake Constance cable is nearly equal to the cable with the lowest self-induction—that from Cuxhaven to Heligoland—but while the latter has a cross-section of copper of 12·6 sq. mm., the former has only 1·77 sq. mm., or about one-seventh. It requires no confirmation to show that the Pupin cable, with its smaller cross-section, is cheaper. It is more easily repairable than when the self-induction is distributed, and if the cross-section of copper were raised the working capacity would also increase.

We are indebted to Messrs. Siemens and Halske for the particulars here given.

THE VERITY DALZIEL SYSTEM OF TRAIN LIGHTING.

Summary.—A description is given of a system of train lighting in which the lamps are supplied at a constant voltage, the regulation being effected by purely electrical apparatus. The machine employed for this purpose is practically a reversible booster, which maintains the lamp voltage constant by giving a positive or negative boost to the dynamo voltage. An arrangement is provided for switching over to a battery when the train comes to rest or slows down.

Some few months ago* we gave a general description of a train-lighting system invented by Mr. Dalziel, of the Midland Railway Co. The original arrangements, although working in a perfectly satisfactory manner, have been submitted to various minor improvements, and we are now able, through the kindness of Messrs. Veritys (Ltd.), to amplify the details of the former article and to give the theoretical reasons which led to the adoption of this design.

The system is designed to obtain lighting direct from the dynamo, thus securing great economy in capital outlay and maintenance owing to the small size of the battery required and the limited amount of work it is called upon to perform. One battery only is employed, and this is used solely to supply current to the lamps when the train is standing or running at very slow speed. The system is essentially a constant voltage one, electrically regulated, and, so far as the regulation is concerned, is absolutely independent of the battery. The voltage is also independent of the demand for current. Greater control of the lighting can, therefore, be allowed to the passengers—a detail of consideration to night travellers which incidentally secures greater economy in running. The system is designed for 50 volts, which voltage secures the use of small cables, and in the case of block trains secures greater uniformity in lighting owing to the lower proportion of the voltage drop. The adoption of 50 volts permits the use of metallic filament lamps, thus securing high efficiency in running.

The system consists of the following parts: generator, regulating machine, battery, automatic switch box, guard's switch, and the usual installation and wiring. Only two sets of adjustments are required. One is made on the automatic switches; the other is on the voltage adjuster which is contained within the switchbox. These are both independent of interchange of apparatus, and when once made are permanent.

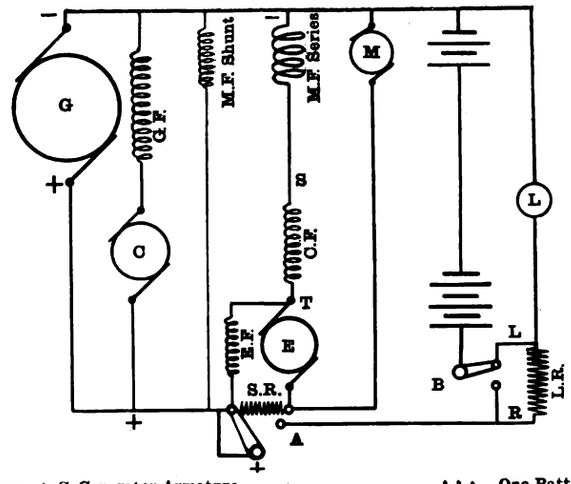

FIG. 1.—DIAGRAM OF CONNECTIONS.

Fig. 1 shows the electrical arrangement of the parts. G represents the generator armature, and GF represents the generator shunt field.

The generator (Fig. 3) is of the usual construction, designed to be slung under the coach and belted up to an axle pulley so as to run at a speed proportional to the train speed. This generator is devoid of all complications in the form of governing gear, but it is

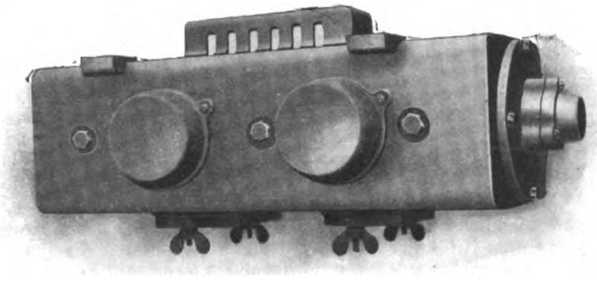

FIG. 2.—THE REGULATING MACHINE.

fitted with an automatic reversing switch for changing the connections when the coach direction is changed. The reversing switch is exceptionally strong in construction and is designed to secure the greatest accessibility for examination. Means are also provided for rapid examination of commutator and brushes. All other details of the generator are strictly in accordance with the most recent practice. Referring to the diagram (Fig. 1), C, E and M represent the three small armatures, controller, exciter and motor of the regulating machine (Fig. 2). CF, EF and MF represent their respective field coils.

It will be noticed that the motor has a series field coil connected as shown. The three armatures are of very small size, and are mounted on one spindle, so that all three run together. Each rotates in its own field, but the three fields have a common yoke, consisting of a box casting containing the complete regulating machine. This part of the equipment may be fixed anywhere under the coach, as it is driven electrically and is a fixture. Its dimen-

* *The Electrician*, Vol. LVII., p. 689.

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sions are decided on mechanical considerations only and remain the same for any size of generator in ordinary use. The diagram also shows the motor starting resistance S R, the automatic switch A, which is designed to operate at a predetermined generator voltage for the purpose of connecting the generator circuit to the lights and the automatic switch B, which works at a predetermined voltage across the controller C, in conjunction with the zero current from the battery to the lamps. This switch connects the battery direct to the generator, the latter then supplies current to the lights through the resistance L R. The relative arrangement of battery, lamps and switches is shown in the diagram (Fig. 1).

Before entering into a description of the operation of the system it should be noted that the armature of the controller C constitutes a reversible booster, which boosts up the line voltage at low speeds and opposes the line voltage at high speeds in order to secure correct

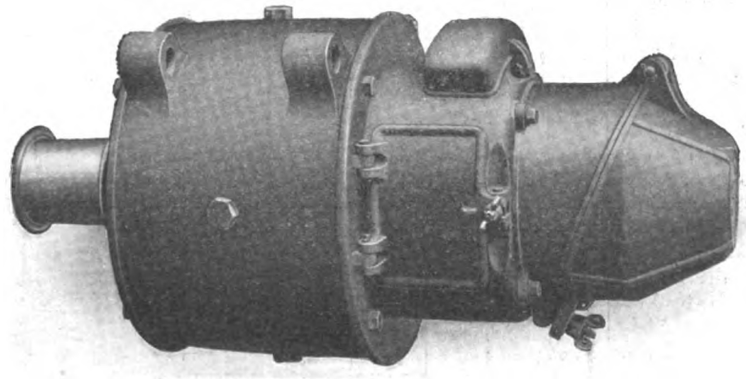

FIG. 3.—VIEW OF GENERATOR.

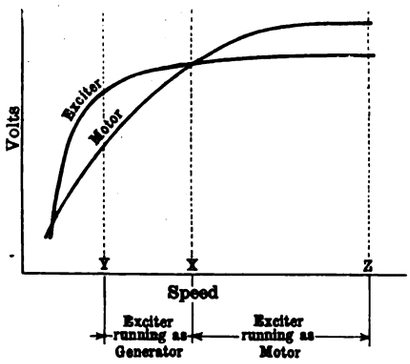

FIG. 5.—CURVES SHOWING ARMATURE CHARACTERISTICS OF EXCITER AND MOTOR.

field excitation at any speed and thus constant line voltage. Attention is also called to the motor and exciter characteristic curves. Fig. 4 shows an ordinary field saturation curve. The motor field is liberal in iron and is comparatively weak, the limits of excitation lying within the thickened parts of the curve. The exciter field for an exactly similar armature has less iron and is comparatively strong, the limits of excitation lying within the thickened portion of the saturation curve marked Exciter in Fig. 4. The armatures M and E being identical, will therefore under the above conditions give different B.E.M.F s when they are supplied with current from a common source, and their behaviour is shown in Fig. 5. The arrangement of connections in the system is such that M is always a motor, and will give a B.E.M.F. as shown by the curve in Fig. 5.

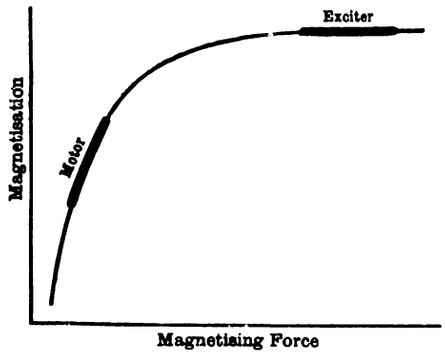

FIG. 4.—CURVE SHOWING MAGNETISING FORCES IN MOTOR AND EXCITER

The armature E being rigidly attached to M, and run in a field of different character, will give a B. E.M.F. curve of another shape, having a higher value at speeds below X and a lower value at speeds above X. The result of this is that the exciter is a generator at speeds below X, but becomes a motor at speeds above X. The extreme limits of regulation are comparatively between lines Y and Z. The generating or motoring direction of current through the exciter circuit (and therefore through the controller field coil CF) causes the controller C to give a positive or negative boost to the dynamo field as required. The whole of the running regulation, however, is practically contained within certain limits between the lines B-Z in Fig. 6, which shows clearly how a perfectly steady voltage is imparted to the generator under the governing influence of the regulating machines.

The actual operation of the system is as follows: Figs. 1 and 7 show the position of the switches A and B as they are in a standing train. It will be seen from Fig. 1 that the generator and regulating portions of the system are isolated on one pole, and that the battery is supplying the lights direct. The switches A and B are retained by gravity in the positions shown, but switch B is held down electrically in this position by the battery discharge current for a purpose which will be described later. On the train starting the reversing switch on the generator is automatically turned over, if necessary, to secure the correct polarity with the train direction. The generator self-excites and supplies current through the controller armature to its own shunt field, to the motor shunt field, and through the starting resistance SR to the motor armature, thus enabling the regulating machine to run up to speed as the train speed and the generator voltage increase. The voltage speedily rises, and, at a train speed of about 15 miles per hour, reaches approximately 45 volts. At this voltage the switch A has been adjusted to operate, and, rising, it short-circuits the starting resistance and connects the generators to the lights and belting through the resistance LR. The immediate effect of the closing of switch A is that the exciter *generates*, and current flows in the exciter circuits in the direction – STE +. This stage is shown in Fig 6 at A. The controller field is, therefore, excited in the direction which causes the controller to boost up the voltage on the generator field winding, which in turn raises the generator voltage to 55. The dynamo now begins to supply current through the resistance LR to the lights. When the voltage has risen to 57 or 58 the dynamo is supplying all current to the lamps through the resistance LR which drops about 7 volts, and no current flows from the battery. The switch B now operates (being no longer held down by any battery discharge current) and turns the battery over to the dynamo direct. The dynamo continues to supply current to the lamps and now also gives a steady current to the battery, which current will gradually decrease as the battery becomes more fully charged. The switch B rises at a train speed of from 17 to 18 miles per hour, and as the dynamo is then supplying the lamps, no perceptible flicker in the light takes place. Between the closing of switches, A and B, the rise of generator volts passes the line × in Figs. 5 and 6, and the exciter thereafter becomes a motor, reversing the controller excitation, which therefore boosts down the voltage on the generator field. As the train speed further increases, the motor current through the exciter circuit rises and by means of the motor series coil strengthens the motor field, thus reducing the speed of the regulating machine. The standard voltage of the exciter is

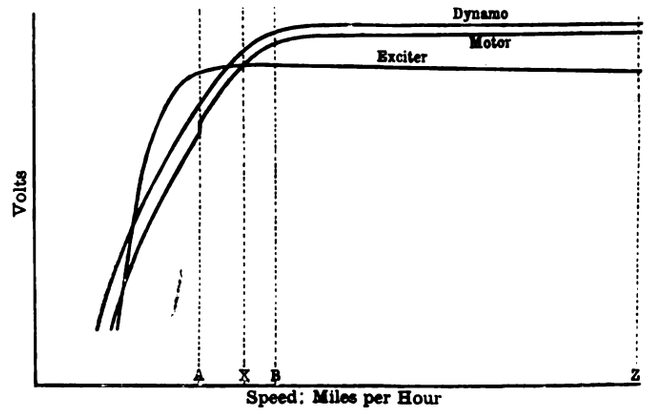

FIG. 6.—CURVES SHOWING THE EFFECT OF REGULATING MACHINE ON DYNAMO VOLTAGE.

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therefore reduced, the current through its circuit is increased, and the controlling effect is further increased in such a manner as further to boost down the generator field voltage, thus maintaining a steady line voltage. The line voltage variation between the minimum and maximum train speeds after the closing of B switch is so small as to be imperceptible, and the system is so designed that it would even be possible to generate a lower line voltage at higher speeds, if such were desirable. As the train speed decreases, the sequence of regulation takes place in the reverse order, and a critical speed is ultimately reached at which the dynamo, in order to generate its standard voltage, will require little or no negative boost to its field, GF. There will then be insufficient voltage across the armature C to maintain the switch B in a closed position, and this switch falling connects the battery direct to the lights. A still further decrease of train speed releases the switch A, which drops to its original position. The battery alone now supplies current to lights.

Fig. 7 shows the switch arrangements, which are contained in a locked polished wood box, and can be placed in a corridor, above a hat rack, or in any convenient spot. The magnet D is excited by the discharge current and performs the double function of (1) holding down the switch B while the battery is discharging, releasing it when the current falls to zero in a starting train, thereby preventing disturbance in the lights, and (2) in the event of an over discharge of the battery (which may take place owing to the lights having been left on in a disused train), holding down the switch B with the charging current which will pass to the battery through the lamp resistances until the battery has recovered itself to such an extent that it will not take an abnormally heavy current when it is connected direct to the dynamo.

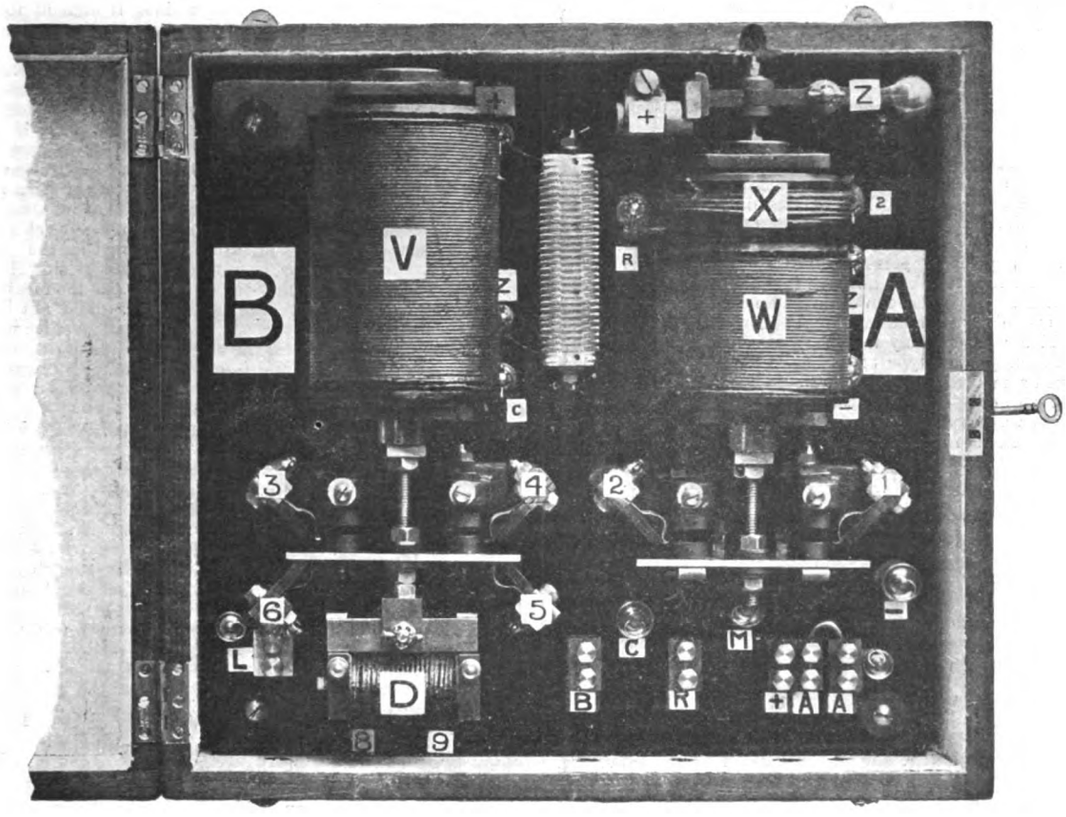

FIG. 7.—VIEW OF REGULATING APPARATUS.

The series coil X on the switch A (Fig. 7) is excited by the total dynamo current, thus giving to the solenoid increased holding power on top load. The coil V on switch B is excited by the voltage across the controller armature and therefore has an increased holding power at top train speeds. The switches are therefore totally unaffected by train vibrations.

SOME NOTES ON UNDERGROUND MAINS.

The following adjourned discussion took place at a meeting of the Leeds Local Section of the Institution on April 25th on Mr. Rogerson's Paper of which we gave an abstract in our issue of April 5th, and the first part of the discussion on which we gave in our issue of April 12th:—

Mr. G. G. L. PREECE said he was quite in agreement with Mr. Rogerson as to the desirability of using a soft and sticky compound which would flow quite easily at low temperatures, and therefore get into every corner of the box, and yet form a solid compound with no tendency to run away at all ordinary working temperatures. He was in disagreement with Mr. Dickinson who would certainly be able to use his fittings again, if using a sticky compound, by the application of a little paraffin. He understood Mr. Dickinson preferred a more hard and brittle compound on account of being able to chip it away and leave his fittings clean. The experience of the speaker's firm—a large experience—at all events supported the use of a soft and sticky compound—the compound known as "diatrine"—and they were constantly using this compound both for low and high-tension work, though it was more expensive than the usual harder compounds which at one time they used for low-tension work. There was certainly a good deal of electrolytic action on lead-covered cables going on, and there were two methods which might overcome same: either you would have to insulate the cables altogether, or have your lead sheathing continuous and bonded. The former method seemed to be almost impossible—at any rate for towns with a decent-sized supply system—but one could always use the second method and connect the leads together. The difficulty lay in the bonding, and each system must certainly be considered on its own merits and conditions, for it was impossible to lay down a hard-and-fast rule such as earthing at one point—the generating station. This might be quite wrong, and in some instances injudicious bonding to earth had been carried out and caused more trouble than if no bonding at all had been attempted. He thought Mr. Rogerson was right when he said that the source of current which was most likely to cause electrolytic action was the leakage current which got on the lead through imperfectly-made joints or end connections; you had there the main reason why lead-covered cables had in many cases been deemed unreliable and also why lead-covered paper cables for ordinary house installations failed in many instances—simply because of end leakages. Such points, therefore, ought to be carefully attended to. He might say that this question was treated very fully in Messrs. Atkinson and Beaver's Paper on "Some Points on the Selection of Electric Cables," read before the Manchester Section of the I.E.E. on January 31, 1905, and reprinted in full later in *The Electrician*. In referring to vulcanised cables Mr. Rogerson had said he did not think that the general quality of rubber cables to-day was as good as 10 or 12 years ago. He did not agree with him for, as a matter of fact, rubber cables were made far more satisfactorily now than they were 12 years ago. He thought that there was a great deal of harm taking place due to the use of cheap rubber cables, especially in house wiring, and he was sure that in time, if continued, its effect would be prejudicial to the increase of electric

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lighting in houses. The usual wiring and installation rules issued by Corporations specified an insulation resistance test after the building was wired, which was practically useless. Bare wire in dry buildings would probably pass that test. Other rules specified 300 or 600 megohm wire; they did not say 300 or 600 megohm grade to British cable makers standards, or at least only one or two did; that would be going in the right direction. It seemed to him that a paragraph should be inserted in the wiring or installation rules specifying that a definite amount of hard fine pure Para rubber should be used in the wire or cable, the compounds to consist solely of such Para rubber mixed with sulphur and mineral matter only. The proportion by weight of such hard fine Para should be at least 30 per cent. for all voltages up to 250 volts, while in the case of 500 volt cables this weight should be increased to 40 per cent. With regard to Mr. Rogerson's remarks on bitumen cables there certainly would be trouble where they came into direct contact with alkaline matter, and he would again refer them to Messrs. Atkinson and Beaver's Paper previously quoted. There was no doubt that bitumen cables were best when laid on the solid system and the most satisfactory solid system to his mind was the asphalt trough system, as no bridge pieces were used. Decentralisation was practically got over by the use of paper as an insulating separation with a bitumen sheath overall; this type of cable was very popular at present especially on tramway work. He was surprised Mr. Rogerson had not mentioned asphalt bridge pieces. These were excellent. He must confess that he himself favoured the armoured lead-covered paper cable laid direct in the ground with lead sleeve joints, which was probably the cheapest and at the same time quite as efficient as any other type of cable. He made the provision, however, that such armoured cable should have the protective materials well impregnated with compound, *i.e.*, the cable should be a solid system in itself. The cost was very slightly more, perhaps 1 to 2 per cent., but they would get the benefit in the extra life of the cable. There was a matter which Mr. Rogerson did not appear to have dealt with, and that was trouble due to moisture getting in at the ends and travelling down the strands of the cable. There had recently been put on the market a cable designed to prevent such trouble. This cable had the interstices between the strands of the conductor filled up solid with a special compound which would not run or become displaced when overheated. This was certainly a splendid thing, and was particularly recommended with bitumen cables, and it was practically a preventative against carelessness in leaving cable ends open and unsealed. There was a consideration which made it hardly quite the same success for distributors and services on ordinary work, and this was that considerably more time would be spent in jointing owing to the sticky nature of the compound. He had taken some costs out and found, as Mr. Rogerson said in his Paper, that three single cables came out cheaper than a multicore cable. The actual cost of the cables was appreciably less, and the extra cost of ducts and laying was very little, and did not make up the difference. Therefore it was beneficial to lay three single cables on the score of price, and personally he considered them more convenient and efficient. He considered that plumbed lead sleeve joints were better than ordinary joint boxes for straight joints on lead-covered cables. He did not know the reasons in favour of boxes, or why they were popular; perhaps it was that with the cast-iron joint box people thought they could dispense with a very skilled man. He thought it a mistaken idea, for a good deal of skill was required for the making of an efficient joint in a box, and therefore a skilled man was as necessary as in the case of plumbed lead sleeves. As an alternative to the lead sleeve made on the spot—and the joint box especially—a cast lead sleeve which had just been put on the market by Messrs. Glover & Co. of Manchester might be used on straight joints.

Mr. S. D. SCHOFIELD said he was quite in agreement with Mr. Rogerson upon the main points. For feeders for lighting purposes he (the speaker) preferred triple concentric lead-covered mains with plumbed joints. For distributors he preferred single-core cables. Underground disconnecting boxes were a continual source of trouble. Where it was necessary to have connections which you could get at, it was by far the cheapest to put pillars overground, and where distributing cables were tapped on to feeders, he fused the distributor through porcelain switch-fuses and brought the feeder on to the 'bus bar in the feeder box. He had had no trouble with these fuses when using fine copper wires in parallel, each wire enclosed in an asbestos sheath. The feeders themselves were protected by fuses on the switchboard at the station. Where the end of one distributor joined up to another distributor fed from another feeding point he had found it advisable to fix overground boxes and fuse all the cables at, say, 50 to 80 per cent. of their capacity. In the case of a fault the fuses would blow and the faulty cable was disconnected from both feeders.

Mr. YERBURY said he was entirely in agreement with the other speakers that the lead should be continuous throughout and plumb joints adopted, and as far as possible cast-iron boxes filled with compound avoided. He entirely agreed with Mr. Rogerson that if the lead was continuous and earthed at suitable places, and there was a proper distribution of the return current, no trouble would take place from electrolysis.

Mr. R. H. CAMPIAN said that Mr. Rogerson had stated that it was well to earth both the lead and the steel tape. He should like to know how he was able to earth the steel tape as well as the lead. It seemed to him that the steel taping would spring back when it was earthed, and consequently cut the lead, and it would be difficult to solder. He had found aluminium fuses the best for feeder pillars, but had experienced trouble in connection with an atmospheric deposit on the fuses, so he had tried the polishing of aluminium fuses with blacklead, and it had given very good results so far, and he was obliged to Mr. Rogerson for the suggestion.

Mr. E. J. MARSH said he should like to ask Mr. Rogerson what he thought the best type of cable for tramway work to feed the trolley line. Lead-covered cables they had found unsatisfactory, as some lengths pitted badly. With regard to the earthing of the lead of tramway cables, one difficulty that arose was that of dealing with the negative cables to the rails, especially in places where the rails were some distance from the power station. In that case, when a fault developed on the negative cable with a difference of potential to earth of, say, 5 to 15 volts, and the whole of the leads were coupled together, the whole of the cables were affected, with a liability of damage, the low-pressure and the conditions of tramway working making it difficult to discover the existence of the fault, which did not show itself on the station instruments under ordinary conditions.

Mr. G. D. ASPINALL PARR said that, respecting the matter of multicore versus single-core cables, it seemed that the single-core cable appeared to be the most satisfactory for distributing purposes. With alternating current one had to deal with considerable electrostatic capacity in all but single-core cables, and in the case of three-core cables it was not at all an easy matter to obtain the numerical value of this. With regard to fuses, he quite agreed with Mr. Rogerson that the blowing of fuses was extremely erratic, and he mentioned that thermal fuses were not altogether reliable, except the aluminium type mentioned. You could get a thermal fuse to blow at any current you wished, depending on the length of fuse and the massiveness of the terminals to which it was joined. He considered that the magnetic blow-out or cut-out was the most reliable. He had some magnetic cut-outs which, of course, would not be suitable for underground work, but they would be suitable for pillar work, which he knew from experience would blow within 1 per cent. of the current that they were set for, and he should say it was no exaggeration to put this percentage at 20 or 25 in the case of thermal fuses, according to the temperature and facilities for cooling.

Mr. W. M. ROGERSON, in reply, said that with regard to the tests for rubber cables and the clause which Mr. Preece suggested inserting in specifications for this material, there was, no doubt, a large amount of cheap cable used for house wiring, but he failed to see how the suggestion would get rid of it. He had used hardened bitumen bridge pieces with fair success, but they were probably expensive to buy, though they could be made cheaply enough. Mr. Schofield had stated his preference for concentric cables for feeders. As far as feeders were concerned, triple concentric cables would be just as good as any other cable; but the objection to concentric cables was that when they were used for distributor purposes you had to cut every few yards in a big town, for services, &c., and he thought with this class of cable used for distributing purposes there was considerable risk. Mr. Campian had asked about the earthing of the steel taping. There was no difficulty in making a plumb joint on to the steel at the same time as it was made on the lead. With regard to cable for tramway poles, which Mr. Marsh referred to, he always used ordinary 2,000 megohm rubber cable and had had the same trouble, with several blisters on the insulation of one length of cable. He should certainly not advise vulcanised bitumen cable for inside the tramway poles and could not recommend anything better than rubber for this purpose. He was afraid you would have the same blistering effect with bitumen, and the bitumen cable would be unsuitable for taking round sharp angles unless its weight could be evenly distributed. He did not agree with Mr. Parr that magnetic blow-outs or cut-outs would be at all successful instead of fusing networks. They had been tried in several places and in the end it had been necessary to tie them up, especially in section pillars for tramway purposes. They were not at all reliable and often acted when they were not required, and failed to act when they were required, owing to corrosion. There was really no objection to thermal fuses, providing you knew the conditions and had the fuse a certain size with a certain length of break, in which case the variation would not be great between the blowing of fuses of equal size from time to time. For mains work it did not much matter if a 200 ampere fuse blew at 200 or 300 amperes as long as it could be relied upon to blow when necessary, as in the case of a heavy short or earth.

TECHNICAL TRAINING OF ELECTRICAL ARTISANS.*

BY C. P. C. CUMMINS.

The training of electrical artisans, as distinguished from the training of electrical engineers, is of such importance to the electrical profession that it is a matter for surprise that it has not received more attention from employers than has been the case in the past. So little attention has it received that it is doubtful whether many of us, if called upon to do so, could give a clear definition of the sort of individual we refer to, when we speak of an "electrical artisan." In this Paper I intend to deal with the training of electrical artisans only, and, to avoid misapprehension, it is well to state that when I use the term I include all those persons who have served a certain apprenticeship, and who have subsequently obtained fairly continuous employment at industrial occupations connected with the practical applications of electricity. Wiremen, telegraph and telephone linesmen, electric bell fitters, armature and bobbin winders, electrical machinery attendants, electrical instrument makers, and makers of electrical fittings and accessories are, therefore, all included; but my remarks refer almost exclusively to wiremen.

* Abstract of a Paper read before the Dublin Local Section of the Institution of Electrical Engineers.

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Employers' Requirements.—From the point of view of the employer, the following are probably the requirements of a really competent wireman; (1) He must be steady and reliable. (2) He must be a good timekeeper and a hard worker. (3) He must be sufficiently intelligent to receive verbal and frequently hurried instructions as to carrying out a job, and then be able to carry it out economically and satisfactorily. (4) He must be capable of running wires and fixing in position the suitable casing or conduit, also the necessary fittings, such as fuses, switches, &c., in their proper places. (5) He must have a general knowledge of the different systems of house wiring; of the differences in supply systems, and the changes in fittings and apparatus necessitated by these differences; of testing insulation; of the mechanism of arc lamps, motor-starting switches, and other electrical apparatus; of gas and steam engines; of the current-carrying capacity and insulating properties of wires and cables; and of complicated wiring work, such as is required for switchboards, &c. (6) He must be able to overhaul a customer's premises, make good minor defects, and make a short, clear report of the work done and of any further work required.

I do not, of course, maintain that all the above qualifications are always essential; it is not to be expected or desired that all the men should possess foremen's qualifications, and when it is not necessary to entrust the men with any responsibility or supervision a far lower standard would be sufficient. Unfortunately, however, a very large portion of the work undertaken by electrical contractors consists of small jobs which are not sufficiently important to warrant the head of the firm devoting a sufficient amount of his time to their proper supervision, and he is consequently forced to rely to a very great extent upon the competency of his workmen; there is, therefore, a pressing need for men who are capable of looking after and appreciating the hundred-and-one small details, attention to which means so much as regards subsequent freedom from faults and satisfaction to customers.

Existing Methods of Training.—Boys who wish to become wiremen have generally been educated in the primary schools. They usually apply to one or other of the electrical contractors, who frequently accept them without premium, and put them to work at a small weekly wage as boy assistants to wiremen. The boys' chances of learning depend upon the proficiency of the wiremen whom they assist, and upon their powers of observation. After a time they acquire a certain amount of proficiency in running casing and wires, soldering joints, &c., and fixing switches and other fittings in position. They also see dynamos, motors, gas engines and possibly steam engines installed, and learn something about their management. Generally the boys' wages are increased periodically, the increase in some cases depending upon the amount of proficiency which they show, and at the end of five or six years they may, perhaps, be paid at the rate of 8d. per hour. Having reached this rate they are recognised as wiremen, and can be enrolled as members of the trades' union society.

Some contractors endeavour to make the boys attend evening technical classes during this period of training, but few attend with any regularity or show any seriousness in their studies. The work done in the evening classes is usually arranged to meet the requirements of the elementary syllabus in electricity and magnetism of the Board of Education, South Kensington, and of the more advanced programme of the City and Guilds of London Institute; both of these examining bodies award certificates to candidates who pass the examinations satisfactorily. The value of the certificates as evidence of competency is not, however, generally recognised, and it is sometimes contended that the instruction given under these programmes does not increase the boy's usefulness to his employer.

Results obtained by Existing Methods.—The results obtained by the existing methods are, as might be expected, very indifferent. Few of the men who consider themselves wiremen, and who demand and obtain 8d. per hour, possess qualifications equal to those which I have outlined. The steadiness and reliability of the men are not subjects for consideration in a paper of this nature, and eliminating these personal factors, wiremen may be divided, as regards their efficiency, into certain groups. I believe that all the existing men may be classified in one or other of the following groups: (1) Men who can run casing and wires and put up fittings fairly well, if the exact positions are clearly marked out, but who cannot be relied upon to lay out work for themselves. (2) Men who can receive verbal instructions as to a small house-wiring job, and who can be relied upon to run the casing and wires in the most economical way and to put up the fittings in the most convenient places. (3) Men who are competent under group 2, and who know how to connect up and adjust electrical apparatus, such as arc lamps, motors, &c. (4) Men who are competent under groups 2 and 3 and whose knowledge of wiring, testing, and electrical apparatus enables them to satisfactorily carry out, under supervision, switchboard or complicated wiring work and the installation of generating plant. (5) Men whose knowledge and experience are sufficient to enable them to act as foremen over a job consisting of a complete installation, including house wiring and supply of generating plant.

Very few of the existing men can be included in groups 4 and 5, and the majority are not even eligible for group 3. It is very doubtful whether the labour of men classified below group 3 is worth 8d. per hour, and the fact of there being large numbers who can only be classified in group 1, and who can, nevertheless, obtain this rate of wages, is evidence of serious defects in the method by which electrical artisans are produced. The present methods of training must, therefore, be considered defective, inasmuch as they produce a considerable number of men who cannot be considered competent, large numbers who can only be considered partially competent and a very few who are really competent, and also because, as a natural consequence of this defect, the really competent men consider themselves in such a strong position, by virtue of their small numbers, that their demands upon employers, and their general independence, very materially reduce their usefulness.

Opportunities which Electrical Artisans have for Qualifying Themselves.—It is quite obvious that intelligent work—*i.e.*, work which bears evidence of a knowledge of the fundamental scientific principles underlying it—cannot be expected from workmen who have had no opportunity of studying those principles. This probably applies with the greatest force to electrical work, because in dealing with electrical phenomena the uneducated workman is handicapped to a far greater extent than his fellows in other trades, inasmuch as he does not possess what Prof. Ayrton calls "an electrical sense." The existing workmen from whom boys have to glean their knowledge, in 99 cases out of 100, possess no electrical sense, and in the remaining case have no time to spend in imparting it. The boy's opportunities for acquiring it while at work are practically nil, and unless after a long day's work he spends his evenings and spare hours reading electrical text-books, which are generally out of his depth and frequently inaccurate, or at technical classes, he will probably never acquire it at all. This being so, it is surely not surprising that so few competent electrical artisans are to be found. I believe that a system of training which did not include a period of apprenticeship would be almost useless; but, unfortunately, in our present system boys taken as apprentices often possess a very small amount of general education. More often than not several years elapse before they realise the importance of studying, and when they join evening classes the small amount of general education which they once possessed has almost disappeared. The importance of boys continuing their education after leaving school by immediately attending evening classes is not sufficiently emphasised, and the advantages of having spent five or six years at school are not made clear to them. Consequently, they are apt to undervalue their education and to make no effort to retain it. The facilities afforded to apprentices for continuing their studies until they have reached a standard of knowledge sufficient to be of practical use to them are, in the majority of cases, quite inadequate. No generally recognised standard of qualification exists for electrical artisans, to the attainment of which boys can from the outset be encouraged to direct their energies. These are all very serious defects, and of such a nature that unless employers generally recognise them and take concerted action they cannot be removed.

Reasons why Employers should Interest themselves.—A moral, if not a legal, obligation rests upon employers, especially if they accept a premium, to do everything in reason to assist apprentices in becoming fully qualified; and as the importance of education is now so fully recognised that it has been made compulsory in its elementary stages, any system of training which does not make provision for continuing the education of the apprentices to such a point as will make it of practical use to them cannot be held to be reasonable. As such a system must result in the waste of some portion of the money expended in the primary schools, which money has been expended with the object of developing a valuable national asset, the continuance of the system is illogical.

If employers, by co-operating with educational authorities, would insist upon the education being arranged with due regard to their requirements, much might be done to improve the conditions of labour which they are frequently so ready to complain of.

Proposed System of Training.—Having outlined the principal defects in our existing system of training, it will be fairly obvious that, in my opinion, the following points should receive special consideration in any revised scheme of training.

Boys should not be taken as apprentices, either with or without fee, unless they possess a sufficient general education. In cases where employers are in doubt as to whether applicants for apprenticeship possess this knowledge, the local technical school authorities will probably gladly assist the employer by examining the candidate and making a report, without any cost to either the employer or the candidate. The necessary amount of education should be very carefully considered and a minimum standard adopted by the employers, who could count upon receiving all the assistance and the information they required to enable them to arrive at a decision from the education authorities. Without going into details as to the minimum standard of education required, I am strongly of opinion that it should not be very low. Few boys under the age of 16 are physically fit for apprenticeship, and as they usually leave the

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primary schools at the age of 14, they can spend two years at one or other of the day trade preparatory schools which are now being established in connection with many technical institutes. It appears to me that the very great value to them of trade preparatory schools has not yet been fully recognised by employers.

During their apprenticeship, and as a necessary condition of it, boys should be required to attend certain specified classes in a technical school. There should be a properly arranged course of instruction for each year of apprenticeship, and attendance at it should be rigidly enforced. Also on the days or hours upon which the boys are required to attend technical classes they should not be expected to remain at work for the same number of hours as on other days.

The course of instruction to be followed during each year of apprenticeship should receive very serious consideration from employers, and should be drawn up by them. In this connection they could also rely upon every possible assistance from educationalists and education authorities, but they should be careful not to be guided to too great an extent by the opinions of others. Few educationalists are capable of arranging and conducting a course of instruction which will be acceptable to the majority of employers, because they are generally too much in contact with the educational side of the question, and it is very difficult for them to fully appreciate that, from the point of view of the employer, who, in spite of himself, is forced to judge all proposals in connection with the management of his business by their profit-earning capacity, the educational aspect is of minor consideration, and the really important point is the capability of the training to provide him with efficient workmen. I do not think that educationalists sufficiently realise the fact that, in endeavouring to interest employers in the education of their apprentices, they must treat the matter on strictly commercial lines. Employers do not, and should not, conduct their business on a philanthropic basis, and in the competition and stress of modern business life an employer cannot afford to introduce reforms unless he is convinced that they will be to his advantage. The admitted need for efficiently trained men is the educationalist's opportunity, and he must do everything in his power to satisfy this demand, but he cannot hope to succeed unless he can associate the employer with him.

In their own interests employers must see to it that a suitable system of training is devised and put into operation; that the fads of individuals are not permitted to unduly hamper the proper working of the system; that the examinations and certificates held and awarded by public examining bodies are arranged to fall in with the requirements of the system; and that the boys themselves are given every possible encouragement and assistance in making themselves proficient. The matter is too important to be dealt with by individuals. It deeply affects the future of our profession, and as I imagine that the large majority of electrical employers are members of this Institution, I would suggest that an advisory committee on education be formed, similar to those already in existence in regard to other branches of the profession, and that this committee should carefully consider the matter and prepare a general scheme, leaving the details of organisation and management to the different local sections. By adopting this suggestion, electrical engineers would only follow in the steps of other employers who are interested in the same question.

DISCUSSION.

Prof. W. J. BARRETT, F.R.S., in a written communication, pointed out that technical education should come from above and should begin with engineers and masters.

Mr. W. TATLOW spoke of the increased necessity of technical training, due to the increased complexity of systems and apparatus, and commented on the absurd antiquation of some electrical syllabuses and the necessity of making the syllabuses practical. In his experience the boys attended technical schools insufficiently equipped in general education. He considered night schools as comparatively useless, and suggested two mornings a week for apprentices; personally his firm would, he thought, allow this.

Mr. A. E. PORTE said he found no difficulty in getting apprentices to attend technical schools, and generally managed to have them take up drawing and mathematics as well as electricity. He believed the teacher should be a man engaged professionally in practical work. He thought there would be considerable difficulty in arranging for attendance of apprentices at day classes, and doubted whether the trade union would help even if masters were willing. He contrasted the estimation in which technical instruction was held in America and Germany with its position in this country, and expressed the opinion that our loss of lead was due to a deficiency of technical training in masters and men.

Mr. MARK RUDDLE thought the noticeable absence of the contractors from that meeting was a striking proof of their want of interest in this most important matter. He had constantly occasion in his department to test the qualifications of boys supposed to be technically trained applying for employment; he considered, judging by results, the training a deplorable failure. He was pleased to see that the plumbers in England and the Automobile Club in Ireland had forced the hands of the respective departments in a practical direction. The Institution of Electrical Engineers and the Master Contractors' Association could do the same if they chose; but, judging by the small interest the Institution took in the educational qualifications of their own members, he had little hope of any very active interference on behalf of the artisan. His department was constantly having to deal with complaints as to lighting really due to elementary ignorance on the part of those who installed the light. He agreed with the suggestion of the lecturer as to the advisability of a syllabus drawn up by a body composed of representatives of the Institution, the master contractors and the men.

Mr. KETTLE pointed out that the difference between the artisan and the electrical engineer was at present almost entirely a social matter, and strongly advocated that definite professional qualifications, equivalent to those which entitled a man to practice as a doctor or a barrister, should be imposed; and that no man should be allowed to enlarge himself upon Society as an electrical engineer, unhampered by any qualifications; in fact, the profession was in a hopeless muddle due to lack of any proper legal qualifications.

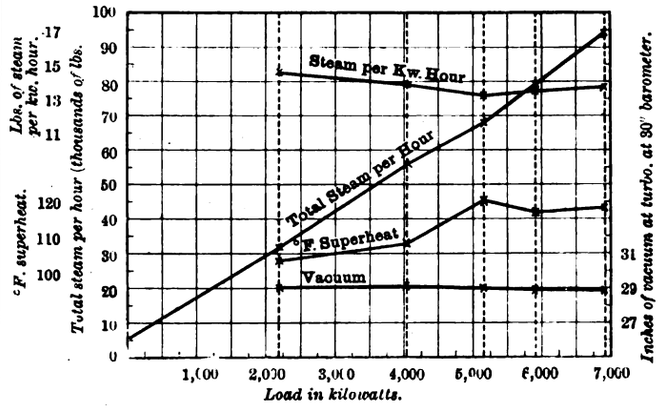
Mr. C. P. C. CUMMINS (in reply) agreed in the universal condemnation of unpractical syllabuses, and believed, from his experience, that the department of technical instruction would sanction a practical syllabus drawn up by those interested. He joined with several speakers in deploring the defects of elementary education which so hampered technical instruction; but this was no fault of the primary school teachers, but the system under which they worked.

Mr. T. TOMLINSON, in putting the vote of thanks, said he hoped the Section would pay Mr. Cummins the compliment of seeing what could be done in the direction indicated.

TEST ON A 3,500 KW. TURBO-ALTERNATOR.

In our issue of May 10th we drew attention to some results obtained with two 1,500 kw. turbo-alternators supplied by Messrs. Parsons to the Kent Electric Power Co., and we particularly mentioned the excellent efficiency obtained with these sets over a wide range of load. We have now received from Messrs. Parsons a copy of a report by Mr. C. H. Merz on some tests on one of the 3,500 kw. turbo-alternators which Messrs. Parsons have recently installed in the Carville power station of the Newcastle-upon-Tyne Electric Supply Co.

These tests were made after the machine had been at work for over six months, and the steam consumption of 13·189 lb. per kilowatt-hour is probably the best result which has ever been obtained with any steam plant in existence. The 3,500 kw. turbines are fitted with a steam automatic by-pass, so that they can deal with



STEAM CONSUMPTION TEST OF 3,500 KW. TURBO. AT CARVILLE POWER STATION. Plotted from actual readings.

large overloads; and it is surprising to see the small change in efficiency with loads between 2,000 kw. and 7,000 kw.

The weight of condensed steam was measured by the Power Company's tank and weighbridge, which had on the day previous to the test been calibrated in the presence of H.M. Inspector of weights and measures and certified correct. The vacuum was measured at the turbine exhaust chamber by a mercury column. Steam temperature and pressure were taken at the turbine stop valve. The speed was taken by a tachometer.

In the final consumption results only the actual output of the generator has been taken into account, no deduction being made for any auxiliaries. The field current of the exciter was supplied from an entirely independent source, but apart from this the machine provided its own excitation. The neutral point of the generator windings was disconnected from earth, and the three phases were loaded by means of a water resistance.

The output of the machine was measured by a special wattmeter, and by the switchboard integrating wattmeter. The current was measured by a special ammeter connected to the same current

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Test No.	Duration (hours).	Mean calibrated kw.	Steam.			Speed. R.P.M.	At turbo exhaust.	Water.		
			Pressure.	Temp. at turbo. °F.	Superheat °F.		Vacuum at 30″ Brm.	Total condensed lbs.	Lbs. per hour.	Lbs. per kw.-hour.
1	½	No load not excited.	180·0	460·0	80·0	1,200	28·875	1,835	3,670·0	..
2	½	No load excited.	211·0	453·3	61·0	,,	28·95	2,603	5,206·0	..
3	1	2,192·87	202·4	492·1	108·0	,,	29·036	31,836	31,836·0	14·517
4	1½	4,045·14	197·4	495·0	108·0	,,	29·066	83,972	55,981·3	13·839
5	1½	5,901·0	195·8	503·2	117·0	,,	28·95	119,182	79,454·6	13·464
6	½	6,921·8	198·4	505·5	118·5	,,	28·765	47,390	94,780·0	13·692
7	1	5,164·07	199·9	508·5	120·5	,,	29·039	68,180	68,180·0	13·189
8	3	5,059·38	194·5	477·9	92·0	,,	29·195	203,559	67,853·0	13·411

transformer as the special wattmeters, and by the switchboard ammeter. These instruments were connected in different phases, giving the balance of load between phases. An ammeter was also placed in the exciting circuit. The switchboard voltmeter, indicating wattmeter and power-factor meter were in circuit and were read every five minutes to check the accuracy of the wattmeter. The special instruments and the switchboard integrating wattmeter were all carefully calibrated both before and after the test, and corrections were made in the measured output in accordance with the mean of the observed errors before and after calibration.

The figures obtained at the tests are given in the above table, and the results are plotted on the diagram.

TUNGSTEN LAMPS.*

BY C. CLERICI.

Of the many new incandescent lamps which, during the last few years, have claimed to supersede the carbon lamp, the tungsten lamp would appear to have the best chance of survival.

The metal, of the chromium group, was discovered in 1781, has an atomic weight of 183·6, a density of 19 and fuses at 3,200°C. It burns in air to a trioxide. It occurs abundantly in nature, but not being ductile it cannot be drawn into wire and the preparation of filaments has to be effected indirectly. Numerous methods have been patented, which may be divided into four main classes.

The first method is that of Dr. Kuzell, in which the metal is reduced to the "colloidal state" by means of an arc between two electrodes of tungsten under water. By evaporation the resulting solution is thickened till it can be worked like clay. This is drawn or squirted into a filament, which after drying is raised to a high temperature to weld it into a metallic filament.

The second method is that of Just and Hanaman, in which tungsten is deposited on an ordinary carbon filament by a process similar to flashing as practised in carbon lamp manufacture. The resulting compound filament is heated to incandescence in hydrogen and water vapour, when the carbon disappears, leaving a tubular metallic filament.

In the third method a fine powder of tungsten is produced by chemical means. This is worked into a paste with some glutinous material and the filament freed from carbon as in the previous method.

The fourth group of methods consists of the preparation of a paste of oxide of tungsten from which a filament is made and afterwards reduced to a metallic state in various ways.

The filaments prepared in these various ways are very fragile, and their resistance is so low that a length of about 6 mm. is required per volt. For even a 100 volt lamp it is necessary therefore to arrange several filaments in series in one bulb, supported on a central stem of glass. The lamps of Italian manufacture exhibited by the author were for 60 c.p. at 100 volts. They absorb 60 watts and consist of six filaments in series, with a total length of 640 mm. and a diameter of 0·05 mm. Efforts have been made to produce finer filaments, and some have been made with a diameter of 0·03 mm., which would correspond to 20 c.p. for a 110 volt lamp, but it is impossible at present to say whether such lamps can be manufactured on an industrial scale.

Life tests of the 60 c.p. lamps show that the efficiency of 1 watt per candle-power is well maintained for a period of 500 to 700 hours, which compares well with the life of the ordinary carbon lamp of 3·1 watts per candle-power. A few lamps have run at this efficiency for 1,500 and even 2,500 hours—a fact which gives hope of a material increase in the average life with improvement in manufacture.

The temperature coefficient of resistance being positive for tungsten, the resistance is less in these lamps when cold than when alight. The 60 c.p. 110 volt lamps mentioned above have a resistance of 33 ohms cold and 170 ohms at the working temperature. In consequence of this there is a rush of current on first switching on, which, in the case of a number of lamps on one switch, may cause inconvenience. The thin filament is, however, very quickly heated, so that the excess current is of very short duration; a dead-beat Weston ammeter shows only 10 per cent. increase. The positive coefficient is, however, of value when the lamp is alight, rendering it less sensitive to variations of voltage than the carbon lamp. It is noteworty that while the resistance of carbon falls in the ratio of about 2:1 up to a temperature of about 1,000°C., and thereafter varies but little, the positive variation of the resistance of tungsten is maintained above the working temperature of the lamp.

A tungsten lamp giving 70 c.p. at 70 watts was compared with a carbon lamp overrun to give the same candle power and efficiency. The filaments were then compared with the following results:—

	Tungsten.	Carbon.
Length	640 mm.	175
Diameter	0·085	0·09
Radiating surface	110 sq.mm.	49·5 sq.mm.
Watts per sq. mm.	0·63	1·41
Candle-power per sq. mm.	0·63	1·41
Reducing the carbon to the same candle-power per square millimetre as the tungsten, the watts per sq. mm. became	—	1·03
Reducing the carbon further to an emission of 0·63 watts per square millimetre, the candle-power per sq. mm. became	—	0·13

It is thus impossible to obtain similar radiation from carbon and tungsten, the proportion of visible radiation at a given temperature being greater in the metal. But the tungsten lamp has the further advantage in practice of permitting a higher working temperature, thus giving a further increase in the proportion of its total radiation which falls within the range of visibility. In this respect it has an advantage over tantalum, though the latter at equal temperatures has a larger proportion of visible radiation.

The actual working temperatures are as follows:—

Carbon (3·1 watts per candle-power)	1,950°C.
Tantalum	2,000°C.
Tungsten	2,300°C.

These temperatures are not related to one another as the melting points of the various materials, since carbon melts at 3,500°C. and tungsten at about 3,200°C. It is probable that they are rather related in the proportion of the vapour tensions of the respective materials. The working temperature, in fact, depends on the slow evaporation of the material of the filament below the melting point.

A New Device for Wiping Joints.—The *Electrical World* gives a description of a machine for wiping lead joints, consisting of three parts—namely, two clamps and a central movable part which does the wiping. The two clamps are attached one to the cable and the other to the sleeve which is to be joined to the cable. The clamps when attached fit the cable and sleeve tightly and are immovable. The central part of the machine can be moved through a complete circle, but in use it is moved backward and forward through an eighth or a quarter of a circle. After the clamps have been adjusted to the sleeve and cable, and are holding the central parts in place, the machine is heated with an ordinary blow lamp. A piece of cold solder placed in a trough in the movable part melts when the machine is hot enough, usually in a minute or two after the lamp is applied. When the solid solder melts, molten solder is poured into the trough and the operator begins the rocking motion which wipes the joint. Corrugations in the apparatus passing over the solidifying solder, force it into a compact mass without holes. As soon as the solder has set, say in two minutes or so, the machine may be removed.

* Paper read before the Milan Section of the Associazione Elettrotechnica Italiana, February 22, 1907. Abstracted from *L'Elettricità*.

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The Series of seven comprehensive Tables of Statistical and Engineering Data relating to Electricity Supply Undertakings of the United Kingdom for Lighting, Power and Traction, which are published annually with "The Electrician," have now been carefully corrected, and are obtainable complete (with Index) in compact book form, printed on hard paper, price 8/-, post free 8/6. (The Set includes a good list of British Colonial Electricity Supply and Tramway Undertakings.)

THE TECHNICAL TRAINING OF ELECTRICAL ARTISANS.

So much has been written about the education of the electrical engineer that the training of the electrical artisan has been almost forgotten, and it has been generally assumed that the simple and usual method of apprenticeship is all that should be necessary. This view is natural enough, considering that apprenticeship has been found satisfactory in mechanical engineering for many years past, but in reality there is not much analogy between mechanical engineering and electrical engineering in the purely electrical parts. They are indeed in many respects essentially different. Mechanical action is visible and can be generally followed out without much difficulty if the movements by which it is produced are carried out slowly. The mode of electrical action, on the other hand, is not visible. There is something mysterious about it to those to whom it is not familiar, and a certain amount of imagination is required to make a mental picture of what is going on. Thus we find that the working of the steam engine is fairly obvious to anyone with a mechanical turn of mind. Even a fair idea of the indicator diagram and the setting of valves may be obtained by the apprentice, but the action of a dynamo or of a motor is much more difficult to grasp. For this reason much is gained by picturing electrical action as being something akin to

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mechanical action; for example, by the introduction of lines of force and other conceptions of that kind.

It, therefore, follows that the training of the electrical artisan should differ materially from that of the artisan who is to spend his days at mechanical engineering. At present the electrical apprentice has to do more or less what he is told, and to pick up his information as best he can. If he is working under a competent hand he may possibly pick up something of the principles underlying his work, though the chance is that any instruction so given will be very defective, and there is a still greater chance that no trouble will be taken to give instruction at all in such matters.

As pointed out by Mr. C. P. C. Cummins in a Paper read before the Dublin local section of the Institution of Electrical Engineers, and which we give in abstract in our present issue, we cannot expect really satisfactory men to be produced by so defective a system of education. Of course, evening classes can be provided, but they do not necessarily give instruction quite of the kind that is necessary; moreover, the average apprentice fails to see why he should attend classes of this kind after a hard day's work. There is a good deal to be said in favour of compulsory attendance at classes during working hours, if employers would only agree to adopt such a course. Mr. CUMMINS makes the suggestion that as boys leave school at the age of 14 they might very well attend classes until the age of 16 before being actually apprenticed. From the employer's point of view this might be so, but we doubt if the deferring of earning a livelihood for two years would be very acceptable to the apprentices themselves. It appears to us that the practical and the theoretical should run hand in hand, but the theoretical instruction should be started at once before the apprentice has had time to forget the knowledge which he has acquired through his ordinary education. In any case what is taught should be essentially that which has a direct bearing upon practical work, and it should preferably be taught by those who are engaged in practical work. Courses of class instruction do not always inspire practical people with confidence, and the examination syllabus has, generally, done a great deal of harm. The subject is undoubtedly of great importance, and we think Mr. CUMMINS' suggestion that suitable means of instruction should be considered by a committee of the Institution of Electrical Engineers an excellent one that should be followed up. It is a matter which concerns both employer and employed, and we can only expect it to be satisfactorily dealt with by a body capable of looking into the question from every point of view.

OBITUARY.

SIR BENJAMIN BAKER, K.C.B.

We regret to record the death from syncope of Sir Benjamin Baker, K.C.B., K.C.M.G., F.R.S., which occurred suddenly on Sunday last at his residence, Bowden Green, Pangbourne. He was in his 67th year.

Benjamin Baker was an Irishman, born in County Carlow in 1840. It was always intended that he should be an engineer, and, after having gone through a preliminary course of study necessary for this career, he was apprenticed to Mr. H. H. Price, a civil engineer in large practice. During the next three years he gained much practical experience in the designing and constructing of machinery, especially of that kind used in foundries and forges; he afterwards studied surveying and the art of designing masonry and earthworks. He then entered the service of the late Sir John (then Mr.) Fowler, with whom he afterwards entered into partnership and carried out many important engineering undertakings.

Although Sir Benjamin Baker designed a large number of engineering structures, the two works with which his name will always be most associated are the Forth Bridge and the Assouan Dam. The history of the former of these is well known. The difficulties that had to be overcome were enormous: the span was unusually long, the depth of water was considerable and coupled with a swift current; the bridge had to be built to withstand the great wind pressure which is usual in the neighbourhood of the Firth of Forth, and the work had to be carried out so that the navigation of the estuary was not interfered with for a single day during the seven years necessary for the completion of the bridge.

The other great work with which he was associated as consulting engineer was the Nile Dam at Assouan, which was necessary for irrigation purposes. The total amount of water which can be stored in this reservoir at present is 1,065,000,000 cubic metres. Sir Benjamin was frankly informed by an Egyptian that this work was impossible, or it would have been accomplished 4,000 years ago.

Sir Benjamin Baker was an adviser on the design of the Thames Tunnel at Blackwall; he repaired several historical bridges, built by Telford, of which one was the famous Suspension Bridge across the Menai Straits. He also designed the curious vessel in which Cleopatra's Needle was brought from Egypt to the Thames Embankment. His connection with electrical engineering was chiefly as consulting engineer for the tunnelling of the Central London and other tube railways.

In 1890, on the completion of the Forth Bridge, Sir Benjamin Baker was made K.C.M.G., and received the further honour of the K.C.B. when the Assouan dam was declared open by the Duke of Connaught in 1902. He was elected a Fellow of the Royal Society in 1890, and received honorary degrees from the Universities of Cambridge and Edinburgh. In 1895 he received the highest position attainable by a British engineer, being elected President of the Institution of Civil Engineers.

He was an honorary member of many foreign and colonial engineering societies, and was greatly interested in the work of the Royal Institution, a meeting of which he attended as recently as last Friday. His cool, quiet judgment and restrained strength were his marked characteristics, and it will not be forgotten that when the accident occurred to the roof of Charing Cross station Sir Benjamin Baker took the risk of personally inspecting the structure, so that he might advise on its repair.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Universal Dictionary of Mechanical Drawing. By GEORGE H. FOLLOWS, Associate Professor of Machine Design and Mechanical Drawing, Carnegie Technical Schools, Pittsburg. (London: Archibald Constable & Co.) Pp. 60. 4s. net.

The title of this book is somewhat ambitious, but when the object of the book is clearly understood the title need not be objected to. The subject matter was first published in "Engineering News," New York, and now appears in book form. It deals with mechanical drawing as a language which should convey positively accurate information to the reader; the "drawing dictionary" should therefore be of service to teachers, students, draughtsmen, foremen and workmen, and should be used as a basis for writing the language. It should be the means of ensuring reasonable uniformity in drawings made by different men in different places.

The book is in no sense a work intended to teach the art of mechanical drawing. It starts with defining an "alphabet of lines;" then follow "letters and lettering," "figures and dimensions," &c. "Standard data" occupy a short chapter and a few "example drawings" make the finale.

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The book is crammed full of valuable suggestions and should be in the hands of all draughtsmen and foremen. More especially in large works employing a large number of draughtsmen, any lack of system is, to say the least, a very expensive affair. The study of this dictionary cannot fail to give help to any head draughtsman who desires to organise a satisfactory system for any particular works.

A few quotations may conclude this notice: "Notation marks for the foot and inch are sloped in the opposite direction to the figures, so that the possibility of confusing with the figure 1 is lessened." "With the general adoption of tracings and blue prints colour sectioning was superseded by line sectioning as used to-day." "Dimensions should be so given that the shop will not have to add or subtract in order to discover required distances." "Don't be afraid of using the English language on your drawings." "See that all the small details, as screws, pins, &c., are standard and stock sizes."

Wissenswertes aus dem Dynamobau für Installateure. By Ernst Schulz. 2.20m. **Schalttafelbau.** By A. Boje. (Hanover: Dr. Max Jänecke.) 2.80m.

These two small handbooks form Vols. III. and X. of the "Bibliothek der gesamten Technik," published by Dr. Max Jänecke, of Hanover.

The object of the first-mentioned volume is to furnish information of a kind that will assist non-technical buyers and agents of electrical machinery in selecting from makers' lists dynamos suitable for their particular requirements, and to bring out clearly the points they should attend to in placing their orders. With the object of appealing to this class of reader, the writer has set himself the task of avoiding the use of mathematics as far as possible, and framing his descriptions in simple language. It may be admitted that he has succeeded very well in carrying this out so far as the discussion of direct-current machinery is concerned, but in the second section, which treats of alternating-current plant, he makes free use of vector diagrams without any introduction to them, and the reader who is not already accustomed to this method of representation will certainly not be able to follow the reasoning in many parts. Furthermore, in the attempt to avoid mathematical difficulties, which are really quite inseparable from the treatment of problems relating to alternating currents, he has repeatedly been forced to resort to explanations of an inexact and misleading nature. Notwithstanding the defects just referred to, the book contains much that should greatly facilitate transactions between the manufacturer and buyer of electrical machinery, and the explanations of what should be considered normal and abnormal conditions, and what variations from the normal rating of machines are in general permissible, are admirably given.

We notice a mis-statement repeatedly made as to the position into which a short-circuited coil tends to place itself, when situated in an alternating field, and the proof given of the fact, that the power transmitted by a current lagging a quarter of a period behind the applied voltage is zero, is very faulty. A short explanation is given of the method of calculating the characteristics of an induction motor from a determination of its no-load and short-circuit currents by means of the Heyland diagram, but the test of the short-circuit current at full voltage, as described, would in many cases lead to damage of the motor, and no warning to this effect is given.

The second volume, on Switchboards, discusses the design and construction of low-tension boards. The major portion of the book is occupied with the laying out of a number of switchboards for a three-wire direct-current generating station for power and lighting, containing descriptions and about 100 drawings and photographs of main power and lighting boards. The general conditions governing the design of such boards are stated in a manner that should be of great assistance to those who are engaged in switchboard work.

A very ingenious use of photography for preparing diagrams of the back-connections for the guidance of the switchboard attendants is given, which consists in photographing the back of the board and taking a reversed print, which thus gives a picture of the connections in their correct positions, as they would appear if they could be viewed through the board.

A NEW LEADING-IN CONDUCTOR FOR ELECTRIC LAMPS.*

BY C. O. BASTIAN.

Summary.—In this Paper the author describes a method by which copper can be used, instead of platinum, for the leading-in conductors of electric lamps. It is necessary that the copper should be used in the form of strip of a thickness not greater than 0·075 mm.

The difficulty of permanently maintaining a vacuum in an electric lamp is not satisfactorily overcome by the use of platinum for the leading-in conductors, as the costliness of this metal tempts the lamp maker to exercise excessive economy in the cross-section and length of the platinum used, and leaky seals may be the result.

In the Siemens seal, which permits of economy in platinum within certain limits, the platinum is completely embedded in glass, being merely a bridge between two heavier conductors, usually of copper and nickel. Now the cooling effect of these two heavy conductors, plus the cooling effect of the mass of surrounding glass, permits the use of platinum having a very small cross-sectional area, and theoretically—though not practically—the length of platinum wire may be cut down to a minimum.

Exactly how far it is practicable to reduce either or both of these dimensions has apparently not yet been ascertained by lamp manufacturers, but it is certain that the recent rapid and considerable rise in the price of platinum is calculated to lead many to attempt a reduction below the limits of safety, and the introduction of some cheap and effective substitute for platinum, which would not be subject to wide fluctuations in price, is now more than ever desirable.

Nickel and steel can be alloyed in such porportions as to have practically the same coefficient of expansion as glass, but leading-in wires of this alloy have not found favour in this country, although it is used in certain cheap foreign-made lamps. The surface of the wire becomes oxidised during the sealing-in process, and the thin layer of oxide is sufficiently porous to allow air to gradually percolate through, so that lamps made with this nickel-steel alloy cannot be stocked for any reasonable length of time without deterioration.

In selecting a suitable conductor for this purpose, the coefficient of expansion is by no means the only detail to bear in mind, and one is limited in one's choice by quite a number of essentialities,

Fig. 1.

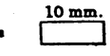

Fig. 2.

which may be set out as follows: (*a*) The metal must be cheap, (*b*) the melting point must be higher than that of glass, (*c*) the quantity of gas occluded must be as small as possible, (*d*) there must be absolutely no tendency to oxidise when heated in air to the temperature of molten glass, (*e*) the coefficient of expansion must be as near that of glass as possible, (*f*) the conductivity must be as high as possible.

The leading-in conductor now to be described has been chosen with due regard to all the above points, and it is the result of experiments extending over several years in the author's laboratory, the final solution of the problem being due to the ingenuity of Mr. George Calvert.

A copper wire of any desired gauge is selected, and of sufficient length to extend from the lamp cap to the filament. Near one end, and along 15 mm. of its length, this wire is rolled flat to a thickness of 0·075 mm., as shown in Fig. 1. Next a 10 mm. length of soft enamel glass tube is slipped over the flattened portion of the conductor, and is melted on to it with a blow-pipe flame. If this blow-pipe flame is properly applied under suitable conditions, the enamel glass can be melted on to the flat copper without the latter oxidising in the slightest degree, and the enamel will then adhere to the clean polished metallic surface just as solder would adhere. The enamel and copper appear to be actually joined together—amalgamated, as it were, one with the other—and not merely in juxtaposition.

It will be evident that this glass-coated metal can now be heated up to any desired temperature short of the melting point of the copper, without the latter becoming oxidised, because the glass coating will effectually prevent the access of oxygen to the surface of the metal underneath it. There is, therefore, nothing to prevent conductors thus prepared being sealed into a lamp stem, as shown in Fig. 3, and such seals have proved most perfect in practice, and have successfully withstood the very severe tests to which they have been subjected during the last eight months.

Out of the first batch of carbon filament lamps made with these leading-in wires—Sineplat wires, as they are termed by the makers—80 were selected for a "life" test. They were arranged in two

* Paper read before the Glasgow Local Section of the Institution of Electrical Engineers. Slightly abbreviated.

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separate groups of 15 each, and connected with a time switch, so that each group was alternately lit for 10 minutes and out for 10 minutes, long enough for the seals to get thoroughly hot and then thoroughly cold. This run was continued for 500 hours; then the time switch was disconnected, and the lamps were given a continuous run for a further 1,000 hours. During this test none of the lamps failed through deterioration of the vacuum. There were two failures, but these were caused by the filaments coming adrift from the leading-in wires through loosening of the paste—purely mechanical faults, having nothing whatever to do with the question of vacuum.

The remaining 28 lamps have been in use intermittently for, perhaps, an additional 500 hours, making an actual burning "life" of about 1,750 hours; but doubtless it is quite as important to note that the lamps were made over six months ago, because, as previously observed, lamps will often lose their vacuum whilst they are merely lying in stock.

An examination of these particular lamps shows that there has been surprisingly little blackening of the bulbs, and the author thinks that it is not generally appreciated how greatly this blackening is dependent on the degree of vacuum maintained.

The conclusions deduced from the test above described have been amply confirmed by several other independent trials, and it is now clear that the Sineplat seals are consistently good when made by hand, whilst preliminary tests with machine-made lamps promise equally satisfactory results.

Copper complies with five of the essential conditions mentioned at first; the condition as to coefficient of expansion is apparently not met, but the flattening of the wire increases the proportion of surface area to mass, and the strain on the glass due to the expansion of the copper is less at any point when the copper is in strip form than if the copper were a cylindrical wire of equal cross-sectional area.

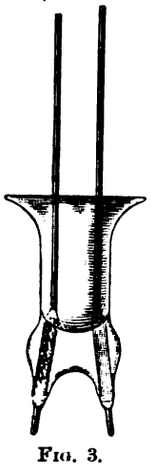

FIG. 3.

As the proportion of surface area to mass of copper is increased, so is the cracking strain of the copper upon the glass reduced, and if the copper is flattened below the point of critical thickness, then no cracking will result. For the lead glass usually employed by lamp manufacturers this critical thickness has been determined by experiment at about 0·1 mm., and with this gauge of copper about 50 per cent. of the seals will crack, but below this gauge—0·075 mm.—no cracking whatever takes place, even though the projecting copper wire be raised to a red heat close up to the glass.

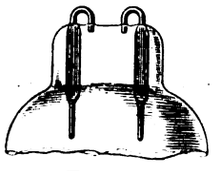

FIG. 4.

It is believed that a further advantage is gained by flattening the copper, as it is probable that the rolling may force out some of the occluded gases by closing up the intermolecular spaces, and the strip certainly appears to contain much less occluded gas than cylindrical wire of the same cross-section. The cheapness of the metal permits of a much larger cross-section being used than would be possible with platinum, and added to this there is the higher conductivity of the copper to assist in keeping the seal cool.

The applicability of the Sineplat seal to X-ray and mercury vapour apparatus may be here suggested, though reports of practical results are not yet available. It can, of course, be used in any of the new metallic filament lamps, in which the relationship between the blackening and degree of vacuum seems to be quite as close as in the case of the carbon filament.

The introduction of a substitute for platinum is not likely to result in any reduction in the price of lamps to the public, as any economy that the manufacturer may effect as a result of this should be set off by improving the quality of the lamp in some other respect.

A New Induction Kjellin Steel Furnace.—The *Engineering News* describes a new Kjellin induction steel furnace which has been put into operation at the Roechling Iron and Steel Works, Voelklingen, Germany. The capacity is 24 tons, 15 tons being poured at the end of a run and 9 tons being left for the beginning of the next run. The power consumption is 736 kw. There are two smaller induction furnaces in operation at these works, and a fourth in construction, having a capacity of 150 tons.

TELEPHONIC TRANSMISSION MEASUREMENTS.

The following discussion took place on Messrs. Cohen and Shepherd's Paper read before the Institution of Electrical Engineers, and of which we gave an abstract in our two previous issues.

Mr. J. E. KINGSBURY said the subject of the Paper was a very deep one, and much beyond anything previously attempted. Speech was divided into two elements—consonants and vowels. Mr. Cohen had shown them that the pronunciation of a consonant gave a definite oscillograph result, but it was clear that the consonant as a definite sound did not exist, as it could not be pronounced except by the addition of vowels. He did not think that it could be said that there was any point where the consonant ended and the vowel began. Mr. Cohen had referred to the interval occurring in the pronunciation of consonants, but it was probable that this was merely a break in the breathing between the vowel and the consonant. In expressing "t" or any other consonant a breathing sound necessarily followed. Consonants on oscillograms, it would be observed, partook of something of the nature of a wave, and this wave appeared either at the end or at the beginning, according to whether the vowel sound came last or first, as in "tea" or "eat." If one took that view, it was evident that the consonants in the oscillograms were negative and did not affect the record made of the vowel sounds. If one considered the enormous complexity of the harmonic formation of vowels the consonant became a comparatively simple item. In his (the speaker's) opinion, in transmission work the consonants could be disregarded altogether—so long as the instruments would transmit the vowel sounds the consonants would take care of themselves.

Major W. A. J. O'MEARA said that the Post Office was much interested in the problems of transmission, and some of the results of their investigations were indicated in the presidential address of Mr. Gavey. The oscillograph diagrams were very interesting. Some three years ago, when some unfortunate difficulty had arisen with a Corporation, he had found it very convenient to produce oscillograms to explain to the magistrate the difficulties of transmission. He thought oscillograms would be of the same assistance to the telephone engineer as diagrams had been to those interested in prime movers. The Post Office had carried out experiments with telephone apparatus, and, of course, had known for some time that the apparatus at present available was not complete or perfect, but it must not be forgotten that the problem was an exceedingly difficult one—they had to place in residences, in the hands of people who were unacquainted with the science of the subject, an instrument which would be required for transmission of speech over ½ mile or so one minute, and another minute for communication with a point perhaps some hundreds of miles distant. Some part of the Paper had already been put to practical use in some recent agreements between the National Telephone Co. and the Post Office.

Mr. J. ELTON YOUNG said that he was glad to notice that the authors had adopted Dr. Kennelly's notation of hyperbolic functions, which was so much easier than any of the older formulæ, such as Heaviside's, also the use of the terms "sending-end" impedance and "receiving-end" impedance, and he would like to see this notation of the impedances sanctioned by the Institution as it was becoming sanctioned by custom. The sending-end impedance was the ratio of the volts impressed to the impressed amperes, while the receiving-end impedance was the ratio of impressed volts to the amperes received. It was the latter quantity they were dealing with in observing the attenuation. It was very satisfactory to find, as they had done in submarine telegraphy, that the alternating-current formulæ were borne out in practice, and that in a simpler way than had been expected. Thus the propagation of signals was reduced practically to the attenuation of a single fundamental frequency, and worked out in absolute agreement with the sine waves assumed in the formulæ. In submarine cable work there was only one important frequency and no more. Similarly, the authors of this Paper had found that the attenuation at a certain definite frequency of, say, 800~, was a sort of measure of the efficiency of telephone circuits, a view which Mr. Gavey had expressed in his inaugural address the year before last, laying it down that the limit of speech was fixed by attenuation or volume, rather than by distortion or articulation. Dr. Kennelly, at the St. Louis Congress in 1904, had said that it was highly probable that the limiting length of circuit over which telephony was commercially possible was that which had a certain definite receiving-end impedance at a certain standard sinusoidal frequency, whether the circuit was overhead or underground, mixed, loaded or natural, and after variations in the sending-end impedance had been taken into account. He thought the foregoing rule had reference to circuits in which the leakage was negligible. Having made some actual experiments, he was fairly sure that sufficient attention had not yet been devoted to the application of systematic non-inductive leaks to telephone circuits. There was, he fancied, too much tendency to look askance at leakage and to relegate the theory of the distortionless circuit to the limbo of abstractions. In the distortionless circuit, as was well known to students of theory, all the frequencies were received with equal attenuation, when the leakage had a particular value. This value, however, diminished the volume too much. The proper leakage was a sort of compromise between the perfectly distortionless value and the perfectly insulated circuit. He would ask investigators to direct their attention to the adoption of this critical artificial leakage. It was probably of the order of a few tens of thousands of ohms per mile, or less. It would be interesting to hear of any data of improvement due to weather leakage. He pointed out that if measurements were made with a pure sine wave, distortion was not being dealt with at all, because the wave being of only one frequency

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the term had no meaning. He would like to know if anyone had tried the effect of a magnetic shunt on a receiving telephone.

Mr. JOHN GAVEY said he was much interested in comparing the oscillograms which had been reproduced in the Paper with those which he had shown in 1905. At first sight they did not appear to be in agreement, but on closer examination it was found that they were really much of the same type. He should imagine that the oscillographs taken by the authors had been taken with a more rapidly-moving plate than in his own case, and therefore came out more distinctly, but otherwise there was a great resemblance belween the two. Referring to these earlier records he did not observe that interval shown by Mr. Cohen between the "explosive" and the vowel sound, but that was possibly due to the slower plate. The question of lines, he thought, whether overhead or underground, could be dealt with on a mathematical basis, and so far all improvements that had been made in the transmission of sound waves over lines had been based on mathematics. It had to be borne in mind, however, that the senses, whether sight or hearing, implied something more than a mathematical instrument. Thus there were different kinds of speakers, but the listener instinctively completed the sounds unuttered, and the impression on the hearing was practically the same. The telephone gave somewhat the same results when talking over long lengths of line. As to loading, the closer the spacing the more the disturbance. The use of a larger conductor, on the other hand, would do away with the loading. This applied more to overhead lines than underground. With underground lines loading was an advantage.

Mr. J. G. HILL said the whole telephonic world owed a debt to the National Telephone Co. for their pioneer work in connection with the subject. As to the percentages of received currents for the various harmonics given in the Paper, it would be interesting to have some information as to the precise meaning of those percentages. He took it that they were useful in so far as they represented the distortion of the voice of the speaker. Information bearing on several points raised in the Paper was contained in an article by Mr. Béla Gáti on "The Measurement of the Constants of Telephone Lines," in *The Electrician*, Nov. 2, 1906. The curves shown in Figs. 6 and 7 of the Paper were of a very varying nature and it would be interesting to know how far these variations affected the calculations which had been made on the subject. He thought the Paper valuable from the laboratory point of view. It was evident that they must rely on the voice test as the principal test.

Mr. A. CAMPBELL said that with regard to the oscillograms of vowels and consonants which the authors gave, much light could be thrown on such problems by the science of (linguistic) phonetics—a science which, he regretted to say, was almost entirely neglected in this country. The authors stated that it was probable that the leakage in telephone cables increased with rise of frequency. From experiments which the speaker had made not long ago on air-dry cellulose* there seemed no doubt of this. Since even in the most highly-dried paper cables there was always some trace of "associated" moisture, they would behave to some extent in the same way. Continental experimenters had found that the same held with electrolytic conduction in dilute sulphuric acid at frequencies of several million per second. Mr. Campbell then showed an experiment to illustrate (*a*) a method of measuring the alternating voltages occurring

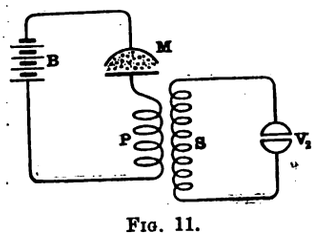


FIG. 11.

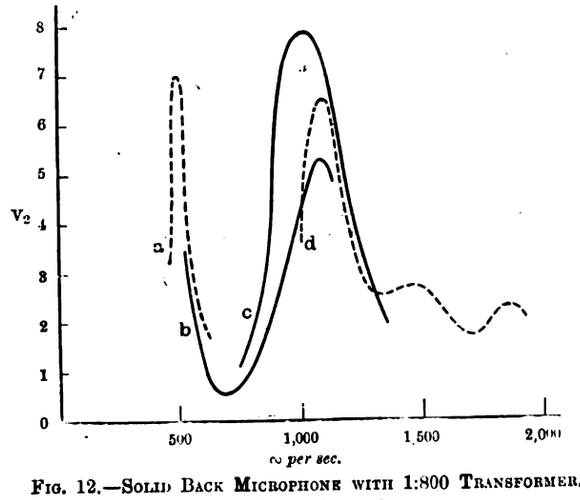
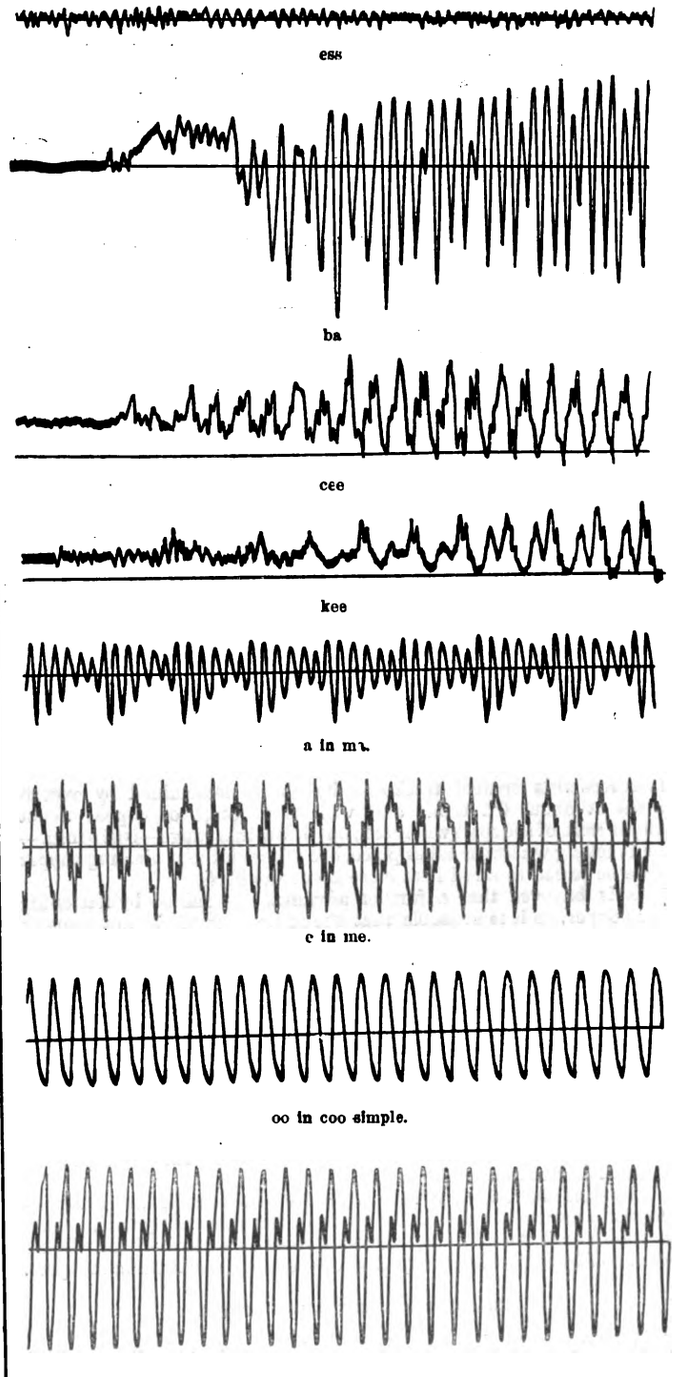


FIG. 12.—SOLID BACK MICROPHONE WITH 1:800 TRANSFORMER.
(a, b, c, d, four Organ Pipes.)

in microphone circuits, (*b*) the behaviour of a microphone transmitter at various frequencies. A solid-back microphone, M, was put in series with a battery, B, of six to eight volts, and the primary P of a transformer (a spark coil) of high ratio, say, 1 : 800. The secondary S of the transformer was connected to a reflecting electrostatic voltmeter, V_2. The deflection of this voltmeter, when sounds were made near the microphone, was a sensitive measurement of the voltage produced. With this arrangement when the nearly pure note of a stopped organ pipe was sounded, and the pitch gradually raised by pushing the plug in, it was seen that the spot of light rushed off the scale when certain notes were reached. He also showed that a "solid-back" transmitter had more than one point of strong resonance. To ensure that the effect was not due to anything in the particular organ pipe the experiment had been repeated with three others all of different lengths. The curves in Fig. 12 showed conclusively that the transmitter was responsible for the resonance effects. It was well known that telephone receivers showed similar points of resonance well within the range of frequency occuring in speech. The marvel was that, in spite of this, speech could be so distinctly transmitted.

Mr. DUDDELL said that about a year ago he had given a discourse in London on "How to Improve Telephony," and in that discourse he had



Time : 1 mm. = $\frac{1}{25\,00}$ second. Current : 1 mm. = $\frac{1}{300}$ amp., say, 3·3 m.a.

FIG. 13.

described similar methods and shown similar views of oscillograms to those of the authors of the present Paper. As to vowel sounds, the records which he had made were similar to the author's, but not identical, which would be explained by the fact that the slightest alteration in the resonant cavity of the mouth altered the character of the sound.

* *Proc.* Roy. Soc., A, Vol. LXXVIII., p. 209.

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Mr. Duddell showed a number of slides representing oscillograms of vowel and consonant sounds, and these we reproduce in Fig. 13. He also showed a film of the well-known song, "A Little Piece of String." The strip on which the record was made consisted of a white half and a black half, formed to the oscillogram curve. By the use of this film and a selenium cell it was possible to reproduce the actual sounds, although in less volume, making a sort of photographical phonograph. As to the question of power measurements, he had used the three voltmeter method in connection with some experiments with the electric arc, and he found it was successful. He thought it was a better method than that adopted by the authors. As to the measurement of small alternating currents, he had considered this matter very carefully, and in 1904 read a Paper before the Physical Society, in which he described the thermo-galvanometer to which Mr. Cohen had referred. Subsequently he had been asked by the French Post Office to lecture on the measurement of alternating currents. He had gone into this matter and made a large number of experiments, using small lamps for measuring the alternating currents. As to the use of iron wire, this wire had a peculiar property, the resistance rising with the temperature very rapidly at certain temperatures. He had carried out tests with both iron and platinum wire, and had come to the conclusion that iron wire was most suitable and much more convenient to use than any form of platinum. He was able to bring to the notice of the members for the first time a new portable form of thermo-galvanometer for measuring alternating currents. Although on the same principle as the original instrument of this kind, it was much more sensitive, taking only 16 milliamperes for the whole scale reading, as against 2 amperes in the older instrument.

[We hope to give an abstract of the remainder of this discussion in our next issue.]

AN EXPLANATION OF THE SHORT LIFE OF FROSTED LAMPS.*

BY E. P. HYDE.

It has long been recognised that the useful life of a frosted incandescent lamp, taken to 80 per cent. of its initial candle power, is only a little more than one-half the life of a corresponding plain bulb lamp. The only explanation which has been advanced, so far as the writer knows, is that the temperature of the frosted lamp is higher, due to the increased absorption by the bulb, and that therefore the lamp reaches any given point in its life, *e.g.*, the 80 per cent. point, in a shorter time than that required for the corresponding plain bulb lamp.

Without entering, at present, into a discussion of the possible temperature effects, it is sufficient to notice that if the shortened useful life can be attributed to this cause, it is very probable that, due to the same cause, the total life of a frosted lamp up to the time when the filament burns out, would also be very much less than that for the plain lamp. On the contrary, the writer has recently been informed by S. E. Doane, chief engineer of the National Electric Lamp Association, that numerous tests made at the engineering laboratories of the association indicate that if the life is taken to the time when the filament burns out the average life of frosted lamps is the same as that for plain lamps.

It would, therefore, seem that some other explanation than that of the effect of temperature must be sought. A possible explanation of the phenomenon recently occurred to the writer and was subjected to a test which showed conclusively that at least a large part of the effect, if not the entire effect, could be accounted for by the proposed explanation. A complete discussion of the investigation, with the detailed numerical results obtained, is to be published shortly in an extended Paper on spherical reduction factors and on the effect produced by plain and frosted bulbs of various shapes on the distribution of light around filaments of different forms. It was thought desirable, however, on account of the general interest in the question of the short useful life of frosted lamps, to publish this preliminary note outlining the explanation of the effect.

If we consider the case of a new plain bulb lamp, a certain small percentage of the total flux of light emitted by the incandescent filament is absorbed by the glass envelope surrounding the filament. When the lamp is frosted a relatively large part of the light which in the plain bulb would pass through the outer surface of the bulb is diffusely reflected back through the glass. In this way a relatively large part of the total flux of light passes through the glass more than once, and so the frosted bulbs show an absorption about 5 per cent. greater than that for the plain bulbs.

Now, the actual absorption coefficient of glass is quite small, so that it is readily seen that if in any way the absorption coefficient is increased appreciably the apparent absorption due to frosting would be increased greatly. This is what happens when with increasing life the strongly absorbing carbon film is deposited on the inside of the bulb. The effect is the same as if the absorption coefficient of the glass had been increased greatly. In the case of an old plain lamp all the light passes through the carbon film once, the small percentage passes through twice, a still smaller percentage three times, and so on. When the lamp is frosted the percentage that passes through more than once is very much larger, and so the carbon film has an opportunity to absorb a much larger percentage of the total flux. According to this theory, although at any time the filament in the frosted bulb may be emitting the same total flux of light as that emitted by the filament in the plain bulb, the absorption of light in the carbon film is much greater in the one case than in the other, and so the apparent intensity of the frosted lamp at any time during life is less than that of the plain lamp, the difference in intensity increasing with the number of hours the lamps have burned.

In order to test the hypothesis in a rough way a frosted spherical diffusing globe was mounted on the photometer bench. At first a new 4 c.p. lamp whose intensity was known was placed inside the globe, and the apparent absorption of the globe was measured. Then an old 4 c.p. lamp on the inside of whose bulb a very perceptible deposit of carbon had formed was substituted for the new lamp. Measurements on this lamp showed a much larger apparent absorption of the frosted globe. Then the new lamp was coated with a layer of lacquer, which absorbed some of the light, and a third determination of the absorption of the globe was made. As before, the apparent absorption was greater than with the bare lamp.

Although in this way the presence of the effect was plainly noticeable, no quantitative results could be obtained, because the conditions were quite different from those existing when the bulb of the lamp is frosted. On account of the small size of the neck of the diffusing globe compared with the diameter of the globe, the largest lamp that could be used filled only a relatively small part of the inside of the globe, and so of the light diffusely reflected back by the frosted globe only a part passed through the lamp bulb. Therefore the magnitude of the effect measured in this way was necessarily small compared with that which would occur with ordinary frosted lamps.

In order to make a quantitative determination of the effect, 10 comparatively new lamps and 12 old lamps that had dropped to 80 per cent. in candle-power were carefully measured for mean horizontal and mean spherical candle-power. They were then sent to a lamp factory and frosted by the acid process, care being exercised to see that the frosting was as nearly uniform for the different lamps as it was possible to obtain. The lamps were then returned to the Bureau of Standards and measured. The new lamps were found to have decreased in mean horizontal intensity by about 4 per cent. on the average, the individual lamps agreeing among themselves to within less than 2 per cent. On the other hand, the older lamps were found to have decreased in mean horizontal intensity by 18 per cent., or 14 per cent. more than the new lamps. In other words, the apparent absorption of the frosting was approximately 4½ times as great for the old lamps at the end of their useful life as for the new lamps. This means that if we were to assume no difference in the physical or mechanical properties of plain and frosted lamps, a lot of plain lamps which would decrease 20 per cent. in candle-power in a definite number of hours, would in the same number of hours decrease approximately 32 per cent. if they were first frosted. The useful life of the frosted lamps to 80 per cent. of initial candle-power would be about 60 or 70 per cent. of the useful life of the plain lamps, a value in approximate agreement with that commonly accepted. This shows that whatever effects may be produced in the lamps by frosting them, the mere absorption by the deposited carbon film, as explained above, is sufficient to account for a decrease in useful life of about 30 or 40 per cent.

A single set of measurements of mean spherical intensity indicated that the new lamps had increased about the same in mean spherical candle-power as in mean horizontal, whereas the old lamps had decreased several per cent. more in mean spherical intensity. This is probably due to the uneven distribution of the carbon on the inside of the bulb.

The following experiment has been planned to determine whether there are any other elements entering than that of the increased absorption of the carbon film due to internal reflections. A large number of carefully selected lamps will be accurately measured, of which 20 lamps will be burned to the "peak" point in the curve, 20 more to a point corresponding to about 60 per cent. of the normal useful life of the lamps and 40 more to the end of their useful life, measured to the 80 per cent. point. 20 lamps will not be burned at all. All of the lamps, except 20 of those at the end of their useful life, will now be frosted at the same time and by the same process, and then all will be burned until the filaments break. In this way different points in the life curve can be reached by different paths. Thus, for example, it will be interesting to note whether the 20 lamps frosted at the end of their useful life will have the same average value as the 20 lamps frosted initially and then burned for a number of hours corresponding to the average useful life of the plain lamps. In this way it is hoped to determine whether any other elements enter to partly account for the relatively short useful life of frosted lamps

* Communication from the Bureau of Standards, Washington, D.C.

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HYSTERESIS AND PERMEABILITY OF IRON IN RELATION TO FREQUENCY.*

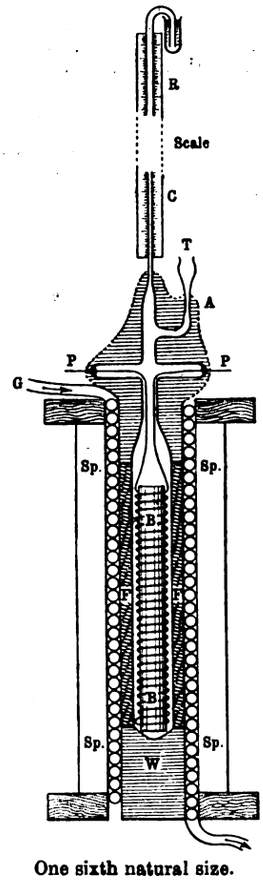
BY LEON SCHAMES.

When iron is subjected to an alternating magnetic force heat is developed, partly owing to hysteresis and partly to eddy currents. The author determines the relation between the loss of energy due to hysteresis and the speed at which the cyclic process is accomplished, and incidentally also the dependence of the permeability upon the frequency.

He used a purely calorimetric method. The sheet-iron to be tested was put in the form of prismatic bundles and inserted in glass tubes filled with xylol and ending in capillaries. The heat developed by frequencies up to 500~ per second was read by the displacement of the meniscus in the capillary tube.

The specimens included Siemens-Schuckert transformer sheets 0·3 mm. thick, and the same material rolled down to a thickness of 0·03 mm. The strips were 20 cm. by 1·8 cm.

The bundle B (*see* diagram) was surrounded by a fine platinum wire, P, immersed in the xylol, and serving to standardise the xylol thermometer. The tube was surrounded by a felt tube, F, and cotton wool, and further by a cardboard tube on which was wound a rubber tube, G, through which cold water was pumped in order to protect the thermometer from the Joulean heat of the magnetising coil which filled up the space Sp.



One sixth natural size.

The effect of the eddy currents was allowed for by calculation, using Arnold's formula

$$W = \tfrac{1}{3} f^2 n^2 B^2 \Delta^2 10^{-4} \text{ erg}$$

for iron of specific resistance 10^{-5}. Here W is the eddy current loss per cubic centimetre and per second, Δ the thickness of the sheet-iron in centimetres, and the other letters have the usual significance. For one of the bundles the loss was 240 ergs per cycle, or 0·5 per cent. of the total loss. In the thicker sheets the eddy current loss is more like 40 per cent.

The hysteresis losses were determined for frequencies 50, 400 and 500, and the maximum induction in the iron was measured by measuring the secondary P.D. and determining the shape of its curve.

The author summarises his results as follows:—

1. If the hysteresis losses are reduced to equal maximum inductions, the loss is independent of the frequency so long as B does not exceed about 10,000. Upwards from that the loss of energy increases with the frequency.

2. The demagnetisation under the same conditions is independent of the frequency.

3. The permeability decreases in weak fields as the frequency increases, and does so most rapidly at its maximum; on increasing the field strength the permeability for different frequencies approaches a constant value, which is the same as that to which it tends in the magnetometric experiments.

Referring to the work of his predecessors, the author points out that many apparent contradictions in their results may be explained. Hopkinson, Maurain and Gray found a practical constancy of the hysteresis area, but since this maximum frequency was 100 and their induction 15,000 it is evident that they could not have discovered any change. Guye and Herzfeld commit the error of reducing to equal exciting currents instead of equal maximum inductions, and since they say nothing about the dependence of permeability upon frequency it is difficult to appreciate the value of this "absolute independence of the hysteresis as regards frequency."

Steinmetz, Niethammer, Krogh, Rikli and Dina appear to have under-estimated the eddy currents, and Corbino and Madelung appear to have completely neglected this important factor, which would require special attention in view of the thickness of the material used by them. The results obtained by M. Wien agree with the author's. The observation of Klemencic is easily explained. In soft iron, where he reaches high inductions, he finds an increase of hysteresis, but not in steel and nickel, on account of the smallness of their permeability and consequent induction.

As regards the dependence of the permeability upon the frequency, M. Wien finds that the permeability in a sine field is always smaller than in a constant field. The differences are greatest at the maximum permeability, as also found by the author. That Wien did not discover the mutual approach of the curves is due to his having worked with small fields not exceeding 29 C.G.S, whereas the author got up to 140 C.G.S. Klemencic also seems to have recognised the running together of the permeability curves, for he says that with increasing frequency the permeability curve approaches more and more to a straight line, and has always the small final value which in static experiments is only attained in strong fields.

* Abstracted from the *Annalen der Physik*, No. 3, 1907.

RESISTANCE AND THERMOELECTRIC FORCE OF OXIDES AND SULPHIDES.*

BY K. BÄDEKER.

The difficulty in the study of pure metallic compounds is entirely one of suitable preparation. The conductivity and thermoelectric force are well within the values we are accustomed to in metals and electrolytes. But pure coherent plates or rods are very difficult to obtain, and can hardly ever be prepared by fusion. Crystals or pressed powders have sometimes been used, but the former are rarely of pure composition, and the latter show coherer effects and irreversible temperature effects. In consequence of these difficulties our knowledge of the electric properties of oxides, sulphides, selenides and hydrides is still very fragmentary, and in many cases there is still a doubt as to whether we have to do with metallic or electrolytic conduction. Silver iodide, when illuminated, is stated by Scholl to possess both types of conductivity. No method has yet been devised for dividing the actual conductivity between the two types. The usual criteria of electrolytic conductivity are decomposition, polarisation and unipolar conduction.

Silver haloids and cuprous sulphide are known to be electrolysed, as also most of the transparent crystals observed by Grätz. On the other hand, metallic conduction is found in the oxides of lead, cadmium, iron, manganese, copper, the sulphides of copper, lead, iron, mercury, nickel and tin, and the selenides of silver and copper.

Several tellurides, phosphides, arsenides and antimony alloys show also good metallic conduction.

Koenigsberger has established the following formula for resistance as depending upon temperature:—

$$\sigma = \sigma_0 (1 + a t) e^{\frac{q}{T}},$$

where T is the absolute temperature and a the coefficient of thermal expansion of gases. It may be written without sensible error in the form

$$\sigma = \sigma_0 \cdot aT \cdot e^{\frac{q}{T}},$$

which shows that for very small absolute temperatures σ increases indefinitely, since the exponential factor converges much more rapidly upon infinity than aT converges upon zero. But for very high T the last factor becomes unity, and the resistivity increases linearly, as observed in metals. The last factor is taken to represent the relation between the temperature and the number of conducting electrons.

It is also evident that for every body which obeys the formula there is a special temperature at which the temperature coefficient changes its sign, so that this sign cannot be used to discriminate between metals proper and electrolytes. Such temperatures are 175 deg. for Ag_2S, 133 deg. for Ag_2Se, 103 deg. for Cu_2S, and 110 deg. for Cu_2Se.

The Method.—The author obtained his specimens by cathode disintegration of the metal on glass or mica, and subsequent oxidation by exposure to the vapour of the metalloid. He thus obtained 20 compounds of cadmium, copper, silver, lead and thallium. Oxides were prepared by direct roasting in air; iodides by immersion in iodine vapour; sulphides and selenides by diffusion of the vapour into the vacuum containing the metal, so as to avoid decomposition by heat. The specimens appeared absoluetly coherent under the microscope, and this appearance was parallelled by their electrical behaviour.

The thickness of the films was determined by weighing with a Nernst quartz-fibre micro-balance, the specific gravity being assumed to be the same as it is on a large scale. A quantitative chemical analysis furnished a test for the thorough combination of the two constituents of each compound.

For the thermoelectric measurements the specimen was mounted between two clamps, as shown in the diagram, and the lower end immersed in paraffin oil kept at 200 deg., while the upper end was cooled by a current of air. The thermometer controlling the paraffin oil was provided with vanes for stirring.

* Abstracted from the *Annalen der Physik*, No. 4, 1907.

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Results.—The chief resistances obtained are shown in the following table, together with some reference values:—

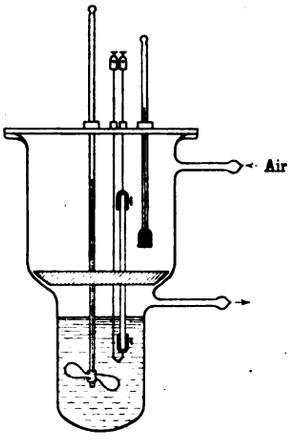
Metallic Conduction.

Platinum.....	0·000014	Ag_2S (at 200 deg.)	0·0017
Bismuth	0·00012	Graphite	0 0028
CuS	0·000125	Cu_2O.....	40·0
PbO_2.....	0·00023 (?)	CuO	400 (?)
CdO	0·0012		

Electrolytic Conduction.

CuI	0·045	30 per cent. H_2SO_4	1·35

The best conductor found is cupric sulphide, and its temperature coefficient is 0·0027, which closely approaches that of pure metals. Another proof of the metallic nature of the conduction is the ratio of its electrical to its thermal conductivity, which is $5·7 \times 10^5$, as against 6×10^5 for an average of other metals. Just as in metals, the temperature coefficient decreases as the layer is made thinner. The thermoelectric force against copper is about 7 microvolts per degree, a value rather above that of most platinum couples. Still higher values were found for cadmium oxide against copper (30), and Cu_2O against Pt (480), which compares favourably with the 100 of the bismuth-antimony couple.



A selenide of copper was suspected to have a conductivity even exceeding the sulphide, but the result is doubtful.

Silver sulphide has a transition temperature at 175 deg., and is then converted into a metallic conductor, whereas silver selenide is always metallic. The transition temperature of Ag_2S is also in evidence calorimetrically. By transmitted light the sulphide changes from coffee brown to reddish brown.

PHYSICAL SOCIETY.

At a meeting held May 10th, Prof. J. Perry, F.R.S., President, in the chair, a Paper entitled

"Stereoscopy with long Base-line illustrated on the Screen,"

was read by Dr. T. C. Porter. The present Paper, containing suggestions and extensions of stereoscopic work, is largely the same as that read to the Royal Photographic Society on January 29th of the present year. The use of a long base-line for tele-stereoscopy had occurred to M. Selb of Brussels, and in 1903 he obtained stereoscopic mountain photographs. The applications of the method for military, geographical, and meteorological purposes, although obvious, do not seem to have been used before, and the author discusses the possibilities of these applications. The paper opens with a brief sketch of the principles of stereoscopy and describes an attempt to measure the limit of stereoscopic vision for the unassisted eye. The power we possess of judging of the difference in distance of two objects in our field of view depends, first, upon various properties of those objects which vary with the said distance, variations to appreciate which we require strictly but one eye, though it may well be that we appreciate them better with two. These properties are the apparent size, the clearness or haziness of an object, the arrangement of light and shade and the shadows cast, and fourth, the apparent motion of the object. The next means of telling the different distances of objects depends—not on the properties of the objects themselves—but on one of the eye itself. It is the effort, made quite instinctively, by which we bring the images of objects to a sharp focus on the retina, *i.e.*, by the effort made in so-called accommodation. The power of accommodation is, however, comparatively limited in its scope, the author's experiments putting the limit for ordinary sight at about 6 ft. from the eye. On these various methods and on the mental deductions following from them and founded on previous experience, depend the whole of the powers of appreciating form and distance, so far as each eye is considered separately. The impressions received by the two eyes when regarding any near object are not the same, because each eye sees from its own position, which differs from that of the other eye by about 2·5 in. in most cases. When an observer wishes to examine a near object he must turn each eye inwards by a certain angle θ, and this he does by making a definite effort. It is this effort of convergence which gives the sensation of spectroscopic relief. When the object is so far removed from the eye that the angle θ, or the convergence for one eye, becomes too small to be appreciated, and, therefore, also the effort necessary for the convergence through this small angle becomes inappreciable, the stereoscopic sensation fails. In other words, stereoscopic sensation will be limited to objects nearer the observer than this distance, which is thus the spectroscopic limit. The author's experiments place this distance for average persons at about 43 ft. The range of stereoscopic effect varies directly as the length of the base-line. If the distance between the eyes could be increased 10 times, the stereoscopic effect would be perceptible to a distance of 430 ft. Such an increase of base-line can be made to all intents and purposes by means of reflectors, and this was first done by Helmholtz. The base-line can also be increased by taking two photographs of distant objects from two different points and viewing them in a stereoscope. However long the base-line, so long as its two ends are about the same distance from the objects and so long as the objects themselves are clear enough and large enough to yield a picture, we have the means of determining the forms and relative distances of the objects however far off they may be. The author showed upon the screen numerous stereoscopic pictures of distant objects, mountains, clouds, &c., and discussed the value of the pictures for military, geographical, and meteorological investigations.

Mr. J. TENNANT expressed his interest in the paper, and said he had shown pictures of clouds, taken by the same method as that employed by the author, in a paper published in 1897. He was not certain that the feeling of convergence was the only thing which determined stereoscopic vision. The estimate of 43 ft. as the limit of stereoscopic vision seemed to him too small, as he had observed stereoscopic effects at distances up to 125 yds. In 1896 he devised a stereoscopic camera and used it to measure the heights and depths of clouds. In some of his cloud experiments he had used a base line ¾ of a mile long. The method was applicable to many subjects and was a most valuable one.

Mr. CRAWLEY said the author's determination of the angle θ was very much larger than that given by Helmholtz. The methods described by the author had been used by Pulfrich in surveying and astronomical work.

CORRESPONDENCE.

CORRUGATIONS IN TRAM RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I was rather disappointed at your not publishing my last letter as I intended you to do. I meant it as a reply to Mr. Briggs' letter. With your permission I will endeavour to show that Mr. Briggs' theory, as published in your issue of 17th inst., is not the correct one. He repeats that he knows one place where a straight rail is corrugated, though only very slightly, although sufficient to swear by. If Mr. Briggs will stand some distance from this rail and look carefully, he will find that it is "not straight," but out of line, and forms a slight curve, and the outer rail of the curve so formed is corrugated. With regard to the Liverpool Overhead Railway being centre-driven, I will refer Mr. Briggs to a Paper read by Mr. Panton before the Institution a few weeks ago, a report of which appeared in *The Electrician*. Mr. Panton contended that corrugations had only become troublesome since the single-ended drive was adopted. If I am not misinformed, the majority of electrically-driven cars and trains are driven from one end of the axle only, at alternate ends. Mr. Briggs says: For the sake of argument, take an ordinary pair of wheels and travel them round a curve of large radius, either the inner or the outer wheel must slip. I have watched pairs of ordinary waggon wheels and have come to the positive conclusion that in all cases the inner wheel follows the rail and the outer wheel skids or jumps to gain the difference in the length of the two rails. I have a pair of manganese rails under observation that are about 100 ft. radius. The outer rail is grooved or corrugated on the gauge edge (not on the tread), but the check on the inner rail is not so marked, which shows, I think, that the outer wheel in all cases has to gain on the inner one. These rails are run on both ways.

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Mr. Briggs says that on curves of very large radius the slip is almost continuous and is not so liable to form corrugations. Now, Sir, these are just the places where the trouble is worst, at least from my experience, and I have a matter of 40 miles of track to contend with. On rounding a curve of 150 ft. radius or less, the cars travel slowly and the outer wheels grind evenly, and, consequently, leave no marks on the rail, but on slack curves the cars travel quickly as a rule, and here the corrugations are found, and only on one rail, the outer or longer. So long as the wheels are constructed as at present—that is, "fast"—and run in rigid axle boxes, all the cross bracing in the world will not stop corrugations, for "something has to go."—Yours, &c., ROAD INSPECTOR.

Liverpool, May 20.

ELECTRICITY SUPPLY TARIFF.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is admitted generally that the multiplicity of "systems" of charging for electricity, retard to a great extent the introduction of new consumers. I notice, however, that many of our enterprising friends, the central station engineers, are devising still more. I refer particularly to the two-rate system, in which a clock controls the mechanism of a meter with two dials.

The restricted or high-rate period is variable and usually on these lines: January, 5 a.m. to 8 p.m.; February, 5:30 a.m. to 8 p.m.; March, 6 a.m. to 8 p.m.

Whilst they are confusing and annoying their customers in this manner, lowering the peaks (and possibly the valleys), quite 90 per cent. of the men who sell electricity are convinced that a maximum demand system is the fairest.

I know the main objection is "the consumers don' understand it," but can it be that the "fairest system" has not been properly applied?

I submit that an arrangement of charging a price per kilowatt of demand, taking the place of the objectionable meter rent, would give satisfaction.

It would appear to be much simpler than either a varying restricted period, or the original maximum demand system of so many units at x and so many at y.

For some months past I have heard of an indicator which can be fitted to a meter (in the same case) at about 12s. to 15s., so that the capital charge is only about one-sixth that of the two-rate apparatus.

The technical value of the system is acknowledged and I trust some of your correspondents will discuss it commercially. —Yours, &c., INDICATOR.

Manchester, May 16.

STENOTELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the realm of invention it most frequently happens that the same idea strikes more than one mind, and herein lies the wisdom of the patent laws in granting protection for the practical application of an idea rather than for the mere conception of it. I was, therefore, not surprised to learn from Mr. S. G. Brown's letter, which appeared in *The Electrician* of May 17th, that one phase of the stenocode principle is mentioned in his patent No. 7,471, A.D. 1900. Indeed, I believe that Lord Kelvin's first thought was to utilise the right and left deflections of his siphon recorder, to form an alphabet the letters of which were designated by single beats of greater or less amplitude (13 of which were to be recorded by the right-handed deflections from different current strengths and 13 by left-handed deflections), and that he only decided to adopt the present Morse notation when he found that it was impossible to sufficiently differentiate so large a number of beats. It is a pity that a suitable compromise such as the stenocode offers did not occur to him at the time, because the public would be now enjoying the benefit of lower rates with better service, whilst cable shareholders might be deriving larger dividends on their investments. Mr. Brown appears to have been fully alive to the possibilities of the subject, but he did not follow it up, from objections which I claim to have overcome. The stenocode idea occurred to me as far back as the early seventies, but in the absence of the necessary important developments, such as Mr. Brown himself is associated with, it was not then a practical proposition.

With regard to the concluding remarks of his letter, it is evident that two most important features in the code aspect of my system were not quite clear to Mr. Brown at the time he wrote—viz, (1) the provision made for an absolute check to guard against the possibility of an error passing unnoticed through the hand of an operator at any station after the message has left the station of origin; (2) the practicability of applying Stenocode principles to any other code of signalling with great advantage, so that these can still be associated with any improvements tending to increase the amount of matter that may be put through in a given time.

Even if, as I hope will be the case, Mr. Brown is successful in his endeavour to increase the actual speed of transmission, yet it will always be a fact that, beyond a limit, increase of working speed must result in improper definition of signals. And the question of lessening the number of contacts per letter, even at a sacrifice of a small percentage of speed, in order to obtain clear signals, is as important at that higher speed as it is now.

Begging your kind indulgence for this letter, which, unavoidably, has to be rather lengthy, I am, yours, &c.,

20, Copthall-avenue, London, May 22. A. C. BARONIO.

NEW FUSES.

The switchboard pattern of Peard's patent fuse is already very well known. It will be remembered that the arc is extinguished by means of a shutter, which is forced by a spring through the molten fuse.

These fuses are now being made in a superior manner which takes all strain off the plaster holder. The contacts are built up on a skeleton frame, the foundation of which is of vulcanite. The frame is then put in a mould and plaster formed round it so that the contacts do not owe anything for their support to the plaster as was the case in the original design, and in the event of the plaster breaking it is not a difficult matter to replace it without interference with the general construction. The new arrangement of the fuse is shown in Fig. 1.

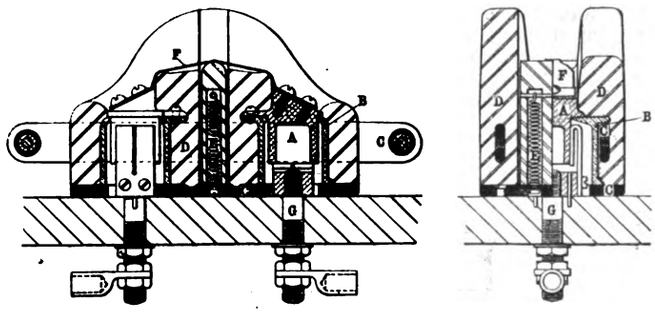

FIG. 1.—END HANDLE TYPE. PEARD SWITCHBOARD FUSE.

Another of Peard's patent fuses, which we consider of some importance, is of a non-explodable, steel-cased tubular pattern. This is specially arranged for protecting underground network circuits, also for mines, theatres, switchboards, and many other uses. The present Board of Trade Regulations call for either circuit breakers or fuses to be fitted for the control of all distributing mains in the streets. This regulation is, at the present, more or less in abeyance owing to the difficulty of fitting circuit breakers, and the fact that there is difficulty in obtaining a satisfactory fuse for use on underground circuits; but the omission to sectionalise a distributing system of mains has been held by the Courts to be negligence on the part of supply authorities.

With the steel-cased tubular fuse the following points are claimed: (1) The fusible conductor, being totally enclosed in a small steel casing, scatters no molten metal, evolves no metallic vapours, and emits no flame or fire. (2) The fuse, which consists of an ordinary copper wire, can be renewed in the course of a few minutes, and the holder cannot be overfused. (3) With this type of holder there are no fire risks, as neither inflammable gases nor neighbouring goods can be ignited by the fuse blowing. (4) The novel construction of the holder ensures the fuse having a small time element, and renders it both rapid and reliable in action. The high

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conductivity and small mass of the fusible metal employed, and the fact that the filling material is not in intimate contact with the fuse wire, results in a low thermal capacity. (5) The cooling action of the special terminals and the short length of wire actually fused, combined with the novel filling material which surrounds it, result in the volatilisation of only a very small quantity of metal, and instantly suppress any arcing. (6) The new form of filling and secondary lining used, being of an extremely simple and practical nature, can be quickly and easily renewed by the user when necessary. (7) The permanent parts of the holder are undamaged by the fuse blowing, and may be kept in constant use. The internal insulation is protected from metallic deposits or films by the secondary mica tube, while the terminal ends are similarly protected from deposition of molten metal by replaceable iron washers. (8) The holder is compact, easily handled, and of sound mechanical and electrical construction.

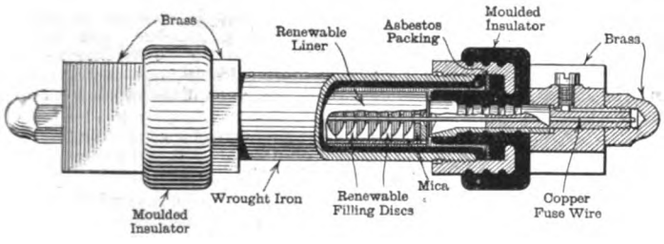


FIG. 2.—SECTION OF STEEL-CASED TUBULAR FUSE.

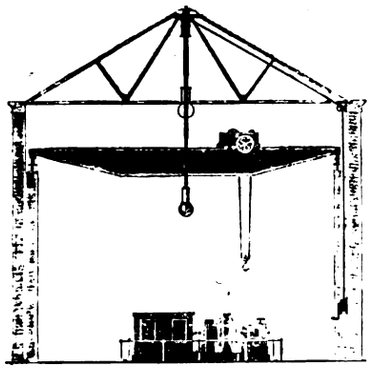
Fig. 2 shows a section of this new pattern of fuse, the external brass contacts of which can be made of any desired form.

These fuses are being supplied by Messrs. Veritys, who have supplied us with the above information.

"TWO-STAGE" ARC LAMP LOWERING GEAR.

Hitherto generating station lighting has mostly been done by arc lamps skied above the crane, or by incandescents or arcs on brackets on the side walls; the latter is more expensive, whilst both systems are inefficient, giving light where it is not wanted.

The London Electric Firm of Croydon have, by their two-stage arc lamp lowering gear, enabled lamps to be suspended below the line or in the wake of the crane, in the centre of the building, where the best distribution of light is obtained. Half the number of lamps hitherto used will probably suffice, thus reducing initial expenditure as well as maintenance costs.



ENGINE ROOM SHOWING POSITION OF ARC LAMP LOWERING GEAR.

We give an illustration of this gear. It consists simply of a telescoping tube, fixed pendant to the plug of their well-known "one working part" arc lamp lowering gear. The normal position of the lamp is below the level of the crane; and when it is desired to move it to its second position above the crane, the wire rope is drawn up, telescoping the tube and thus raising the lamp out of the way. The pendant portion of the gear is provided with a knuckle joint so that nothing serious would happen in the event of the crane being accidentally run against it. The contact itself can be fixed to the tie rod, ridge, principal, girder or any other member of the ceiling, or to a pipe extension therefrom. The wire rope is used merely to raise or lower, and is relieved of all weight by the suspension or "catch" when the lamp is in position. To lower the lamp to the ground for trimming, a few turns of the winch is all that is necessary.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

We intimated in our last issue that Dr. J. A. Fleming was preparing a statement to present to the Committee which has been sitting to consider evidence for and against the ratification of the Radio-Telegraphic Convention. This statement was to be supplementary to that which was given in the last and the preceding issues of *The Electrician*. This has now been sent in, and we make the following extract:—

Dr. FLEMING: As regards the history of electric wave telegraphy, evidence has been put in denying to Mr. Marconi the credit of being the true initiator of practical wireless telegraphy and representing it as having been in existence before the date of his first British patent in 1896. Sir William Preece has stated that wireless telegraphy existed before Marconi, who, when he came to this country, only brought with him a new way of doing an old thing. This remark, though perfectly true in a sense, does not sufficiently emphasise the novelty of Mr. Marconi's method. Mr. Marconi brought to this country not merely an alternative to some pre-existing methods, but something quite beyond them and capable of doing that which the older and now extinct forms could not possibly achieve. Dr. Fleming proceeds to extract from Sir William Preece's lecture at the Royal Institution in 1897, and also from a magazine article by Prof. Slaby in 1898, and he claims that this contemporary testimony showed that Mr. Marconi did more than continue the work of others, and introduced something new. With regard to a claim by Sir Oliver Lodge that Dr. Muirhead was in 1894 struck with the applicability of electric waves to telegraphy, Dr. Fleming refers to "The Work of Hertz and some of his Successors," published in book form in 1891 after the delivery by Sir Oliver Lodge of lectures in London and Oxford. Dr. Fleming states that there is no single word on the subject of wireless telegraphy in that book, whereas in the second edition, published in 1898, after the date of Mr. Marconi's first patent, a chapter is added on the history of the coherer principle, originally published in November, 1897, in *The Electrician*, in which (Dr. Fleming states) Sir Oliver Lodge refers to Mr. Marconi's work in terms of depreciation. The real proof of the novelty of Mr. Marconi's work is (Dr. Fleming contends) to be found in the entire absence of any reference in contemporary literature prior to 1896 to the actual and practical achievement of wireless telegraphy by electric waves. No one could point to a single patent for electric wave wireless telegraphy dated prior to Marconi's British specification No. 12,039 of 1896. Dr. Fleming classes as a refined distinction Sir Oliver Lodge's statement that he does not use an antenna, but employs in his system an elevated aerial which is made of wire but is not a wire up a mast. Sir Oliver Lodge also claims that he does not employ an earth connection, which is a feature of Marconi's invention, while in his more recent patents, such as No. 11,348 of 1901, Sir Oliver Lodge states that he employs an earth connection at both transmitter and receiver, and in this particular specification he stated that "one terminal of his working condenser has an aerial conductor of appropriate length and capacity, reaching up a considerable height, connected to it, and the other terminal of the said condenser is connected either to the earth direct or through another condenser to the earth." Dr. Muirhead, in his evidence, stated that Sir Oliver Lodge was granted a master patent for tuning (No. 11,575 of 1897). Against this (continues Dr. Fleming) I put on record the following facts: In and before 1900 Mr. Marconi invented certain great improvements in tuned or syntonic telegraphy, involving the use of certain forms of oscillation transformer, and obtained British patents for these inventions. On applying for equivalent German patents, the German Patent Office referred him to Sir Oliver Lodge's above-mentioned 1897 patent as a possible anticipation. I was requested by the Marconi Co. to go to Germany and discuss the matter. I had certain tuning coils and apparatus for tuned wireless telegraphy made as closely as possible like the apparatus figured in the above-mentioned Lodge specification, and also other apparatus as described by Marconi. Experts from the German Patent Office met me in June, 1900, at Borkum, on the North Sea, and I exhibited the apparatus to them and invited them to test it on a wireless circuit then established between the island of Borkum and a certain lightship. The apparatus made in accordance with Lodge's specification failed to work, while that made in accordance with Marconi's worked perfectly. The German Patent Office therewith granted patents to Marconi for these inventions.

In the course of the evidence before the Committee, statements have been made by Mr. Marconi and myself that the electric waves used in wireless telegraphy cannot merely be characterised by their wave-lengths, but other qualities, such as amplitude and damping, must be specified as well to define a wave, and that there are three types of waves now used—(1) strongly damped intermittent wave trains, (2) feebly damped intermittent wave trains, and (3) undamped or persistent wave trains. Each of these is created by a particular form of transmitter and is detected by a particular form of receiver. If we compare electric waves with waves in the air-producing sound, we may say that the above three types of electric waves are analogous to (1) a number of short blasts on a trumpet, (2) a number of prolonged more or less drawn out blasts on a horn, and (3) a continuous note on an organ pipe. The short blasts on the trumpet at regular intervals correspond to the series of rapidly-decadent vibrations constituting the strongly-damped wave, the prolonged blasts on the horn corresponding to the more prolonged train of feebly-damped waves and the continuous note on the organ pipe to the undamped electric waves. It was stated in evidence by Sir William Preece and by Mr. Gavey that the use of these different types of wave generator and receiver is no barrier to intercom-

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munication, but this evidence is not supported by Mr. Maskelyne, who stated that, with the Poulsen apparatus, "if you work on an exclusive wave you have to work at a non-intercommunicating station—that is an exempted station—and it would be used to communicate with Poulsen apparatus only, as it could not communicate with other apparatus." The particular witness, therefore, who has most knowledge of the Poulsen apparatus is in entire disagreement with Sir William Preece on this point. All practical experience shows that intercommunication requires a uniformity of structure or type in the receiving and transmitting apparatus, and it can only be effected between apparatus of diverse types by abolishing their characteristic differences of structure. No one could deny that a kind of electric but inefficient system might be devised, the apparatus of which would be a sort of hybrid or cross between the different types now used, which could intercommunicate, but would have lost all the advantage of each type separately. If the Committee have difficulty in deciding between the opinions of divers witnesses, the matter can be sufficiently settled by the fact that many such patents have been taken out by Mr. Poulsen and his colleague Mr. Pedersen for special forms of receiver adapted for the Poulsen transmitter, and there could have been no object for inventing special forms of receiver if all other forms of known receiver were equally adapted for the reception of continuous or undamped waves. Further, Mr. Maskelyne gave evidence that the regulations of the Convention system could not be applied to the Poulsen system unless at the same time the stations were equipped with a De Forest system for receiving the ordinary damped waves as well, and that apparatus for both systems would have to be installed in stations if the undamped and damped wave systems came into general use. If it is necessary, I can furnish an experimental proof, by means of my cymometer for measuring electric waves, that the arrangement of a receiving circuit adapted for detecting intermittent trains of damped waves will not respond without alteration to continuous or persistent waves of the same mean power. It might be further illustrated by the fact that light emitted by a body, such as a star, which consists of persistent electric waves, can affect a photographic plate when too feeble to affect the human eye; and, on the other hand, very brief flashes of light, such as those from a lighthouse, can affect the human eye, whilst they may not be able to affect a photographic plate. The eye and the plate are receivers of a different kind, adapted to detect different kinds of waves.

The matter may, then, be put in a series of propositions, which I submit are justified by accepted scientific facts: (1) That intercommunication implies identity of type of apparatus for transmission and reception; (2) that various types of apparatus for transmission and reception are now in use and are likely to be; (3) that these different types will not naturally intercommunicate; (4) that they can only be made to inter-communicate by abolishing their distinctive differences, making, in fact, some intermediate type which is neither one thing nor the other.

Dr. Fleming proceeds to refer to the question of overhearing of messages by foreign or strange stations, and points out that at the present time the causes for interference or overhearing, and the remedies for it, are to be found in the effects of electric resonance. Full scientific explanations of these principles, covering what is called syntonic telegraphy or the tuning of electric circuits, were given long before the date of Sir Oliver Lodge's 1897 British patent. They were, for example, fully set out in two papers published in 1895 in Germany, in "Wiedemann's Annalen," by Oberbeck, and in the same publication by Bjerknes, and, as these principles go to the very root of the chief controversial points before the Committee, Dr. Fleming sets out the well-known mechanical effect of a heavy weight suspended by a rod or string possessing mass or inertia, commonly called weight, and proceeds to point out the application of this effect to the case of wireless telegraphy, where two electric qualities, inductance and capacity, are analogous to the mass or weight and the pliability in the pendulum. Hence (continues Dr. Fleming) if a particular receiver is arranged for one kind of wave—say a continuous or persistent wave—it is not suitable for the reception of another kind of wave, say an intermittent damped wave, as used in spark telegraphy. In other words, if the receiver is constructed to be affected by the regular persistent impulses of an undamped wave, such as a Poulsen transmitter, it will not be affected by the intermittent feebly-damped wave given by the present type of Marconi transmitter and vice versa. Dr. Fleming contends that the evidence of Mr. Maskelyne affirms and agrees with this statement of the case, in opposition to the opinion of Sir William Preece. He continues: If we suppose several ships, each equipped with a different type of transmitter, attempting to communicate with a coast station, it is useless to say that the operator can adjust his apparatus to suit the arriving wave. He does not know what type of wave to expect, he cannot diagnose it until he receives it, and he cannot receive it until he has arranged his apparatus to suit it. Hence a practical impasse arises, and intercommunication is impossible unless one type of wave is everywhere employed. Identity of wave-length is not sufficient, there must be essential identity in type of wave, and therefore in type of apparatus, for transmitting and receiving. To-day we have three types of wave, five years hence we may have four or five types, and this will still further increase the impossibility of intercommunication. Dr. Fleming therefore contends that satisfactory general intercommunication of wireless telegraph stations and ships is only practicable if all are equipped with apparatus of the same type, that the progress of wireless telegraphy will tend to extend the existing number of types of electric waves and methods of employing them, and that the progress of invention will be arrested if intercommunication is made compulsory. The Poulsen apparatus will not intercommunicate at present with the Marconi, and can only be made to do so by alterations or changes that will make each lose its essential feature and efficiency. If the system of irregular intermittent waves types by Anders Bull or the twin wave system of Arton were to be developed into practical forms, as they may be, they would not communicate either with the Poulsen or the Marconi systems. Advocates of intercommunication endeavour to turn this difficulty by saying that in a short time all companies will employ persistent waves like Poulsen. This, Dr. Fleming holds, does not affect his argument, and will simply mean that any progress beyond the use of a persistent wave is arrested. We have no reason to believe that this will be the case, having in view the possibilities of wireless telephony, as well as wireless telegraphy and other things which the future must have in store for us. If, therefore, the Convention is ratified, it logically implies and will inevitably compel a certain uniformity of apparatus. The pace of progress will be reduced and the difficulty of trying or introducing new inventions on a practical scale will be enormously increased. On the other hand, if the Convention is not ratified, free play will be given to all the motives tending to foster scientific ingenuity. If Great Britain does not ratify the Convention a certain amount of overhearing or interference may arise, say from stations on the coast of France, but such matters may easily be the subject of special arrangements until such time as scientific advance provides the full remedy. Meanwhile, British stations, not being bound by the Convention regulations, will be free to employ any wave-length or amplitude or type of wave most suitable for avoiding such interference. As regards the erection of other non-Marconi stations on the south coast of England, Dr. Fleming sees no objection to this from a purely technical point of view if the development of wireless telegraphy in Great Britain is allowed to proceed on natural lines, unhampered by official restrictions such as those proposed by the Convention.

A further argument against the ratification of the Convention which deserves consideration is as follows: It seems to have been taken for granted in the proposed Regulations of the Convention, and by those who have advocated ratification, that the Marconi Company possess no fundamental or basal patent rights in Great Britain in connection with wireless telegraphy by electric waves, and that anyone is free to employ antennæ for transmission and reception and earth connections, or equivalent means, at both stations with systems of spark telegraphy or any other mode of producing the electric waves. It is true that the principal Marconi patents for electric wave telegraphy have not yet been tested as to scope and validity in British Courts of Justice. But, in spite of amateur opinions expressed on this subject, there are substantial reasons, based on eminent legal opinions, for the belief that patent rights of a fundamental kind are possessed by the Marconi Company and by Mr. Marconi in virtue of those patents. I speak with an intimate knowledge of the subject, because for the past eight years it has been part of my duty to examine and report on those patents, in consultation with counsel, to assist in the litigation which has taken place in the United States and also in the German Patent Office oppositions. There is abundant evidence to show that, without the use of antennæ and earth connections, or other equivalent, at both stations no wireless telegraphy by electric waves can be conducted. Whatever may have been the additional improvements made in the aerial apparatus, it is perfectly certain that these are of no utility apart from the fundamental inventions which first made this new telegraphy possible. If the exclusive right of user of these fundamental elements should prove to be the property of the Marconi Company, when tested by litigation, it is unavailing to speak of it as an injurious monopoly, for it is a recognised and legal monopoly conveyed by the Crown in virtue of the Patent Acts, and those who venture within the area marked out by the patents risk the pains and penalties of infringement. It is, surely, then a fair argument that the Government, having conveyed these potential patent rights to an inventor and placed upon him the onus of defending them, has an obligation to do nothing to render his task more difficult, much less impossible. If, however, the Government ratifies this Convention, or even if they permit Convention-controlled wireless stations in Great Britain, they are, in effect, supporting and aiding in the formation of a powerful coalition which has for its proposed objects what Sir Wm. Preece calls "equality of opportunity" and others "the breaking down of the so-called Marconi monopoly," but which is, in reality, a skilfully organised plan to make of no effect the advantages which have been gained by that company by priority of invention and by superior commercial organisation and foresight at a time prior to 1904, when it was open to all and every inventor or wireless company to enter the field and to do the same if he or they could.

Apart, therefore, from the general arguments against ratification, based on the immature condition of the art and the radical impracticability of general intercommunication by reason of variety of apparatus, which has nothing to do with the rights of any particular corporation, we have a special argument against ratification or the establishment of Convention-regulated stations in Great Britain from the point of view of justice to established interests. But for the assumed protection of the patents granted to Mr. Marconi, and the assistance thus given in securing the large financial support necessary for the creation of a commercial organisation, it is certain that wireless telegraphy by electric waves would have been nothing but a scientific toy or inventors' pastime up to the present day. The Government (continues Dr. Fleming) is bound to proceed on the assumption that the fundamental Marconi patents are valid until they are proved invalid and this contention is enormously strengthened by the fact that no patent for electric wave wireless telegraphy exists in any country prior to the one applied for in Great Britain by Mr. Marconi in June, 1896, and the assumption is that the above-mentioned patent is not merely valid but broad. The Government cannot, therefore, pledge itself to any course of action, such as is involved in the ratification of the Convention, without ipso facto denying the existence or even the possibility of the existence of rights it has already granted—that is to say, without prejudging the scope and validity of the Marconi patents.

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LEGAL INTELLIGENCE.

Marylebone Borough Council v. Mellier & Co.

On Friday, at Westminster (London) County Court, plaintiffs sought to recover £7 odd (the value of certain meters) from defendants, who were consumers of electric energy supplied by plaintiffs. On the meter reader visiting the premises the meters (the property of plaintiffs) had been removed. It was denied that any notice was received from defendants (by telephone or otherwise) that the premises were about to be demolished. Defendants relied on a telephone notification.

Judge WOODFALL found that the onus of proof of sufficient notice was upon defendants. He was asked to say defendants had done all prudent men could do, but he thought prudent men would have given notice in writing. Plaintiffs denied receiving any notice. Defendants said they gave notice by telephone, but they could not prove into whose ears the message went. Their duty was to give notice that they were vacating the premises on which was the property of plaintiffs, of which they were the bailees, gratuitous bailees or otherwise did not matter. He gave judgment for plaintiffs for six guineas and costs.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A leading electrical house in Bombay requires a thoroughly-trained electrical and mechanical engineer with commercial experience. Starting salary £25 per mensem. Three years contract. See advertisement.

Birmingham Corporation require for their Summer-lane electric generating station a shift engineer, over 25 years of age and with sound mechanical and electrical engineering training. Commencing salary £150, rising to £250 per annum. Also a power-house foreman, over 30 years of age (commencing wages £2. 5s., rising to £3. 5s. per week). Applications to the city electrical engineer and manager (Mr. R. A. Chattock), 14, Dale-end, Birmingham, by 28th inst.

A commercial traveller is required by a firm of British glow lamp manufacturers See an advertisement.

A teacher of physics is wanted for Tottenham Polytechnic. Remuneration 12s. 6d. per evening. Applications to the secretary (Mr. J. W. Tomlinson), the Polytechnic, S. Tottenham, by June 3.

The Postmaster-General has appointed Mr. E. Catley and Mr. W. Noble as superintending engineers in succession to Mr. J. W. Woods and Mr. A. J. Stubbs, promoted. Mr. Catley will take charge of the North Metropolitan and Mr. Noble of the Central Metropolitan districts.

Mr. W. H. Moorhouse, manager of Barnsley tramways, has been appointed manager of the Llandudno & Colwyn Bay Light Railway.

Mr. G. E. Swift, mains superintendent at Plymouth Corporation electricity department, has been selected for the position of mains superintendent at Chester.

Mr. H. Large has been appointed switchboard attendant at Stoke Newington.

Acton.—The equivalent of 26,000 8 c.p. lamps is connected to the mains of the electricity department.

Amalgamated Association of the Tramway and Vehicle Workers.—At the annual conference at Nottingham on Wednesday it was reported that there were delegates present from 95 branches, representing over 13,000 members.

The conference urged that more discretion be exercised by the Board of Trade in laying down a speed limit on gradients and other difficult tracks, also that steps be taken to secure the adoption of brakes of automatic and instantaneous action, free from wires or complicated mechanism liable to get out of order without being observed.

Argentina.—The "Review of the River Plate" states that Florencio Varela Municipality is considering the substitution of electric for gas lighting and the Compañia Alemana de Electricidad will submit an offer to supply current from their Ardrogué station.

The Metropolitano, La Capital Nueva & Gran Nacional Tramways Companies, Buenos Ayres, have withdrawn their petition for assent of the Municipality to their proposed amalgamation owing to an unfavourable report on the proposal by the technical advisers of the Municipality.

The electricity works at Gualeguaychú, which are being erected by Buxton, Cassini & Co., will commence supply of current about July.

At a recent meeting of the Institution of Engineers of the River Plate the hon. secretary and treasurer, Mr. Ernest Danvers, M.I.E.E., was the recipient of an illuminated address on the occasion of his departure for Europe. Mr. Danvers was the second president of the Institution and has been hon. secretary and treasurer for many years.

Australasia.—The "Australian Mining Standard" says a suction gas plant is being installed in connection with Deloraine (Tasmania) electricity supply scheme.

Mr. J. Black, M.I.E.E., in a report to Napier (N.Z.) Council, states that the total cost of establishing electricity supply and electric tramways will be about £45,000, a tramway to Taradale increasing their expenditure to £77,000. The Council have decided to apply for an Order-in-Council to authorise them to carry out the scheme so far as their area is concerned and have communicated with other local authorities on the route of the proposed Taradale line with a suggestion that they apply for powers in respect of their districts.

Barnes.—Sanction has been received to borrow £6,700 for electricity supply extensions, viz., £5,700 to be repayable in 17 years and £1,000 for meters in 5 years.

Batoum (Russia).—The Caucasus Copper Co. was formed some six years ago to acquire copper deposits in the province of Batoum and is on the eve of completing its new works for the treatment and smelting of the ore procured from the mines of Dzansoul. Smelting operations are to be very shortly commenced. The magnitude of this concern, combined with the large quantities of copper ore on their properties, foreshadows a prosperous future for this British enterprise. Another British enterprise in the Kutais district, in the neighbourhood of Batoum, is that of manganese mining, the manganese concession being considered to have a bright future before it. This industry has greatly developed of late owing to the demand in Europe and America for the commodity.

Writing on the subject of the chief requirements for the Baku oil fields and the industries relating thereto, Mr. Consul Stevens states that electrical appliances of all kinds are required. Apart from electric lighting, electric power is being employed to a great extent on the oil fields for drilling and pumping, owing to the great economy of space effected and the facility of handling. So far all the electric plant in use has been supplied from Germany. Steam turbines have lately come into considerable use on the oil fields for driving dynamos and for pumping. In a few cases these turbines have been tried with success in driving the drilling rigs and baling drums in wells, their chief advantage being economy in steam, compactness and ease of removal from one well to another. The smaller horse-power machines are chiefly in demand.

Beaulieu.—Lord Montague of Beaulieu is making arrangements for the supply of electricity for the lighting of this village.

Birmingham.—The arrangement between Birmingham and Aston Corporations and the British Electric Traction Co. for a through service of tramcars between the city and Aston boundary at Chain Walk was brought into operation on Wednesday.

Budapest-Vienna Electric Railway.—In our issue of 10th inst. (p. 156) we gave brief particulars of the project for the construction of an electric railway between Budapest and Vienna.

The "Pester Lloyd" now announces that Count Paul Czápáry and Ingenieur Emil Török have acquired from the Detroit (U.S.A.) Construction Co. the sole rights for the employment in Europe of the company's new Leffler (third rail) system of electric traction, and these two gentlemen have, in conjunction with the International Railway Co. (U.S.A.) and Mr. B. Nove (president of the Detroit Construction Co.), applied to the Hungarian Government for a concession to construct and work a railway on this system from Budapest to Vienna, and will make a similar application to the Austrian Government in respect of the Austrian portion of the project. The proposed line will start from an underground station under the Rochuspital in Budapest, and cross the Danube between Káposztásmegyer and Békásmegyer; it will then proceed along the right bank of the Danube and cross the river again in a direct line from Komárom, and cross the Austrian frontier at Dévény. After once more crossing the river between Grosz Entzersdorf and Freudenau, the line will end in an underground station at Karlsplatz in Vienna. It is stated that the system has been successfully tried by the Detroit Construction Co. on their own railway network, and that its advantages will be demonstrated by the company on a line (in America) of 200 km. (about 124 miles) in length before constructing the European line. The Budapest-Vienna route will be 260 km. (about 160 miles) in length, and a generating station will be erected to serve every 80 km. (about 50 miles), and will supply current for the railway and also for industrial purposes. Some trains will traverse the whole route in two hours. The International Railway Co. has undertaken to provide the necessary capital (about £5,000,000).

Bulgaria.—The Belgian Agent and Consul-General at Sofia points out the advantages to manufacturers of the registration of their trade marks in Bulgaria. In addition to the protection secured, he says, the goods are well advertised, particulars of all the marks registered being published in a "Bulletin" which is sent out gratuitously.

Bury-Bolton Tramways.—A through service of electric tramcars between Bury and Bolton was inaugurated on Monday.

Calcium Carbide Works in Ireland.—There is a considerable amount of water power in Ireland which might be used for the production of power for electro-chemical or electro-thermal operations, and several waterfalls are being utilised for the production of calcium carbide. In connection with one of these schemes an order has, we

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are informed, recently been placed by Mr. F. Broadbent, M.I.E.E., for a 640 H.P. Gilkes turbine coupled to a 430 kw. single-phase Mather & Platt alternator. This set is the second set of this size for the works in question, and the turbine will operate on a 34 ft. total fall and develop the power at 300 revs. per min. Owing to the possibility of getting the furnaces close up to the water power, the alternators are run at low voltage (50) and are capable of developing up to 10,000 amperes. They are self-regulating for constant output and the turbines are not, therefore, hydraulically governed. Special attention has, of course, had to be given to the conductors carrying currents of the magnitude of 10,000 amperes.

Customs Duties.—Under the Convention of Commerce and Navigation between France and Roumania, signed on March 6 last, the following are the reduced duties chargeable on French goods imported into Roumania and the reductions from the general tariff. British goods are subject to the same reduced duties :—

Electric apparatus for telegraphs, telephones, transmission of power, lighting, bells, interruptors, medical and chemical batteries, &c., 80 lei per 100 kilogs (20 lei reduction) = £1. 12s. 6d. per cent. The present duty on electric accumulators and battery plates, 20 lei per 100 kilogs = 8s. 2d. per cwt., and the present duties on electric and other motor vehicles (which are set out on p. 455 of "The Electrican" Electrical Trades' Directory and Handbook for 1907) are not covered by the commercial treatise entered into by Roumania with other nations, but are conventionalised by the present Convention, and consequently the duties will not be increased while the Convention remains in force.

Dockyard Electrical Work.—Owing to the increasing use of electricity by the Navy and in Dockyard work, &c., the Admiralty recently issued special instructions defining the duties and responsibilities of the electrical engineers' and the constructive and engineering managers' departments :—

The lubricating of motors driving machines in the shops of the constructive and engineering managers is to be done by the man who lubricates the machines, and not by the man sent from the electrical engineer's department. The repair and maintenance of all mechanical parts of machines are to be done by the constructive and engineering departments, according to ownership. The bolting down and fixing of all motors for driving machines in the constructive and engineering departments is to be done by the department to which the machine belongs, but the electrical engineer's concurrence in the arrangements is to be obtained for carrying out the work. To ensure efficiency and secure definite responsibility, all machines and plant used solely by either the constructive or engineering departments should be entirely in the charge of that department for care and maintenance, but care must be taken to requisition the electrical engineer to carry out purely electrical repairs. Arc lamps are to be attended to by one of the skilled labourers attached to the shop. Repairs to clocks, typewriters and torpedo directors are to continue to be carried out in the electrical engineer's department. The employment of joiners in the electrical fitting shop is to be limited as much as possible, and any work which can be done to better advantage in the joiners' shop is to be done there. As the constructive manager is held responsible for the strength and watertightness of a ship as a structure, the fixing of all fittings, machines and apparatus should be done by his department, and under the supervision of his own officers. The manufacture and fitting of all brackets, glands, deck pipes, casings, clips of cable, securing the brackets for fitting, work of an entirely mechanical nature, should also be done by the constructive manager. The principles underlying the division of work between the constructive manager and the electrical engineer are to be held as applicable to work in which the engineering department is directly interested.

Dunfermline.—Mr. M. Buchan (of Buchan & Partners, Edinburgh) has been appointed by the Council to prepare a report on the electricity supply question, and particularly on the relative merits of municipal works and bulk supply.

Electrical Legislation.—Islington Borough Council are to convene a conference of representatives of the Metropolitan borough councils who are electric light undertakers with a view to securing the re-introduction by the Board of Trade of the Supply of Electricity Bill.

Electricity in Cold Storage.—The directors of the London Central Markets Cold Storage Co. state that the more extended trial of electrical power during the present season has justified their action in substituting electric for steam power.

Electricity in Mining.—At the meeting of Harrison, Ainslie & Co. (Ltd.) last week Sir O. R. Slacke said that, after the fullest inquiries and consideration, the directors had come to the conclusion that a large electrical installation, with centrifugal pumps, would be by far the most efficient means to unwater their flooded mines.

The estimated cost of that enormous plant and consequent work amounted to £50,000. After a thorough examination into the position and prospects, a syndicate, comprised of their own shareholders, agreed to find the money. The plant was being supplied by the Electrical Company, and it would be capable of dealing with 16,000 gallons of water a minute, gradually decreasing to 8,000 gallons of water a minute, at the maximum depth, which quantity was largely in excess of anything hitherto encountered, and allowed a margin of more than double what they were ever likely to require. The contract was made as long ago as Dec. 1905, and the negotiations were entered into a long time before that. Estimates were obtained from all the big electrical firms before the contract was entered into, and they came to an arrangement with almost the only electrical company which was in a position to undertake such a gigantic work. The directors' report was adopted.

Exeter.—The city electrical engineer (Mr. H. D. Munro) has issued some figures showing the progress made by the electricity undertaking during the past decade.

The number of consumers has increased from 164 to 1,022, and the equivalent number of 8 c.p. lamps connected from 8,000 to 60,000. The new generating station has enabled the department to cope with all demands for increased power, and the number of units sold for light and power has increased during the past year from 143,000 to 672,000, in addition to 519,223 for the tramways. There has been a corresponding increase in the revenue from electricity supply and meter rents. In 1897 it was £3,538, last year £15,902. The consumers connected for lighting now include about 400 private houses, about 550 business premises, about 25 public buildings and about 20 places of worship, besides about 80 power consumers.

Hastings.—The Corporation have authorised the erection of eight oriflamme arc lamps in place of 20 gas lamps and one incandescent electric lamp.

Hastings-Bexhill Tramways.—The Hastings & District Electric Tramways Co. has now been operating for over 12 months, and so popular is the service in local circles that the company has been asked to carry out extensions of their system, including a line to Sidley.

Holyhead.—The Council have applied for sanction to borrow £3,000 further for the electricity undertaking.

Italy.—*Genoa and District.*—It is announced that the State railways have adopted Ing. Corsa's scheme for electric traction on the railways through the Goivi Tunnel over the Appennines. Tenders have been invited for power station buildings, electrical and mechanical plant, &c. It is said that the adoption of electric traction will double the present potential traffic on the lines and relieve the present congestion.

The Genoa Electric Tramway Co. propose to construct three branch lines to Pontedecimo, Sestre Levante and Voltri on private roadways, the public roads being used only at crossings. The object of these extensions is to enable a higher speed to be adopted to relieve some of the railway passenger traffic in the immediate neighbourhood of Genoa. The estimated cost is about £2,000,000. The total length of lines owned by this company is 81·855, operated 80·681. The car stock numbers 214 motors, 110 trailers and 4 funicular. The number of passengers carried in 1906 was 46,589,791; total receipts £258,123, expenses £169,234. The company employs 1,421 persons.

It is announced that capitalists at Milan and Savona have formed a company for erecting and equipping electric power works in the valley of Albenga with the object of supplying the leading industries, and ultimately a tramway service along the Western Riviera, with electric power. Already a number of important iron and steel works have promised support to the undertaking.

The imports into Spezia in 1906 from the United Kingdom included machinery and parts thereof (including marine engines, boilers, dynamos, &c.) 86·5 tons, compared with 1,110 tons in 1905. Germany came next with 65·5 tons, Belgium 45·5 tons. In scientific and other instruments of precision Spezia took 439 cwt. from the United Kingdom, compared with 75 cwt. in 1905, Germany coming next with 19·5 cwt.

The "Gazetta Ufficiale" for May 8 contains a law authorising the construction and working by *Milan* Municipality of an extension of their electric tramway.

Sicily.—The late Italian Ministry included in their scheme of improvement of the public services a new bronze wire line of telegraphs between Rome and Palermo (1,052 km.), a new bronze wire line between Naples and Palermo (803 km.), a new bronze wire line between Rome and Catania (907 km.), and a subaqueous telegraph cable between Reggio and Mesina (31 km.), in addition to ordinary iron wire lines between Palermo and Caltanisetta (132 km.) and Catania-Caltanisetta-Gargenti (199 km.). In addition a wireless telegraph station is to be established at Palermo, and a new telephone line between Naples, Mesina and Palermo, as well as a number of district lines, aggregating 623 km. of line for the year 1907-8, 1,081 km. for 1908-9, 160 km. for 1909-10 and 146 km. for 1910-11. In addition to these extensions urban telephone lines are to be constructed in Trapani, Caltanisetta and Syracuse.

At the quay of Mesina 12 500 c.p. arc lamps have been erected, 23 ft. from the ground line, at intervals of 197 ft., with a view to facilitate the loading and unloading of vessels at night.

Kirkcaldy.—For the year ended May 15 the electricity department generated 1,150,000 units of energy. 625,000 units were supplied to the tramways, 100,000 to the public lamps, and about 300,000 for private lighting and power. The demand for electrical energy for lighting and power is increasing rapidly and the Dunnikier Collieries have entered into an agreement for a supply of power which represents about 450,000 units per annum. The Fife Forge Co. and Hutchison & Co. have also entered into contracts for

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taking energy for lighting and power to the extent of about 450,000 units per annum. During the year 320 new connections were made.

Light Railway.—Maidstone Corporation Light Railways (Extensions No. 2) Order has been submitted to the Board of Trade for confirmation. Objections by June 8.

London Electricity Supply.—Shoreditch Borough Council have called a conference of representatives of the metropolitan borough councils to consider the question of electric supply for London with a view to making some arrangement with London County Council which will sufficiently safeguard the interests of the various borough authorities in regard to their electrical undertakings.

Morecambe.—Mr. John Gardner, the tramways manager at Chester, was recently consulted by the Council to report on the conversion of the local tramways to electric traction. After considering Mr. Gardner's report the Council have unanimously decided to prepare a scheme for carrying out his recommendations. Mr. Gardner has received the thanks of the Council for his exhaustive report.

New Coal-loading Device.—A contrivance for loading coal has recently been invented by Cavs. L. Calcagno and C. Orengo, of Genoa. This consists of a cylindrical tube containing a specially designed screw worked by a 10 H.P. electric motor. The tube has at one end an inverted funnel, into which the coal is emptied, and the action of the screw transfers the coal to the top end. On reaching this point it falls through a strong linen funnel into the holds or bunkers of vessels, &c. It is stated that coal can be loaded by this means at the rate of 30 tons per hour, and not only is great economy of time and labour effected, but there is much less dirt and loss of weight through drifted coal dust.

One of the above-named gentlemen has also invented an automatic intercepter of lubricating matter, which is claimed to effect great economy in the use of lubricating oils, and prevents the oil penetrating into the boilers. The device is said to be both simple and inexpensive.

Obituary.—We regret to record the death of Mr. Ronald Gordon Grant, a member of the staff of the Cleveland & Durham Electric Power (Ltd.), who expired suddenly on the 19th inst. The funeral took place on Wednesday from the residence of his brother-in-law (Mr. P. C. Pope), of Hale, Cheshire.

We also regret to record the death of Mr. W. J. Johnston, well-known, both in the States and on this side, as an experienced technical journalist. Mr. Johnston was born in Ireland in 1851, and emigrated to America in the early seventies. First as proprietor of "The Operator," and later of its successor the "Electrical World," Mr. Johnston has since been associated with several other technical journals. His death occurred on April 28, and was due to cerebral hemorrhage.

P.O. Engineering and Stores Association.—Mr. E. Brown (Birmingham) presided at the twelfth annual conference of this association on Monday.

The report of the general secretary (Mr. E. A. Morgan, Birmingham) stated that there was an increase in the membership of 468, while the accounts showed a debit balance of £44. 10*s.* due to exceptional expenditure during the year of £137 in presenting evidence on behalf of the association before the Parliamentary Committee of Inquiry into the grievances of postal servants. Mr. E. A. Morgan was appointed general secretary and editor of the "Telegraph Engineering Journal."

Presentation.—On leaving Kelvin & James White (Glasgow) to join the Blackburn electricity staff, Mr. Thos. Wallwork has been presented by the managers and staff with a silver cigarette case, gold sleeve links and an umbrella.

Provisional Order Transfer.—Westhoughton District Council give notice of intention to transfer to the Lancashire Electric Power Co. the powers, &c., of the Westhoughton Electric Lighting Order, 1902, for £210. The Council have the right to repurchase at the end of seven or any subsequent seven years.

Richmond.—The Council are recommended by the Tramways committee to allow the overhead system of tramways in Kew-road and also to invite the London United Tramways (1901) (Ltd.) to obtain powers to construct tramways over Kew Bridge.

Russia.—The acting British Vice-Consul at Baku (Mr. McDonell), writing in regard to possible openings for British trade in his district, states that there is a demand for electrical machinery and plant, not only for electric lighting, but also for drilling, pumping, &c., for the oil fields. All such plant is at present supplied by Germany. Steam turbines have lately come into use on the oil fields, and are now being used for driving dynamos and for pumping. In one or two cases they have been tried with success for driving the drilling rigs and baling drums in wells. Their chief advantage, besides a slight economy in steam, over the ordinary steam engine, is their compactness and the comparative ease with which they can be moved from one well to another. Should these turbines eventually take the place of engines in the derrick they will then be in great demand. They should be of, say, 40 H.P. to 100 H.P.

San Francisco.—In a report by Mr. Consul-General Bennett on California and the neighbouring districts extended reference is made to the terrible earthquake of last year. Mr. Bennett states that the first effort made when a semblance of order was restored was to put the telegraph and cable services and the tramway service into some kind of order. Special credit is given to the street railway companies for the energy displayed, and Mr. Bennett points out that the opportunity was taken to convert the old cable tramway services into electric lines.

A demonstration of the enormous capabilities of California in the matter of water-power development is being given on the Feather River, 20 miles north of Oroville (co. Butte). At the point selected there is a great bend in the river of horseshoe shape, over 15 miles in circumference, the neck of the bend being 15,000 ft. across where the horseshoe begins. But the channel of the river is over 500 ft. lower than that at the upper bend. Here the Great Western Power Co. of California proposes to drive a tunnel through to the bank of the lower stream 25 ft. square, and to concrete the walls the entire length, thus allowing the whole of the volume of the Feather River to flow uninterruptedly to the opening 15,000 ft. away and there to discharge at a point 500 ft. above the river bed. A dam is to be built across the chasm, where the flood will be diverted from the upper stream. At the level of the river a power house is to be erected large enough to contain eight generating units each of 15,000 E.H.P. Half the plant is to be first installed and it is anticipated will be in work by June, 1908. It is expected that San Francisco will be enabled to utilise this transmission service, the distance from the city being 175 miles.

Shoreditch (London).—The Finance committee recommend that in future the electricity department be debited with half the cost of opposing electricity supply bills, &c.

Southampton.—An unopposed inquiry was held last week into the application of the Council for sanction to borrow £17,000 for extensions of the electricity generating plant and mains.

Spain.—The Bulletin of the French Chamber of Commerce at Barcelona states that a new company, entitled La Dinámica Española, with a capital of 5,000,000 pesetas, has been formed at Barcelona to utilise waterfalls on the Tagus for the production of motive power and transmit it to Madrid. La Industria Eléctrica de Barcelona is increasing its capital with a view to modernising the equipment of its generating works, and a company has been formed at Torres (Jaén) to establish electric lighting works in that town.

Stepney (London).—The Electric Lighting committee recommend that, before actually inviting tenders for the erection of new electricity works at the Blyth's Wharf, the advice of a prominent engineer should be obtained upon the estimates and specifications prepared by the borough electrical engineer and manager, Mr. W. C. P. Tapper.

With reference to the L.C.C. (Electric Supply) Bill, the same committee think the measure as now drafted has no promise of any better conditions than those foreshadowed in the Bill as originally introduced with regard to the compulsory acquisition of the undertakings of the Metropolitan Boroughs, and the Council are advised to proceed with their opposition.

Stoke Newington (London).—The agreement with Hackney Council for electricity supply terminated on April 30, and the change over of the High-street supply to Stoke Newington Council's mains was effected on May 1.

Taxes on Catalogues sent to British Colonies.—Inconvenience and loss have been caused to British manufacturers on account of the taxes levied by some British Colonies on catalogues received through the post. Confusion has arisen both in regard to the nature of the packages to be taxed and the methods of collecting the taxes.

We learn that the Manufacturers' Association of Great Britain have received inquiries in regard to this matter, and are making representations with a view to inducing some of the Colonial Governments to adopt more convenient methods of collecting these taxes. The Association have prepared a memorandum respecting tariff duties for the guidance of manufacturers, from which the following information is taken:—

In agreement with the Customs Union Convention of 1906 there is a common tariff for the *Cape of Good Hope*, *Natal*, *Orange River Colony*, the *Transvaal*, and *Southern Rhodesia*, under which the duty on catalogues, price lists, &c., has been fixed at 25 per cent. ad val. (or 2d. per pound) whichever may be the greater, but packets less than 8 oz. enter free. The tax is collected as a surcharge, there being no arrangements at present for paying it in Great Britain, and the best method to adopt when forwarding catalogues through the post is to remit the duty on each packet to the Postmaster-General in the capital town in each Colony, and mark the package "Duty paid to the Postmaster-General." As, however, English stamps will not be accepted in payment of duty, a postal or money order must be remitted.

The *Australian Colonies* have one common tariff under which catalogues, price lists, &c., are charged with a duty at the rate of 3d. per pound. The duty is waived on all packages sent through the post which do not exceed 4 lb. in weight. On packages heavier than 4 lb. duty should be remitted by postal or money order to the Deputy Postmaster-General of the State to which catalogues, &c., are addressed and each

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package marked as above mentioned; if this is not done the duty will be collected as a surcharge.

The duty on catalogues sent through the post to *Canada* is 5d. per pound, and those requiring to prepay the duty can do so at any district post office in Great Britain. [It will be remembered that the postages on newspapers published at intervals of not more than one month has recently been reduced to 1d. per pound or portion of a pound.—ED.]

There is no tariff duty on catalogues sent by British firms (other than printers) to *New Zealand*, excepting on leaflets and circulars sent out in quantity for distribution.

Where a large number of catalogues are to be distributed in any particular colony, the Manufacturers' Association recommend that these be forwarded in bulk to an agent on the spot, who should pay the duty and repost them locally.

Union v. Non-Union Workmen—Friction having arisen among the workmen employed by the Wakefield electricity supply department, the city electrical engineer (Mr. H. A. Nevill) recently notified that—

In consequence of recent trouble and general upset of the smoothness of the station, occasioned by the friction between non-union men and union men, it has been definitely decided that on and after May 30 no union men will be employed, and should any of the employés be desirous of retaining their posts they may do so by handing in their names to the city electrical engineer.

U.S.A.—The electric tramway system of *Baltimore* is being extended in all directions. The chief extension now in course of construction lies between Baltimore and Washington, and is expected to be open for traffic in July next. The service embraces the Anapolis, Baltimore and Washington line, 21 miles in length, now partly worked by steam, and another 9 mile length between Washington and Laurel, Maryland.

At a point about 40 miles of Baltimore there is in course of construction across the Susquehanna River an immense concrete dam about 3,000 ft. long, 68 ft. wide at the base and 40 ft. above the normal surface of the river. 100,000 H.P. of electric power is to be generated from this source and will be used to supply Baltimore, Philadelphia, Wilmington and Chester (Delaware), York and Lancaster (Penn.), and some other smaller towns with power for industrial and traction purposes. The dam was begun in November, 1906, and it is anticipated that the owning company will be in a position to supply electric energy within three years from this date. The estimated cost of the enterprise is put at £2 000,000.

In reporting upon the trade of *Chicago* Mr. Consul Finn states that a very notable increase in the use of electric trade signs for advertising purposes is a feature of recent developments in this district, the off-and-on method of illumination of these signs being adopted to a large extent both over and on buildings and in many shop windows.

In connection with the general question of advertising Mr. Finn calls attention to the advantages he claims for the establishment of a sample room or permanent exhibition of British manufactures, comprising chiefly light articles. He states that his endeavours to bring these advantages before British manufacturers have not met with any considerable success, and urges that, while the British merchant is holding his own in this market as compared with other foreign countries, he could do better if he would adapt himself to the methods in vogue in Chicago. But to do this he must advertise, and he would, doubtless, then do a large mail order business. Mr. Finn has, however, either overlooked or is unacquainted with the vagaries of the American express delivery companies. We can ourselves speak of the vexation which accompanies any dealings through the so-called "parcels post" of the United States. In one case recently a copy of one of our publications was sent to Chicago, all postage fees paid, and complying, so far as we are aware, with all the conditions of the Post Office. On the other side the consequence was called upon to pay $3.25 (13s. 6d.) before the company handling the package would release it. American houses to whom these goods are consigned evidently feel that there is no possibility of satisfactorily explaining matters on that side, so that wherever possible they deduct the amount of the surcharge from their remittance. From this cause it is impossible for British houses to do business with United States firms. We have ourselves for years past experienced more difficulty and more annoyance with orders from the United States than in our dealings with any other country in the world. This possibly accounts for the lack of success of Mr. Finn's well-meant efforts to establish a sample room. British firms are not disposed to encourage the carrying companies to whom their packages are entrusted on the other side in their practice of extortion.

One of the Illinois electric railroads have added sleeping carriages to their service, and several other electric roads serve meals on their trains. This competition with the main steam railways is causing much concern to the railway companies.

The number of steel freight cars on the railways in the Chicago district is increasing rapidly, and some of the railways are experimenting in steel passenger cars.

It is claimed for the town of St. Louis in this district that amongst the manufactures which are fast forging their way to the front is the manufacture and handling of electric machinery, electric lamps, and electric supplies of all kinds.

Venezuela.—An interesting report is issued on the trade of Caracas and district for 1906 by the British Vice-Consul, Mr. E. F. Gray. References are made to the introduction of electric machinery for driving factories with energy generated by water power. There appear to be a number of rivers in Venezuela offering facilities for the generation of electric current. The utilisation of these facilities is given as an explanation of the comparatively small imports of coal into the country, nearly all the existing factories being driven by electricity.

Amongst the advances made during 1906 with British enterprises in Venezuela may be mentioned the partial substitution of electric working for steam on the Central Railway. The railway to El Valle, near Caracas, in which British interests are chiefly involved, has also adopted electric traction, and British engineers are commencing the electrification of the Caracas tramway system.

Walthamstow.—Mains are to be extended to supply light and power to Messrs. Fordhams' factory, subject to the proprietors agreeing to take current for not less than five years.

Recently the Council asked the L.G. Board to receive a deputation with regard to certain surcharges in connection with the electric lighting undertaking, but the Board have intimated that they cannot see their way to alter their decision.

Water Power in India.—"Indian Engineering" announces that the Bombay Government has been collecting information as to the water power available in the Presidency, and has issued a report on the subject.

It appears that there are few perennial streams in the Presidency with water continuously available for the generation of electrical energy, as in most cases the streams dry up in the hot weather, while in a few cases the water is used for irrigation. However, the Western Ghâts afford unusual facilities for immense water power, but so far the problem of the storage of the power available during the monsoon remains unsolved. The question of constructing tanks or reservoirs has been considered from time to time, but as the narrow strip of land at the head of the Ghâts will not admit of the construction of reservoirs at reasonable cost, no use has yet been made of the power. As already announced in *The Electrician*, a Bombay firm has worked out a project for the development of the water power, and this is now under the consideration of the Bombay Government. There are other sites along the Ghâts where similar projects are possible, but these cannot be ascertained without a detailed survey, such as the Government is not in a position to undertake. The Vaiturna in Nasik and Thana and the Kali Nadi afford the best prospects. The former rises in Nasik above the Ghâts and falls down into Thana below, at about 12 miles from Igatpuri station on the G.I.P. Railway and 90 miles from Bombay. The amount of power which could be obtained from this river by means of storage work is stated to be over 100,000 H.P. continuously. The possible sites for power works on the Kali Nadi, which rises at Castle Rock on the Marmagoa Railway, would be within 60 miles of Belgaum, Dharwar, Hubli, Marmagoa and Karwar. The power that could be obtained from this river with storage works is probably more than that possible on the Vaiturna. The potentialities of these streams are so great that the Government is of opinion that care should be taken to preserve them from being wasted or locked up in small concessions, and a large scheme for the development of the whole system of power and irrigation on each river should first be worked out. The Government has directed the officers, when preparing projects for large storage reservoirs for irrigation, to consider at the same time the possibility of generating electric power from such reservoirs.

Workhouse Lighting.—Heston and Isleworth Council have agreed to supply electric current to Brentford workhouse, provided the Guardians take during the next five years a minimum of 50,000 units per annum, at 3d. per unit.

Works Driving.—All the tools and machinery at the extensive new works of Messrs. Cammell, Laird & Co., Tranmere Bay, Cheshire, will be driven electrically. Electric current will be supplied by electric generators driven direct by gas engines, Mond producer gas plant having been ordered.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Blackburn.—The net profit of the electricity department for the year ended March 31 was £1,528, against £276 in 1905-6.

The net profit on the tramways undertaking was £511. This is the first year a profit has been made by the tramways department.

Chester.—The income of the electricity department for the year ended March 31 was £16,843, an increase of £143 over 1905-6.

The annual expenses were £8,554, against £7,664. From the net revenue of £8,289, interest (£3,527) and sinking fund (£3,487) had to be deducted, leaving a profit of £1,275. The outstanding loans amount to £94,033 and the sinking fund is £6,868.

Dundee.—The receipts of the tramways department for the year ended May 15 were £57,672, an increase of £7,518 over 1905-6.

The passengers carried numbered 15,520,021, an increase of 2,433,625. Working expenses will approximate £36,000, leaving a gross profit of about £21,000 to meet interest and sinking fund, &c.

Hanley.—The accounts of the electric lighting department for 1906 states that the capital expended is £96,991. 11s. 5d., an increase of £3,217. 7s. 5d during the year.

The total receipts amounted to £15,695. 16s. 5d., including £12,778. 10s. 6d. net from the sale of current for private lighting and

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"The Electrician" in Canada.—The circulation of *The Electrician* in Canada has for many years past included a considerable number of the leading electrical engineers in the country, and most, if not all, of the principal manufacturing and supply houses. The recent changes in the postal arrangements, under which *The Electrician* can be posted to Canada for 1d. per copy, will enable us to cover a wider field in that country, and we have made arrangements by which all persons and firms engaged professionally and industrially in electrical engineering in Canada will receive copies of *The Electrician*.

£2,634. 3s. 4d. from public lighting. Generation expenses came to £4,922. 18s. 4d., cost of distribution to £187. 16s. 5d., public lamp maintenance to £485. 12s. 9d., rent, rates and taxes to £1,138. 18s. 8d., management expenses to £1,197. 14s. 2d., special charges, &c., making the total expenditure £8,094. 3s. 9d. The gross profit was £7,601. 12s. 8d. After paying interest on loans (£2,649. 5s. 4d.) and on overdraft for extensions (£47. 4s. 9d.), sinking fund instalment (£2,377. 13s. 4d.) and amount paid off of loans (£400. 11s. 9d.), and bank interest and charges (£32. 14s. 2d.), the net balance is £2,157. 14s. 5d. 1,355,682 units of electric current were generated, of which 220,762 were supplied to public lamps, 4,909 were sold by contract, and 876,523 were sold to private consumers by meter. There are 427 public lamps, and the total maximum supply demanded was 985 kw. The total commercial cost of the current generated was 2·85d. per unit (including 1·20d. for loan and financial charges), compared with 3·51d. (1·52d. for loan and financial charges) in 1905.

In the report of the borough electrical engineer (Mr. C. H. Yeaman) it is stated that the units sold increased by 21·2 per cent., and the maximum load on the plant by 13·2 per cent., causing a rise in the load factor from 11·94 per cent. to 12·77 per cent. Although the reduction in price of current has had a temporarily adverse effect upon receipts, it has been amply justified by the decrease in the number of complaints and by the increased demand. Mr. Yeaman thinks that, in order that electricity should continue to compete with other illuminants, it is necessary that further concessions should be made to consumers, especially the large and long-hour consumers. Progress in illuminating engineering is very rapid, and it is curious (adds Mr. Yeaman) that, although the public generally call for a much higher standard of lighting (both internal and external), consumers are adverse to paying annually as much as formerly for the lighting or their premises. At the beginning of 1905 there were 47 motors (of a total of 155½ H.P.) and 25 small fans connected to the mains, but at Dec. 31, 1906, there were 80 motors (391½ H.P.) and 31 small fans. In 1906 206,724 units (representing £1,192) were sold for power, against 85,692 in 1905. In two years the motor output has been nearly trebled, while the average price has fallen from 1·723d. per unit in 1904 to 1·384d. in 1906. Contracts are being arranged for over 40,000 units annually, at a rate which is considerably under 1d. per unit. The motor hiring department has been most useful during the year, several consumers having been obtained who would not have taken up electric driving unless its advantages had been demonstrated. The present arrangements of the department are directed to the hire-purchase or deferred-purchase system, rather than simple hire, thus reducing the liabilities incurred by the department and locking up a smaller sum in motors. Further progress has been made in pushing the sale of electricity through the publicity department, and the results more than justify the expenditure incurred. A canvasser has been engaged, and he has been provided with literature in order to be able to deal with every phase of his business. Lectures were delivered at the Municipal secondary school in the autumn of 1906, which were largely attended by existing and possible consumers, when the latest types of electric lamps and apparatus were shown. Other opportunities were taken to exhibit lamps and apparatus, and experience has coincided with the results of other towns that the publicity department is an essential and integral part of an electricity supply undertaking and that it is not sufficient to wait for consumers to come on, but that the merits of the supply should be made known to every one in the district. Among Mr. Yeaman's recommendations is one that the wiring rental for 1906 be retained for future use for deferred payment wiring as the L.G. Board will not sanction any further loan for this purpose.

Launceston (Tasmania).—The report on the working of the municipal electricity undertaking for 1906 shows that, after allowing for bad debts, the receipts were £14,915 (against £12,995 in 1905).

Working, distribution, management and general expenses were £6,520 (against £5,533), the apparent increase being due to the fact that in the two previous years a large proportion of salaries and management expenses were charged against construction account. Gross profit was £8,395 (against £7,462). Interest and sinking fund absorbed £7,163 (£5,994), and net profit was £1,232 (£1,468). It is estimated that a surplus of over £3,000 will result from the current year's working, owing to the increasing demand for current for power and lighting.

Leeds.—The draft revenue accounts for the year ended March 31, presented to the Electricity committee last week, shows a substantial growth in the sales of electric current for power and lighting.

The receipts from private lighting were £79,251. 1s. 11d. (against £72,983. 7s. 3d. in 1905-6), from street lighting £4,536. 1s. 6d. (£3,554. 3s. 8d.), from power £24,472. 8s. (£17,718. 11s. 1d.). Total receipts were £108,259. 12s. 5d. (£94,256. 3s.) and working expenses were £32,467. 15s. 10d. (£28,305. 18s. 4d.). After applying £14,272. 2s. to extraordinary renewals (£3,494. 6s.), the gross profit was £61,519. 14s. 7d. (£62,455. 18s. 8d.) Income tax, interest and redemption charges were £58,109. 17s. 6d. (£59,210. 12s. 5d.), leaving £3,409. 17s. 1d. to be carried to reserve (£3,245. 6s. 3d.). During the year 11,368,956 units were generated (against 9,197,259), the average price was 2·28d. per unit (2·46d.), and the total expenses (including extraordinary renewals, interest and sinking fund) were 2·21d. per unit (2·38d.), leaving a surplus of 0·07d. per unit (0·08d.). Capital expended during the year was £15,467. 19s. 3d. (£10,550. 14s.). There are 307,933 35 watt lamps installed, compared with 297,139 in 1906, and the aggregate horse-power of motors is 6,880, compared with 5,471 H.P. 4,870,942 units were sold for power and heating and the revenue was £24,472 8s. (average of 1·21d. per unit, or £4 per horse-power installed). The load factor was 18 per cent., against 17 per cent., and the maximum load was 7,470 kw., compared with 6,730 kw.

Leith.—Traffic receipts of the electric tramways for the year ended May 15 were £26,375. 17s. 5d., an increase of £6,435. 6s. 10d. over the previous year. 8,519,476 passengers were carried, an increase of 1,975,058.

Luton.—The accounts of the Electricity department for the year ended March 31 show total annual receipts of £6,389. 5s. 3d., including £5,982 net from sale of current for private lighting and power and £141 from public lighting and £221 from meter rental.

The annual expenses were £2,886. 16s. 6d., including £2,056 for cost of generation, £70 for distribution, £148 for rates and taxes, and £489 for management expenses. The gross profit was £3,502. 8s. 9d., and after paying interest (£1,309. 18s. 9d.) and instalment of principal (£392. 0s. 11d.) and sinking fund (£937. 11s. 2d.), the net profit was £862. 17s. 11d. 726,557 units of electric current were generated, 12,519 units were supplied to the public lamps and 673,799 to private consumers. There are 10 arcs and incandescents for public lighting and the total maximum supply demanded was 515 kw. The capital expended is £43,853. 10s. 5d., an increase of £7,174. 14s. 9d. during the year.

Portsmouth.—The net profit on the past year's working of the electricity department is £10,700, of which £3,500 is to be allocated to relief of rates, £1,000 to fire insurance fund and the remainder to reserve. The profit is about £1,100 less than last year, owing to the reduction of charge by ½d. per unit.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

The Higher Education committee of *Portsmouth* Corporation invite tenders for (1) supply and fixture of switchboards and wiring, (2) electric light fittings, and (3) special electric light fittings in the new Technical Institute. Tenders to the Chairman of the committee, Technical Institute, Arundel-road, Portsmouth, by May 28. See advertisement.

Belfast Tramways and Electricity Committee invite tenders for a lighting switchboard to control 2,000 kw. and one motor generator for their East Bridge-street electric station. Specifications, forms of tender, &c., from the acting city electrical engineer (Mr. Thos. W. Bloxam). Tenders to the town clerk (Sir Samuel Black), City Hall, Belfast, by noon June 1. See advertisement.

Edinburgh Corporation require tenders by 10 a.m. May 27 for steam, exhaust and circulating water pipe-work at M'Donald-road electricity station. Specifications, &c., from the City Electrical Engineer or from Sir Alex. B. W. Kennedy, 17, Victoria-street, London, S.W.

Edinburgh Corporation also want tenders by 10 a.m. June 3 for constructing sewer shaft and laying iron pipe line for condensing water for M'Donald-road station. Specification, &c., from the City Electrical Engineer or from Sir Alex. Kennedy.

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Sheffield Electric Lighting committee invite tenders for steam turbine, alternator, exciter, condenser and other accessories. Specifications from the general manager and engineer (Mr. S. E. Fedden), Corporation Electricity Supply Dept., Commercial street, Sheffield. Tenders by 10 a.m. May 27.

Derby Corporation invite tenders for supply and delivery of bitumen insulated cable. Particulars and forms of tender from the borough electrical engineer (Mr. T. P. Wilmshurst), 16, Full-street, Derby.

Nelson Electricity committee want tenders by June 3 for supply of a Lancashire boiler, with superheater and steam pipes. Specifications from borough electrical engineer.

Ilford Council want tenders (by noon June 11) for repair and maintenance of the storage battery at the electricity works. Forms from the Electrical Engineer.

Bradford Electricity committee want tenders (by 10 a.m. June 7) for 12 months' supply of best steam coal. Forms from the Electricity Offices.

Penrikyber Navigation Colliery Co. (*Penrhiwceiber*, Glam.) want tenders by June 6 for supply of electric lamps and fittings, ironmongery, oils, &c.

Heston and Isleworth Council want tenders (by noon June 3) for supply of electricity meters

London County Council require tenders by 11 a.m., June 11, for supply of electrically-operated car-traversers. Forms from the clerk.

The Danish Telegrafdirektoratet, Teknish Afdeling, Frederikskolms Kanal 28, *Copenhagen*, require tenders by noon May 27 for supply of 65,000 kilogs 5 mm. and 15,000 kilogs. 3·5 mm. cold-drawn copper wire, 35,000 kilogs. 0 8 mm. insulated single and 35,000 kilogs. 0·8 mm. insulated double wire. Conditions and specifications may be seen at the Board of Trade, 73, Basinghall-street, London, E C.

The officer-in-charge of the *Australian Commonwealth* offices in London (Capt. Collins, C.M.G.), 72, Victoria-street, S.W., has available for the use of British manufacturers forms of tender and specifications for the following contracts for supply of material, &c., for the Postmaster-General's department: Common battery telephone material for Tasmania (tenders by June 15), telegraph stores for Queensland (tenders by noon June 24), telegraph and telephone material for South Australia (tenders by July 10), four sections of common battery switchboard and 650 subscribers' telephones (tenders by Sept. 2). The invitations to tender have appeared in recent issues of *The Electrician*.

TENDERS RECEIVED AND ACCEPTED.

The contract with W. T. Henley's Telegraph Works Co. for house services and cable laying in Stoke Newington (London) has expired, and a new contract for a year on the basis of a revised schedule of prices has been entered into, with power to the Council to determine at the end of six months.

Westminster City Council have accepted the tender of the Alliance Electrical Co. for rewiring premises at £127. 10s.; that of R. Waygood & Co. for a hoist and 4½ H.P. electric motor at £60; and that of Richmond & Chandler for a chaff cutter and sifter and 5 H.P. electric motor at £62. 12s.

Woolwich Council received three tenders for the supply of an electric motor to work the economiser scrapers at the Plumstead Baths, and that of Veritys Limited at £31. 10s. has been accepted. Also tendered, Marples, Leach & Co., £40. 14s.; Sun Electrical Co., £51. 18s. 6d.

Malvern Council have accepted the following tenders for stores for the electricity department:—

W. H. Keys, bitumen; British Insulated & Helsby Cables, joint and junction and house fuse boxes; International Electric Co., meters; Burnaby & Chantrell, oils; J. Edwards, waste.

Poplar Council have conditionally accepted the tender of Clarke, Chapman & Co. (at £2,100) for supply and erection of a Woodeson boiler with chimney, superheater, &c. The Stirling Boiler Co. tendered at £2,440 and Babcock & Wilcox at £2,660.

Barnes Council received eight tenders for the supply and erection of steam, exhaust and other piping at the electricity works, and that of Edward Le Bas & Co. (at £215) was accepted.

Stoke Newington (London) Council received 12 tenders (varying from £119 to £238) for wiring the Town Hall, and the lowest, that of W. J. Fryer & Co., was accepted.

Southport Council have accepted the tender of G. Allen & Co. for manganese steel at £1. 17s. 4d. per cwt., and that of Belliss & Morcom for an engine governor.

Burslem Council have accepted the tender of E. M. Evans for wiring the education offices.

Camborne Council have accepted the tender of S. Lean for the installation of electric fire alarms.

Harrogate Council have accepted the tender of R. Falshaw for wiring Grove-road Schools.

BUSINESS NOTICES.

The head offices and stores of the Maxim Electrical Co. (Ltd.) have been removed to Parliament Chambers, Great Smith-street, Westminster, S.W., where all future communications should be sent. Telegrams, Arconcello London. Telephone 774 Westminster.

The Armorduct Mfg. Co. have acquired a freehold building site Witton, Birmingham, for the erection of new works.

Royce (Ltd.) have appointed Mr. C. S. Mallett to represent them in the London and South-Eastern district. Mr. Mallett has occupied for some years the position of works manager of the company's electrical works, and later acted as purchasing agent to the company, and so is fully conversant with the latest practice as regards the construction and installation of electrical generating plant, motor driving, cranes, lifts, &c. Mr. Mallett's address is (pro. tem.) 7, Queen's-gardens, Tetherdown, Muswell Hill, London, N.

Fras. H. Hornblower, W. H. Dwerryhouse and Sir P. Elly Bates, trading as the Electro-Galvanising Synd. (Ltd.), have dissolved partnership. Debts by Mr. Hornblower.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the failure of Francis Williams, electrician, 17, Orchard road, Bemerton, Salisbury, gross liabilities are £285. 4s. 7d., unsecured liabilities £276. 15s. 7d. and assets £23. 3s.

The Cowper-Coles Metals Extraction Synd. (Ltd.) is being wound up voluntarily. Claims to Mr. C. Hammond, Hayle, by July 1.

Witting, Eborall & Co. (Ltd.) (in liquidation) is being wound up voluntarily. Claims to Mr. S. E. Witting, 49, Cannon-street, London, E.C., by July 31.

The Buchholtz Reversible Turbine Synd. (Ltd.) is being wound up voluntarily, and Mr. G. Noble, 32, Poultry, London, E.C., is liquidator.

A meeting will be held at Jas. Worley & Son's, 37, Lime-street, London, E.C., on June 25 to receive an account of the winding-up of the Wallace Lamp Synd. (Ltd.)

Arc Lamp Business for Sale.—Pursuant to an order made by Mr. Justice Warrington in the matter of the New Century Arc Light Co., Ltd. (Bush v. the Company and Others), tenders are invited for the purchase of (1) the goodwill of the business carried on at Iliffe-street, London, S.E., of electricians, mechanical engineers and manufacturers and vendors of arc lamps and accessories, &c.; (2) the benefit of contracts and orders on hand; (3) the plant, machinery, tools, fittings, &c.; and (4) the entire stock in-trade of the company. Tenderers may offer for the goodwill of the business only, &c. Tenders (to be sent to the receiver, Mr. E. J. Palmer, Finsbury-pavement House, London, E.C., on or before June 10) will be opened at noon on June 13. Particulars and conditions of sale and forms of tender can be obtained from Mr. E. J. Palmer, or from the solicitors, Messrs. Stanley, Woodhouse & Hedderwick, Bank Chambers, 45, Ludgate-hill, London, E.C. See also an advertisement on another page.

Plant for Sale.—Mr. V. Newport advertises for sale a 1 B.H.P. Morton gas engine, a 50 volt 10 ampere compound-wound dynamo, belting, main switchboard and instruments, Luna arc lamps, &c.

Some electric lighting plant (Marshall engine and boiler, feed pump and injector, belt-driven compound-wound Crompton dynamo, switchboard, &c.) is advertised for sale in another column

Telephone Installation for Sale.—An advertiser has for disposal a second-hand private telephone installation, comprising 25 hole switchboard with indicators, five pairs of cords and plugs, micro-telephone, seven table instruments, eight wall sets, battery boxes, &c.

Agency Wanted.—An electrical engineer, shortly proceeding to New Zealand, desires to represent a high class firm. See advertisement.

Partnership Required.—An electrical and mechanical engineer in large experience wishes to obtain an interest in a well-established and sound engineering business. See an advertisement.

Disclaimer.—The editor of "South African Engineering," the oldest of the South African engineering papers, desires it to be known that there is no connection between "South African Engineering" and the South Africa Engineer Co. (Ltd.), which latter publication was mentioned in an action recently tried before Mr. Justice Lawrance.

CATALOGUES, &c.

Electric Power.—An artistic wall-sheet is being sent out by Messrs. Bruce Peebles & Co., London Wall-buildings, E.C., which admirably illustrates the capacity of the company for the production of dynamo electric machinery for industrial power purposes. It consists of some seven illustrations of Peebles' power plants and motor installations, these views being effectively displayed. Messrs. Bruce Peebles place their experience at the disposal of prospective clients, an experience acquired in the application of over 100,000 H.P. of motors in Great Britain alone. We understand

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that the wall sheet is intended for distribution amongst station engineers, to hang up in show rooms or exhibitions, and that a large number have been distributed in this way and greatly appreciated. The company will be pleased to forward copies to all bona-fide inquirers.

Flexible Enamel.—The controversy as to the bending properties of insulating enamel for steel conduit is becoming exceedingly keen. Simplex Conduits (Ltd.) send us a small piece of tin coated with flexible conduit enamel, with the invitation to submit this to a bending test. The letter accompanying the sample states that the enamel does not flake off when bent, and from our own tests we can confirm this. Only after very severe handling, such as would be unlikely to obtain in practice, does the coating show any signs of leaving its support.

Cable Boxes.—A number of booklets is to hand from W. T. Henley's Telegraph Works Co., which deal with their standard types of house service boxes, joint box compounds, dividing boxes and pavement frames and covers.

Constructional Steel and Iron Work.—Peirson & Co, St. Dunstan's-hill, London, E.C., are issuing a useful catalogue of prominent examples of their iron and steel structures. The illustrations include views of the Bankside station of the City of London Electric Lighting Co, coal bunkers and elevator tower for Shoreditch Borough electricity works and one of the power stations of the West Ham Corporation. There are also a number of tables of strengths of safe working loads on rolled steel joists, girders, stancheons, &c.

B.E.P. Motors.—The British Electric Plant Co., Alloa, N.B., are to be complimented on the style and arrangement of their catalogue No. 140, which gives details of their dynamo and motor products. A complete specification of the machines is set out, and prices are given of the various patterns manufactured.

Accumulators.—J. C. Lyell & Co. (Ltd.), 55, Victoria-street, Westminster, S.W., send us their latest pamphlet on "Verdol" accumulators, specially built for ignition work.

D.C. Motors.—The Barriett Electric Mfg. Co., of Cincinnati, send us their bulletin No. 5, dealing with their standard manufactures in small D.C. motors and generators.

A.C. Motors.—Price list No. 102A, issued by Marples, Leach & Co, deals with this firm's latest types of two and three-phase induction motors with short-circuited and slip-ring rotors. We understand that there are no joints in the electrical circuit of the short-circuited type, the windings being cut from solid metal and slipped into place. The slip-ring machines are fitted with a special brush-lifting and short circuiting device, by which the brush can be raised after the motor has been started and the rings short-circuited by the same operation. This dispenses with wear and tear of the rings and brush gear.

Maxim Products.—The Maxim Electrical Co. have issued a bundle of leaflets illustrating some recent work carried out by the company. The subjects of the pictures mainly relate to lighting installations by Maxim arc lamps, a number of the new tube stations being included in the series.

Electric Light Accessories.—A catalogue is to hand from Gent & Co, Leicester. This gives details and illustrations of every kind of electric lighting accessory necessary for the wiring of any building.

Wall Card.—The issue of large cards for the display of a variety of engineering products is not frequent, and we are, consequently, rarely asked to pass comment upon them. We think, however, that Messrs. Mather & Platt are to be congratulated upon the design, arrangement and production of a card of this class. In addition to views of their Salford and Park works the card contains numerous illustrations of their principal products. The illustrations are well placed and are backed by a suitable design, which is never sufficiently obtrusive to distract the eye from the main objects on the card.

CO_2 Recorders.—The latest pattern "Sarco" CO_2 Recorder is described in a pamphlet just issued by Sanders, Rehders & Co. Accompanying the circular is a list of users of Sarco apparatus in all parts of the United Kingdom.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from May 14 to 17, with the ports of destination:—

Africa—Alexandria, £220; Cape Town, £26 (including £21 telegraph material); Delagoa Bay, £14; Durban, £279; Mombasa, £62; Port Nolloth, £19; Port Sudan, £689 (including £570 telegraph material); Suez, £18 (telegraph material). *Argentina*—Buenos Ayres, £579 (including £254 telegraph material); Rosario, £291 (telegraph material). *Australasia*—Adelaide, £78; Auckland, £134; Fremantle, £21; Invercargill, £45; Melbourne, £930; Otago, £115; Perth, £80; Sydney, £785; Wellington, £75. *Belgium*—Brussels, £16; Ghent, £124; Ostend, £12. *Brazil*—Rio Janeiro, £11 (telegraph material). *Burma*—Rangoon, £21. *Canada*—Halifax, £135 (telegraph material); Montreal, £141; Toronto, £1,083. *Canaries*, £46 (telegraph material). *Ceylon*—Colombo, £25. *China*—Shanghai, £2,352; Tientsin, £210. *France*—Bordeaux, £27; Boulogne, £86; Paris, £41. *Germany*—Bremen, £3,035 (including £3,030 telegraph material). *Holland*—Amsterdam, £205 (including £142 telegraph material); Flushing, £10; Rotterdam, £143. *Hong Kong*, £44. *India*—Bombay, £998; Calcutta, £2,030; Chittagong, £160; Madras, £84 (including £49 telegraph material). *Italy*—Genoa, £620. *Japan*—Nagasaki, £1,229; Yokohama, £9,561 (including £8,835 telegraph cable). *Persia*—Balek Pappan, £169 (including £68 telegraph material). *Russia*—Odessa, £197; St. Petersburg, £168. *Straits Settlements*—Singapore, £277 (including £20 telegraph material). *Sweden*—Stockholm, £600 (telegraph cable). *Uruguay*—Monte Video, £225. *U.S.A.*—New York, £41 (telegraph material). *Venezuela*—La Guayra, £8. *West Indies*—Dominica, £14; Port Swettenham, £36 (telegraph material); Trinidad, £61. Total (for four days), £28,705, against £16,952 for seven days last year (May 16 to 22).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

March 4, 1907.

5,155 ALBION MOTOR CAR CO. & MURRAY. Magneto-electric generators.
5,159 MALLOCH. Telephone receivers.
5,164 MANDERS. Producing oscillatory from continuous currents.*
5,170 PARSONS. Steam turbine.
5,173 JAKSCHE. Steering for electric travellers in lifts.
5,179 SKINNER. Holders for incandescent lamps.
5,194 POSTANS. Electrical ignition apparatus.
5,203 KRIEGER & COMPAGNIE PARISIENNE DES VOITURES ELECTRIQUE. Commutators and brush carriers. (Date applied for, 16/10/06*†).
5,209 MEDHURST. Combined portable telephone and telegraph instrument.*
5,210 BEARD. Electric magnetic motors.
5,223 JOHNSON. (Chemische Fabrik Griesheim-Elektrom, Germany.) Electrodes for electrolytic purposes.
5,297 TRACEY. Code indicator, automatic vocabulary of code words or device for facilitating code telegraphy.
5,300 GARROD. Point arrangements of the side slot conduit system of electric traction.
5,301 IGEVSKY. Electric furnace.*
5,331 WILLIAMS. Line tappers for electric wires. (Date applied for, 8/3/06.)*†
5,332 DUNWOODY. Wireless telegraphy. (Date applied for, 23/3/06.)*†
5,334 EISENSTEIN. Producing undamped electrical oscillations.*
5,338 LEITNER. Electric heaters.
5,339 LEITNER. Quick-acting "make-and-break" switches.
5,345 ALLMANNA SVENSKA ELEKTRISKA AKTIEBOLAGET. Electric furnaces. (Date applied for, 7/3/06.)*†
5,350 WARWICK MACHINERY CO. (G.E. Co., U.S.) Turbines.
5,351 PIERCE. Receiving apparatus for wireless telegraphy. (Date applied for, 16/3/06.)
5,354 EISENSTEIN. Producing electric oscillations.*

March 6, 1907.

5,364 CHAMBERS & BENNETT. Sparking plugs.
5,389 CHAMBERS & BENNETT. Synchronised high-tension ignition systems.
5,402 SUCHOSTAWER. Electric traction on the surface-contact system.
5,415 B.T.-H. Co. (G.E. Co., U.S.) Transformers.
5,416 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
5,424 DAMSEAUX. Incandescent lamps of variable intensity and their supports.
28,897A/06 COWPER-COLES. Electro-deposition of iron. (Date applied for, 18/12/06.)*†

March 7, 1907.

5,470 GARDNER. Microphones and telephonic transmitters.
5,477 GREY. Electric air-gun target.
5,488 GANGE. Railway and tramway tracks.
5,499 STUTTMAN. Arrangement of brushes in brush dynamos.*
5,502 BOLTON & COVENTRY WATCH MOVEMENT MFG. CO. Switches.
5,509 LAMME. Connection system for dynamo-electric machines. (Date applied for, 2/8/06.)*†
5,514 COWPER-COLES. Reproduction of drawings and the transmission of pictures by telegraph.
5,522 HAWLEY & JONES. Electromagnetic separator drum for grain and similar conveyors.
5,532 FESSENDEN. (McCarty Wireless Telephone Co., U.S.) Wireless transmission of sonorous vibrations.*
5,537 BAMES. Magneto-electric ignition devices for internal combustion engines.*
5,538 FERRANTI. Turbine blades.
5,547 SIEMENS BROS. & CO. & DIESELHORST. Cables containing induction coils.*
5,548 SIEMENS BROS. & CO. & FERREIRA. Apparatus for electrically operating and controlling semaphore signals.*
5,560 STEWART. Working of points and plough guides on electric tramways.
5,564 MERSHON. Concatenated control of alternating-current motors.*
5,565 MERSHON. Alternating-current machines.*

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5,574 B.T.-H. Co. (G.E. Co., U.S.) Insulating material and processes.
5,575 B.T.-H. Co. (G.E. Co., U.S.) Electric conductors for use as incandescing bodies in electric lamps.
5,576 B.T.-H. Co. (G.E. Co., U.S.) Apparatus for treating electric conductors, especially in the manufacture of filaments.

March 8, 1907.

5,604 Ely & Grote (trading as Foster & Co.) Arc lamps.
5,630 Ward. Switches particularly applicable to internal combustion engines.
5,634 Cowper-Coles. Manufacture of electric conductors.
5,635 Cowper-Coles. Transmission of pictures and messages.
5,651 Raybould. Electric light fittings and raising and lowering same.
5,652 Fynn. Alternating-current motors.
5,654 Berry. Ventilating alternating-current transformers.*
5,655 Petersson. Electrically-reducing oxide ores and the like.*
5,657 Petersson. Charging electric furnaces for producing carbide from lime and carbon.*
5,671 B.T.-H. Co. & Hopps. Control of electric vehicles.
5,672 B.T.-H. Co. (G.E. Co., U.S.) Incandescent electric lamps having metallic filaments.
5,673 B.T.-H. Co. & D'Arcy. Electricity meters.

March 9, 1907.

5,698 Greenwood. Applying charcoal as an insulating material.
5,728 Dawe. Electric winding appliances and operating same.
5,732 Turnbull. Turbines.
5,733 Golby. (La Societe Alsacienne de Constructions Mecaniques, France.) High efficiency alternating polyphase collector motor.*
5,741 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
5,746 Porschke. Turbine engine.
5,748 Lund. Telegraphic apparatus.
5,749 Griffiths & Bedell. Cable for electric traction on the stud-contact system.
5,751 Mackenzie. (Bolle & Co., G.m.b.H., Germany.) Electric smelting furnace.*

March 11, 1907.

5,826 Lundberg, G. C. Lundberg & P. A. Lundberg. Switches.*
5,836 A. P. Franklyn & Seyfert. Alternating-current commutator motor.*
5,849 Mueller. Magnetically-releasable locking device for miners' lamps.*
5,853 Steinacker & Plisnier, jun. Wireless telephony.
5,865 Nalder Bros. & Thompson, Harris, Wallis-Jones & Cox. Automatically breaking an electric circuit in the event of a leakage to earth.
5,866 Erben. Dynamo-electric machines. (Date applied for, 16/1/07.)*†
5,877 Woolley & Higgins. Electric traction system and apparatus.
5,887 Dekker. Treating minerals by electrolysis.*
5,890 Felten & Guilleaume-Lahmeyerwerke A.G. Electric coils having self-induction for shortening the time of energising and de-energising such coils. (Date applied for, 20/4/06.)*†
5,899 Boult. Sparking plugs. (Macquaire, France.)*

March 12, 1907.

5,904 Foster. Electrical instruments of the thermal type.
5,908 Snape. Commutator devices.
5,916 Stevenson. Voltaic lighthouse apparatus.
5,920 Garsed. Life guards of tramcars and like motor vehicles.
5,925 Triquet. Primary cell.*
5,937 Lord. Electrical apparatus.*
5,946 Fickelscheer & Bergheiser. Safety device for tramcars.*
5,957 Rodman. Reducing depreciation in lead storage batteries. (Date applied for, 24/3/06.)*
5,958 Mair. Push-button apparatus for operating or controlling electric lifts.*
5,964 Walker. Brush-holders for dynamo-electric machines.
5,975 Murray and Jackson. Telephone systems.
5,987 Solari. Vehicle with collapsible pole for radio-telegraphy.*
5,999 Walther. Electric alarm thermometer. (Date applied for, 12/11/06.)
6,006 Bowden, Robinson & Jacks. Prepayment mechanism for electric and gas meters.
6,013 Romer. Central battery telephone exchange system.
6,021 B.T.-H. Co. (G.E. Co., U.S.) Dynamo electric machines.
6,026 Dawe. Electromagnetic coupling for power transmission.

SPECIFICATIONS PUBLISHED.

1906 Specifications.

21,232 Siemens Bros. Dynamo Works & Lydall. Dynamo electric machinery.
21,585 Gebrüder Siemens & Co. Electric contacts consisting of mixtures of metal and carbon. (Date applied for, 30/9/05.)†
21,586 Billeter. Electromagnetic mechanism for reversing the motion of machine tools.
21,670 Noeggerath. Unipolar dynamo electric machines. (Date applied for, 4/10/05.)
22,845 Dorman, Smith & Baggs. Fusible cut-outs.
23,379 Lindblad & Stalhane. Transformer furnaces. (Date applied for, 8/5/06.)
24,683 Allgemeine Elektricitäts-Gesellschaft. Alternating current distribution systems. (Date applied for, 3/11/05.)
28,048 Kallmann. Comparison or standardisation of electrical measuring instruments. (Date applied for, 5/7/06.)
29,147 Lake. Storage battery.

1907 Specifications.

217 Marenghi Mechanical organs or pianos with an electric lighting arrangement for producing luminous effects.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

BICKERTON'S ENGINE SYND. (LTD.) (93,396.)—Reg. May 16, capital £10,000 in £1 shares, to adopt an agreement with H. L. Bickerton and A. Firth, and to carry on the business of mechanical engineers, electricians, gas, oil and electric engine and motor mannfacturers and dealers, &c. Reg, office, 54, New Broad-street, London, E.C.

CABLES ACCESSORIES CO. (LTD.) (93,345.)—Reg. May 13, capital £7,000 in £1 shares, to acquire and carry on the business of an electrical and mechanical engineer carried on as the Cable Accessories Co. Reg. office, Britannia-street Works, Tividale, Staffs.

STATUTORY RETURN.

MADEIRA ELECTRIC LIGHTING CO. (LTD.)—Return to Jan. 13 (filed March 26) gives capital as £20,000 in £1 shares, all of which have been taken up. £1 per share has been called up on 14,000 and £14,025 has been received, including £25 on 100 forfeited shares. 6,000 shares are considered as fully paid. Mortgages and charges £15,000.

MORTGAGES AND CHARGES.

T. A. W. CLARKE (LTD.)—A debenture dated May 2, 1907, to secure £1,000, charged on company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, J. T. Clarke.

WARREN BEATTIE & CO. (LTD.)—A debenture dated May 7, 1907, to secure £1,500, charged on company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, H. Drummond, 6, Sackville-place, Newcastle-on-Tyne.

CITY NOTES.

MEMORANDA (May 23).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 30⅞d.—31d. per oz. Consols 84$\frac{5}{16}$—84$\frac{1}{16}$ for money, 84$\frac{3}{8}$—84$\frac{7}{16}$ for account; 2½ per cent. annuities 83—83$\frac{3}{8}$. Consols Pay Day, June 3; Stocks and Shares Continuation Days, May 28 and June 11, Ticket Days, May 29 and June 12; Pay Days, May 30 and June 13; Mining Share Carry-over Day, May 27.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—Lord Vaux of Harrowden stated at the meeting yesterday that the gross profit on the past year's operations was £65,802, against £73,929, whilst the profit on sales of securities only realised £4,755, against £8,001. Expenditure on property account had been increased by the purchase of additional plant. During the year the Australian branch had been closed, owing to increasing competition, and in future that business would be carried on upon a basis which would not involve much local risk, or the maintenance of a large local staff. Owing to the fact that most of the towns of the United Kingdom had now completed the equipment of their electric tramway systems, there had been a serious diminution in the demand for tramway rolling stock. Under these circumstances the directors had turned to the manufacture of main line rolling stock, and had been successful in securing important contracts. The industry had involved a large initial expenditure.

BULUWAYO WATERWORKS CO. (LTD.)—In the directors' report for 1906 it is stated that the gross profit from the sale of electric current amounted to £4,815, an increase of £262. The average number of electricity consumers was 541, an increase of 5·9 per cent., the number of units sold being 174,925, an increase of 6 per cent.

ELECTRIC TRACTION CO. OF HONGKONG (LTD.)—The directors' report for 1906 states that the net profit for the year was £6,566. 19s. 1d., of which £6,000 has been set aside in respect of depreciation, the balance (£566. 19s. 1d.) being carried forward. The Colonial Government have assented to the tramway rights, hitherto held by the Hongkong Tramway Electric Co. (the Ordinance company) being transferred to this company, and, in consequence, the Ordinance company has been wound up.

LEAMINGTON & WARWICK ELECTRICAL CO. (LTD.)—At the meeting yesterday (Thursday) the directors reported that the capital expenditure during the year amounted to £13,801, of which £11,207 was incurred in connection with the electric tramways reconstruction and equipment, and £2,593 in connection with the power station and equipment for the supply of electricity. The funds necessary were advanced by the British Electric Traction Co. The amount now owing to the latter company is £28,035, and to discharge the debt it is proposed to make an issue of debentures. The accounts show credit balances of £5,179 from traction and £208 from electric supply, and sundry receipts £45. Deducting administration and general expenses (£1,268), debenture and other interest (£114), &c., the balance is £4,044, which, with £537 brought forward, makes £4,581. The directors recommend a dividend of 4 per cent. on the ordinary shares for the year, leaving to be carried forward £1,258.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to 413,804 common and 500,000 preferred $100 shares of the *Mackay Companies*. The committee have been asked to grant quotations to 100,000 10s. fully-paid ordinary shares and 150,000 £1 fully-paid preference shares (in lieu of the preferred shares) of the *Kalgoorlie Electric Power & Lighting Corpn. (Ltd.)*

VENEZUELA TELEPHONE & ELECTRICAL APPLIANCES CO. (LTD.)—Meetings of the first and second mortgage debenture-holders will be held on May 30 to authorise the issue of £30,000 6 per cent. prior lien debentures

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 15	1,303	+ 11	50	68,668	+ 1,726
Airdrie	,, 10	221	+ 5	18	4,024	- 1
Anglo-Argentine	,, 20	17,519	+ 2,222	20	330,591	+ 28,907
Ashton-under-Lyne Corp	,, 18	373	+ 41	8	3,085	+ 433
Ayr Corporation	,, 18	235	- 5	1	235	- 5
Baker St. & Waterloo By.	,, 18	2,360	+ 1,001	10	23,335	+ 8,746
Barnsley	,, 10	164	+ 3	18	2,896	- 60
Barrow	,, 10	233	+ 11	18	4,042	+ 9
Bath Electric Trams, Ltd.	,, 15	839	+ 39	20	13,833	+ 17
Birkenhead Corporation	...	...	...	...	...	...
Birmingham Corporation	,, 18	6,182	...	7	40,358	...
Birmingham & Mid.	,, 3	759	...	17	13,027	...
Blackburn Corporation	,, 15	1,087	+ 25	§7	8,274	+ 653
Blackpool Corporation	,, 16	531	+ 5	6	4,209	- 849
Blackpool and Fleetwood	...	...	...	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 19	2,147	+ 271	7	14,961	+ 107
Bournemouth Corporation	,, 15	1,532	+ 45	¶6	10,767	+ 52
Bradford Corporation	...	...	...	...	...	...
Brighton Corporation	,, 19	878	+ 53	7	5,953	- 413
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 17	5,152	+ 56	14	66,561	- 177
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 18	1,257	+ 137	7	7,104	- 14
Burton Corporation	,, 19	283	+ 22	7	1,928	- 148
Bury Corporation	,, 12	996	...	7	6,790	...
	,, 19	999	...			
Calcutta Tramways Co.	,, 18	R14,662	‡ R3,899	19	R999,851	+ R11,674
Camborne-Redruth	,, 18	130	+ 18	20	2,196	† 73
Cardiff Corporation	...	...	...	...	...	...
Cavehill	,, 10	75	+ 13	18	1,280	+ 47
Central London Railway	,, 18	5,828	- 865	20	123,292	- 12,725
Chatham & Dist. Lt. Rys.	,, 16	740	+ 96	¶19	12,838	+ 979
City & South London Rly.	,, 19	3,156	+ 474	20	58,997	+ 1,516
City of Birmingham	,, 10	2,911	...	18	49,194	...
Colchester Corporation	,, 15	203	+ 9	...	...	...
Cork Electric Trams Co.	,, 18	460	- 38	20	8,282	- 186
Croydon Corporation	,, 17	1,492	- 35	‡7	9,477	- 585
Devonport & Dist. Trams	,, 10	433	+ 14	18	7,979	+ 140
Dover Corporation	,, 18	202	- 6	7	1,477	- 123
Dublin & Lucan Railway	,, 17	110	+ 4	20	1,953	- 11
Dublin United	,, 17	5,610	+ 643	†20	96,071	+ 4,352
Dudley Stourbridge	,, 10	830	+ 49	18	11,523	- 80
Dundee Corporation	,, 15	1,120	+ 86	60	56,920	† 7,483
East Ham Council	,, 18	932	+ 8	7	6,218	- 153
Exeter Corporation	,, 17	298	+ 40	‡7	2,078	+ 195
Falkirk and District	,, 15	274	...	7	2,033	...
Gateshead & Dist. Trams	,, 10	1,015	+ 77	18	17,852	+ 659
Glasgow Corporation	,, 18	18,163	+ 1,647	50	854,673	+ 69,297
Glossop	,, 18	136	+ 7	20	2,680	+ 74
Gravesend—Northfleet	,, 10	236	+ 8	18	4,040	+ 121
Great Northern & City Rly.	,, 18	1,761	+ 10	20	36,656	+ 133
Gt. Northern, Piccadilly, &c.	,, 18	4,089	...	20	96,719	...
Greenock & Port Glasgow	,, 10	655	+ 6	18	11,284	+ 139
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 10	260	- 7	18	4 625	- 256
Hastings Elec. Trams Co.	,, 16	1,048	+ 424	20	16,284	...
Hong Kong	,, 18	$7,945	+ $1,107	7	$153,921	...
Huddersfield	...	...	...	...	...	...
Hull Corporation	,, 18	2,409	+ 308	7	16 223	+ 902
Ilford District Council	,, 18	494	...	7	3,275	- 119
Ilkeston District Council	,, 15	151	+ 19	7	967	+ 121
Ipswich Corporation	,, 18	389	+ 21	7	2,592	- 120
Isle of Thanet Co.	,, 18	454	+ 62	33	9,871	‡ 230
Jarrow	,, 10	133	...	18	2,043	...
Keighley Corporation	,, 16	160	+ 15	46	6,929	+ 549
Kidderminster & District	,, 10	109	+ 14	18	1,762	- 57
Kilmarnock Corporation	,, 18	200	+ 40	52	8,229	+ 135
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 16	1,271	+ 310	20	21,102	+ 1,311
Lancashire United	,, 15	1,221	+ 290	§20	22,413	+ 6,151
Leamington	,, 10	143	+ 1	18	2,533	- 121
Leeds Corporation	,, 11	6,560	+ 555	7	44,554	+ 3,095
	,, 18	6,605	+ 640			
Leicester Corporation	,, 18	2,365	+ 137	20	42,350	+ 492
Leith Corporation	,, 18	494	+ 39	52	26,379	+ 6,443
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 19	1,509	+ 164	20	28,232	+ 312
Liverpool Corporation	,, 11	11,014	+ 357	19	198,083	+ 3,179
*London County Council	,, 11	32,116	+ 6,070	6	176,857	+ 19,381
London United	,, 17	7,198	+ 624	†20	110,716	+ 3,923
Lowestoft	,, 18	161	+ 11	33	5,011	+ 684
Maidstone Corporation	,, 18	115	+ 12	7	750	+ 6
Manchester Corporation	,, 19	14,956	+ 2,084	7	97,631	+ 9,055
Mersey Railway	,, 18	1,790	+ 176	20	36,593	+ 1,706
Merthyr	,, 10	214	+ 16	18	3,680	+ 217
Metropolitan Dist. Railway	,, 19	7,884	- 250	20	156,555	- 3,198
Metropolitan Elec. Trams	,, 10	4,575	+ 1,211	18	73,691	+ 16,987
Middleton	,, 10	345	+ 26	18	5,837	+ 118
Nelson Corporation	,, 18	111	+ 10	8	1,152	+ 102
Newcastle-on-Tyne Corp.	,, 18	4,052	+ 311	7	28,151	+ 753
Newport (Mon.)	,, 18	630	+ 55	7	4,490	+ 253
Northampton Corporation	,, 17	437	+ 26	‡7	2,852	- 52
Oldham, Ashton & Hyde	,, 10	602	+ 35	18	10,626	+ 708
Oldham Corporation	,, 19	1,864	+ 255	8	15,474	+ 1,705
Perth (N.B.) Corporation	,, 15	116	+ 10	52	7,985	...
Perth (W.A.) Elec. Trams	,, 17	1,364	- 39	20	29,590	- 620
Peterborough	,, 10	125	+ 8	18	2,022	+ 25
Portsmouth Corporation	,, 18	1,761	+ 1	7	12,880	- 120
Potteries	,, 10	1,890	+ 92	18	33,355	+ 461
Preston Corporation	,, 15	715	+ 1	7	5,086	+ 201
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 16	577	+ 105	47	3,789	+ 563
Rothesay	,, 10	95	- 17	18	1,563	- 7
Salford Corporation	...	...	...	...	...	...
Sheerness	,, 8	55	- 1	18	915	- 18
Sheffield Corporation	,, 13	5,152	+ 573	8	13,385	+ 2,649
Singapore Trams	,, 18	$9,365	+ $1,410	7	$69,307	+ $12,060

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	May 15	346	+ 19	7	2,088	- 115
South Metropolitan	,, 10	752	...	18	12,773	...
Southport Tramways	,, 10	257	+ 1	19	4,345	- 250
South Staffs	,, 10	884	+ 97	18	15,931	+ 1,225
Stalyb'dge, Hyde, &c., Jt. Bd	,, 18	768	+ 1	7	5,374	+ 174
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	...	...	...	...	...	...
Sunderland and District	,, 17	442	+ 73	20	8,203	+ 1,081
Swansea Trams	,, 10	823	+ 30	18	14,645	+ 407
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 10	41	- 1	18	730	- 51
Tynemouth and District	,, 10	176	- 21	18	3,067	- 364
Tyneside Trams Co.	,, 15	459	+ 40	20	8,079	+ 700
Victoria, Elec. Supply Co. of	April 14	851	- 31	3	3,453	+ 972
Wallasey District Council	May 18	790	+ 68	7	5,443	+ 185
Walsall Corporation	...	...	...	...	...	...
Warrington Corporation	...	...	...	...	...	...
West Ham Corporation	,, 16	2,514	+ 268	7	16,648	+ 929
Weston-super-Mare	,, 8	63	- 12	18	837	- 54
Wolverhampton Co.	,, 10	462	+ 65	18	7,637	+ 187
Wolverhampton Corpn.	,, 15	842	+ 32	18	15,041	...
*Worcester	,, 10	276	+ 10	18	4,515	- 86
Wrexham	,, 10	93	+ 2	18	1,755	- 24
Yorkshire W.R. Trams	,, 19	1,132	+ 453	20	21,670	...
Yorkshire Woollen District	,, 10	970	+ 68	18	16,851	+ 1,127

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., May 22.	Rate % Yielded.	Dividend Due.	Business Week to May 22. High- est.	Business Week to May 22. Low- est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	7⅞—7¼	5 1 6	Ap, Oct	7⅞	7⅛
6	2/9	Do. 5½ per Cent. Cum Pref.	5 1/16—5 1/8	4 12 3	..	..	..
St.	6¾	Do. Permanent 6% Deb. Stock	133 —136	4 8 8	..	..	..
St.	5¾	Auckland Elec. Trams. 5% Deb. (red.)	101 —107	4 13 6	..	..	..
£	..	Brisbane Electric Trams. Invest. Ord.	2⅜—3	3 15 0	..	2⅛	2⅜
5	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5⅛	4 18 9	..	..	..
St	4½	Do. 4½ per Cent. Db. Prov. Certs.	98 —102	4 8 0	..	99	..
St.	7¾	British Columbia El. Ry. Df. Ord.	123 —127	4 14 3	..	..	..
St.	6¾	Do. Pref. Ord. Stock	106 —111	4 10 0	..	..	..
St.	5¾	Do. 5% Cum. Perp. Pref. Stock	102 —1 6	4 14 3	..	10 1/8	..
40	4½	Do. 4½ per Cent. 1st Mort. Debs.	99 —10	4 8 0	..	101	100½
100	4½	Do. Vancouver Power Debs.	102½—1 4½	4 6 0	..	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	3½—3¾	4 0 0	..	3 5/16	3⅜
5	3/0	† Do. 6 per Cent. "A" Cum. Pref	4¾— ⅝	5 11 6	..	..	..
5	3/0	† Do. "B"	4¾—5½	5 14 0	..	4 1/16	..
St.	5¾	Do. 5 per Cent. Debs.	105 —115	4 7 0	..	..	..
St.	5¾	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	..	..	..
St.	5¾	Buenos Ayres Elec. Trams. (1901) Ltd.	98 —101	4 19 0	..	..	..
10	5½	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	100 —104	5 5 9	..	..	..
100	6¾	Do. 6 per Cent. 1st Deb. Bonds	100 —105	5 14 0	..	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7½—8	5 0 0	..	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅜	4 7 0	..	..	..
1	4½	Do. 4½% 1st Deb. Stock (red.)	105 —108	4 3 3	..	..	..
St.	..	Cape Electric Tram Shares	⅜ ⅝	..	..	..	..
..	5¾	Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —100	5 0 0	..	..	..
1	5¾	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 - 90%	5 11 0	..	90	88
10	5¾	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 —95	5 5 0	..	..	..
5	6¾	Do. 6 per Cent. "B" Ditto	80 - 81	7 2 6	..	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 1/16—1 1/8	3 9 6	..	..	..
100	9 7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1 1/8	5 1 0	..	..	..
St.	5¾	Do. 5 per Cent. Reg. Mort. Debs	98 —101	4 19 0	..	..	..
St.	5¾	Madras Elec. Trams. 5% Deb. Stk.	93 —101	4 19 0	Ja, Jul	96	..
St.	4½	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —104	4 6 6	..	103½	..
St	6¾	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	..	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	123 - 128	3 2 6	..	..	..
..	5¾	Do. 5 per Cent. 1st Mt. $500 Db	95¾—97¾	5 3 0	..	96½	96
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¾—5¼	5 14 0	..	..	..
10	3/1½	Bombay E. S. & T. 6 Cm. Pf. £8 pd.	7⅞—8⅜	5 15 0	..	8⅜	8⅛
St.	4½	Do. 4½ per Cent. Deb. Stk. (red.)	95 — 98	4 11 9	..	..	..
5	5/3	†Calcutta Elec. Supply Ord.	7½—8½	5 2 0	..	..	..
5	2/3	† Do. £4 paid	6 —7	..	..	..	..
50	5¾	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	..	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2 1/16—2 3/16	..	..	..	..
St.	5¾	Do. 5 per Cent. Deb Stock	88 —92	5 8 6	..	..	..
St.	5¾	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 — 98	5 2 0	..	..	..
St.	6¾	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 —109	5 10 0	..	..	..
1	0 7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	5/8—11/16	..	..	..	..
St.	5¾	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½—97½	5 2 6	..	..	..
1	1 6	Rand Electric	1 1/16—1 1/8	..	..	..	..
1	0 3	†River Plate Electricity Co. Ord.	2 1/16—2 1/8	..	..	2 1/16	..
1	1 2½	† Do. 6 per Cent. non-Cum. Pref.	1 1/16—1 1/8	6 8 0	..	..	..
St.	5¾	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	..	..	..
5	3 0	Rosario Elec. Co. 6 Pref. (1-20,000)	5 —5½	5 9 6	..	..	..
..	5¾	Shawinigan Water & Power 5 per Cent. Bds., Scrip	98 —100¾	5 0 0	..	..	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

Shrs.	Last Dividend	Name.	Price Wed., May 22.	Rate % Yielded.	Dividend Due.	Business Week to May 22. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	9⅛–10⅛	6 16 6	..	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9½–10	4 10 0	..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1⅛–10⅝	5 11 8	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	101 –104	4 6 6	..	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜–5⅛	5 5 0	..	..	..
St.	4 %	Do. Do. 1st Debs.	97 –99	4 11 0	..	97	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 – 9	5 11 0	..	..	..
5	3/6	Do. 7 per Cent. Pref.....	7⅛– ⅛	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co 4% Guar. Db. Stock	100 –103	3 17 6	..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	4⅜– 4⅝	5 18 0	Feb, Aug	4⅛	3 15/16
£	2/3	Do 4½ per Cent. Pref.	4 –4⅛	5 0 0	Feb, Aug	4⅛	..
St.	4 /	Do. 4 per Cent. Deb. Stock (red.).....	93 – 99	4 1 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜–4⅛	5 9 0	..	..	..
5	2/3	Chelsea Electric Supply Ord.	3⅛–4⅛	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 –107	4 4 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord...	9⅜–10⅛	5 17 0	Feb, Aug	10⅛	10
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅛–12⅛	4 16 0	Jan, July	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 –124	4 0 9	June, Dec	124⅛	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	..	99	..
5	5%	County of Durham Elec. P.D. Ord.....	4⅛–4⅜	4 7 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜–5	5 4 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅜–8⅛	5 17 6	..	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10⅜–11⅛	5 4 0	Mar, Sept	11⅛	..
St.	4½%	Do. 4½ % Deb. Stock (all paid) (red.)...	1 6 –10 9	4 2 6	..	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	95 –98	4 12 0	..	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅛–5⅛	5 2 0	..	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	..	..	..
St	4½%	Do. 4½ 1st Deb. Stock (red).....	97 – 100	4 10 0	..	..	..
5	5 0	Hove Electric Lighting Ord.	7 – 7½	6 0 0	..	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8⅛– 9⅛	5 5 0	..	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜– 7	4 5 9	Jan, July	..	..
St.	4 /	Do. 4 per Cent. Deb. Stock (red.).....	97 – 100	4 0 0	..	..	..
St.	4%	Kensingtn. & Knytbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 1 2	3 13 0	..	..	..
3	2 4½	London Electric Supply Ord.	1⅞–2⅛	5 13 0	..	..	..
5	3 0	Do. 6 per Cent. Pref.....	4⅛–5⅛	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	£5 – 98	4 2 0	Mr,Jn,S,D	..	..
5	4/0	Metropolitan Electric Sup. Ord.	5⅜– 6⅛	6 11 0	April, Oct	6 1/16	5 15/16
£	2 3	Do. 4½ per Cent. Cum. Pref.	5 –5⅛	4 5 6	Jan, July	5 1/16	..
St.	4½	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 8 –109	4 2 9	June, Dec	..	..
St.	3½	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	92 – 94	3 14 6	..	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98⅞	4 12 0	..	97⅛	97½
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅝–9⅜	5 8 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	99 –101	4 10 0	Jan, July	..	..
5	8 /	Newcastle Elec. Supply Ord.	7⅛–7⅞	5 8 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛–5⅞	4 7 9	Feb, Aug	..	..
100	4 %	Do. 4 per Cent. Mort. Deb. red. 1907.	99 –100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 –1 1/16	2 16 6	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 –101	4 10 0	Jan, July	..	..
10	9 0	Notting Hill Electric Ord.....	12 –13	5 15 0	March ..	..	..
5	4 6	Oxford Electric Ord.	6 –6⅛	5 8 0	March ..	..	..
St.	4 /	Do. 4 per Cent. Deb. Stock	86 – 94	4 1 6	..	..	..
5	5 0	St. James' & Pall Mall Elec. Ord.	7⅜–7½	6 1 6	Feb, Aug	8	7½
5	3/6	Do. 7 per Cent. Pref.	6⅛–7⅛	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	88 –93	3 15 8	..	.8	..
£	..	Smithfield Markets Electric Sup. Ord...	1⅛–2⅛	..	..	..	..
St.	4 %	Do. 4 per Cent. Deb. Stock	73 – 77	5 4 0	..	..	..
5	3 0	South London Electric Supply Ord.....	2⅛– 2⅜	6 8 0	..	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜–⅝	3 6 9	..	..	..
1	0/8⅛	Do. 7 per Cent. Cum. Pref.....	1⅛–1⅜	4 15 0	..	1⅛	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	10 – 103	4 7 6	..	..	..
5	2/6	Urban Electric Supply Ord.	1⅞–2⅛	10 0 0	..	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	2⅜ 3⅛	7 3 0	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	..	95⅜	..
£	6 6	Westminster Elec. Sup. Ord.	9½ 10⅜	6 3 0	Mar, Sept	..	..
5	2 3	Do. 4½ per Cent. Cum. Pref.	5⅛–5⅜	3 15 8	..	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 – 95	4 4 0	..	92	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜–⅞	5 14 0	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛–1	5 0 0	..	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	..	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 – 99	4 11 0	..	96	..
10	9½%	Bristol Tramways & Carriage Ord.	14⅛ –14⅝	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 –9⅜	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	101 – 102	3 18 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2 – 2⅛	12 0 0	..	2 1/16	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6⅛ 6⅝	8 13 0	Feb, Aug	6⅜	6⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	99 – 103	4 17 0	..	99	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	79 –82	5 9 6	..	81	79
St.	4%	Central London Ordinary Stock.....	70 –72	5 11 0	June, Dec	71⅜	..
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	..	..	..
St.	4%	Do. Deferred Stock	52 – 55	7 5 0	..	..	..
100	4%	Do. 4 per Cent. Debs.	103 – 106	3 15 6	..	..	..
St	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	83 –86	4 13 0	..	..	..
£	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½– 5	5 0 0	..	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 – 1 1	3 19 0	..	..	..
St.	2%	City & South London Rly. Con. Ord. ...	41 –43	4 19 0	Feb, Aug	41⅛	41⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 –121	4 2 9	Feb, Aug	..	..
St	5%	Do. (1896)	115 – 118	4 4 9	..	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	..	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 –105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	11⅛ – 12⅛	5 13 6	..	..	..
10	6/0	Do. 6 per Cent. Pref.....	13⅛ 14⅛	4 2 9	..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2⅜ –3	..	..	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 –88	4 11 0	..	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ l. b. St	93 –101	4 9 0	..	..	..
10	9%	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11½	5 6 6	Mar, Sept	..	..
St	4½%	‡ Do. 4½ per Cent. Debs.	99 – 101	4 9 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 –2	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 –73	5 9 6	..	..	..
St.	4 7/6	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 –98	..	..	..	..
10	..	Liverpool Overhead Railway Ord.....	1⅜ –1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 –90	4 9 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜ –7⅝	5 14 3	..	7⅝	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	85 – 89	4 10 0	..	87	87⅞
St	..	Mersey Con. Ord. Stock	3 – 5	–	..	..	..
St	..	Do. 3 per Cent. Perp. Pref.	7 – 10	–	..	..	..
1	..	Metropolitan Elec. Tramways Def.	1/16– 3/16	..	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	5/16– 7/16	5 3 0	..	5/16	..
St	4½%	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0	..	97	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾ – 1⅛	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	3⅞ 4⅛	6 8 0	..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	6 13 5	Feb, Aug	..	..
St.	4½%	‡ Do. 4½ per Cent. Deb. Stock	90⅛ –95⅛	4 10 6	..	..	..
1	3/56d	S. Met. Elec. Trams & Ltg. 6% Cm. Pref	5/16– 1/2	5 16 6	..	..	..
St.	36 3½	Do. 4 per Cent. Deb. Stock	82 – 86	4 13 0	..	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	86 – 90	5 11 0	..	..	..
..	5%	Underground Elec. Rys. Co. of London ...	74 – 77	6 19 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1⅛	–	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛–3⅜	–	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs	90 – 94	4 15 9	..	..	..

Shrs.	Last Dividend	Name.	Price Wed., May 22.	Rate % Yielded.	Dividend Due.	Business Week to May 22. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅛–¼	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜–⅝	7 16 0	..	..	..
1	2/4½	Babcock & Wilcox Ord.....	3⅜–4	5 0 0	..	..	..
1	0/7½	Do. Pref.....	1⅞–1⅞	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅛–7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.....	5⅛– 6⅛	4 16 0	Jan, July	..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 –1 5	4 5 9	..	..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3	..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 –1⅛	..	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£4 – £8	5 18 0	..	..	..
2	..	Brush Electrical Engineering	⅛–⅜	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	1 –1½	8 0 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 92	4 13 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 –78	5 14 6	Jan, July	..	..
5	5 0	Callender's Cable Con. Ord.....	1⅛–1⅛	6 13 3	Jan, July	10⅛	10⅜
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛– 5⅜	4 7 0	Jan, July	5⅜	..
St	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106⅛–108⅜	4 3 0	Nov, May	..	..
1	0/0	† Castner-Kellner Alkali Co.	1 3/16–1 5/16	5 14 0	..	1 3/16	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	..	99⅜	..
1	0 9⅛	Chadburn's (Ship) Telegraph Ord.	1 3/16–1 5/16	7 5 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16–1 1/8	5 4 0	..	..	..
3	1/6	* Crompton & Co. (Nos. 1 to 51,000).....	1⅜– 2⅛	3 10 8	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96⅞–99⅞	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16–1 1/8	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 – 105	4 5 6	..	104½	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1 –1⅛	10 2 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛–2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	86 – 87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 –92	5 8 6	..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅛–1⅛	10 0 0	H'lf-yearly	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅛– 2⅛	11 0 0	..	2 3/32	1⅞
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	87 – 90	5 0 0	..	..	..
2	..	Electric Construction Co.....	⅛–⅜	..	July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅛– 2	7 0 0	July	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8⅛– 9⅜	5 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 –96	4 4 0	..	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅜–12⅜	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5⅛– 5⅜	3 18 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 –109	4 2 6	..	..	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15⅛–16⅛	6 2 6	Feb, Aug	15⅞	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 –100	4 0 0	..	..	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	⅜–⅞	7 6 0	..	1⅛	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1	6 0 0	..	..	..
St.	4½%	To. 4½ per Cent. Perp. Deb. Stock ...	97 –100	4 10 0	..	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	30⅛–31⅛	5 14 8	Mar, July	31⅛	3 1/2
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100⅛–103⅜	3 17 0	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛– 2 3/16	5 19 0	..	2⅛	2 1/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛–1⅛	4 1 0	..	1⅛	1 1/16
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 –117	4 5 6	..	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 –104	3 17 0	..	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 –107	4 4 0	..	107	105½
10	6 0	J. G. White & Co. 5 per Cent. Cum. Prf.	9⅛–10	5 0 0	..	..	..
5	..	Willans & Robinson Ord.	1⅛–1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅞–4⅛	..	Apr, Oct	1⅜	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	79 –83	4 16 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	–	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 –91	5 10 0	..	..	..
St.	15/0	Anglo-American	61⅛–64½	6 0 6	F,My,Ag,N	..	..
St.	30,0	Do. Preferred	107⅛–108½	5 11 0	F,My,Ag,N	108½	107
St.	13%	Do. Deferred	20⅛–20⅜	4 5 3	F,My,Ag,N	20⅜	2 1/8
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92⅛–94½	4 4 6	Jn,Ap,Jy,O	94⅛	92⅝
10	5 0	Cuba Submarine Ord.....	8 –8½	5 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	16 –17	5 19 0	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜–3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅞– 9⅛	5 8 0	April, Oct	..	..
5	4½%	Do. 4½ per Cent. Deb.....	103⅝–103⅞	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	15½–15⅝	5 17 6	Ja,Ap,Jy,O	15⅝	15½
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	..	..
St.	65/0	† Eastern Ordinary .....xd & bonus	139 –141	4 18 6	Ja,Ap,Jy,O	140⅜	139
St.	17/6	† Do. 3½ per Cent. Pref. Stock	88½–90¼	3 17 3	Ja,Ap,Jy,O	90	89⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104⅛–106⅜	3 15 0	May, Nov	..	..
10	2/6	Eastern Extension	13⅜– 14⅛	4 19 0	Ja,Ap,Jy,O	14	13 1/16
St.	4%	Do. 4 per Cent. Deb. Stock	104½–106⅛	3 15 0	Feb, Aug	106	105⅜
St.	4%	Eastern & S. African 4% Mort. Deb. 1900	98 –101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	£98⅛–100⅛	4 0 0	May, Nov	0 1/2	..
10	30 0	G.N. (of Copenhagen), with Coupon 70...	84 –86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 –102	4 8 0	June, Dec	..	..
25	2/6	‡ Indo-European..... ex all	56⅜ – 58⅛	5 11 0	May, Nov	5 1/2	..
100	4%	Mackay Companies Common	70⅛–72½	5 10 0	Jan, July	..	..
100	4 %	Do. Preference	71⅛–72	5 11 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜–⅝	..	..	⅜	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	£99⅛–100⅜	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 –10⅛	8 16 0	..	..	..
2½	1/3	‡ West Coast of America	1⅛– 1⅜	3 12 9	..	..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1/16–1⅛	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	8 – 8½	7 1 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6½–7½	..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	100 –103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅞– 14⅜	4 19 0	Mr,Jn,O,D	14⅜	13⅞
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 –105	3 16 0	..	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 –94	4 5 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 –101	4 19 0	..	..	..
5	3 0	Chili Telephone	6⅜–7⅛	5 11 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1/16–1 1/16	4 14 0	..	..	..
1	0/6	Do. 5 per Cent. Pref.	⅛–1	5 0 0	..	..	..
St.	6%	National Co. Pref. Stock	108 –110	5 9 0	..	110⅛	108⅜
St.	5½%	Do. Def. Stock.....	104½–106⅜	5 3 0	..	106⅛	105⅛
10	6 0	Do. 6 per Cent. Cum. 1st Pref.	11½–13⅛	4 9 0	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛–5⅞	4 10 0	Feb, Aug	5⅛	..
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	95⅜ –97½	3 11 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 0	..	100⅜	..
1	0/9⅜	Oriental	1⅛–1⅛	4 17 6	April, Oct	1⅛	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅛	4 16 0	..	..	..
St.	1%	Do. 4 per Cent. Red. Deb. Stock	93 –94	4 2 0	..	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	£9 –102	4 7 0	..	..	..
£	3 0	United River Plate.....	£7–7½	5 9 6	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 11 0	June, Dec	..	..
St	5%	* Do. 5 per Cent. Deb. Stock (red.).....	100 – 102	4 9 3	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3 0	Elec. & Gen. Investment 6% Cum. Pref.	4 –5	6 0 0	..	11	..
10	2 0	Globe Telegraph & Trust.....	10⅜–11	5 0 0	Ja,Ap,Jy,O	..	..
10	3 0	Do. 6 per Cent. Pref.....	13⅝–14⅛	4 5 0	Ja,Ap,Jy,O	14 1/16	14
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Hot-Wire Oscillographs.

THE electromagnetic form of oscillograph has been so universally used during the last few years that it was with a feeling of some surprise that members listened to a description last week, at the Institution of Electrical Engineers, of an oscillograph depending simply on the heating properties of a current. For such an oscillograph it is necessary to produce, in the first instance, a polarised form of instrument, which is done by superposing the alternating current on a constant continuous current, traversing a double system of heated wires in differential fashion. But the difficulty which will occur to everyone as a most formidable one, and generally considered as insuperable, is the natural sluggishness of a hot wire system, and the fact that it is losing heat at a rate dependent on the temperature. This difficulty is overcome by Mr. J. T. IRWIN in an ingenious way by combining the instrument with a condenser shunted by a resistance for pressure measurements, and with a self-induction for the measurement of current. Regarding the heated strips as very leaky thermal condensers, they are compensated by an electric condenser which is made appropriately leaky by the resistance in parallel with it. The whole arrangement is a very pretty illustration of the application of elementary laws of heat and electricity.

The L.C.C. Power Scheme.

A FURTHER stage in the career of the London County Council's power scheme was completed last Monday after a short debate in the House of Commons, and as the result the Bill was read a second time and was referred to a "Hybrid" Committee. The debate was more than usually uninteresting, and as the speakers appeared to know little of the technical phases of the problem the usual random statements were noticeable. Sir E. CORNWALL regarded the Bill as a panacea for all the supposed electrical evils, which would grow to a terrible magnitude if the Bill were rejected, and if the existing companies could no longer be kept at bay. Mr. CAVE, on the other hand, who spoke from the point of view of Kingston, curiously enough failed to see the virtues of the Bill, although it is supposed to provide advantages for outside ratepayers at the expense of the ratepayers in the London district, and he stated that outside authorities in writing to the London County Council had only received the bare satisfaction of acknowledgments to their letters. The one important point in the debate was that in the event of powers being conferred on the London County Council to transfer or lease its powers, the conditions are to be embodied in the Bill, or in a subsequent Bill. Now that the scheme has reached the Committee stage, the proceedings will doubtless become more interesting.

Telephonic Transmission Measurements.

ELSEWHERE in this issue we conclude our abstract of the discussion on Messrs. COHEN and SHEPHERD'S Institution Paper on "Telephonic Transmission Measurements." As was evident from the discussion, this Paper has aroused considerable interest in telephonic work, and Mr. GILL'S appeal that more attention should be paid to the subject by the technical colleges was timely. A considerable amount of experimental work is undoubtedly still required, and the oscillograph is proving of inestimable value to those engaged in carrying out such research. In investigations of this kind theory and experimental research should go hand in hand, and we are glad to find that Mr. GILL recognises the value of such work as that of Mr. HEAVISIDE. Theoretical investigations of that kind are not easily understood, and on that account are apt to be undervalued as a means of progress in a subject of great difficulty, and one that has remained somewhat stationary for years. It is very noteworthy, as Mr. EVERSHED mentioned during the discussion, that, although the telephone was introduced about 30 years ago, it still remains, as an

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instrument, practically what it was at that time. Some colleges are now paying considerable attention to the subject of telephony, but generally it is not sufficiently recognised, and consequently does not receive the attention which is due to it.

Turbo-Generators.

In our last issue we gave results of some tests carried out by Mr. Merz on a 3,500 kw. turbo-alternator by Messrs. Parsons in which a consumption of 13·189 lb. of steam per kilowatt-hour was obtained, and was claimed to be the best result ever recorded for steam generating plant. This record has not remained for long unchallenged, for we notice in the annual report of the General Electric Co. (U.S.A.) that four Curtis turbo-generators of 8,000 kw. capacity are in operation in one of the stations of the Chicago Edison Co., and that a recent test on one of these machines showed a steam consumption of less than 13 lb. of steam per kilowatt-hour. In fairness to Messrs. Parsons we may mention that the test at the Carville power station was taken on a machine which had been at work for six months, that the conditions of the test mentioned by the General Electric Co. are not stated, and, of course, the Curtis set was very much larger. Doubtless Messrs. Parsons will be prepared to create a further record in due time, but meanwhile such figures serve to draw attention to the excellent results obtainable with large turbine sets. When account is also taken of the small ground space occupied, the absence of vibration and the great capacity for overload, it is not surprising that turbine sets are now so much in favour for electric power stations, even though reliability is a feature that is still claimed as an asset belonging essentially to the reciprocating type of engine.

More Business with Less Profit.

In some of our manufacturing concerns the cutting of prices has now been carried to such a point that the profit made on certain work is scarcely worth considering. This seems to be the case in the work of the Brush Electrical Engineering Co., and may account for the opinion expressed by Mr. E. Garcke at the annual general meeting last week that an effort had been made to improve the position by doing a larger volume of trade at a smaller proportion of profit, though he ventured to think that the policy should be to do the smallest amount of work that was necessary to carry on the business, and to do that at a larger profit. There are a good many people who will probably disagree with Mr. Garcke, for the whole aim of standardisation is to enable the manufacturer to do a larger turnover with a smaller profit on each item, and yet to produce a financial result which is on the whole entirely satisfactory. It is quite possible, however, that Mr. Garcke was not quite correctly reported, and that what he really wished to convey was the opinion that work showing a profit below a certain amount should be avoided. A good many companies seem to be working almost on the principle of doing evil that good may come. In the case of a manufacturing company, the evil consists in doing work with no profit in the hope that work will result later on which will bring profit as well as work; but it is not unlikely that the day may come when the continual doing of evil in this way will be found to produce too little good to make it worth doing at all.

Telepathy and its Cure.

For some reason or other the secretary of a learned society is popularly supposed to be a compendium of knowledge of all kinds, and on that account he is apt to receive inquiries almost embarrassing in their character. The following letter is an instance of the kind of knowledge that is expected, and was actually addressed to the secretary of one of the well-known scientific societies, though, for obvious reasons, we think it best to leave the epistle incomplete by omitting the name of the writer:—

Sir: Can you kindly inform me if Electuary is the name of the medicine that is used to drive out or destroy all Telepathy-influences out of the body, or what the name is, and where it can be obtained? A friend of mine is very interested in it.

Yours truly,

A further application ran as follows:—

Dear Sir: For various reasons I have the idea that my Phrenic nerves have been electrified for some considerable time. I have inhaled plenty of ground metal dust in my occupation under the influences of Telepathy Influences, or some Wireless Telegraphy. The presence of crystallised substances lends colour to my belief. Have you any opinion to give me regarding Telepathy, or so-called imaginations?

Yours faithfully,

P. S.—What are these new Italian forces we read about in the newspapers in scientific readings on spiritualism? I have an idea they have been very busy with me.

For the benefit of our readers who may not know, we may mention that an electuary is a "confection" of medicinal powders made up with honey or sugar. No doubt telepathy is somewhat rampant at the present time, and may become an epidemic, but we fear that even the hyssop of our forefathers would be insufficient as a remedy, and a drug sufficiently powerful to remove such influences from the afflicted would be terrible to contemplate. It is interesting, however, to learn from a final communication that tincture of aluminium is one of the acknowledged remedies for telepathy.

Association of Teachers in Technical Institutions.—A conference of this Association was held at Leeds last week when a number of Papers were contributed by members. In the course of one of the discussions Mr. W. J. Lineham said that the greatest difficulty in technical education was the lack of sympathy and interest on the part of the employers. Mr. Duncan (of Leeds University) stated that their best students came from the elementary schools, and by far the worst were those from Eton, Harrow, Winchester and Rugby.

Cable Interruptions.	Date of Interruption.
Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907

Electrical Appliance for Ascertaining the Cross-sectional Area of Wire Rope.—Mr. C. McCann recently brought forward, before a meeting of the Transvaal Institute of Mechanical Engineers, a method for obtaining electrically the cross-sectional area of wire ropes. The arrangement, which is specially adapted for use on haulage ropes in mines, consists of a transformer whose primary is connected to an alternating supply, while its secondary is in series with an ammeter and a coil, wound on a hollow bobbin; this coil is placed round the rope whose cross-section is to be determined. The self-induction of the secondary circuit is low when the rope is not passing through the hollow coil, but rises on its insertion, producing a decrease in current in proportion to the self-induction produced. For a particular coil, a $1\frac{1}{8}$ in. rope brought

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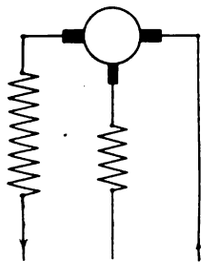
down the current from 220 to 120 amperes, and for every 1 per cent. alteration in the mass of the rope the current varied 1 ampere. The instrument can be calibrated for any particular size of rope as required, and it is intended that the coil should be kept permanently round the haulage rope, so that any decrease in the diameter can be at once noticed. It is understood that the Rope and Safety Catch Commission intend to test this appliance.

Incorporated Municipal Electrical Association.—The twelfth Annual Convention of the Incorporated Municipal Electrical Association will be held at Sheffield, from June 25th to 28th, under the presidency of Mr. S. E. Fedden. A very complete programme of meetings, visits and entertainments has been arranged. The Lord Mayor of Sheffield will welcome members of the Association on the opening day, and the presidential address will be delivered. Among the Papers to be read are: "Extension of Electricity Supply to Outlying Districts," by Mr. R. L. Acland; "Depreciation," by Mr. C. H. Yeaman; and "Alternating Current Distribution," by Mr. A. J. Cridge. The annual general meeting will be held on June 27th. Visits have been arranged to the River Don Works of Messrs. Vickers Maxim, and to the generating stations of the Sheffield Corporation. An excursion will be made to the "Dukeries," and there will also be a reception by the Lord Mayor of Sheffield. The annual dinner will take place on June 27th. It is particularly requested that all members intending to avail themselves of the facilities afforded during the Convention should communicate with the Secretary as soon as possible.

Three-Wire Generator.—An objection which has been urged against the usual three-wire generator relates to the fact that, since the series field winding is arranged in two parts, it is necessary to duplicate the equaliser conductors when several compound-wound machines are to be connected in parallel. Mr. E. Rosenberg has taken out a patent in which he proposes to connect the main series winding in only one of the outside leads and to provide a supplementary winding in series with the neutral conductor of the system, as indicated in the diagram. The supplementary winding is provided with half the number of turns of the main winding, and is electrically connected in circuit so that its magnetism adds to that of the main winding when the two are traversed by currents flowing in the same direction. It is evident that when the two sides of the three-wire system are equally loaded there will be no current flowing in the supplementary winding, while when a difference of load occurs this winding will be traversed by a current equal in value to the difference between the currents in the two outside mains. In other words, the supplementary winding is traversed by a current which is the algebraic sum of the currents in the outside mains.



Electric Goods Locomotive.—The Brooklyn Rapid Transit Co. has just completed a very large electric locomotive for goods traffic. According to the *Street Railway Journal* it is 31 ft. long over all and 7 ft. 3¼ in. wide over the side sheathing. The total weight, including the equipment, is about 57 tons. The two trucks are of the Baldwin type with 37 in. diameter steel-tyred wheels. The truck wheel base is 5 ft. 10 in., and the distance between truck centres is 16 ft. Each truck carries two motors rated at 150 H.P. each and geared 15 : 54. Two trolley wheels are required to collect the current. All of the machinery, air reservoirs, &c., except the motor compressor, are placed inside the car. Special precautions were taken to prevent earths, all suspended material being insulated from the hangers with insulated bolts, and the wires run in loricated conduits. The control system is of the unit-switch type. Manual control has been retained and the limit switch and line relay omitted because for a great portion of the time the locomotive will be used for shunting. The first notch of the controller gives the "coupling" position when it is intended to move the locomotive a few inches in coupling cars. On this notch two extra resistance frames are inserted; in addition, there are seven more series and seven multiple positions. The resistances are mounted on each side of the locomotive, and are enclosed in sheet-iron boxes. They are cooled through slits made in the side of the locomotive. The contactors are also mounted in the car. There are three main lighting switches and two change-over switches. The former are for the 50 c.p. head-lights, gauge and marker lamps, and on the centre circuit are five 16 c.p. incandescent lamps. One change-over switch changes the marker and gauge lights and the other the head-light. These switches are mounted on a side wall panel at one end of the locomotive. The battery-charging current comes through the compressor motor circuit, but no current can flow to the batteries until the energising of a relay, which closes the battery circuit. This prevents the current to the compressor from reaching the battery until the opening surges have died down.

Electric Railway from Milan to Genoa.—The United States Consul at Milan gives the following particulars of an electric railway, 85 miles in length, which is to be built between Genoa and Milan. The cost is to be £9,400,000. Electricity will be generated by water power by three 24,000 H.P. turbines. To complete the line 19 tunnels will have to be built, the most important being 12 miles long, which will require six years for its construction. The cost of the line will be about £100,000 per mile. It will have a double track, the trains being hauled by electric locomotives. The latter will be combined with baggage cars, with two sets of trucks, having four axles, each axle being driven by a 300 H.P. motor, and will weigh 45 tons. It will be possible to operate at a speed of about 54 miles an hour over the parts with a gradient of 1 in 125, and at a speed of 80 miles an hour on the level. Trains will be run of three cars, each car carrying 50 persons, the whole train weighing 150 tons. These figures are for the express and local trains. The express trains will run every two hours. The locals will run much oftener, and will collect passengers from the smaller towns and take them to the express station further along the line, where passengers can transfer. All locals will, after leaving Milan, take all passengers collected from the smaller stations to the station of Tortona—the only express station—as well as those locals starting from Genoa. The express trains will take passengers from Milan to Genoa, or vice versa, in 1½ hours, while the locals will require 2½ hours. In this way there will be 20 trains per day, carrying an average of 6,000 persons. The 70 to 100 goods trains which will run every 24 hours will have combination locomotive and baggage cars of the same size and power as those of the passenger trains, and will pull 30 waggons, each weighing 22 tons, which includes 12 tons of goods on each car, so that the train will pull in all 700 tons. These trains will run at a speed of 20 miles an hour on the inclines and about 35 miles an hour on the level. To prevent accidents, there will be no level crossings along the line and 372 bridges will be built. The principal tunnel will be constructed from both ends at once, and at the same time in eight places along the line, shafts being sunk for the purpose. In all, this tunnel will be constructed from ten borings at the same time. By the time the tunnel is ready the whole line is expected to be finished.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, May 31st (to-day).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

7:30 p.m. Meeting in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. Paper on "Some Experiments in the Magnetic Character of Vessels," by Capt. W. Bartling. (Adjourned discussion.)

MONDAY, June 3rd.

SOCIETY OF ENGINEERS.

7:30 p.m. Meeting at the Royal United Service Institution, Whitehall. Paper on "Working Experiences with Large Gas Engines," by Mr. C. A. St. G. Moore.

FRIDAY, June 7th.

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street. Lecture on "Studies in High Vacua and Helium at Low Temperatures," by Prof. Sir James Dewar, F.R.S.

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RESULTS OBTAINED BY THE USE OF CAR-METERS.*

BY M. WATTMANN.

In this report upon results obtained on the Continent by the use of car meters, the author discusses the value of such meters as a check on the ability of the motorman. The meter used may be an ordinary electric current supply meter, but a much simpler and cheaper instrument consists of a clock which registers time when current is being supplied to the car. An example is given showing how the price of current decides to some extent the type of meter to be used.

We are able to supplement this report by a diagram showing the economy effected at Frankfort by the use of meters, and we also give some details of the clockwork meter made by Messrs. Hartmann & Braun for this purpose.

Since the cost of current in tramway operation may rise to 20 or 25 per cent. of the total working costs, it is important that as great a reduction as possible should be made in the consumption, and this reduction is a gain which is not much decreased by the first cost and upkeep of any apparatus used for this purpose. The consumption depends, in the main, on the motorman; and most tramway managers, especially those who have had the meters in use for some time, agree that by this method of control the skill of individual motormen may be determined. Figures obtained from a number of tramways, where these meters are installed, show a reduction of from 4 to 20 per cent. in the current consumption.

Two systems of meters are at present used—current meters and clockwork meters. Only watt-hour meters have been employed as current meters. One of the members in answer to the *questionnaire* proposed the use of ampere-hour meters, by the employment of a nearly constant voltage; but this system does not yet appear to have been adopted. Clockwork meters consist of a simple clockwork movement, which is in gear until the motorman switches off the current; these instruments, therefore, measure the time the car is using current. A third type of meter—revolution meters—have been tried in Hamburg and Frankfort; they indicate the number of revolutions of the wheels (and thus indirectly the distance covered) while the car is under current. This type of meter does not appear to have given good results, for it is no longer in use.

Clockwork meters do not measure what is required—the consumption by the car—and it may be asked why these intruments have been used for a system of current control. As mentioned by a number of members, the current meter is sometimes affected by the shaking of the car; further, its accuracy decreases after a few weeks and its indications then become valueless. Numerous tests, which have been lately carried out in Cologne, completely confirm this opinion. All the current meters that were tested lost their accuracy, and their use on a large scale has been abandoned. It should, however, be noted that some makes, which (according to answers received) have given good results, were not tried in Cologne. According to numerous members, the meters tried have not given satisfaction; others state that they have given good results. It must, therefore, be concluded that the different types of meter placed on the market are of very different qualities. In Berlin, for instance, Thomson-Houston and Eibig meters have been used since 1901; they are considered very accurate, require little attention and after six months' service only show differences of 1 or 2 per cent. At Bremen, where 131 Eibig meters are in use, they are highly praised on account of the ease with which they are repaired and their sufficiently exact operation. At Hamburg, where more than 600 of these meters have been installed since 1903, the system is considered simple and solid in construction. Its upkeep is small, and cleaning and adjustment can be done easily and quickly. It therefore appears that apparatus does exist which gives satisfactory results if carefully handled. It may be remarked that, according to the information furnished, the degree of accuracy required in this apparatus and the value set upon their good operation are quite individual matters, and this may explain the differences of opinion. A number of members lay inconveniences to the charge of current meters that do not occur in clockwork meters, notably their lack of accuracy and uncertainty of operation. Clockwork movements, which work with an almost absolute accuracy under all conditions and, notwithstanding the shocks to which they may be submitted, only require repairs very seldom, have been known for a long time. The movement of the gearing, which is worked by the handle of the controller is, besides, so simple that there can be no mistake about the good operation of this apparatus.

* Translation (somewhat abbreviated) of a report by Herr Wattmann (Direktor der städischen Strassenbahnen, Köln) on the replies received by the Union Internationale de Tramways et de Chemins de Fer d'Intérêt local, in response to the *questionnaire* sent out to the members, presented at the annual meeting at Milan.

Further, the price of the clockwork meters is much less than that of the current meters, for, from the replies given to the *questionnaire*, it appears that the total price for installing a current meter is between £6 and £10, and for a clockwork meter about £2.

If from the point of view of the accuracy of the readings obtained, of the good operation of the apparatus and of the lower first cost and upkeep, the clockwork counters are at the present time preferable to the current meters, and will probably be equally so in the future; then it remains to be discovered whether, as regards the end to be attained, clockwork meters will replace current meters. Opinions differ on this point. Partisans of current meters contend, not without reason, that the idea of measuring the current is only to economise it, and that the motormen can only be made to reduce the consumption, if they see that the current used by them is really measured and not a third quantity, which has no direct relation with the energy consumption. Partisans of clockwork meters consider, on the contrary, that the time during which the car is under current is in practice sufficiently proportional to the energy used under the same traffic conditions. Theoretically, it is clear that there is no actual relation between the energy consumption and the time during which the car is under current, for, even without the use of the resistances, the energy expended by the motors is never constant for equal lengths of time. Doubtless, for a given length of track the shorter the time under current the less will be the current consumption, if the motorman passes as quickly as possible over the resistance notches and degrades a minimum of energy in braking. These two conditions will be evident if it is considered that the expenditure of energy will be a minimum when none is degraded by the brakes; in other words, when it is entirely used for driving the cars. Working on the resistances, like braking, implies a loss of energy. The most rational way of making a journey between two points would be to bring the controller to full speed as soon as possible, to leave the handle for some time on the last notch and then allow the car to reach the stopping place by its acquired velocity, without braking. This method of driving a car consumes a minimum of energy. The energy consumption and the length of time under current no longer vary in the same ratio when the car carries two motors allowing parallel and series operation. Parallel working of the motors will give the least time under current, for in this case there is a large energy consumption in a shorter time. As electric cars are now generally equipped with two motors it may be feared that the use of clockwork meters will cause the motorman to operate as much as possible in parallel, leading in certain cases to rather uneconomical working. In my opinion this point cannot be determined theoretically, and must be left to be decided by experience.

The energy-consumption depends, not only on the skill of the motor-man, but also on other circumstances, which in certain particular cases cannot be taken into consideration because they cannot be foreseen. It has been said that reducing the energy cousumption to a minimum does not always imply rational operation. For example, the motorman who passes rapidly over the resistance notches not only starts by jerks, but wears out the motors. The energy consumption can never, and should never, be used for determining indubitably the exact skill of the motorman. If, however, experience shows that the total time the car is under current is sufficiently proportional to the current consumption, doubtless this method of control will produce, as regards economy of energy, the same results as the direct measurement of current consumed. From answers received to the *questionnaire*, it appears that three undertakings (Frankfort, Dusseldorf and Hagen) have been able, by the use of clockwork meters, to obtain a large decrease in energy consumption, the results obtained at Frankfort being specially noteworthy. Since May, 1905, clockwork meters have been installed on 241 cars and great economies of energy have been obtained. The greatest economy was 19 per cent. during one month, as compared with the corresponding month of the previous year. (A graphical representation of the results obtained are shown in a curve following this report.) The results obtained by the use of clockwork meters may be considered as favourable. It is, however, premature, on account of the small experience acquired, to pronounce definitely on the value of these instruments, and it is thought more prudent to leave the question as to which of the two meters, clockwork or current, preference should be given for the control of the motormen open.

In order to be able to study thoroughly, whether the clockwork meter really possesses all the qualities necessary for judging the skill of the motormen, it would be of great interest to make a practical test by fixing a clockwork and current meter on the same car and comparing the readings of the two apparatus.

Some members are only supporters of the control of motormen by meters in a general way; some fear that the personnel, in order to reduce the energy consumption to a minimum, will not keep to the prescribed time table, and others that the motormen will start up too quickly and drive without the caution necessary for the safety of the passers by. These points need not be exaggerated, for meters have been employed on a large scale and have not yet caused the dangers to which allusion has just been made.

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With reference to the first cost of meters, it has already been mentioned that the cost of current meters including the fixing varies between £6. 5s. and £10, and for clockwork meters between £1. 15s. and £2. Though the first cost of different types of meter does not vary much, it is otherwise with the cost of upkeep; according to answers received, the upkeep varies per 100,000 car-km. from 3s. (Dresden) to £7. 10s. (Copenhagen). If, however, members who have had long experience are consulted, the differences are not so marked. Thus at Berlin the expenses are 17s., at Hamburg 27s. 6d. and at Magdeburg 21s. 2½d. It is interesting to note the length of service between two examinations; at Dresden it is six months, at Hamburg two months, and at Magdeburg one month. With reference to the upkeep expenses of clockwork meters, the results obtained on the Frankfort tramways show that they have been used for eight months on all cars and that during that time no repairs have been considered necessary. Besides, as these meters consist only of a simple clockwork movement, it is probable that the upkeep expenses will be a minimum.

In considering how the meter readings should be applied to the control of motormen, the question arises up to what point it is necessary to take into account all the accidental factors which influence the energy consumption, and how this is to be done. The principal factors are: (1) The type of motor car. (2) Type and number of trailers. (3) Particulars of the line (gradients, curves, frequency of stops, speeds, &c.). (4) The state of the atmosphere. (5) The coefficient of occupation of the cars and the importance of the general traffic in the districts served. The skill of the motorman cannot be determined in a trustworthy manner on a single journey; it can only be obtained after a succession of journeys. Under these conditions the factors which influence the energy consumption will compensate each other as the number of observations becomes greater. The atmospheric influence can be more easily eliminated, as this is the same for each motorman. In the same way with the occupation coefficient and the general traffic in the areas served. Concerning this last point it may be remarked that the daily routine of the tramway personnel is generally established by a predetermined arrangement. As the importance of the traffic at the same hour and on the same line is a practically constant quantity, it follows that for the same shift the factors which influence the energy consumption in one way or another are of a very nearly constant value. The occupaton coefficient of the cars and the importance of the traffic of the street will influence all the motormen in the same way when all have worked the same shift.

Under certain conditions the line profile may have an important effect on the energy consumption. It is evident that steep inclines increase the consumption, while steep declines decrease it. The consumption may be greatly increased by the number and sharpness of the curves, by frequent stops, by the ease with which the motorman can watch the track, and by the amount of the general traffic in the area served, which may necessitate frequent application of the brakes.

The influence of the peculiarities of the line on the energy consumption is very important. Besides, it is not always possible to organise the shifts in such a way that during the period of control (usually a month) all the motormen will have made nearly the same number of journeys on the different lines. The peculiarities of the lines cannot, then, at first be eliminated. This method of working is followed by all members who use the system of meter control.

The influence of the type of car on the energy consumption is relative; it is important when the types in service are very different. When the weight of the car does not vary much it need not be taken into consideration in calculating the energy consumption. It is, however, evident that the number of trailers must be taken into account, though as regards their type what has been said about motor-cars also applies.

If the means employed by members to utilise the readings of the meters are studied, two well-determined methods are noticed, in spite of differences in detail. One of these is employed exclusively with clockwork meters. In the first case, the meter card on which the readings of the meter are recorded is on the car for a day; in the second case it is on for a month. After verification by the motorman the conductor notes the reading in his way-bill at the end of each journey. As the same car is generally used successively by different motormen, and during the course of the day it may sometimes draw one or more trailers, it is necessary that all these particulars should be noted on the card, in order that the skill of the different motormen may be obtained from their energy consumption. A standard consumption, which will serve as a basis, must be established for each line. This standard will vary with the route, the type of car and the number of trailers.

In order that this standard consumption may be obtained with the greatest possible accuracy, the current consumption for each line for each type of car and for each different make-up of the train is noted on every journey. A series of observations is thus obtained, whose mean gives the standard consumption for the case considered. This method is rather complicated, but it gives the most exact results. A method of control like that detailed naturally gives rise to a fair amount of administrative work. It may be simplified if, when calculating the current consumption, the different types of car and the number of trailers are represented by a reduction coefficient based on experience. By this coefficient the different consumptions can be reduced to that of the "standard car without trailer." The consumptions of the standard car need only be noted for each line. The mean value of these different consumptions will give the "mean consumption of a standard car without trailer for a journey on a certain line." Simple multiplication of this value by the reduction coefficient will give for each line the standard consumption for the different types of car and the amount required for the trailers. Several members simplify this method still more, for they do not determine the mean consumption for each line afresh each month. They are content to find once for all a standard consumption based on former observations. They consider it no longer necessary to calculate monthly the different mean consumptions. All the methods have one common point, the determination of a standard consumption for each section of the line. This standard consumption once determined allows the work of the different motormen to be evaluated. It may be noted that the methods used for this purpose are sometimes very different, but they all agree in that the arithmetic mean of the different consumptions on each section should be the basis for judging each motorman.

Certain members base the valuation on the ratio of the watt-hour consumption per day to the standard consumption. Others determine it per car-kilometre or per ton-kilometre. One undertaking is content to mark the motormen on a scale from 1 to 5. In this last method the standard consumption corresponding to each of the marks is previously fixed. It is different for each line and for each composition of the train. For example, on a certain line for a service with one trailer motormen receive mark 1 when they consume less than 120 hectowatt-hours, mark 2 when the consumption is between 121 and 133 hw. hours, mark 3 when it is between 134 and 140 hw.-hours; mark 4 when it is between 141 and 154 hw.-hours, and mark 5 when it exceeds 154 hw.-hours. The monthly marks are determined either by taking the mean of the marks for each journey or by determining mean daily marks.

When the system of control is by clockwork meters, the method employed for evaluating the readings are different to those described above, which are all based on the use of current counters. The cards on which the readings are noted are no longer attached to each car but to each motorman.

On tramways the working hours of the personnel are generally laid down by an arrangement of several "shifts." These shifts are worked by all the motormen in turn. They are fixed in advance, so that a certain shift contains the same hours, the same number of journeys, the same make up, and sometimes also the same type of car. It follows that each shift is repeated each day under the same traffic conditions. It is therefore rational to take as a basis of comparison not the consumption per journey, but the consumption per shift. In this method a standard basis value must be established for each shift. Members who use this method have determined once for all this standard basis value by previous trials. This method is still further simplified when the motormen and the conductors simultaneously change shift and when they always change cars together. The readings of the clockwork meters can always be entered directly on the waybill by the conductor, and as special cards are no longer necessary, this method considerably reduces the clerical work. The calculation of the current consumption, or, rather, of the length of time under current of the cars, can be made at the same time as the other calculations obtained from the waybills. The motorman's mark can be determined by the use of a small table giving the standard consumptions. Then the marks obtained daily by the different motormen are collected in a special table and the arithmetic mean deduced.

A review of the different methods used for the evaluation of the meter readings shows that there are certain fairly complicated methods, which doubtless give rise to long calculations. There are, however, others which are very simple and only require a minimum of administrative work, but are inconvenient because less accurate. If the accuracy of the different methods of control is compared—that is, if we seek to find out to what extent the different factors influencing the current consumption have been taken into consideration—it will be recognised that the determination for each period of observation of a mean standard consumption of the different types of motor car, with or without trailers, removes all errors due to the motor cars and trailers; up to a certain point it even removes errors due to the meters. Errors due to the motor cars may result from defects in the propelling mechanism. In trailers these causes of error need hardly be feared, and it is quite sufficient to note the influence of the trailers on the current consumption, reducing the consumption on journeys with trailers to the consumption with a single motor car by a reduction coefficient. This simplification seems more commendable, as the load of the car is never taken into consideration, and this load, especially for trailers, is of some importance, for in that case the ratio of dead weight to the load is subject to large variations. But

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even in motor cars defects in the propelling mechanism are neither sufficiently frequent nor important enough to justify in themselves the inconveniences caused by a fresh determination of the mean values. But the eventually bad operation of electric meters should be noted; it is evident that a current meter operating badly may modify the results considerably. In calculating afresh each time the mean value of the consumption by each car, not only is this cause of error eliminated but the difference between the mean and the standard consumption is determined. It is probably for this reason that most members who use current meters consider that they cannot avoid the inconvenience caused by fresh determinations of the mean consumption. Clockwork meters, on the other hand, operate more regularly and, owing to the fact that this system of control is based on the length of time the cars are under current, the determination of the mean consumption for each particular car is not possible.

In considering the advantages of the methods which have just been described the idiosyncrasies of the different lines should be taken into account; the method of control should be suitable to the inherent peculiarities not only of the working methods but of the ine profile and of the organisation of the administration itself. In general way, however, I consider that preference should be given to the simplest methods, for in consequence of the great number of readings the errors which may arise, even in the more complicated methods, cancel out and allow sufficient accuracy to be obtained in practice. This compensation of errors inherent to each separate reading is greater the longer the period over which the observations extend. If, for example, the marks are only given to the motorman monthly, during this time all motormen will have done practically the same work—*i.e.*, all will have operated about the same number of times, with full and empty cars, on dry and wet rails, or on different types of car. A large error made in any one reading will not be important, for it will disappear in the mean value given by a long series of observations. Experience seems to confirm this point of view in this respect, that even undertakings that use the simplest methods in applying the meter readings are unanimous in recognising that the results obtained by the meters thoroughly agree, as regards the individual skill of each motorman, with personal observations.

Different members use different methods for applying the meter readings to instigate their motormen to reduce the current consumption to a minimum. A relatively large number reward the best motormen with monetary premiums. The results thus obtained have been satisfactory, and this method has not been found inconvenient. Other members, on the other hand, are lukewarm supporters of the premium system; they think that the distribution of these premiums would cause the motormen to pay more attention to ways of reducing the consumption and to neglect other factors necessary for the good operation of the cars. The e latter are content to give unskilled motormen further instruction, or to place them under the inspection of the head motorman. Several members try to work upon the self-esteem of their personnel by publishing the results obtained by each motorman in the various depôts.

The administrative expenses necessary for the evaluation of the figures obtained from the meters are naturally very different, varying from 12s. to £4 per 100,000 car km. (62,500 car miles).

The following conclusions may be drawn from the answers given to the *questionnaire*. It is thought that the experience obtained up to the present is sufficient to show that the use of meters affords a very appropriate method of determining the skill of motormen. It is also thought that, by the use of relatively long periods of observation, the secondary factors, which influence the current consumption, are sufficiently taken into consideration, *i.e.*, sufficiently counterbalanced to obtain an exact idea of the skill of the different motormen. The chequered career of the method of meter control may be attributed, on the one hand, to the fact that manufacturers placed on the market numerous types of current meters, certain of which were badly designed and not fit for their work; but also, on the other hand, because only tests made on a large scale give favourable results, for the mean consumption can then be deduced from a large number of readings.

With regard to the point whether the skill of the motormen can be determined by the use of meters, the question does not appear to be sufficiently cleared up for a definite opinion on the subject to be given. Experience obtained up to the present by the use of clockwork meters is of a too recent date, and although a further confirmation of the brilliant results may be obtained in the future it is not less true that there is a possibility of seeing them modified.

Objections of a rather theoretical order sent by certain members regarding current meters do not appear to be a sufficient reason for condemning them. We are of opinion that practical use alone can determine the value of these apparatus. If the clockwork meters come up to expectation, that is to say if they appear as suitable as the current meters for determining the skill of the motorman, there is no doubt that preference will in future be given to them. It seems scarcely probable that manufacturers will ever be able to place on the market a watt-hour meter as cheap, as sure in service, and as solid in construction as the clockwork meters actually obtainable.

If the application of meters gives a method of determining the skill of the motorman it also leads to a decrease in current consumption and thus to a reduction in working expenses. However, the price of current plays an important part, in that expenses necessitated by the upkeep and depreciation of the meters and also by the administrative work of evaluating the readings, sometimes counterbalances the economies realised in the energy consumption. An example of this is interesting. Suppose that each motor car runs 40,000 km. per annum. If 1,000,000 car-km. are run per annum, 25 motor cars will be needed. If the price of each current meter is taken at £8, the total cost will be £200. The annual expenses will be:—

Interest and depreciation (15 per cent.)	£30	0	0
Upkeep, 25s. per 100,000 car-km.	12	10	0
Administrative work	25	0	0
Total	£67	10	0

If the price for energy is taken at 1·2d. per kilowatt-hour and the total consumption, including trailer service, is about 600,000 kw-hour, the cost of energy will be £3,000. If the use of current meters effects a 10 per cent. reduction, there is a resultant economy of £300 in the expenses for current, from which must be deducted the expenses set forth above—*i.e.*, £67. 10s. The net saving will, therefore, be £232. 10s. If, on the contrary, the price of current is only 0·7d., and if the consumption only decreases 5 per cent., the

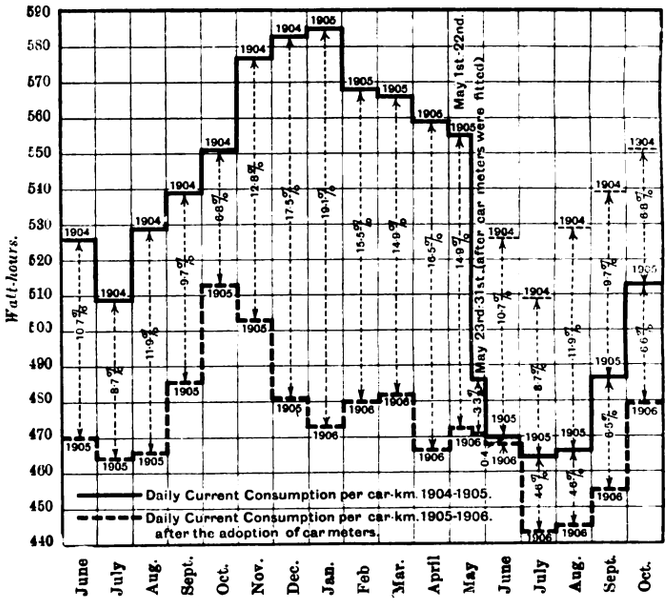

FIG. 1.—DIAGRAM SHOWING SAVING BY THE USE OF CAR METERS EFFECTED AT FRANKFORT.

resultant economy, in the expenses for energy, is £90, from which must be deducted, as before, a sum of £67. 10s. The net saving is then only £22. 10s.

If instead of current meters the cars are equipped with clockwork meters, the first cost for 25 at £2 each will be £50, and the annual expenses are:—

Interest and depreciation (12 per cent.)	£6	0	0
Upkeep, 10s. per 100,000 car-km.	5	0	0
Administrative work, £1 per 100,000 car-km.	10	0	0
Total	£21	0	0

The employment of clockwork meters will, therefore, give a net saving in the first case of £279, in the second of £69. These two examples show that, in the case where current is very cheap, and supposing that the motormen already work satisfactorily, the use of current meters is not justified, on account of the resulting heavy expenses; the employment of clockwork meters in this case is, however, economical. The premiums awarded to motormen have not been taken into account in the above cases, and these would, of course, be deducted from the saving obtained.

The answers given to the *questionnaire* show that, although opinions differ in details, the use of car-meters has made great strides. The differences of opinion are numerous, so that a wish may be expressed that those undertakings where meters have been installed will continue their experiments, and will place before the Union Internationale statistics which will allow certain open questions to be decided.

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In connection with the above report by Herr Wattmann on "Results obtained by the use of Car Meters," we are enabled to give, through the kindness of Messrs. Hartmann & Braun, of Frankfurt-a-M., a description of the type of meter in use on the tramways of that town. The economies effected by its adoption are well shown in the curve (Fig. 1), for which we are indebted to the engineer of the Stadtischen Strassenbahnen, Frankfurt, and the results are favourably commented upon by the author in his report.

The apparatus, which is illustrated in Figs. 2 and 3, consists of a clockwork arrangement driven by a spring. The clockwork runs down in about 300 hours and is wound up by hand. As the meters only operate for about a third or fourth part of the total travelling time, the clockwork will go without winding for about 45 working days of 20 hours each. Automatic electric winding was considered superfluous and a wholly undesirable complication. The meter is provided with hour and minute hands and the dial is divided in the ordinary way. This method of dividing the dial was chosen, as on tests carried out with other recording instruments divided into units, tens and hundreds, mistakes were made in the readings. A dial with the usual clock divisions can be read off accurately and quickly by all employees.

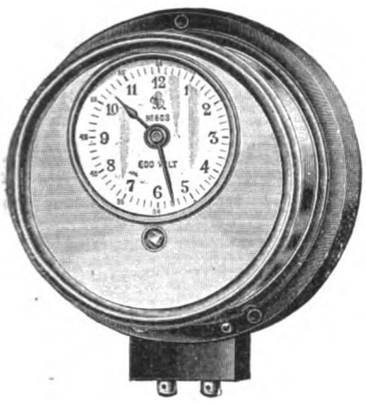
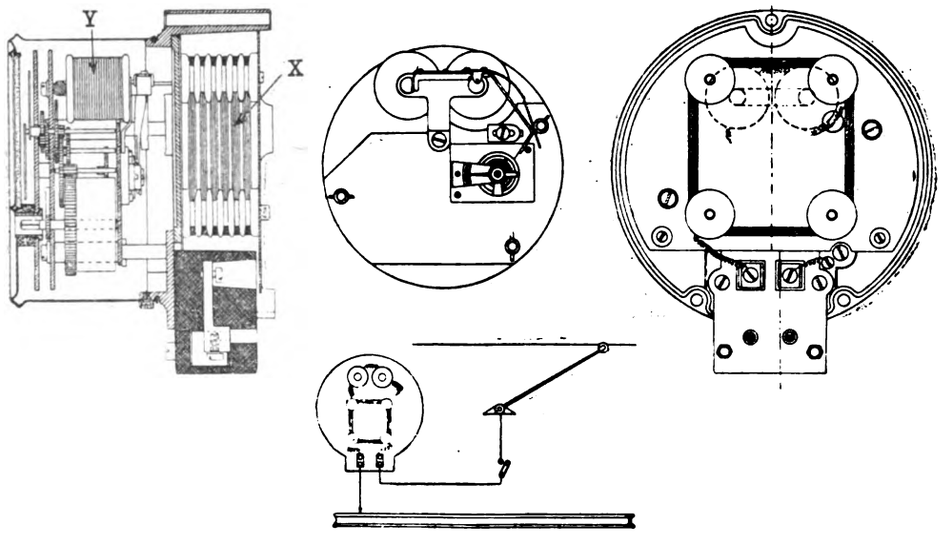


FIG. 2.—HARTMANN & BRAUN'S CLOCKWORK CAR METER.



X = Series Coil. Y = Magnet Coil.

FIG. 3.—DETAILS OF CLOCKWORK METER.

The balance wheel, which is usually locked, is released by the armature of an electromagnet as soon as current flows through the winding of the latter. If the electromagnet is connected directly in the motor circuit, its pull decreases with the current, and for this reason it would have to be provided with turns sufficient to act with the weak current flowing, while the car is running down hill. The restricted space, and the fact that it is easier to fix apparatus with small conductors, caused the electromagnet to be fitted with a high resistance winding. The pull of this electromagnet is so arranged that the meter is cut in or out with certainty when the voltage is between 350 and 600. The electromagnet winding and series resistance are in parallel with the main circuit containing the motor and starting resistances. As soon as the motorman switches on, the electromagnet, not being dependent on the controller notches, will be excited by a constant current, the armature will free the balance wheel and the meter will come into operation. When the circuit is broken the armature re-locks the balance wheel. The clockwork movements are surrounded by a dust-tight case, which is earthed to avoid accidents arising from a failure in the insulation. The conductors are sealed into terminals, which at the same time prevent unlawful tampering. Lead fuses are placed in the positive conductor, as is a choking coil for protecting the instrument against atmospheric discharge. The meter is fixed in a corner inside the car, so that the position of the hands can be read off from the interior of the car or from the driver's platform. Only one meter is necessary for each car. Fixing the meter on springs was considered superfluous after the experience obtained with motor-car instruments.

THE SPEED OF FLICKER PHOTOMETERS.

BY J. S. DOW.

Summary—In this article the author describes some experiments intended to investigate the connection between the sensitiveness of a flicker photometer and the speed at which the flicker disc is driven. A distinction is drawn between the photometric comparison of sources of light which are similar in colour and heterochromatic photometry. In the first case a wide range of speed is permissible. But if the illumination of the photometer disc is very low this range is reduced and the sensitiveness of the photometer also becomes less. When sources of light which differ very greatly in colour are compared the speed at which fusion of the flicker occurs is higher, and the range of speed over which maximum sensitiveness is possible is much narrower than in the former case. These facts are illustrated by curves connecting the frequency of the flicker and the smallest percentage change of illumination which the photometer enables us to detect.

The fact that the sensation of flicker is dependent upon the speed of the flicker disc has often been referred to as a source of uncertainty in connection with the flicker photometer. It is, of course, well known that the photometer becomes insensitive if the speed is too high, and Mr. Trotter, in a recent letter to *The Electrician* (February 15, 1907, p. 695), referred to the apparent necessity of obtaining an exact "critical" speed as an inherent disadvantage of instruments of this class. It therefore occurred to the writer that some curves, on the lines suggested by Mr. Trotter, illustrating the connection between sensitiveness and speed would be of interest.

In the experiments from which these curves are derived the author made use of a grease-spot flicker instrument on similar lines to that recently devised and described by Mr. Wild (*The Electrician*, July 20, 1906, p.). 529

The grease-spot disc was driven by a special-governed electrical phonograph motor, by means of which a very constant speed could be maintained. In making measurements it was found most convenient to keep the photometer stationary and to move one of the sources of light. The sources of light employed were glow lamps, across the terminals of which a constant P.D. was maintained.

The following method of defining the sensitiveness of the photometer was adopted. The movable source of light was brought up until the photometer appeared to be exactly in balance. The positions, on either side of this point, in which it could just be seen that the photometer was out of balance were then noted. The mean of a set of these observations enables one to determine the change of illumination, on either side of balance, which could be definitely detected by the photometer, and the reciprocal of this quantity was termed the sensitiveness of the instrument. It should be noted, however, that individual attempts at setting the photometer in balance would probably lie well within this range of illumination, and, of course, the means of a series of such attempts would agree closer still, probably, under the very best conditions, well within 1 per cent.

When comparing lights of the same colour, and under the

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very best conditions, a change of illumination of about 1·6 to 1·8 per cent. on either side of photometrical balance could be detected. This corresponds to a total range of about 8-9 mm. at the centre of a 2 metre bench, for a movable photometer.

With a Lummer-Brodhun contrast photometer the writer can get considerably better results than this, but the above range of sensitiveness is probably as narrow as the average photometrical arrangements permit of and sufficed for the purpose of the experiment. On the other hand, it is possible that a more perfect form of grease-spot disc than that attained by the author would lead to greater sensitiveness.

In considering the relations between speed and sensitiveness of a flicker photometer we must distinguish between the state of affairs when we compare two lights of the same colour and the state of affairs when two lights differing very greatly in colour are compared. In both cases, if the flicker disc is driven too rapidly, the sensitiveness of the photometer falls off, but the limiting speeds in the two cases will not be the same.

The Comparison of Lights of the Same Colour.

In this case, if the speed is too high, one finds that the photometer can be moved over a considerable distance on a photometrical bench before the flicker becomes visible. The speed at which this stage is reached depends to some extent upon the illumination.

But it is evident that if the photometrical surfaces were quite perfect and the illumination of each was the same, the boundary between the two, even when stationary, would become indistinguishable. We should, therefore, expect to find that when the photometer was in the position of balance no flicker would be visible at any speed.

This was found to be the case at all moderate or quick speeds. But when the speed is very low indeed and the illumination fairly high, a flicker due to imperfections in the flicker disc was usually visible. It is not easy to make a grease spot in which the boundary between the photometrical surfaces can be made to vanish completely. In addition to this, any want of planeness in the disc, or variations in the reflecting power of different portions of the same surface, &c., may give rise to a flicker which is not noticeable under ordinary conditions, but is evident if the speed is very low indeed.

This, of course, reduces the sensitiveness of the photometer.

Apart from this question, however, if the speed approaches a value so low that the observer is able to follow the boundary of the photometrical surfaces with his eye as it crosses the field of view, the genuine sensation of flicker is not produced and the sensitiveness of the instrument falls accordingly.

Some experimental results obtained with the apparatus already referred to are shown in Fig. 1. In the diagram the smallest change of illumination detectable by the photometer is plotted as ordinate. As abscissa is plotted the frequency of the flicker—*i.e.*, the number of times the photometrical surface presented to the eye—is changed per minute. In this case the flicker disc was divided into four quadrants, the alternate quadrants being greased. The frequency is therefore four times the speed of the disc itself.

The chief results brought out by these curves are as follows :—For illuminations above 10 candle-metres or so, the curves, at different illuminations, begin to coincide and the sensitiveness of the photometer is in each case maintained at its maximum value over a range of frequency of about 450 to 1,100. For illuminations below about 5 candle-metres the higher speeds become inadmissible, the range of frequency over which maximum sensitiveness occurs is more restricted, and also the sensitiveness itself becomes less. Indeed, according to the author's experience, the flicker photometer seems to require an illumination of at least about 2 to 5 candle-metres to be operated at all satisfactorily.

A range of frequency of about 400 to 1,200 was, therefore, found to be desirable when comparing lights of the same colour. It is also evident that, with the great range of speed available for illuminations of 5 candle-metres and upwards, there should be no difficulty in striking and maintaining a speed which will give satisfactory results.

The Comparison of Sources of Light Differing in Colour.

In order that an object may become indistinguishable from its background the illumination and colour of both must be the same. The present case, therefore, in which the photometrical surfaces are illuminated by light of different colours, differs essentially from the former one.

In Fig. 2 are shown some curves, analagous to those in Fig. 1, in which are given the results of comparing a nearly pure green against white light. The curves differ from those in Fig. 1 chiefly in two respects.

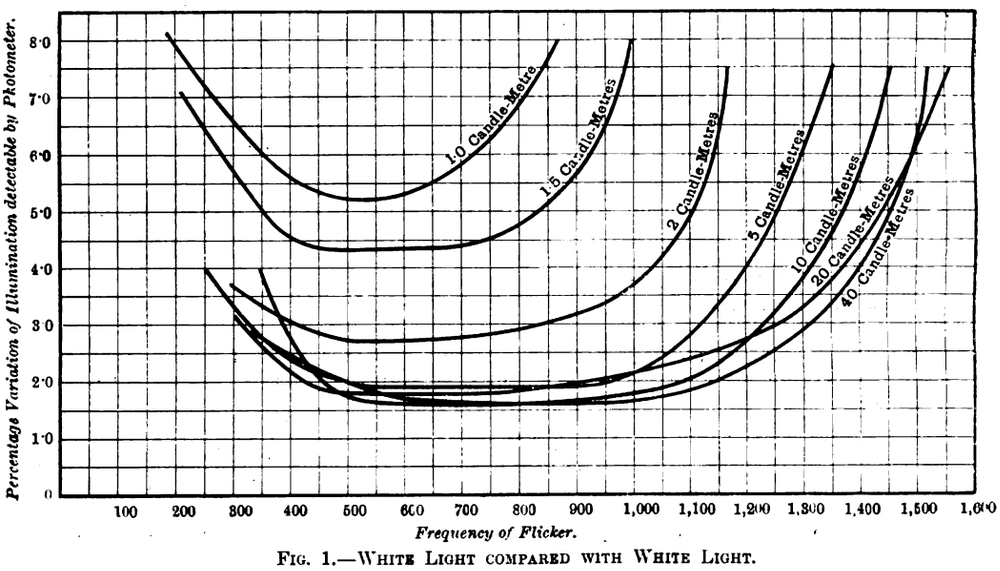

Fig. 1.—White Light compared with White Light.

The speed at which the greatest sensitiveness is reached is much higher than before. Also, while the same order of sensitiveness as before is attainable, the range of speed over which it can be obtained is much more limited. For an illumination of 20 candle-metres, for example, the frequency should lie between 1,200 and 1,400.

It is naturally to be expected that, at a given illumination, a much higher speed than before should be required, for the marked difference in *colour* between the photometrical surfaces itself gives rise to a flicker if the speed is too slow. This flicker cannot be made to disappear for any position of the photometer and, therefore, interferes with the possible accuracy of the instrument. Even under these conditions, however, a little practice enables one to judge the position of minimum flicker with a fair degree of accuracy, unless, indeed, the speed be very much too slow. But the range of speed is naturally much more restricted than when the colours of the two lights are the same.

From the results given in Fig. 2 it is easy to calculate out curves connecting the appearance of the field of the photometer with the speed in the manner suggested by Mr. Trotter in the letter before referred to.

These are given in Fig. 3, in which the abscissa represents the scale in centimetres at the mid point of a 2 metre bench, and the ordinate the frequency. The curves are obtained by plotting the positions of the photometer in which a flicker is just perceptible against the frequency. Some limiting positions

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of the photometer in which, in spite of the presence of a continuous flicker, it would be just possible to see that the photometer was out of balance, are also shown, in order to illustrate the loss in sensibility at too low speeds.

The exact limiting point at which the flicker can *just* be made to disappear is not very definite experimentally, but probably lies somewhat as shown by the dotted portions of the curves. If a point could be found at which the two branches of the curve met one would infer that, at this particular frequency, no change of illumination could exist small

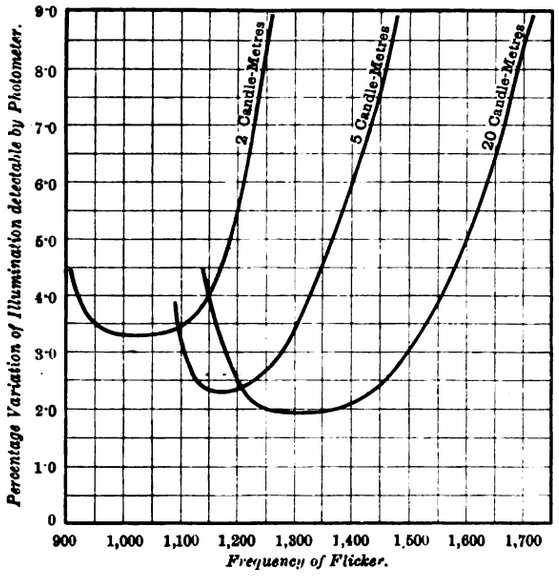

FIG. 2.—GREEN LIGHT COMPARED AGAINST WHITE LIGHT.

enough not to be detectable by the eye. This condition cannot, of course, be fulfilled experimentally.

At an illumination of 20 candle-metres the frequency at which it becomes impossible to get rid of the flicker is in the neighbourhood of 1,250. The accuracy—as indicated by the

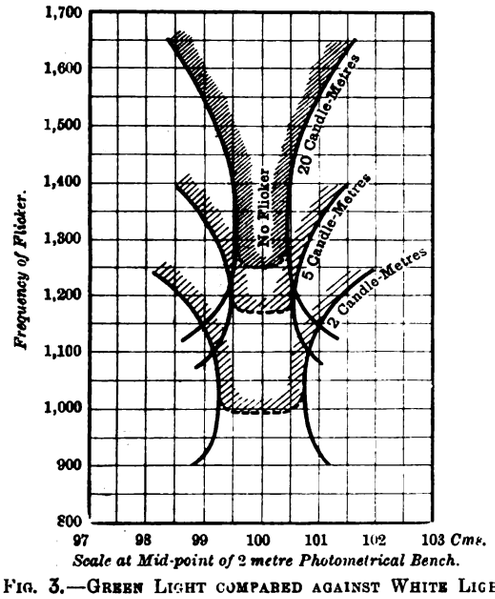

FIG. 3.—GREEN LIGHT COMPARED AGAINST WHITE LIGHT.

widening of the horizontal distance between the branches of the curve—is at a maximum for a range of frequency about 1,230 to 1,400. At considerably lower illuminations corresponding curves are obtained in which the range of frequency corresponding to maximum sensitiveness is lower. At higher illuminations curves not differing greatly from those at 20 candle-metres are to be expected.

The colour difference between the sources was in this case greater than any likely to occur in practice. When dealing with such relatively smaller colour differences as exist, for instance, between the light from an incandescent mantle and an Argand burner, results intermediate between those in Figs. 1 and 2 may be expected.

The following, therefore, seem to be the chief conclusions to be drawn from these experiments.

When comparing lights of the same colour, the range of frequency over which the sensitiveness of the photometer is at its best is sufficiently great to make it an easy matter to select a satisfactory speed. This speed should answer over the range of illuminations met with in ordinary work, but if the illumination is very low a lower speed is necessary, and a diminished sensitiveness may be expected. When comparing lights differing widely in colour a higher speed is required and the satisfactory range of speed is much more restricted. It is, therefore, not so easy to strike the exactly correct speed as in the former case, but a little practice enables it to be found by trial without much difficulty.

Finally, it should be noted that very great exactness cannot be expected from experiments of the nature described. The sensitiveness of the eye to a flicker seems to be easily altered, and is particularly susceptible to the effects of fatigue. One would, therefore, expect results obtained on different days to differ somewhat, and this has been the writer's experience. It is also inevitable that, in the course of the prolonged series of readings which such an experiment demands, the element of fatigue should be present. The repetition of these experiments, however, has always led to the same *general* results. Lastly, it must be noted that the eyes of different observers do admittedly differ considerably in their perception of flicker, and the legitimate deductions from these experiments are, therefore, limited by the fact that they were obtained for the writer's eye only.

THE CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY.

The system of underground tube railways in London, due chiefly to the late Mr. Yerkes, is now practically complete, for the concluding line, "the last link," which runs from Charing Cross via Euston to Hampstead and Golder's Green, with a branch to Highgate, is now nearly ready for traffic and will probably be open for public use by the end of June.

The length of the route from Golder's Green to Charing Cross is about 5½ miles, and the branch line to Highgate amounts to about another 1½ miles, so that a very considerable increase is being made in London's underground means of locomotion.

The new line makes communication at Charing Cross with the District Railway and the Bakerloo tube, at Leicester-square with the Great Northern, Piccadilly & Brompton tube, and at Euston with the recently-opened extension of the City & South London Railway. In addition to the traffic which will result from intercommunication with the above-mentioned underground railways, the line also provides facilities for passengers travelling on the London & North-Western Railway via Euston and by the Midland Railway via Kentish Town. From the map (Fig. 1), which shows the new tube line, its relation with the other tube lines is easily seen, and a very good idea is obtained of the excellent facilities for rapid travelling now offered by the Underground Electric Railways of London. The London & North-Western Railway terminus has always been rather inaccessible, but this new tube to Charing Cross, and the increased facilities offered by the recent extension of the City & South London Railway for travelling to or from the Bank and the southern parts of the city, should remove all such difficulties, and prove of great convenience to a large number of travellers. It would, however, have made a more convenient general arrangement if the different tubes had been so constructed as to afford through running. According to present arrangements it is impossible for rolling stock to be transferred from any one tube to the others.

The traffic on the previously opened tubes has fallen far short of expectations, but it is to be hoped that, with the new intercommunications offered by the lines more recently opened,

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the conditions may be considerably improved, and appreciable assistance furnished for the solution of the problem of London traffic.

number of houses are already being erected in the vicinity of the station, and, as soon as the tube is opened for traffic, the excellent facilities which it offers for rapid travelling between

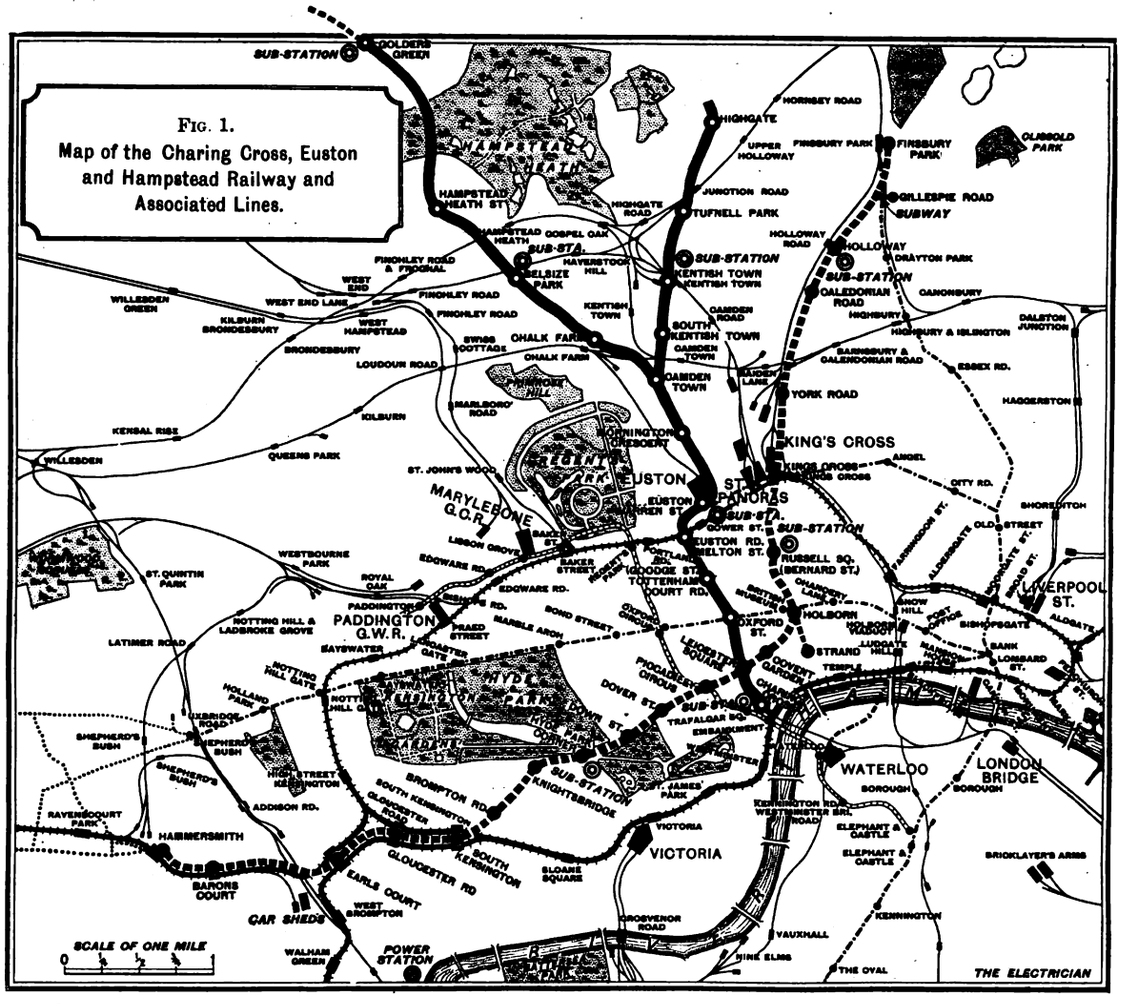

FIG. 1.
Map of the Charing Cross, Euston and Hampstead Railway and Associated Lines.

CHARING CROSS, EUSTON AND HAMPSTEAD RAILWAY.
GREAT NORTHERN, PICCADILLY AND BROMPTON RAILWAY.
BAKER STREET AND WATERLOO RAILWAY.
OTHER ELECTRIC RAILWAYS.
OTHER RAILWAYS.
METROPOLITAN DISTRICT RAILWAY.
" " " (JOINT OWNERSHIP OR RUNNING POWERS.)
LONDON UNITED ELECTRIC TRAMWAYS.

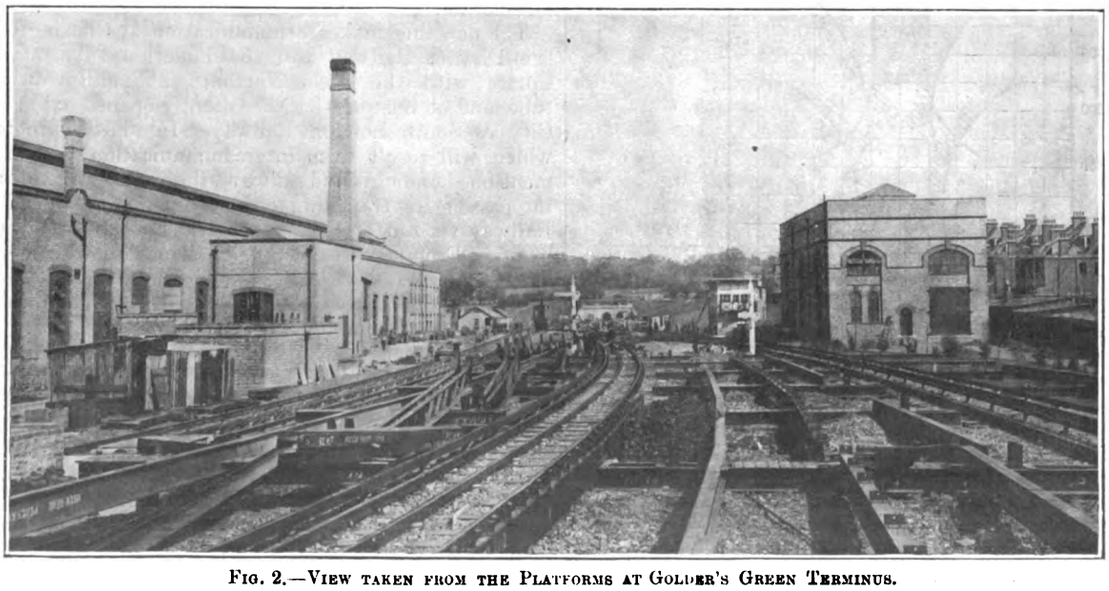

FIG. 2.—VIEW TAKEN FROM THE PLATFORMS AT GOLDER'S GREEN TERMINUS.

The present suburban terminus of this new tube is at Golder's Green, and the station is adjacent to the Finchley-road. At present the surroundings are quite rural, but a the City and pleasant country surroundings will induce many people to reside in the neighbourhood of Golder's Green. Fig. 2 is a general view taken from the position of the plat-

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forms at the terminus and looking back along the line. As will be noticed from this view, the last few hundred yards of the line are above ground, and the two entrances to the tunnels can be plainly seen in this view. Adjacent to the

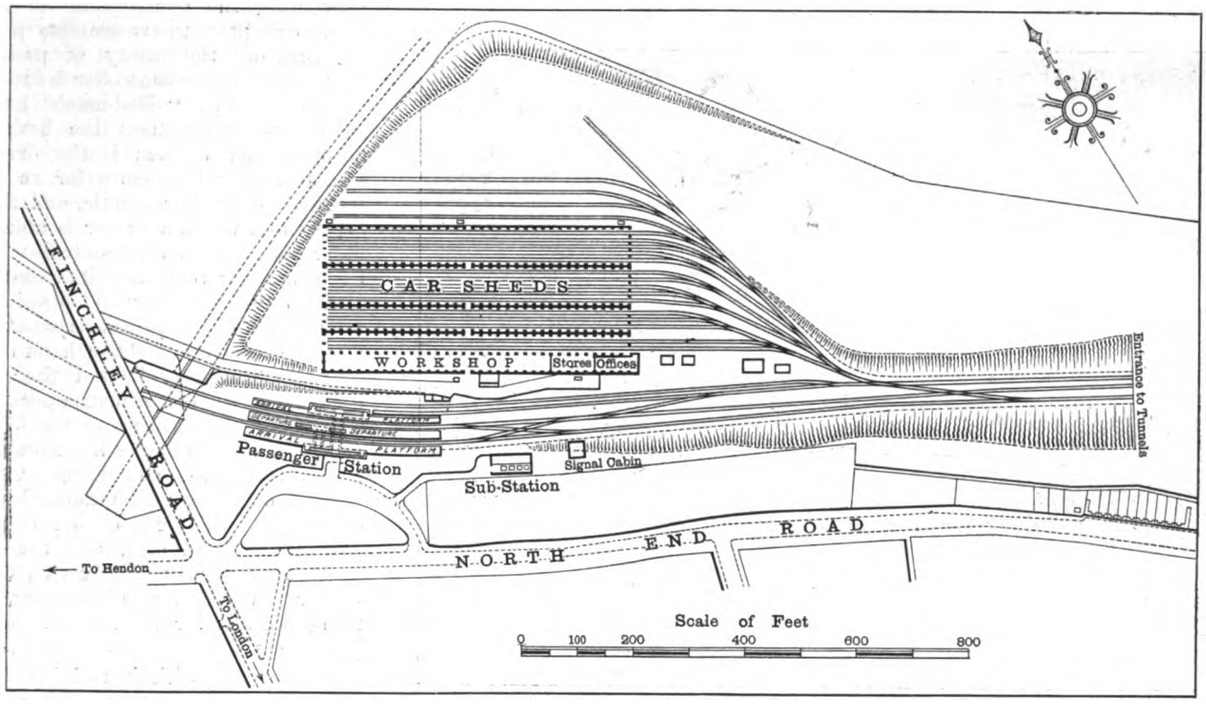

FIG. 3.—PLAN OF GOLDER'S GREEN TERMINUS.

terminus at Golder's Green are the car sheds for the rolling stock.

As will be seen from Fig. 3 a great improvement has been made in the terminal arrangements for dealing with traffic. The tracks are interconnected so that an incoming train may run in on either side of the central platform and, after discharging passengers on one side, take in passengers on the other side. Thus it can start on its return journey, crossing if necessary to the correct return track, without any loss of time as is usually the case where

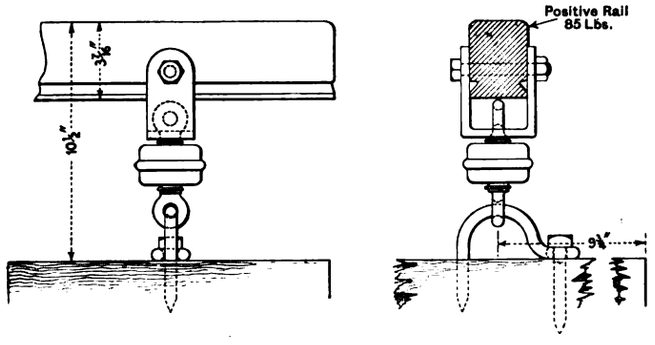

FIG. 4.—METHOD OF ANCHORING CONDUCTOR RAIL.
Scale 1 : 8.

an arrangement of separate arrival and departure tracks is adopted.

The construction of the track and tunnels is of exactly the same type as that adopted on the other tube railways, and has been recently described in *The Electrician* in connection with the other tube railways.

Each of the running tunnels is 11 ft. 8 in. diameter on the straight sections of line, and increases at curves up to 12 ft. 6 in. on those of short radius. The tunnels at the stations increase to a diameter of 21 ft. 2½ in.

The contract for carrying out the tunneling was let to Messrs. Price & Reeves, and the work was carried out under the supervision of Mr. H. H. Dalrymple Hay.

The running rails, which are in lengths of 45 ft. were supplied by the Carnegie Steel Co., and in order to obtain smooth

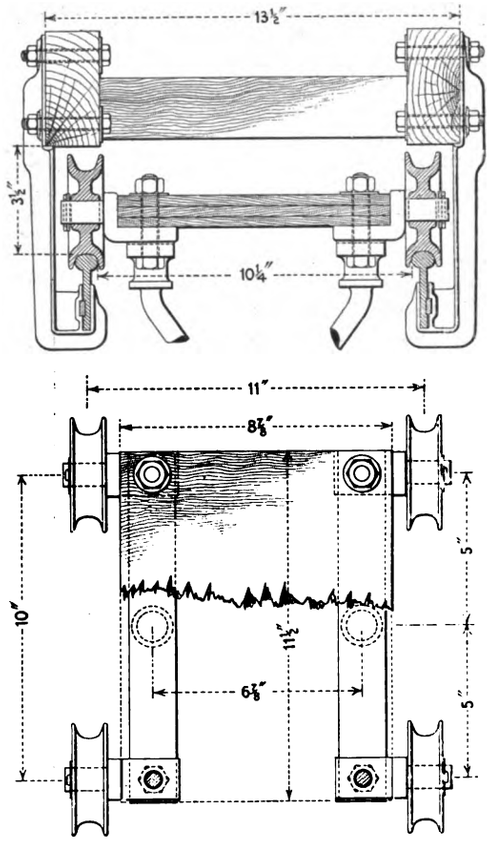

FIG. 5.—TROLLEY CARRIAGE USED IN CAR SHEDS.

running a felt pad is placed under each chair. The gauge of the track is the standard 4 ft. 8½ in.

The ventilation of the tunnels, as on the other tubes, is effected by exhaust fans, each capable of drawing out about

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19,000 cubic ft. of air per minute. Fresh air enters by means of the lift shafts and the staircases.

The positive conductor rail is fixed outside the track on Doulton stoneware insulators and the negative conductor rail is placed midway between the running rails on porcelain blocks. Trouble has sometimes been experienced on electric railways due to the creeping of the conductor rails. On the Hampstead tube a very simple means has been adopted for anchoring the conductor rails. As will be seen from Fig. 4 it consists of an iron attachment bolted to the conductor rail and fastened down by means of a strain insulator of the ordinary type, which is held in position by means of a spiked hook fixed in the end of a wooden sleeper.

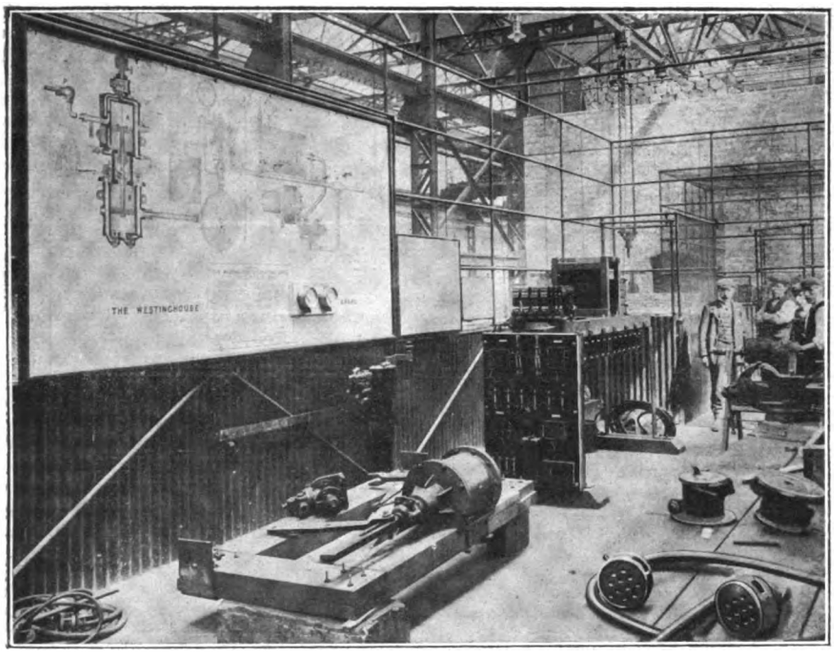

FIG. 6.—"MOTORMEN'S SCHOOL" IN GOLDER'S GREEN CAR SHEDS.

The rolling stock is of exactly the same design and appearance as that used on the Great Northern, Piccadilly and Brompton tube, which was described in *The Electrician*, Dec. 7, 1906. The B.T.H. electrical equipment consists of four 200 H.P. motors per train, and the control is on the standard Sprague-Thomson-Houston multiple unit system. This system, which was described in *The Electrician*, Vol. LI., p. 64, in connection with the District Railway, consists of a series of electromagnetic contactors and switches operated from electrical control circuits connected to the master controllers at either end of the train. A view of the interior of the driver's cab was given in *The Electrician*, Dec. 7, 1906, p. 283.

The control cables run the whole length of the train between the master controllers, but owing to the Board of Trade regulations no power cables are allowed to be carried along the carriages, so that each motor car obtains its current from independent collector shoes.

In each driver's cab is also an electrically-driven air compressor and air reservoir for operating the pneumatic brakes.

In case a train should overrun any of the signals, a lever which projects above the rail, and which is operated by the signals, comes in contact with a lever on the motor car of the train, and opens the vacuum pipe of the pneumatic brakes to the atmosphere, so that the train is very rapidly brought to a standstill. In case of an emergency, due to the signals not operating, the motorman is able to prevent the opening of the vacuum pipe by means of an auxiliary handle and valve.

In addition to the arrangement mentioned above for preventing the overrunning of signals, additional precautions are also provided for securing the safety of passengers. Thus, each master controller is fitted with the well-known "dead-man's handle"; with this arrangement the brakes are automatically applied if the driver releases his hand pressure for an instant from the controller handle, and the only occasion on which a driver is able to remove his hand from the controller is when the controller reverse switch has first of all been put into the "off" position. The brake valve is also placed adjacent to the master controller, and the hand brake is placed immediately behind the position occupied by the driver when operating the controller. In addition to the Westinghouse air brake and the hand brake mentioned, there is, of course, the emergency method of electrically braking by means of reversing the motors. With all these precautions mentioned, and the use of fireproof coaches, it will be seen that the Underground Railways have done everything possible for securing the safety of passengers.

In connection with the training of motormen, it is very interesting to note that what is called a "motormen's school" has been fitted up in the car sheds at Golder's Green. This school is shown in Fig. 6, and it will be noticed that means are provided for enabling the new motormen to become thoroughly acquainted with the actual working of the apparatus under their control. Current at full working pressure is supplied to a master controller, and the working of the electromagnetic contactors can be easily seen by the learners. The air-brake apparatus is also fitted up, and diagrams are provided so that the motormen may obtain a clearer idea of the working of the different parts of the apparatus. We believe that this is the first motormen's school which has been

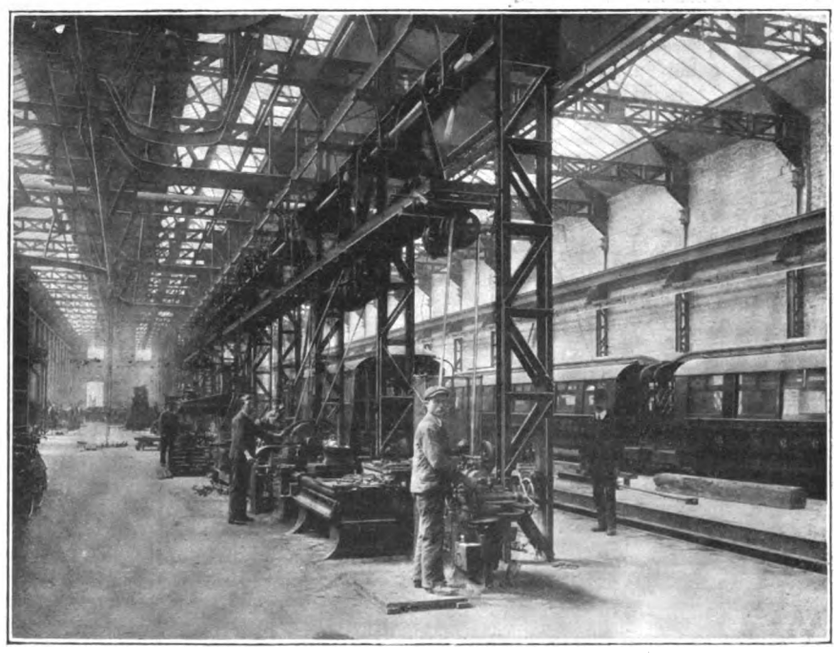

FIG. 7.—REPAIR SHOP IN GOLDER'S GREEN CAR SHEDS.

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thus fitted up, and it should certainly prove of benefit both to the motormen and to the company.

The position and arrangement of the car-sheds are seen in the general plan (Fig. 3), and they are also noticeable on the left-hand side of Fig. 2. The car sheds are divided into several sections, and altogether 15 lines of track are provided. The conductor rails terminate outside the doors, and current is supplied to the trains when inside the sheds from two overhead conductor rails, which may be seen close against the wall on the right-hand side of Fig. 7.

A special small trolley carriage (Fig. 5) runs on these overhead conductors, and a flexible cable with a special plug hangs down from the trolley. This plug can be fitted into a special socket fixed on the motor car of the train. In this way a very simple means is provided for obtaining the necessary current for traction purposes, with increased safety to the employees, due to the absence of live rails.

Fig. 7 shows part of the machine shop where the repair work will be carried out; it will be noticed that the machines are conveniently situated with respect to the tracks, whilst the smiths' hearths and fitters' benches are placed against the wall on the left-hand side. The machine tools comprise a planing machine, shaping machine, wheel press, pneumatic hammer, punching and shearing machine, lathes up to 48 in., drilling machines, &c. A wood workshop is also provided. The shafting for the machines in these shops is driven by British Thomson-Houston motors.

Adjacent to the car-sheds are the stores and offices; the former are well divided into different sections, so that the materials in hand can be easily checked. The offices on the ground floor comprise manager's office, general office, time-keeper's office, &c., whilst upstairs a very large drawing office is provided.

An interesting addition to the usual arrangements at similar car-sheds consists of a plug board representing the car-sheds, with holes provided for each car length of space in the sheds. In these holes will be placed numbered plugs corresponding to the numbers of the cars occupying such spaces. It will thus be easy for any workman to go direct to any particular car requiring attention, and this system will save a good deal of time which otherwise is always lost by workmen wandering listlessly about in search of some particular car.

(To be concluded.)

THREE-PHASE TRANSFORMATION.*

A. S. McALLISTER.

A study of the fluxes required for three sinusoidal electromotive forces displaced from each other by 120 electrical time degrees will show that at any chosen instant the sum of any two of the fluxes is equal in value and opposite in direction to the remaining flux. The significance of this result is that if a transformer core be constructed with three legs, each wound with the same number of turns, and if the three windings be subjected to electromotive forces in true three-phase relation to each other, each coil and core will operate exactly like the primary winding and magnetic circuit of a separate single-phase transformer. In consequence of this fact, by increasing the material of a core-type single-phase transformer by slightly more than 50 per cent., the rating of the equipment becomes exactly 50 per cent. greater than a three-phase transformer. Thus by adding a little over 50 per cent. to the material of a 10 kw. core-type transformer there is obtained a three-phase transformer whose rating is 15 kw. Such a polyphase transformer is capable of performing the work of three 5 kw. single-phase transformers Δ connected or Y connected, or of two 8·66 kw. transformers V connected, or of one 7·5 kw. and one 8·66 kw. transformer T connected.

The relative merits of the three-phase transformer and the combination of single-phase transformers that may be employed for obtaining the same service are frequently discussed on the basis of the decrease in cost of the several types of transformers with increase in rating, and on such basis it has been shown that the three-phase transformer is the cheapest, because it represents in its construction 150 per cent. of the cost of a 10 kw. transformer, while the other combinations are more expensive on account of requiring an equal or greater aggregate rating in smaller transformers. It is intended to show that, quite apart from the decrease in manufacturing cost with increase in size of transformer units, the three-phase transformer possesses a real advantage in requiring less material and being more efficient than other transformer combinations, and that the advantage in this one respect is quite appreciable even when the three-phase transformer is of large capacity. Mention will also be made of the advantages of the T-connection of two transformers when a three-phase transformer cannot be obtained.

Referring now to Fig. 1, which indicates the relative increase in constructive material required for changing a single-phase to a three-phase transformer having a 50 per cent. larger rating, it will be noted that 50 per cent. more copper must be used and that the iron must be increased by slightly more than 50 per cent. As an average value it may be stated that the weight of iron per kilowatt rating will be about 6 per cent. greater than, and the weight of copper exactly the same as, that for a single-phase transformer having 66⅔ per cent. as large a rating. Using values obtained from a certain commercial line of single-phase core-type transformers, as published in the bulletins of the manufacturer, it is found that the copper of a 10 kw. transformer weighs 17·3 lb. per kilowatt and the iron weighs 22 lb. per kilowatt, while the corresponding values for a 5 kw. transformer are 23·6 lb. of copper and 25·6 lb. of iron. Thus a 15 kw. three-phase transformer requires 17·3 lb. of copper and 23·3 lb. of iron per kilowatt, while three 5 kw. single-phase transformers require 23·6 lb. of copper and 25·6 lb. of iron per kilowatt. Moreover, the copper loss in the three-phase transformer at full load is 17·7 watts and the iron loss 11·2 watts per kilowatt, while the corresponding losses for the three single-phase transformers are 20·0 and 12·2 respectively. Thus the full-load efficiency of the three-phase transformer is 97·2 per cent., and of the three single-phase transformers 96·9 per cent.

The results of a series of calculations similar to the above, covering the complete line of transformers ranging in capacity from 0·75 kw. to 75 kw., are indicated graphically in Fig. 2, where smooth

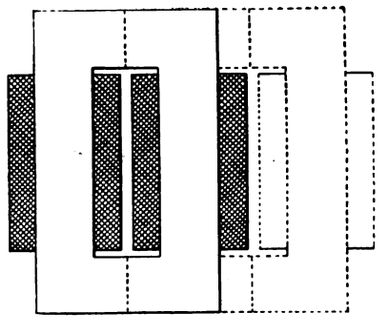

FIG. 1.—ACTIVE MATERIAL FOR SINGLE-PHASE AND THREE-PHASE TRANSFORMERS.

curves have been drawn through more or less irregularly-placed points. It will be seen at a glance that for each value of power to be transformed the three-phase transformer requires less constructive material and is more efficient than three single-phase transformers having the same combined rating. It is to be noted, however, that a single single-phase transformer of the same total rating requires much less material and is more efficient than the three-phase transformer unit. The above facts deal with the fundamental phenomena involved in the design of transformers, and they are independent of the decrease in manufacturing cost with the increase in size of transformer units. The last-mentioned decrease serves, moreover, to emphasise the relative advantages of the three-phase transformer; it is, however, more pronounced the smaller the units, because the cost approximates a constant value per pound of material for extremely large transformers, but approaches more nearly a constant value per transformer unit in very small sizes.

Although in selecting the material and determining the dimensions of any certain line of transformers the designer arranges each unit as a compromise between the demands of lightness and efficiency, quite independent of the other units of the same line, the fact remains that the best compromise for each unit is so related to that for the other units that there results a definite rate of decrease of loss, or of weight, per kilowatt with increase in capacity of the transformers of each line. A study of numerous lines of single-phase transformers as manufactured at the present time shows that the loss in watts per kilowatt in any certain line of transformers may be expressed, with an error that is quite small by the following equation—

$$L = \frac{k}{W^x},$$

where W is the rating of the transformer in any chosen unit, k is the loss in watts per kilowatt for a transformer rated at one unit, and x is an exponent, the value of which varies slightly with the

* Abstracted from the *Electrical World*.

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rating, but is practically constant over a large range. It has been found that for almost all lines of transformers, including core-type and shell-type, high-voltage and low-voltage, high-frequency and low-frequency, air-blast, self-cooling and water cooled, x has a value seldom much greater or less than 0·26; it is larger at low ratings and also at very high E.M.Fs. The significance of this result is that the loss in a 3 kw. transformer is three-fourths as large per kilowatt as that in a 1 kw. transformer of the same line; the loss per kilowatt in a 30 kw. transformer equals 75 per cent. of that in a 10 kw. transformer, a 300 kw. transformer has a loss per kilowatt three-fourths of that of a 100 kw. transformer, and a 3,000 kw. transformer suffers a loss of 75 per cent. as large per kilowatt as that of a 1,000 kw. transformer, and so on. It is worthy of note that of the numerous lines of transformers examined, the one upon which the calculations indicated in Fig. 2 were based, shows the most marked disagreement with the above equation. The divergence was such as to be unfavourable to the three-phase transformer; hence the comparison to be drawn from Fig. 2 in no respect exaggerates the advantages of the three-phase transformer.

Although in any certain line of transformers the core loss per pound of iron and the coil loss per pound of copper do not vary appreciably throughout a limited range in rating (that is, the magnetic and current densities are constant), yet the ratio of iron to copper changes somewhat with the size of the transformer. Thus two transformers having exactly the same loss per pound of iron and per pound of copper, and the same total loss per kilowatt, may not weigh the same per kilowatt; moreover, the constructive material may not cost the same per kilowatt of rating or per pound of total weight. However, throughout a limited range it may fairly be stated that the weight of transformers in a certain line varies directly with the losses. The maximum adverse divergence for all lines examined was found to be in the line selected for the comparison in Fig. 2. If the relations here deduced were absolutely correct for all

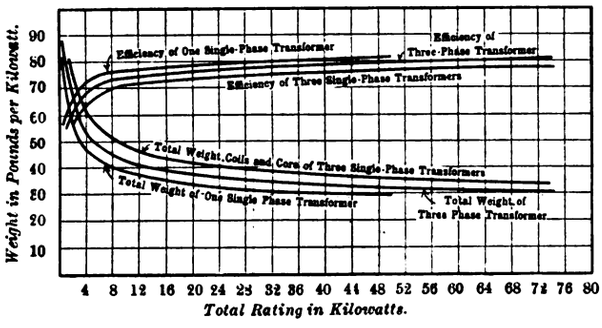
Weight in Pounds per Kilowatt.
90
80
70
60
50
40
30
20
10
Efficiency of One Single-Phase Transformer
Efficiency of Three-Phase Transformer
Efficiency of Three Single-Phase Transformers
Total Weight, Coils and Core of Three Single-Phase Transformers
Total Weight of One Single Phase Transformer
Total Weight of Three Phase Transformer
4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80
Total Rating in Kilowatts.

FIG. 2.—COMPARISON OF TRANSFORMER EQUIPMENTS, GIVING THE SAME TOTAL OUTPUT.

sizes of transformers, the following conclusions could be drawn—minor disturbing effects being ignored:—

A single-phase transformer weighs 25 per cent. less than three separate transformers having the same total rating: its losses at full load are also 25 per cent. less. A three-phase transformer weighs 16·5 per cent. less than three separate transformers; its losses are also 16·5 per cent. less. Two transformers V-connected weigh exactly the same as three separate single-phase transformers for the same power transmitted; the losses are also equal. Two transformers T-connected have a combined weight 5 per cent. less than three separate transformers either Δ-connected or Y-connected or than two transformers V-connected; the losses are likewise 5 per cent. less. It is believed that the comparisons here made are fair in every respect to each type of transformer or interconnection of transformers.

From the above considerations it would seem that for the transformation of three-phase power the three-phase transformer is to be preferred to any other possible equipment. So far as concerns the cost of the equipment and the efficiency in operation, two T-connected transformers are preferable either to two V-connected transformers or to three transformers Δ-connected or Y-connected. In comparing the T-connection with the Δ or Y-connection it is to be noted that each connection accomplishes the transformation without sensible distortion of phase relations. The T-connection allows the neutral point to be reached equally as well as does the Y-connection. The Δ-connection, however, is the only one capable of transforming in emergencies with one disabled transformer.

With reference to its ability to maintain balanced phase relations, the T-connection is much better than the V-connection. For the starting of three-phase motors at reduced voltages, where the transformers are in use for only a small fraction of the total time, the distortion of phase relations may not be serious; but for continuous operation the distortion should not be permitted. For the latter condition the T-connection is preferable in every respect to the V-connection, and in many cases it should prove more advantageous than either the Δ or the Y-connection of three separate transformers.

It is worthy of note that the prime requisite for the T-connection of the transformers for three-phase work is met when the two transformers possess the same ratio of primary to secondary turns and a tap is brought out from the central point of one of the transformers; the two halves of both the primary and the secondary windings of the latter transformer should be well interspaced to prevent excessive magnetic leakage. It is not essential that the former transformer be designed for exactly 86·6 per cent. of the voltage of the latter; the normal voltage of one can be 90 per cent. of the other, without producing detrimental results. Moreover, transformers designed for the same normal E.M.F. and intended for V-connection can be T-connected with considerable improvement in service.

MEASUREMENT OF INSTANTANEOUS VALUES OF ELECTRIC LIGHTS ON ALTERNATE CURRENT.*

BY DR. JOHANN SAHULKA.

In *The Electrician* for December 14, 1906, a piece of apparatus is described by J. T. Morris by means of which the instantaneous values of the light given by an electric lamp, fed with alternate current, can be measured. This consists of a disc having radial slits, which is secured to the spindle of the alternate-current generator. When fastened in any given position, the light to be measured passes through the slits, and is received on the photometer, which then records the value of the light at any point in the course of a complete period. In this way, values can be obtained showing the curve of illumination, as depending on the variation of current in the course of a period. A similar piece of apparatus was exhibited by me at a meeting of the Electrotechnical Institute of the Poly-

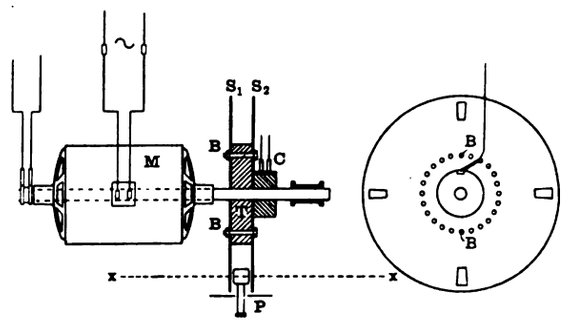

FIG. 1.

technic in Vienna in the middle of November, 1906, which was devised by me some years ago and is shown in Fig. 1. I arranged two parallel discs, fitted with slits, on the spindle of a synchronous motor; the head of the photometer is placed between the discs. In this way it is possible to determine, not only the curve, but also the absolute values of the light. Contact pieces were also placed on the spindle of the motor by means of which the curves showing the shapes of the current and voltage waves could be plotted out. By means of this apparatus it is possible to show the dependence of the instantaneous values of the light on the form of the current wave. I have described such curves under the name of "light-hysteresis" curves.

Another method which I have proposed to apply is founded on the following considerations. The instantaneous value of the light given by an alternate-current incandescent lamp or of an arc lamp depends not directly on the current strength, but rather on the state of incandescence of the filament; a definite resistance of the lamp corresponds to this state. Seeing that the resistance varies throughout each half of a period, the current curve is distorted when compared with the voltage curve. With carbon filaments during the increase of the current the resistance has a relatively higher value than during the decrease; with metallic filaments, the opposite is the case. The zero points of the curves for the current and voltage waves fall together. In order to find the curve showing the variation of the resistance of a lamp, the curves showing the variations of current and voltage are determined, and by dividing the values of the ordinates of these curves, the resistance curve can be determined. When this has been done, the light values corresponding to the ordinates of the resistance curve can be determined by calibrating against a continuous current lamp. The resistance of the lamp can be determined from the readings of ammeter and voltmeter. By means of series resistances, the lamp can be made to have resistances corresponding to the values already obtained on the resis-

* Abstracted from the *Elektrotechnik und Maschinenbau*, February 17, and March 17, 1907.

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tance curve, and at each point the light is measured. In this way, the curve of light values is obtained, which corresponds to those obtained on alternate current. This method has, however, proved to be inexact on account of the small variations of resistance, even in the case of metallic filaments.

In a further communication the author describes another method, based on similar principles, which he has successfully applied. The appended diagram (Fig. 2) shows the arrangement of the apparatus. The resistance of the lamp L, which is to be tested, is determined by means of the Wheatstone bridge, alternate current being passed through the circuit. The four arms of the bridge consist of a small resistance, w_1, of about 10 ohms, a resistance, w_2, of about 100 ohms,

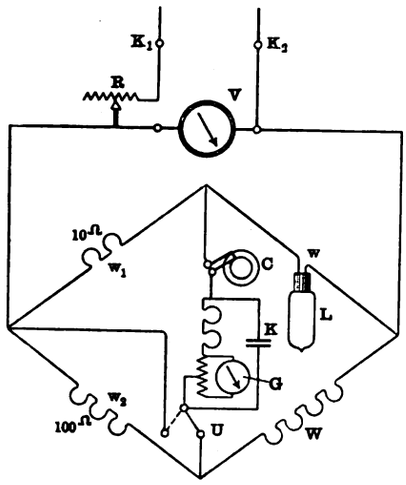

FIG. 2.

the resistance of the lamp and an adjustable resistance, W. A resistance, R, is placed in the main circuit, and can be adjusted so as to give the normal voltage to the lamp, which is kept constant throughout the test. In circuit with the galvanometer is placed a Joubert contact disc, driven by a synchronous motor. If for a given position of the brush on the contact disc, the resistance W is

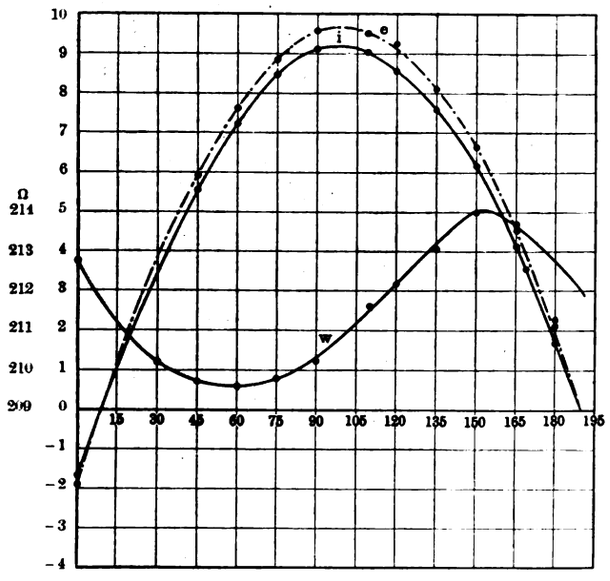

FIG. 3.

so adjusted that no current passes through the galvanometer, then the resistance of the lamp is equal to $W\frac{w_1}{w_2}$. By changing the position of the brush gradually the resistance curve of the lamp can be plotted out. The current curve can be determined in a similar way. A two-way switch is placed in the galvanometer circuit, and is shown at U in the diagram. It is then possible by means of the galvanometer to measure the voltage across w_1, and this voltage is proportional to the instantaneous value of the current flowing through the lamp Consequently the resistance of the lamp and the current flowing through it can be measured for each position of the brush on the contact disc, and in this way the two curves can be plotted.

The following tests were carried out on these lines on an osmin lamp of the Westinghouse Company, which gave 58·9 Hefner c.p. on 110 volts, taking 58·2 watts. It was run on alternating current at 116·5 volts, with a frequency of 50. For the measurement of the resistance the Ayrton shunt to the galvanometer was adjusted to give a sensibility of unity, and a resistance of 50,000 ohms was put in series. For measurement of the current the shunt was adjusted to give a sensibility of one-hundredth, and the series resistance was 100,000 ohms. The capacity of the condenser K was 1 mfd. Table I. gives the readings.

Table I.

Phase angle.	Resistance in ohms.	Current × constant.	Volts × constant.	Hefner c.p.
0	212·7	− 1·75	− 373	78·4
30	210·2	+ 3·57	+ 751	68·5
45	209·7	+ 5·60	+ 1,175	66·8
60	209·6	+ 7·30	+ 1,530	66·4
75	209·8	+ 8·45	+ 1,772	67·1
90	210·25	+ 9·15	+ 1,924	68·7
110	211·6	+ 9·02	+ 1,908	73·9
120	212·15	+ 8·70	+ 1,845	76·0
135	213·05	+ 7·60	+ 1,619	79·7
150	214·0	+ 6·17	+ 1,320	83·9
165	213·65	+ 4·25	+ 909	82·4
180	212·7	+ 2·15	+ 457	78·4

The first column gives the phase angles, and the second the resistance of the lamp. The third gives the instantaneous values of the current, being the readings on the galvanometer scale ex-

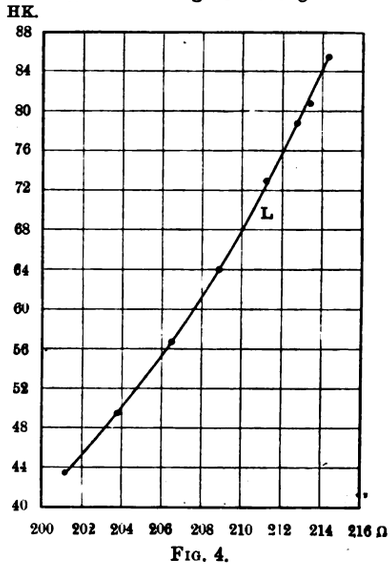

FIG. 4.

pressed in centimetres. The fourth column is the product of the two preceding ones, and gives values proportional to the instantaneous values of the voltage on the lamp. The last column contains the candle-power. This is obtained by interpolation from Table II., which gives the candle-power when the lamp is run on direct current at different voltages, and consequently with different resistances.

Table II.—*Tests with direct current.*

Voltage.	Current in amperes.	Resistance in ohms.	Hefner candle-power.
102·0	0·5065	201·4	43·7
105·0	0·5155	203·7	49·4
108·9	0·5275	206·5	56·5
112·2	0·5370	208·9	64·0
114·0	0·5415	210·5	69·6
116·0	0·5490	211·3	73·1
117·0	0·5510	212·3	76·7
118·0	0·5550	212·6	78·5
119·0	0·5575	213·4	80·8
120·2	0·5610	214·2	85·0

From these figures it will be noticed that the resistance of the lamp varies between 209·6 and 214 ohms—*i.e.*, by 2·1 per cent. on either side of the mean value. The candle-power varies by 23 per cent. Naturally these figures depend on the material of which the filament is made, on the frequency, and on the thickness of the filament.

Fig. 3 gives the current, voltage and resistance curves, as shown in Table I. The abscissæ are the phase angles, and the scales for

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the ordinates w, i and e are respectively 1 ohm, 1 unit and 20 units. The difference between the curves for e and i is slightly smaller on the ascending than on the descending portion; this is the result of the fact that the resistance is less over the ascending part of the curve. Carbon filaments, of course, have the opposite peculiarity. The moments of maximum and minimum values for the resistance differ by 60 deg. from those for current and voltage, and correspond to the moments of greatest and least intensity of the light. Fig. 4 gives the values of the light as ordinates in Hefner candle-power, and of the resistance in ohms as abscissæ. Fig. 5 gives the so-called hysteresis curves. The narrow loop is obtained by plotting the instantaneous values of the current as abscissæ, and the corresponding values of the voltage as ordinates (on the scale of 10 units to one division). The lower side of the curve gives values corresponding to the increase of the current, and the upper side those for the decrease. As already stated, the formation of this loop is due to the change in the resistance of the lamp. A similar curve for arc lamps has been given by T. Simon in the *Elektrotechnische Zeitschrift*, p. 822, 1905.

The second curve in Fig. 5 gives the light-hysteresis curve for the osmin lamp. The curve should really be extended on the other side of the axis of y, so as to give values corresponding to the negative values of the current. If so completed, it somewhat resembles the shape of the figure 8. It will be noticed that at the moment when the current is zero, the value of the light is about its mean. The light decreases with increase of current, and reaches its minimum value when the current has reached about 75 per cent. of its maximum value, owing to the fact that during the preceding period the loss from radiation exceeds the heating effect of the current. Even at the moment when the current reaches its maximum

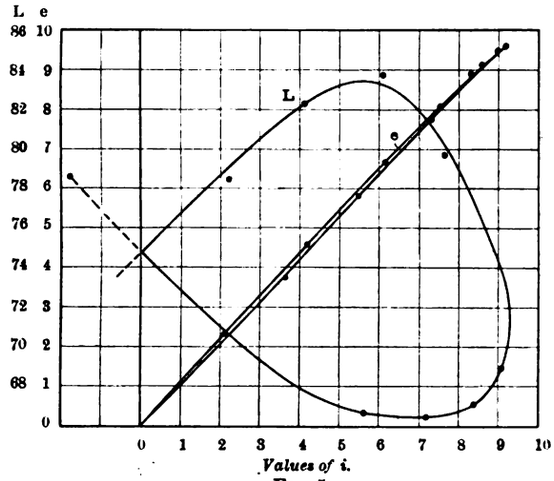

FIG. 5.

value, the light is less than at the instant when the current is zero. The maximum value of the light is then rapidly reached during the time in which the current decreases from its maximum, and from this point the light decreases, and a precisely similar portion of the light-curve is traced out on the left side of the axis of y.

A VITAL ELECTRIC TRACTION PROBLEM.*

In view of the recent steps taken in the adoption of electricity in dealing with the dense traffic handled at important railroad terminals, and the recent unfortunate accident at a curve on the Harlem Division of the New York Central & Hudson River Railroad, it is of importance that the question should be settled as to whether the present methods of track construction are suited for use with heavy electric locomotives. In order to do this the probable and known effects of both types of locomotive upon track and roadbed must be analysed and compared, particularly upon curves. An endeavour has been made to do this, using types of locomotive used by the New York Central for the purpose.

The New York Central accident occurred on a $3\frac{1}{5}$ deg. curve, having a radius of 1,858·5 ft.; the superelevation of the outer rail was $4\frac{1}{2}$ in. The track is laid with 100 lb. rails and 20 ties are used per rail length, being spaced about 21 in. centres. The rails are spiked down with one spike on each side of each rail and tie plates are used. The ties are of yellow pine, chesnut and oak bedded in broken stone ballast to their full depth. From the standpoint of the railroad manager the track construction is of modern type, of the heaviest construction and thoroughly adapted to high-speed traffic. In considering the roadbed question it must be remembered that, with the exception of heavier rails, an increased number of ties per mile, the use of broken stone ballast and slightly larger spikes, the method of construction used to-day remains the same as it was 30 years ago. In the meantime the weight of locomotives and other rolling stock has been largely increased and the operating speeds have risen, and a large number of trains attain, on portions of their run, speeds exceeding 50 miles per hour, and some trains on long runs are scheduled at such speeds.

At the point where the accident occurred there were no rail braces used on the outer rail, and the speed scheduled was 56·6 miles per hour. The speed of the train to which the accident occurred was between 50 and 60 miles per hour according to the motorman and an inspector riding in the cab, and 70 miles per hour according to the testimony of passengers.

The track was laid with tie plates, and while these act to hold the spikes up to the rail and to prevent the rail from cutting into the tie, they at the same time reduce the frictional resistance with which the rail resists lateral displacement. A point that must be considered is that the weight upon the rail is an important factor in holding it in place.

One of the points well known to those having to maintain tracks is the continual tendency of curves to get out of line; and the use of transition spirals, while it tends to reduce this trouble, cannot entirely obviate it.

With wooden ties it is well known that the outward force on curves rapidly pulverises wood under the outer edge of the rail flange and necessitates the trackmen adzing the tie off to get a new bearing surface. These forces have also been known to attain sufficient intensity to slide the rail along the ties, crushing the spike into the wood, and in some cases partly pulling them. The rail also tends to deflect or spring more or less between the spikes, and in the course of time the flange of the rail cuts or wears a groove in the spike immediately under its head. This wearing occurs more rapidly under heavy high-speed traffic than under other conditions, and is well known to experienced trackmen. Such grooves will greatly weaken the spike as regards its shearing resistance.

Upon the curves the outer rail is elevated in order to partly counteract the centrifugal force tending to throw the moving train off at a tangent.

According to the formula $e=\frac{v^2G}{Rg}$, where e = superelevation in inches, v = velocity in feet per second, G = track gauge in inches, R = radius of curve in feet, g = gravity = 32·2, for a speed of 60 miles per hour the superelevation of the outer rail should be 7·31 in. instead of the $4\frac{1}{2}$ in. as measured. The equilibrium speed for a superelevation of $4\frac{1}{2}$ in. is 47 miles per hour. The speed scheduled at this point, according to the testimony, was 57·6 miles per hour.

The train to which the accident occurred consisted of five coaches and two electric locomotives, two locomotives being used owing to the fact that the contact shoes on one side of each locomotive had been broken off; the shoes on one locomotive were on the opposite side to those on the other, and as the contract rail is not continuous on one side of the track, being broken at cross-overs and turn-outs, it was necessary to use both locomotives in order to avoid danger of the train stalling at such a gap in the contact rail. The use of the two locomotives does not affect the stresses produced in the track. The weight of the wrecked train was 335·25 tons.

The electric locomotives used by the New York Central were designed and built by the American Locomotive Co. and the General Electric Co. They are of the 2-8-2 type.

N.Y.C. Electric Locomotive Dimensions.

General—	
Class of traffic	Fast passenger.
Gauge, standard	4 ft. 8½ in.
Total length over buffer platforms	37 ft.
Extreme width	10 ft.
Running Gear—	
Driving wheels, eight, diameter	44 in.
Truck wheels, 2 front, 2 rear, diameter	36 in.
Trucks	Centred by springs.
Diameter of driving axles	8½ in.
Wheel Base—	
Driving	13 ft.
Total	27 ft.
Weight—	
On driving wheels	137,000 lb.
On truck wheels	52,000 lb.
Total in working order	189,000 lb.
Power—	
Supply, direct current	600 volts.
Conductors	Overhead and third rail.
Motors, four GE-84-A, each 550 H.P.	2,200 H.P. rated.
Maximum power of locomotive	3,000 H.P.
Normal full-load current	3,050 amperes.
Maximum current	4,300 amperes.
Normal draw-bar pull	20,400 lb.
Maximum starting draw-bar pull	32,000 lb.
Speed with 500 ton train, on level	60 miles per hour.

Control: Sprague-General Electric multiple unit, with automatic current-limiting lock in the master controller. Series-parallel, from four motors in series to four in parallel.

* Abstracted from the *Electrical Age*.

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The locomotive was designed to enable an acceleration of 0·5 to 1 mile per hour per second to be obtained with trains up to 800 tons and to give a maximum speed of 60 miles per hour with a 500 ton train.

The two-wheel trucks at either end were connected to the main frame by a radius arm and, owing to the short wheel base, the locomotive was very flexible laterally.

In Fig. 1 a graphical comparison is made, showing approximately the distance from the top of the rail to the centres of gravity and the location of the points of spring suspension with reference to their centres of gravity for the steam and electric locomotives. The triangle CGS, SPS, SPS being for the steam and CGE, SPE, SPE being for the electric machine. The effect of this spring suspension is to introduce a certain amount of pendulum action in the side sway of the two machines, also the centrifugal force of the suspended weight has a tendency to move it entirely independent of the running gear. This side force can be resolved into two components with regard to its effects, one of them tending to compress the springs on one side of the machine and to lessen the load on the opposite spring, the other component being a force parallel to the tops of the rails and tending to force the outer rail on a curve outward or on a tangent to spread the rails.

The difference in the method of suspension of the two machines arises from their mechanical differences. In the steam locomotive the journals on the driving axles are located between the wheels, which brings them very close together. In the electric locomotive the space between the wheels is entirely occupied by the motors, hence the journals are outside of the wheels, and nearly twice the distance apart of those for the steam locomotive. At the same time the centre of gravity of the electric machine is much closer to the

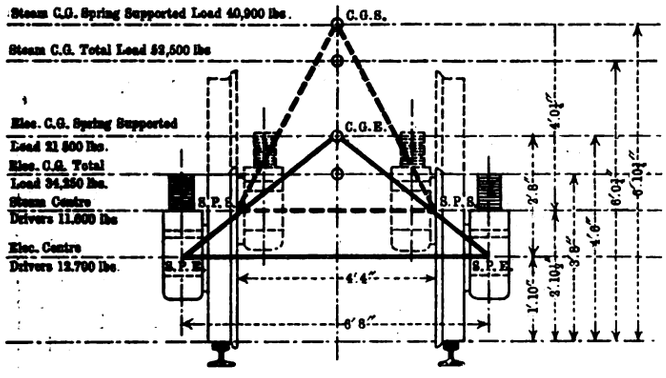

FIG. 1.—GRAPHICAL COMPARISON OF THE LOCATION OF THE CENTRES OF GRAVITY AND POINTS OF SUPPORT OF THE STEAM AND ELECTRIC LOCOMOTIVES USED BY THE NEW YORK CENTRAL AND HUDSON RIVER RAILROAD. Full lines Electric Locomotive; Dotted lines Steam Locomotive.

top of the rails than that of the steam machine. While this low centre of gravity makes the electric locomotive less liable to upset, and reduces the effect of the side lurches in their effect upon those riding in the machine, the horizontal impact of the machine against the side of the rail will be somewhat greater than for a steam locomotive, as the largest component of the force of these lurches causes side pressure and tends to displace the outside rail on the track laterally.

The following table gives the horizontal centrifugal force generated by the axle loads of steam and electric locomotives in passing around a 3⅛ deg. curve at different velocities reduced by the effect of gravity due to 4½ in. and 7·31 in. superelevation:—

Centrifugal Force due to Total Weight on Axle in Pounds.

Speed. Miles per hour.	Electric drivers.		Steam drivers.	
	4½″ Elev.	7·31″ Elev.	4½″ Elev.	7·31″ Elev.
50	335	−1,395	513	−2,027
60	1,692	− 28	2,593	− 47
70	3,284	+1,564	5,035	+2,395
80	5,161	+3,441	7,912	+5,272

The above forces can be resolved into two components, one producing pressure on top of the rail, the other pressure on the side of the rail tending to force it laterally out of position. These force components are tabulated below for superelevations of 4·5 in. and 7·31 in.

The accompanying tables are of interest in regard to the total difference between the two types of locomotives. In the electric locomotive the spring-supported load is 21,500 lb., compared with 40,900 lb. in the steam machine; the weight of the drivers, armatures and

Centrifugal Force in Pounds Parallel to Tops of Rails.

Speed. Miles per hour.	Superelevation 7·31 in.		Superelevation 4·5 in.	
	Elec. drivers.	Steam drivers.	Elec. drivers.	Steam drivers.
50	−1,380	−2,010	334	511
60	− 28	− 47	1,687	2,585
70	+1,550	+2,380	3,275	5,020
80	+3,415	+5,230	5,144	7,895

Centrifugal Force in Pounds Pressure on Top of Rail.

Speed. Miles per hour.	Superelevation 7·31 in.		Superelevation 4·5 in.	
	Elec. drivers.	Steam drivers.	Elec. drivers.	Steam drivers.
50	−180	−254	27	41
60	− 4	− 6	135	207
70	+200	+312	263	402
80	+447	+688	413	633

axle being in the former 12,750 lb., against 11,600 lb. for the drivers and axle of the latter. From this it can be seen that the gyroscopic action would be very nearly equal, as would flange pressure due to the weight of these parts. Therefore any difference in the action of the machines must be due to the spring-supported weight and the method by which it is hung, as is shown in the diagram. The following table compares the centrifugal force due to the normal spring-supported weight on the driving axles of both locomotives together with the component of this force which would pass into the springs and become vertical pressure on the rail on a curve of 3⅛ deg. with 4·5 in. superelevation:—

Speed, miles per hour.	Centrifugal force.		Component on springs.	
	Elec. drivers.	Steam drivers.	Elec. drivers.	Steam drivers.
50	210	421	80	390
60	1,062	2,046	424	1,810
70	2,062	3,936	824	3,670
80	3,240	6,199	1,300	5,740

The force of the blow resulting from side lurches is small, owing to the fact that there is only ⅜ in. play in the axle journals. But there is another point to be considered—track irregularities and curves. In taking a curve the entire suspended weight is forced to travel sideways at a rate equal to the versed sine of the angle through which the train moves in one second. This energy produces only static pressure on a true curve with all of the ties tamped equally tight and all of the spikes tight against the rail flange. The impact forces due to curvilinear deflection can be computed by the formula—

$$\frac{WV^2}{2g} = E$$

In which

E = foot pounds energy in moving body.

W = weight of moving body in lbs.

v = velocity in feet per second.

g = gravity = 32·2.

For the case in hand the weight of the moving body will be the centrifugal force due to the speed less the effect of gravity due to the superelevation. This has been computed for 3⅛ deg. curve with 4·5 in. superelevation.

Spring-Suspended Load on Electric Locomotive Drivers.

Speed. Miles per hour.	Versed sine in feet of distance travelled per second.	Foot-pounds energy due to curvilinear deflection on the curve.
50	1·445	6·8
60	2·083	72·0
70	2·853	261·0
80	3·682	682·0

This energy, which may come into action at any irregularity of the track equal to the versed sine given above, is resisted entirely by the spikes and the friction between the rail and the tie plate. The coefficient of friction of metal on metal varies from 0·25 to 0·15. For the case in hand the friction may have been anything between 4,300 lb., increased by the unbalanced centrifugal effect and that due to a thoroughly well-lubricated surface. This frictional resistance is less than the side pressure of the locomotive at a speed above 75 miles per hour at 4½ in. elevation. This would bring the resultant lateral resistance on the spikes alone above a speed of 75 miles per hour. Owing to the fact that the track is elastic laterally as well as vertically, it is very improbable that circumstances should arise by which the entire energy of lateral displacement would be concentrated on one spike.

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Track spikes, used with 100 lb. rails, are § in. square, their area in shear being 0·4 sq. in. and the bearing area of the rail against them is 0·2 sq. in. According to tests the shearing strength of steel is 8/10 of its tensile strength, or from 48,000 lb. to 50,000 lb. per square inch. According to some experiments it would require from 360 to 440 ft.-lb. to shear a § in. square spike. It is probable that less energy would be required after the spike had been in the track a while as the area in shear becomes reduced. From this it can be seen that the factor of safety in this piece of track, supposing one spike only to act and considering the spring-suspended load only, was from 50 to 64 at 50 miles per hour, from 5 to 6 at 60 miles per hour and 1·4 to 1·7 at 70 miles per hour, and 0·53 to 0·65 at 80 miles per hour on the basis that the irregularity of the track is equal to the versed sine in feet. On the other hand, if, as held by many of the most eminent railroad engineers in the country, not less than two spikes resist the shearing stresses then we have a factor of safety at 70 miles per hour of from 2·8 to 3·4. It must be borne in mind that this assumed speed is 24 miles per hour in excess of the speed for which the curve is elevated.

HOT-WIRE WATTMETERS AND OSCILLOGRAPHS.*

BY J. T. IRWIN.

Summary.—In this Paper the author describes a new type of hot-wire instrument, which can be used for measuring voltage, current and power. He also shows how it can be adapted for use as an oscillograph, and also for recording B – H curves.

Up to the present, polarised hot-wire instruments have not been used, and herein the author describes a new type invented by him and some of the uses to which it can be applied.

In Fig. 1 CD and EF are two wires or strips of the same size; one pole of a battery, B_1, is applied to DE, and the other pole of the battery is connected through two resistances, R_1R_1 to C and F. If the resistance of CD is equal to EF $= r$ (say), then there will be a current, b, flowing in each wire. If another current, a, from any other source is sent from C to F through both the wires in series, the whole current a can be assumed to pass through the strips CD,

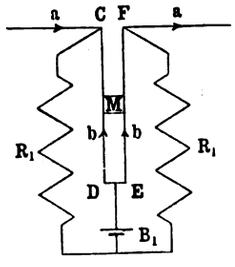

FIG. 1.

EF owing to the resistances R_1R_1 being large compared with the resistance of the strips, then the rate of heating in the right-hand wire will be $(a+b)^2r$, and the rate of heating in the left-hand wire will be $(a-b)^2r$. The difference in the rate of heating will be equal to $4abr$. In any case the difference in the rates of heating is proportional to $4abr$. Therefore, if b and r are constant, the difference in the rates at which energy is given to the two strips is proportional to the current a, and if the current a reverses in sign, the difference will reverse in sign. If the wires CD and FE are each drawn back with equal and constant tension at their middle point, then a small mirror, M, placed across the two wires will be deflected through a certain angle proportional to the difference in temperature between the two wires and this difference in temperature is proportional to $4abr$ if the current a remain constant for some time. Therefore, one has a polarised instrument in which the deflection for small angles is practically proportional to the current.

Although it might seem an easy matter to arrange to draw back the two wires with equal and constant tension, it is difficult when one considers that the movement in some particular instruments may be of the order of $\frac{1}{10000}$th of an inch. It is also necessary that the initial sag of the two wires should be the same, so that the sensibility shall be the same. The author spent some considerable time in trying to arrange two springs to draw the two wires back or push them forward with equal tension, and although he could get the deflection on each side equal to within about 10 per cent., this method was abandoned in favour of a better arrangement shown in Fig. 2. The wires CD and EF in Fig. 1, instead of being pulled back at their middle point, pass over independent and insulated pulleys P, P′ and return almost parallel to each other and to their outgoing length as shown in Fig. 3, where the wire CC′D′D corresponds to the wire CD in Fig. 2. A similar wire EE′F′F will pass over the pulley P′; these two systems of wires are tied together diagonally, that is, the wire CC′ is tied at its middle point to the middle of the wire F′F, and the wire EE′ is tied back at its middle point to the middle of D′D. This is shown in Fig. 4. Now as the current passing through the wire CC′ is the same as that passing through D′D, if they are of the same length and of the same size, the expansion of each wire will be the same since the rate of losing heat is the same. The pulley P will not rotate and will only serve to ensure that there is equal tension on each wire. The pulleys P, P′ are drawn up by the spring S. If there is no current passing through CC′D′D or EE′F′F, and if the wires are exactly similar at the same temperature, then the sag of the wires CC′, D′D, EE′, and F′F will be equal in each case. If a current is sent through the four

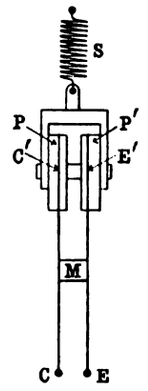

FIG. 2.

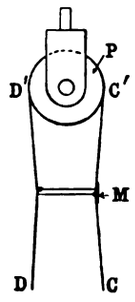

FIG. 3.

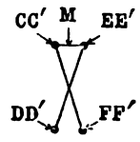

FIG. 4.

portions, in series, then there will be an increase in length in all four wires, but there will be no deflection of the mirror. If the wire CC′D′D is heated it will sag more than the wire EE′F′F, and therefore the mirror will be tilted by an amount depending on the difference in the rates of heating in the two wires. This is very approximately correct for this type of instrument. Fig. 5 shows the curve connecting deflection with current passed through the two strips in series, when another constant current is sent through the two strips or wires in parallel as shown in Fig. 6. It will be seen that it is very nearly a straight line, any deviation from the straight line law being almost within the limits of experimental error. The only objection to the instrument used in this way is that it requires a constant exciting current, and this would be a drawback to its general use. It could be used as an ammeter, voltmeter, or ballistic coulombmeter.

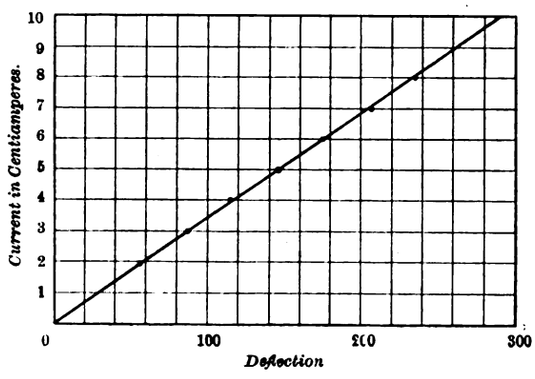

FIG. 5.

There is a special case, however, where the instrument described has many advantages—namely, where it is required to measure the instantaneous voltage across two points or the instantaneous current flowing in a circuit. Suppose one wishes to measure the P.D. at every instant between two points, AB (Fig. 7). The instrument CDEF is placed in series with a non-inductive resistance, R_4. If the difference of potential across AB varies very slowly the deflection of the instrument will be practically proportional to the P.D. at every instant. But even by immersing the wires and mirror in oil, which enormously increases the rate of cooling, the instrument could only indicate accurately for frequencies up to about 5 per second. To make the instrument practical for ordinary frequencies, the resistance R_4 in Fig. 7 is shunted by a condenser, K. The resistance of the instrument itself is low compared with the resistance R_4, being about $\frac{1}{200}$th of it for a R.M.S. voltage of 100 across

* Abstract of a Paper read before the Institution of Electrical Engineers.

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AB. In this case there is a current flowing through the instrument at any instant proportional to the difference of potential across AB, plus a current proportional to the rate at which the potential across AB is varying, this last current flowing into the condenser.

To make the difference of temperature at every instant proportional to the quantity stored in the condenser, the condenser is shunted with a resistance, R_4, and the current can be arranged to produce a difference in heating effect equal to the radiation losses which are proportional to the voltage. In fact, one may regard the strips as thermal condensers, which are very *leaky*, and to compensate for this leakage one makes the electric condenser equally leaky by shunting it with a resistance.

When these conditions are fulfilled the difference in temperature between the two sets of wires will at every instant be proportional to the voltage across the two points AB, that is, assuming the drop across the instrument itself is small compared with the voltage across R_4. Whether the deflection at every instant will be proportional to the voltage across the points AB depends upon the forces acting on the moving parts, on the inertia, and on the damping. This will be considered further on.

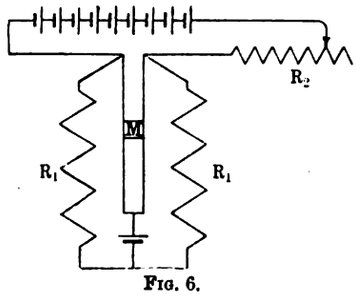

FIG. 6.

To use the instrument for indicating the instantaneous value of the current flowing in a circuit the arrangement shown in Fig. 8 is used, where the current is comparatively large compared with that taken by the strips.

A coil with self-induction L and resistance R is placed in the main circuit AB. The P.D. across the two strips and the current that flows through them in series is proportional to $cR+L\frac{dc}{dt}$, and if R and L are chosen so that R/L=the ratio of the difference in the rates of dissipating heat to the difference in the quantity of heat stored for a given difference in temperature, then the difference in temperature will be proportional to the instantaneous current in AB. The author gives a proof of this in his Paper.

If the current flowing in AB is very small, then the arrangement shown in Fig. 9 is more suitable, where practically all the current

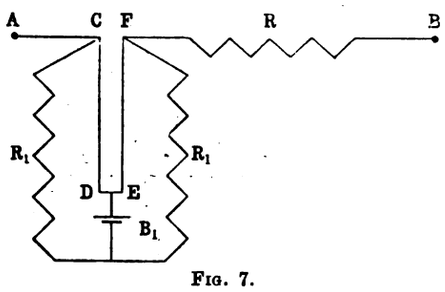

FIG. 7.

flows through the two strips in series and through the primary of a transformer, the flux in which is practically proportional to the current. The secondary of the transformer is of few turns, and the ampere turns on the secondary are small compared with the ampere turns on the primary. When this is so the current flowing in the secondary is proportional at any instant to the rate of change of the primary current.

To enable the instrument to indicate the instantaneous power given to a circuit, the author shows that the difference in the rate of heating of the two strips should be equal to $vc+v\frac{dc}{dt}+c\frac{dv}{dt}$.

Before considering how to get a deflection proportional to the instantaneous watts given to a circuit, it is advisable to consider how the instrument could be used for indicating the mean power given to a circuit.

Mr. M. B. Field has shown, Patent 15,168[07], that if a is the instantaneous value of the current flowing in a circuit, and b is the instantaneous value of the voltage, the instantaneous power given to the circuit is $a\,b$ watts, also as $(a+b)^2-(a-b)^2=4\,a\,b$; that is, the power given to a circuit is proportional to the difference between the sum of the current and voltage squared and the difference of the current and voltage squared.

Of course a and b may be only proportional to the main current and main voltage respectively. Suppose a circuit arranged as shown in Fig. 10, where R_3 is a resistance in the main circuit and R_4 is a resistance in series with the strips r_1r_1 in parallel placed across the main circuit. The author shows that the difference in the rate of heating is proportional to C_2v—that is, to the watts spent in the circuit.

The author generally mounts three instruments together to show at the same time three waves—say, current, P.D. and power. Three P.D. waves can be shown at once, say, the P.D. difference across a resistance and inductance in series and the P.D. across the resistance and the P.D. across the inductance separately. As the instruments can quite easily have independent exciting circuits—say, a small 4 volt battery for each—and as the wires of each instrument can be easily insulated from the others and from the case, it is possible to have a potential of 200 volts or more between the various instruments, as long as care is taken in making the connections.

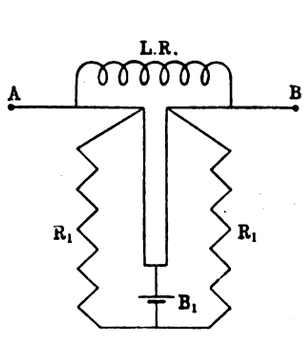

FIG. 8.

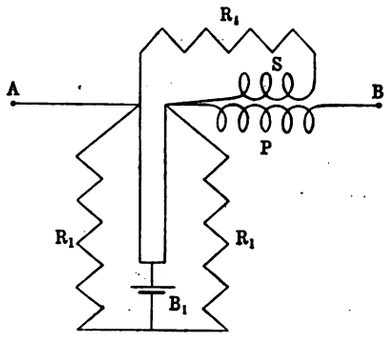

FIG. 9.

The instrument is made with three elements and is very compact, weighing complete with its levelling screws only 1¾ lb. The mirrors are fairly large, being 4 by 1·5 mm. for projection purposes, the natural period is about $\frac{1}{400}$th of a second, but it can be made much less by using a smaller mirror and tying back the wires more at the centre; in fact, if necessary, any natural frequency up to 20,000 per second is quite possible.

Altering the tension with which the wires are stretched does not alter the natural period very much, the amount the wires are tied back having a greater influence than the tension. In a particular

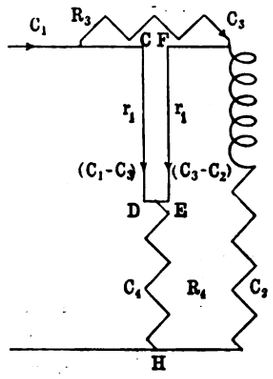

FIG. 10.

case, altering the tension on one instrument from 10 oz. to 6·6 oz. only increased the natural period from $\frac{1}{3200}$th of a second to $\frac{1}{2000}$th of a second.

As shown earlier in the Paper, the deflection can be made proportional at every instant to the instantaneous voltage across two points, or to the instantaneous current flowing in a circuit independent of the frequency, and this although the instantaneous deflection is not proportional by any means to the current flowing through the instrument itself. Since the difference in rate of heating of the wires isequal to 4 abr where b and r are constant, the difference in the rate of heating of the two wires is proportional to a and the temperature difference to at or quantity of electricity that has passed through them. Then, if there is comparatively little difference in the rate of radiation compared with the difference in the amount of heat stored in the strips in a given cycle, or if the difference in the heat radiated can be compensated for, the deflection of the instrument will be proportional to the quantity of electricity that has passed through it, and can be used to indicate the instantaneous flux linking with a circuit. This is very useful for drawing hysteresis loops for iron or showing the instantaneous value of the quantity of electricity stored in a condenser.

(To be concluded.)

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THE INSTITUTION OF ELECTRICAL ENGINEERS.

The report of the Council of the Institution of Electrical Engineers for the past session, which was presented at the annual general meeting last week, shows a very satisfactory state of affairs. The membership is steadily increasing, and this year for the first time the total membership exceeds 6,000, though the rate of increase is not so high as it was a few years ago. This, however, can scarcely be expected. The Students' Section is noticeable for its steady growth and for its activity, both in London and in some of the local sections, where special students' meetings are held.

During the past session there has been no lack of Papers, and these have been of more than usual interest. It has sometimes been said in the past that the Papers read in London compare unfavourably with those read at local sections, but we do not think that this view can be taken of the Papers read during the past session.

Turning to the internal work of the Institution, it is evident that a great deal has been done, and that the members forming the various committees have not spared themselves in endeavouring to carry out work of real

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utility. The new edition of the Wiring Rules has been so recently discussed in our columns that we need not do more than refer to them, and express satisfaction at the announcement that they have been adopted by 32 Fire Offices. This is certainly a move in the right direction, and we hope that before long no Fire Offices having rules of their own will remain. Any points of interest to the Fire Offices can very well be considered by the Wiring Rules Committee of the Institution, and any points referring exclusively to fire risks will certainly receive sympathetic consideration.

The position of *Science Abstracts*, which in past years caused the Council a good deal of anxiety, appears to be increasingly satisfactory. Whereas the contribution of the Institution towards the cost of this publication in 1905 was £676, the amount fell in 1906 to £394, and there has been very considerable financial support from the general public. The sum contributed by the Institution cannot be considered a large amount towards the production of a work of reference of increasing value, such as all those who use the Abstracts must find them to be, and we do not think that any members can feel that such a sum is ill-spent

As to the financial position generally, this appears to be sound, the net assets amounting to over £40,000. But although a building site has been acquired, it will no doubt be a long time before the Institution can have a home of its own, unless some private benefactor arises, for the building fund is less than £21,000 at the present time, including the sum spent on the site. The growth of the fund is steady, the increase during the year amounting to over £875, but even so it will be many years before a sufficient sum will have been obtained to provide an adequate building, or that the general funds will admit of the increased charges due to upkeep.

We are glad to see that a serious attempt is at last being made to bring the library up to date and to make it worthy of the Institution. Up to the present time it has been little more than a library in name. The Library Committee, however, have taken matters seriously in hand, with the result that a sum of £650 is being expended in the purchase of books, and the yearly grant of £75 for new books and binding has been increased to £150. The accommodation has also been improved, and it appears that the library will very shortly be one of real utility to the electrical engineer.

Another point of the greatest importance referred to in the report is the procedure in nominating candidates for election to the Council. According to the articles of association a list of the candidates nominated by the Council must be announced at an ordinary general meeting a certain time before the annual general meeting, and any Member may make further nominations, provided these are sent in to the secretary in writing within seven days after the ordinary general meeting at which the Council nominees are announced, and provided that such additional candidates are proposed and seconded by two Members and supported by eight other Members. This may sound at first sight a reasonable sort of proposition, but as a matter of fact it is practically impossible for the list of nominations to be considered and other candidates to be put forward in so short a time. A matter of this kind is evidently one requiring discussion and careful consideration before any fresh nominations are made, and it is also necessary to obtain the sanction of the new nominees as well as the support of the number of Members mentioned. Consequently, the time allowed is altogether inadequate. In order to overcome this difficulty the Council have decided that in future the names of their nominees shall be circulated to all members of the Institution at least a week in advance of the ordinary general meeting at which the announcement is to be made by the Council. It is well that the Council should take the members into their confidence as far as possible in making their nominations, for it is frequently felt that a certain number of engineers who are occupying a leading position in the profession have no concern with the affairs of the Institution. This feeling is a source of weakness. We think that it should also be remembered that, although dissatisfaction may sometimes be felt at the nominations that are made it is a very drastic step for any member to oppose the nominations of the Council. Such a step can never do any good to the Institution, and it is difficult to get members to take an active part in such a movement, however strongly they may feel on the subject. It is, therefore, all the more necessary that the Council should take as broad a view as possible in the selection of candidates, so that they may fairly represent the views of the Institution as a whole.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Electrons, or the Nature and Properties of Negative Electricity. By Sir Oliver Lodge, F.R.S. (London: George Bell & Sons.) Pp. xvi.—230. 6s. net.

This work is based upon a Paper read before the Institution of Electrical Engineers in 1902, and reproduced in *The Electrician* at the time (*see* Vol. L., p. 313, &c., and Vol. LI., p. 123, &c.) Kaufmann's proof of the purely electrical mass of the electron is added, and the electrical theory of matter is discussed in greater detail. The book forms a useful summary of the experimental and theoretical work carried out for the purpose of determining the properties and quantitative characteristics of the electron. Special chapters are devoted to the speed and e/m of cathode rays, to the ionisation of gases, and to the determination of the mass of the electron. The bulk of the remainder deals with what the author calls the electric theory of matter, being an attempt to explain inertia in terms of inductance. Thomson's latest experiments and conclusions are admitted to have dealt a "heavy blow" to this theory, but the author does not regard the matter as finally decided, and in any case a candid exposition of the pros and cons of the question cannot fail to be valuable. Last year's experiments of Kaufmann do not seem to have been considered, unless a remark on p. 230 can be taken as referring to them. The author touches lightly upon some of the applications of the electron theory to the ordinary manifestations of electrical activity, such as conduction and radiation, and makes a first attempt to bring cohesion within the scope of electrical science, though this can hardly be described as very convincing. A number of miscellaneous questions are dealt with in the 12 appendixes. One of the most interesting of these deals with the size of the orbit of a radiating electron, which is of the order of 10^{-8}, or the size of the atom to which it is attached. This is the calculation touched upon in Pellat's recent investigation of the maximum wave-length emitted by such electrons. The dimensional speculations in appendixes C and D are open to considerable criticism. If anything is certain in this imperfectly explored field, it is that μ, the magnetic permeability, is not a "density" (mass per unit volume). As regards the

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dielectric constant, it has no meaning apart from the electric charges contained in the medium, and is expressible in terms of the number and configuration of those charges. This fact at once marks it off from the gravitational constant, which is independent of all matter contained in the medium. The author sums up in favour of the provisional theory that the ultimate elements of which atoms are constituted are—in their dynamical relations—purely ethereal structures of some sort which probably we cannot yet adequately imagine.

Transformatoren und Asynchronmotoren. By W. WINKELMANN. (Vol. V. of "Grundriss der Elektrotechnik," edited by A. Königswerther). (Hanover: Dr. Max Jänecke.) Pp. 136. 4.20m.

This useful little work contains a sketch of the theory of choking coils, transformers, and induction motors and generators. Very little knowledge is assumed on the part of the reader, and the explanations given are characterised by brevity and clearness. The choking coil is first dealt with, as it forms a suitable introduction to the study of transformers, and the design of a choking coil to fulfil given conditions is fully worked out by way of example. The theory of the transformer is treated in considerable detail, and a good deal of space is given to the consideration of magnetic leakage. About two-thirds of the entire work are devoted to induction motors. The general principles underlying the action of an induction motor are first explained, and then its theory is developed by the aid of graphical methods, the circle diagram being introduced in the form originally given to it by Heyland. The predetermination of leakage coefficients and the calculation of the E.M.F. induced in the windings of an induction motor are then dealt with. We would specially commend the chapter which contains practical data relating to induction motors: it is replete with thoroughly practical and up-to-date information regarding such motors. The last chapter contains a sketch of the asynchronous generator and of compensated and compounded asynchronous machines. The engineer and student alike will find this little volume of 136 pages a useful and reliable guide to the subjects with which it deals.

The Science Year Book. Edited by Major B. F. S. BADEN-POWELL. (London: King, Sell & Olding.) 5s.

The third annual edition of this book opens with a portrait of Lord Rayleigh as frontispiece, and contains a large number of useful scientific data, details of learned societies and educational establishments and biographies of well-known men. It would seem, however, to require more careful revision. For instance, under the heading of learned and scientific societies, last session's presidents are frequently given. As in most cases the session starts in November, the book must have gone to press very early. A diary, bound up in the same volume, enhances the usefulness of the work.

RECENT CONTRIBUTIONS TO ELECTRIC WAVE TELEGRAPHY.*

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The achievements and possibilities of wireless telegraphy have not yet ceased to interest the public mind. In less than 10 years from the practical inception of that form of it conducted by electric waves, it has developed into an implement of immense importance in naval warfare and manœuvres. It has provided a means of communication between ship and shore which has added greatly to the safety of life and property at sea. It has so far altered the conditions of ocean travel that great passenger liners, separated by vast distances on stormy seas, speak to each other through the æther with far-reaching voices, and are never out of touch with land during the whole of their voyage from port to port.

You are doubtless aware that it is now the usual thing for an Atlantic liner equipped with long-distance receivers to be in communication with either the Marconi stations at Poldhu in England or Clifden in Ireland and that at Cape Cod in the United States throughout the voyage, and at the same time to exchange messages not only with other shore stations when passing but with a score or so of sister vessels during the journey.* On board many of the Cunard liners small daily newspapers are published containing the latest news of the day sent by wireless telegraphy from both coasts.

Every important Navy in the world has now adopted it in some form as an indispensable means of communication. In our own Navy, Admiral Sir Henry Jackson, to whom the country is so much indebted in this matter, informs me that every ship above the size of a torpedo boat is or soon will be fitted. Large battleships carry fairly high-power transmitters for long-distance work. The Admiralty are satisfied that this method of signalling is of the greatest utility, and there is no need to remind you of the evidence of this furnished in the recent Russo-Japanese war. No modern liner or large passenger vessel is now complete without a wireless telegraph equipment, and an elaborately organised system of communication has been created by the Marconi Company in connection with this marine telegraphy.

Concurrently with this practical development of the art, much scientific investigation has been conducted, having for its object the elucidation and measurement of the various physical operations involved, as well as further improvements. There comes a time in the history of every applied science when the ability to measure

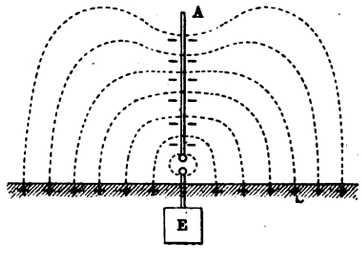

FIG. 1.—LINES OF ELECTRIC FORCE ROUND AN ANTENNA BEFORE DISCHARGE.

precisely the effects concerned is a condition of further progress. It is this alone which enables us to test our theories or hold in leash hasty opinions as to the possibilities of the invention.

In considering then, during the present hour, some of the recent contributions to this new telegraphy, we may pay a moment's attention to the nature of the things or effects in it which can be measured. An essential element in all electric wave telegraphy is the elevated insulated wire or wires called the antenna, in which high frequency electric currents are set up, and from which the electric waves radiate. Consider a long vertical wire insulated completely from the earth and charged with electricity (*see* Fig. 1). There must be somewhere on the surface of the earth near by a charge of opposite sign. If the wire is negatively charged, then on its surface there is, according to modern views, an excess of negative ions or electrons, and on the ground surface round the wire there is a deficiency—that is, there is a positive charge. Furthermore, in

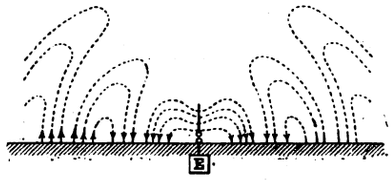

FIG. 2.—DIAGRAMMATIC REPRESENTATION OF THE DETACHMENT OF SEMI-LOOPS OF ELECTRIC STRAIN FROM A SIMPLE MARCONI ANTENNA.

the interspace around the rod there is a state of strain of some kind distributed along certain curved lines, commonly called lines of electric force. From one point of view these lines may be regarded simply as a convenient mode of delineating the direction of the strain having not more material reality than lines of latitude and longitude. There are, however, some reasons for considering that they *do* possess an actual physical existence and that they are a necessary part of the mechanism of atoms and electrons.† They

* A Friday Evening Discourse delivered at the Royal Institution of Great Britain, Friday, May 24, 1907.

* The Cunard liner "Lucania" which arrived March 18, 1907, at Liverpool from New York reported that she was, when in mid-Atlantic, in communication by wireless telegraphy with Poldhu, in Cornwall, and Cape Cod, in the United States, at the same time. During the voyage she spoke with 32 North Atlantic steamers, and with 24 of these she had wireless communication.

† *Cf.* Faraday, "Experimental Researches in Electricity," Vol. III., Series 29, 3,278, 3,297 and 3,299; "On Physical Lines of Magnetic Force." Faraday used the expression physical line of force to denote their concrete reality as distinguished from a mere geometrical conception. Also in his Paper "Thoughts on Ray Vibrations," *Phil. Mag.*, Series 3, Vol. XXVIII., 1,846, he considers that light may be a vibration propagated along lines of force. See also J. J. Thomson, "Electricity and Matter," p. 63, for an argument for the physical reality of lines of electric force drawn from the ionisation of gases by Röntgen rays.

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have a strong resemblance in many ways to the vortices or vortex lines which can be created in a fluid. Moreover, just as vortex lines in a fluid can be self-closed or endless, or else terminate in little whirlpools on the free surface of the liquid, so lines of electric force can form either closed loops or else have their ends terminating on opposite charges of electricity—that is, on an electron at one end and the positive charge of an atom, whatever that may be, at the other end. Suppose, then, that the rod is suddenly connected to the earth at the bottom end by allowing it to spark to the earth. Its electric charge rushes out—that is, the excess or deficit of electrons on its surface disappears, and this movement of electricity constitutes an electric current flowing into or out of the rod from the earth. The electrons, however, possess inertia or mass, hence when they rush out of the rod into the earth, they not only discharge it but overdo it, and leave the rod with a positive charge. They then rush back again and the process repeats itself, and we thus obtain a rapid ebb and flow of electricity into and out of the wire called a series of electric oscillations. Each rush, however, is feebler than the last and, therefore, the oscillations decay away or, as it is termed, are damped. The energy represented by the initial charge is frittered away partly owing to collisions of the electrons and atoms in the rod and spark during the movement and partly because the electron radiates or communicates its kinetic energy to the medium when it is accelerated or retarded.

We have next to attend to the effects taking place outside the rod or antenna. As the negative charge disappears from the rod owing to the removal of the excess of free electrons from its surface the ends of the lines of electric force which abut on it and stretch between it and the earth glide downwards along the rod and end by forming a semi-loop of electric force or strain with its ends or feet resting on the earth. This arises from the facts that the lines of force exercise a lateral pressure on each other, whilst lengthways they are in a state of tension, and also that lines of electric strain

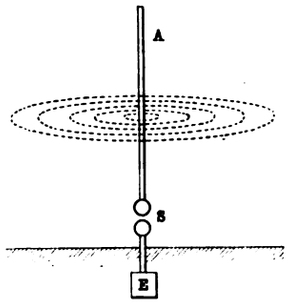

FIG. 3.—LINES OF MAGNETIC FORCE ROUND AN ANTENNA DURING DISCHARGE.

cannot exist inside a conductor such as a spark. Hence, when the spark happens, the lines which a moment ago stretched across the spark-gap disappear. There is then an unbalanced pressure on the remaining lines which are thus squeezed in towards the gap and deformed so that they finally extend, not from rod to earth, but from two adjacent places on the earth, and form a semi-loop (*see* Fig. 2).

But, as above explained, the rod does not simply become discharged. Owing to the inertia of the electrons they more than discharge the rod; they overdo it, and leave it positively charged. This, then, implies that a fresh system of lines of electric force grows up between the earth and the rod and the first-formed set of semi-loops is pushed outwards. Then the process is repeated as the oscillations of the electrons in and out of the rod die away, and in the space around we have a system of semi-loops of electric force being pushed outwards in every direction as shown in the diagrams.*

There is, however, another factor involved in the process. The movement of the electrons into and out of the rod constitutes an alternating electric current, and this is accompanied by the production of an alternating magnetic field, the direction of which is represented by a system of concentric circles with their centres on the antenna (*see* Fig. 3). When the current in the rod is reversed in direction the field is not reversed at all parts of space instantaneously, but the reversal is propagated outwards with the speed of light. Accordingly, the electric oscillations in the antenna create periodic variations of magnetic force and electric force in the space outside. At points near the earth's surface some way from the rod the magnetic force is parallel to and the electric force perpendicular to the surface of the earth or sea. Experience shows that electric wave telegraphy over any large distances cannot be conducted unless the antenna is so placed that the electric force is perpendicular to the surface of the earth or sea.

At any distance from the antenna and at any one spot the magnetic and electric forces are therefore periodically varying in magnitude, and owing to the finite rate of propagation of the forces through space we find that at certain equi-spaced intervals these forces are similarly reversed in direction at the same instant.

When we speak of the length of the electric waves we mean the shortest distance which separates two adjacent places at which either the electric or magnetic force reverses direction in the same way at the same instant.

In wireless telegraphy the length of waves employed may vary from 200 ft. or 300 ft. to many thousands of feet or several miles. The determination of this wave-length is a practically important matter, and, accordingly, instruments have been designed specially for its measurement by Dönitz, by Prof. Slaby and by me.

I have ventured to name my own appliance for measuring long electric wave lengths, a *Cymometer*.*

The importance of the measurement is as follows: We know that the properties of short electric waves constituting light and radiant heat depend upon their wave length and that some bodies are opaque to light waves but transparent to heat waves. So in the case of the much longer ether or electric waves used in telegraphy the ease with which they pass through buildings, forests, and even mountains or cliffs, or round the earth's curved surface, is determined by their wave-length. Waves of one or two hundred feet in length are considerably obstructed by the closely packed houses in

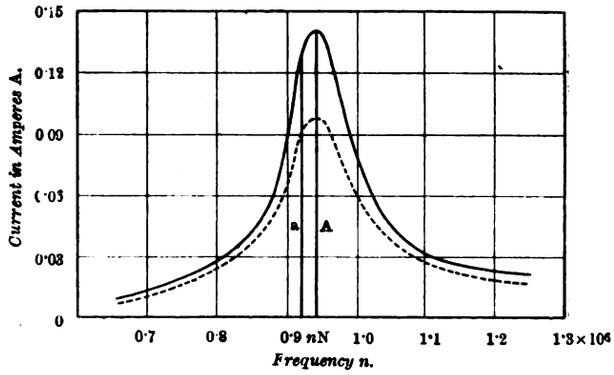

FIG. 4.—RESONANCE CURVE OF LOOSELY COUPLED OSCILLATORY CIRCUIT.

a town, but much longer waves go easily through them. The measurement of the wave-length is made to depend upon the fact that there is a simple relation between the velocity of these waves (which is the same as that of light), the *periodic time* of the oscillations in the antenna and the wave-length as expressed by the formula *wave-length = velocity × periodic time*, Since the velocity is nearly 1000 million feet per second the wave-length in feet is easily found when we know the frequency of the oscillations in the antenna. This last quantity can be found by placing near to the antenna a circuit in which secondaryelectric oscillations can be sympathetically induced by those in the antenna. For this purpose we must have a circuit which possesses the two qualities of capacity and inductance. This is secured by joining in series some form of Leyden jar or condenser and some form of spiral wire or inductance. Moreover, we must have the means of varying this capacity and inductance so as to bring the cymometer circuit into tune, as it is called, with the antenna. Every such circuit containing capacity and inductance has a natural period of electric oscillation, resembling in this respect the time of swing of a mechanical system composed of a heavy body suspended by an elastic spring.† In my cymometer the condenser part consists of one to four sliding tubes, each consisting of a pair of brass tubes separated by an ebonite tube. The outer tubes can slide off the inner ones, and so vary the capacity. The inductance consists of a long spiral of copper wire, and the circuit is completed by a thick copper bar. Matters are so arranged that when the outer tubes are drawn off the inner tubes so as to vary the electrical capacity, the effective amount of the spiral included in the circuit is simultaneously varied in exactly

* In referring to lines or semi-loops of electric force as moving through space, we do not necessarily mean to imply that each line is ear-marked so that it preserves an individual identity. All that actually happens at any point in the field is a periodic oscillation or cyclical change in the electric and magnetic force at that point. This, however, is repeated successively from point to point, and we may hence speak of the line of force as moving just as we speak of a surface wave on water as moving forward, when, in reality, the only movement in the latter case is a small up and down motion of the water at each place, or at least a circular motion of no very great extent.

* See *Proc.* Roy. Soc., Vol. 74. p., 490, 1905, "On an Instrument for the Measurement of the Length of Long Electric Waves." Also *Phil. Mag.*, June, 1905, "On the Applications of the Cymometer."

† If the capacity C is reckoned as usual in microfarads, and the inductance L in centimetres, then the time period T of the oscillation is given by the formula $T = \sqrt{CL}/5083000$.

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the same proportion. To determine when the time period of the cymometer circuit is in agreement with that of the antenna I use a Neon vacuum tube. Some three years ago I found that such a tube was extremely sensitive to a high frequency electric field, being caused to glow brilliantly when subjected to its action.

You are already familiar with the beautiful method discovered by Sir James Dewar for obtaining neon from atmospheric air by the use of charcoal at very low temperatures, and tubes filled with rarefied neon prepared by his process are able, as I have shown, to serve important purposes in connection with wireless telegraphy.

In the cymometer a Neon tube is connected to the opposite coatings of the condenser. If, then, the cymometer bar is placed near to the lower part of a transmitting antenna and we slide along the outer condenser tube, thus varying the capacity and inductance of the instrument, provided it has a suitable range, a position will be found in which the Neon tube glows brightly. The cymometer is equipped with a scale which shows for every position of its handle the corresponding frequency or time period and the related wave-length. Hence the simplest operation, which a child can perform, serves to determine in one instant the frequency of the oscillations in the antenna and the wave-length of the radiated waves. I have devised instruments of this type covering the whole range of wave-length measurement from 50 ft. or 100 ft. up to 20,000 ft. or more. An instrument of the same kind, but with a more sensitive oscillation detector than a Neon tube, can be used to measure the wave-length of waves being received on the antenna. The cymometer has other uses besides wave-length measurement. One of these is to draw a resonance curve, and thence deduce the rate of decay of the oscillations in a train and their number. In a train of oscillations the time period occupied by each oscillation, whether of current or

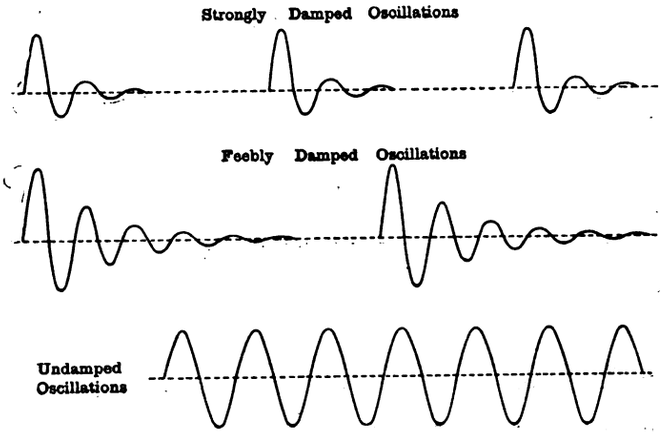

FIG. 5.

potential, is the same, but the amplitudes die away in geometric ratio. Hence the ratio of two successive amplitudes or oscillations is constant and the natural logarithm of this ratio is called the *decrement*. We can determine this decrement when we know the frequency of the oscillations in the primary circuit and the currents induced in any secondary oscillation circuit placed near to the first when the latter is in exact syntonism and also slightly out of syntonism with the primary. Employing a formula of Bjerknes we can find the sum of the the decrements D and d of the primary and secondary circuits by the formula

$$D+d=\pi\left(1-\frac{n}{N}\right)\frac{a}{\sqrt{A^2-a^2}},$$

where a is the current in the secondary circuit when it is tuned to a frequency, n, and A is the maximum current when the secondary circuit is tuned to agree with the frequency N of the primary circuit. For this purpose I modified the cymometer by including in the bar two fine resistance wires against one of which a sensitive thermo-junction of iron and bismuth is attached. This enables me to measure the value of the current in the cymometer bar. The process of measurement is then as follows: We place the cymometer alongside the antenna and slide along the handle slowly, thus altering its time period or natural frequency. We observe the current and frequency, and plot a curve called a resonance curve showing the secondary or cymometer current in terms of the frequency. This curve rises to a maximum value, sometimes very sharply, the maximum corresponding to the condition of exact syntonism between the antenna and cymometer circuits* (*see* Fig. 4). From the curve we can determine the sum of the decrements of the cymometer and antenna. A second experiment made with a known additional resistance inserted in the cymometer bar enables us to eliminate the decrement (d) of the cymometer itself, and thus find that of the antenna alone. When this is done we know what percentage each oscillation in the antenna is of the previous one. Suppose we agree that when the oscillations have decayed away to 1 per cent. of their initial value the train shall be considered to be finished, then another simple formula $M=\frac{4{\cdot}604+D}{2D}$ enables us to find the number of the complete oscillations M in a train when we know the decrement D.*

Electric oscillations are classified into highly damped, feebly damped and undamped varieties, corresponding to few, many and infinite oscillations in a train (*see* Fig. 5). In electric wave telegraphy we have

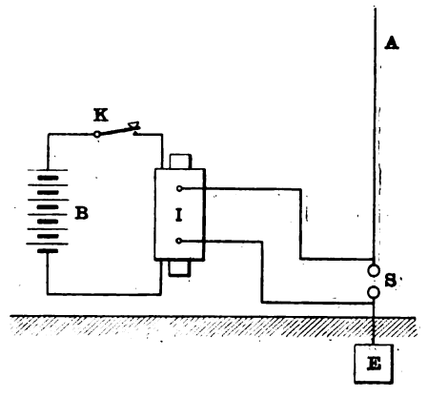

FIG. 6.—ANTENNA EMITTING STRONGLY DAMPED TELEGRAPHIC ELECTRIC WAVES.

various kinds of transmitters or wave-makers, which are intended to create these types of oscillation. In the first case, if we set up an antenna and connect the lower end to one of the spark balls of an induction coil, the other being to earth, we have an arrangement which produces highly damped oscillations and waves (*see* Fig. 6). This is due to the fact that since the capacity of the antenna itself is small the energy which can be stored up in it and liberated at each spark discharge is also small, at most a fraction of a foot pound or a few foot-pounds. Hence it is rapidly frittered

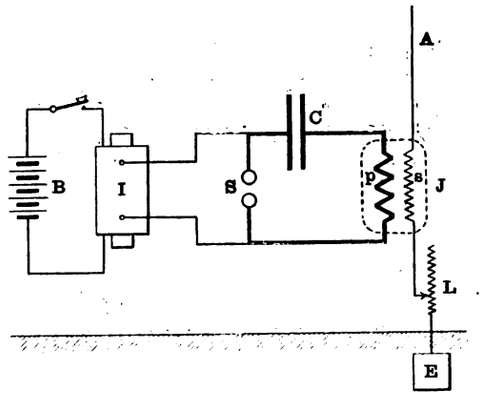

FIG. 7.—ANTENNA EMITTING FEEBLY DAMPED TELEGRAPHIC ELECTRIC WAVES.

away by resistance and in radiation and the oscillations are few—say, half a dozen or so—and highly damped. If, however, we form an oscillation circuit, consisting of a large condenser inductance and spark gap, we can store up a larger amount of energy and liberate this suddenly across the spark-gap at each discharge. If, then, these oscillations are made to induce others in a directly or inductively connected antenna, we can liberate the energy as radiation, and, having a larger store to draw upon, create longer trains, say, of 20 to 100 more feebly-damped oscillations (*see* Fig. 7).

Corresponding to these types of transmitter there are various suitable forms of receiver. With a highly damped radiator we must use some form of wave detector, such as a coherer, which is chiefly affected by the first or maximum oscillation, and this must be inserted in a receiving circuit which is easily set in oscillation by a single or, at most, a few electromagnetic impulses. On the other hand, this renders the receiver more liable to disturbance by vagrant

* If the damping of the secondary circuit is small, as it is in the case of the cymometer circuit, then the resonance curve is very sharply peaked or rises quickly to a maximum when the primary oscillations are feebly damped, provided always that the "coupling," or mutual inductance of the two connected circuits is small.

* See the "Principles of Electric Wave Telegraphy." Fleming, p. 167.

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electric waves due to atmospheric electricity, or other transmitters if of sufficient strength. If, however, we employ a feebly damped radiator emitting long trains of waves of, say, 20 to 50 waves we can make use of a stiffer receiver circuit—that is, one containing a good deal of inductance—and a detector, such as Marconi's magnetic detector, which operates under the action of feeble but oft-repeated and properly-timed impulses. We have, then, the advantage that the receiving circuit can be made far less sensible to non-syntonic or isolated impulses unless these are of extreme violence.

Again, there are certain forms of detector, such as the thermal and one of my own to be described presently, which are affected by the product of the mean square value of the oscillations during a train and by the number of trains per second. Hence in this case the effect on such a receiver at a given distance under the same conditions will be increased by increasing the number of trains of oscillations per second as well as by diminishing damping in each train. It was, therefore, foreseen that we should gain some advantage by the use of undamped trains if some form of electric radiator could be found emitting waves continuously like the steady note of an organ pipe rather than sounds like intermittent blasts on a trumpet or blows on a drum.

(*To be continued.*)

TELEPHONIC TRANSMISSION MEASUREMENTS.

In this issue we conclude our account of the discussion which took place on Messrs. Cohen and Shepherd's Paper read before the Institution of Electrical Engineers, and of which we have previously given an abstract.

Mr. J. E. TAYLOR said the authors stated that the volume was of prime necessity, and that articulation was, comparatively speaking, of secondary importance. He agreed with them so far, but thought there was a slight tendency on the part of telephone experts to ignore the question of distortion. Mr. Duddell and others had shown that a very great deal of distortion was introduced by the diaphragm of the transmitter, by the line, by the receiving instrument, and in some cases by the speaker himself. Improving the instruments would remove a proportion of the distortion, but the removal of the line distortion would be possibly a more difficult matter, and he thought telephone engineers should give some consideration to this matter. In many cases very much depended upon clearness of articulation; wireless telephone installations, for instance, depended considerably upon articulation for successful working. The main cause of distortion was the different attenuation produced on different frequencies, and if the ratio of the attenuation was taken at, say, the lowest important frequency of speech, as compared with the ratio for the highest frequency of speech, this would give the measure of distortion on the telephone circuit. With regard to microphone transmission, this did not, by any means, give a reliable sine wave.

Mr. H. LAWS WEBB said that the author's investigations showed that the early ideas of telephonic transmission were originally too high, leading to the use of very expensive line plant. Few people realised, when speaking from London to Glasgow, that for the time they had the exclusive use of 300 tons of copper worth at present about £30,000. The investigations described in the Paper went to prove that the high standards originally fixed were unnecessary, inasmuch as it was shown that it was not necessary to reproduce every variation of speech wave, and in fact the waves could be flattened out and otherwise distorted and still give a good commercial result. This was not really extraordinary, because the same thing happened in ordinary air transmission. He would like to say a word for the consonant, which he thought was very unjustly depreciated. He remembered a good many years ago astonishing a number of telephone people by analysing the capital account of a large telephone system, and showing that 75 per cent. of the capital cost was in line plant. This was a suburban system, and the percentage was therefore a little high, but in most of the present systems in England 70 per cent. of the capital was in line plant. The economic value of the Paper, as showing that less copper and less space could be safely adopted, was very great.

Mr. S. EVERSHED said that the telephone was invented 31 years ago, and as an instrument it was to-day precisely what it was then. Within a few weeks of the receipt in this country of the first telephone instrument he had constructed a telephone with a couple of baking powder boxes and pieces of tin, and it had acted, for short distances at any rate, as well as the telephone of to-day. The question of articulation was a very important one. In his experience articulation was one of the worst faults that telephones had to deal with. The problem before them was the transmission of currents of a number of different frequencies through a line. They could send them in all right, but they came out with the wrong amplitudes and the wrong phases and the whole thing distorted. His experience was that phase relationship was not very necessary for the proper understanding of speech. He thought that scales of current and time with the oscillograms shown by the authors would be an advantage.

Mr. ALEX. RUSSELL said the Paper was of value not only to the telephone engineer, but to the engineer concerned in the transmission of single-phase currents. He thought diagrams 6 and 7 very interesting and of great value, showing that Heaviside's theory was substantially correct. In reference to the exceedingly interesting matter given in the appendix, he thought the authors might with advantage have extended the mathematics a little.

Mr. F. TANDY hoped that the Paper would not lead to the ignoring of articulation. Up to a certain length of line it was true distortion could be ignored, but in long-distance transmission it became a very important element, preventing the extension of lines beyond a certain limit. The application of inductance considerably improved the shape of the wave, and one was able to speak over a longer length of line. There was no real information given to practical telephonists which would enable them to determine the right amount of inductance to put into a working circuit to get the very best results. He had found from observations that inductance actually increased the transmitted currents, and also the received currents, under favourable conditions.

Mr. D. H. KENNEDY said that he had been waiting to hear whether anyone would refer to the possibility of eliminating the human element at the sending end by the use of a gramaphone as a sending instrument. Experiments that he had made with the gramaphone had impressed him very much with the possibilities in that respect. Every endeavour should be made to extend the present commercial limits of long-distance circuits.

Mr. W. H. THORROWGOOD said he had made many experiments with telephone lines, and got fair results with iron wire. Those experiments were not quite completed, but he would suggest that, instead of adding inductance, coils of iron wire should be used. The question of using iron wire lines for telephone circuits had not received the attention it deserved.

Mr. F. GILL said that during the past seven or eight years telephone practice had undergone an entire change, a fact which did not seem to be appreciated even by telephone men, and which was certainly not appreciated by those outside the business. So far as he could judge, the schools were not devoting any serious attention to telephone problems, such as wave propagation. A student coming from a college into a central station or works could carry some of the work he had done at the college into his work; but, if he entered the telephone business, he was certainly able to bring only very little indeed out of the schools to his work. He thought the schools should give more attention to this subject. Outside those actually engaged in the business, the art was really confined to very few men. Heaviside, Pupin and Kennelly were the only ones that he could remember. As a telephone man, he would like to say that it was high time that Mr. Heaviside was recognised. He had been for a long time ignored, and by some even ridiculed, but in the past few years he had slipped into acknowledgment in a quiet and unostentatious way It was, he considered, quite time that they let Mr. Heaviside know that they recognised him.

Mr. B. S. COHEN, in reply, said that Mr. Campbell's interesting experiment showed that the transmitter resonated strongly to certain frequencies. Wein had already shown that the receiver resonated, and Heaviside had pointed out line resonance. With all those sources of distortion they could only wonder at the analytical power of the human ear. Mr. Kingsbury seemed to think that the consonants would look after themselves if the vowels were taken care of. It was not at all clear, however, how far this was true. The Welsh language was an example. It must be remembered that when carrying out telephone articulation tests, the most frequent failures seemed to occur with consonants such as b, p, d, t, and their experience was that it was the consonants that failed first. Leakage in telephone cables seemed scarcely applicable. Too much attenuation was introduced, which could not be compensated for by increasing the energy transmitted, as in telegraphy. The distortionless condition for 20 lb. cable worked out at about 200 ohms insulation per mile, and the attenuation was increased six-fold. The authors would take 800~ and 1,500~ in practice as the average and the highest important frequencies. It appeared almost inconceivable that the transmitter distortion might counteract the line distortion, and, anyway, there was, of course, no relationship between the two effects, though there might be accidental coincidence sometimes. Mr. Hill appeared to have some misgiving as to whether the results obtained with instruments of precision would not upset some of the results obtained with the voice and ear for sending and receiving respectively. He (Mr. Cohen) thought this was due to a misunderstanding. The ear must be the final arbiter in settling the transmission efficiency of a new type of circuit or instrument. Concerning leakage, the percentage increase in attenuation from that cause appeared to be small in the case of ordinary light telephone cables. 100,000 ohms per mile would, probably, have a negligible effect on 10 lb., 20 lb. and 40 lb. unloaded cable. The measurements referred to in the Paper were not corrected for leakage, as this would have quite an inappreciable effect, even assuming 140,000 ohms per mile. He had made some experiments with iron wire for barretters, but never very successfully. The lamps he had used for his bolometer were different from those used by Mr. Duddell. They were more sensitive than the ordinary lamp, and their resistance was about 1,000 ohms. Mr. Taylor, Mr. Tandy and Mr. Kennedy were all strong on articulation, and it was interesting to note that those three gentlemen were all Post Office engineers. When he had mentioned that articulation was to some extent rather negligible, he was referring more particularly to the comparatively short local junction lines and subscribers' lines; but when one had to deal with long trunk lines it was evident that articulation was more important. He still, however, considered that volume was the principal consideration. The wave filter was originally described by Prof. Kapp. The arrangement consisted of doubly wound loading coils in series, the loading coils having inductances of about 1·7 each, and a condenser was put across to junctions of the loading coils. He had found it advantageous to have some amount of non-inductive resistance in series, which appeared to make the filtering more abrupt. Mr. Taylor had mentioned the thermo-galvanometer; they did not mean that the thermo-galvanometer was not so satisfactory owing to its being a more sensitive instrument, but that they had found more trouble from external disturbance. They would furnish the time scale to the oscillograms, as requested. In reference to Mr. Kennedy's

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mention of the gramaphone, they had one for a number of experiments, but the chief fault in its use was that the records deteriorated considerably, and the articulation in that case became a factor to be dealt with. As to the lines of future progress, the insertion of inductances and the study of impedances of the terminal apparatus appeared to be the most promising lines of progress. The use of iron wire for telephone lines had been carefully considered, and for a number of reasons was not satisfactory. The amount of inducance obtained by the use of iron wire did not compensate for the extra resistance.

THE HISSING POINT OF THE METALLIC ARC.*

BY W. G. CADY.

This Paper is a preliminary report dealing chiefly with the arc between iron and copper terminals. The fact should not be overlooked that the so-called iron arc is, in air, an arc between molten globules of magnetic oxide of iron. By letting the arc burn until it has become normal, observations can be made that compare in accuracy with those in the case of the carbon arc.

Observations were first made to verify the generally accepted linear equation $E = a + bl$ connecting volts across arc with length of arc for iron electrodes. When curves were drawn showing the potential drop as a function of the length for different currents, it was found that the curves had approximately a parabolic form, suggesting that the equation should have a term involving $\sqrt{l}$.

The difficulty encountered in obtaining reliable observations in the neighbourhood of 1 ampere led to the detection of an abrupt change in the iron arc, analogous to the hissing point of the carbon arc. For currents below 1 ampere the arc burns quietly and there is no well-defined spot of light on the globule at the anode. As the external resistance is decreased so that the current increases beyond a value depending largely on the curvature of the globule, the arc suddenly contracts, a bright spot appears on the anode, hissing commences, P.D. drops and current increases slightly. Experiment showed that the effect is confined mainly to the anode. When the current is decreased the change back to the quiet stage does not take place until the current has become smaller than it was when hissing commenced, due, doubtless, to the high temperature at the anode. From the point of view of spectroscopy, it would be of considerable interest to find out whether the spectrum of the iron arc suffers a change at the hissing point. A brief examination showed nothing further than a general brightening of lines, but the question whether all lines are brightened to the same degree deserves attention.

When the current is increased to about 2 amperes, the iron arc emits a whistling sound, and the spot at the anode has a tendency to travel around rapidly, describing a circular ring. This recalls Trotter's observation of the rotation of the hissing carbon arc. It is planned to examine this phenomenon more closely, with the aid of an oscillograph.

With copper electrodes the hissing point can also be found. It occurs, with electrodes 6 mm. thick, when the current is about 0·5 amperes, with about 110 volts across the arc. The arc between aluminium electrodes was too unsteady for the detection of the effect. Zinc has thus far shown no hissing point. Something resembling a hissing point was found with an arc in air between a mercury anode and carbon cathode, but this may have been due to disturbing causes.

Lecher's assertion that the iron arc is a discontinuous discharge, while the copper arc is perfectly continuous, was put to the test for both the quiet and the hissing stages. A bolometer was substituted for the hot wire used by Lecher, but it soon became evident that the capacity and self-induction of the bolometer circuit tended to set up oscillations, causing a "singing" iron arc. This fact tends to discount Lecher's conclusions and to make the method inapplicable. Good results were obtained by connecting a self-inductance of low resistance in series with the arc. The bolometer and condenser in series were then connected in parallel to the self-inductance. In this way the bolometer became heated by oscillatory currents set up in the arc, without danger that the bolometer circuit could disturb the conditions in the arc. The results are briefly these: the carbon and iron arcs, when quiet, are continuous; when hissing, they are oscillatory. The copper arc seems always to be oscillatory, and the smaller the current the more is the bolometer heated. This point, as well as bolometric tests with other metals, is soon to be investigated.

Electric Cranes for Docks and Harbours.—Swansea Harbour Trustees have decided to go on their annual tour of inspection to Glasgow and the Tyne, in order to examine the electrical equipments at those places.

* Abstract of a Paper presented at the New York meeting of the Physical Society. From the *Physical Review*.

THE TROTTER UNIVERSAL PHOTOMETER.

A general view of a portable photometer, which has lately been placed on the market by Messrs. Everett, Edgcumbe & Co., is illustrated in Fig. 1. The design is due to Mr. A. P. Trotter, and it is claimed that the instrument is capable of measuring the illumination at any required angle; that the readings are obtained with ease and accuracy, irrespective of the colour of the light; and that the readings are easily checked. To obviate the use of the "flicker" method, an application of Crova's law was suggested for

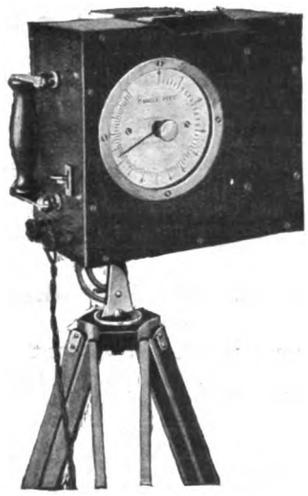

FIG. 1.—GENERAL VIEW OF THE INSTRUMENT.

eliminating the colour difficulty. Crova found that if two lights, differing even as much as daylight and an ordinary candle, were viewed through a yellow screen their relative illumination was unchanged. An adaptation of Crova's method, which consists in passing the light through a solution of definite composition and thickness, has been employed in the present photometer.

Fig. 2 shows the photometer diagrammatically. A small standard lamp, L, throws a beam of light, which is reflected by the mirror M on to the screen S_1. This is viewed through three small slits in the screen S_2, which receives the illumination to be measured. S_1 can be rotated

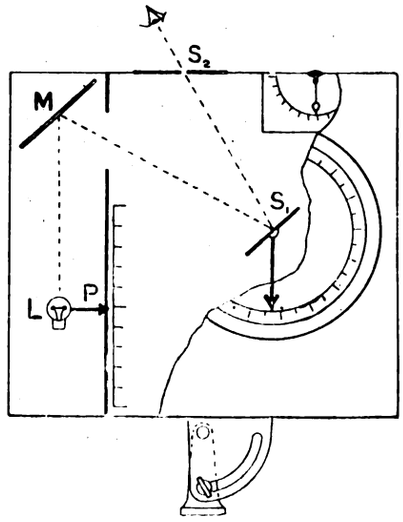

FIG. 2.—DIAGRAMMATIC VIEW SHOWING POSITION OF MIRROR AND STANDARD LAMP.

about its axis and the illumination thereby varied until a balance of brightness between S_1 and S_2 is obtained. The illumination of S_2 is then read off on a direct reading scale. As shown in Fig. 1, the instrument is for portable use, and is attached to a very light and strong folding tripod stand provided with a pivoted and hinged head enabling the photometer to be turned in any direction and set at any required angle. For ease in carrying, the 4 volt battery, which actuates the incandescent lamp, is in a separate portable wooden case. The lamp itself is carefully aged and standardised, and can be relied upon to retain its candle-power almost indefinitely since it is only in use during the actual time the reading is being taken, which

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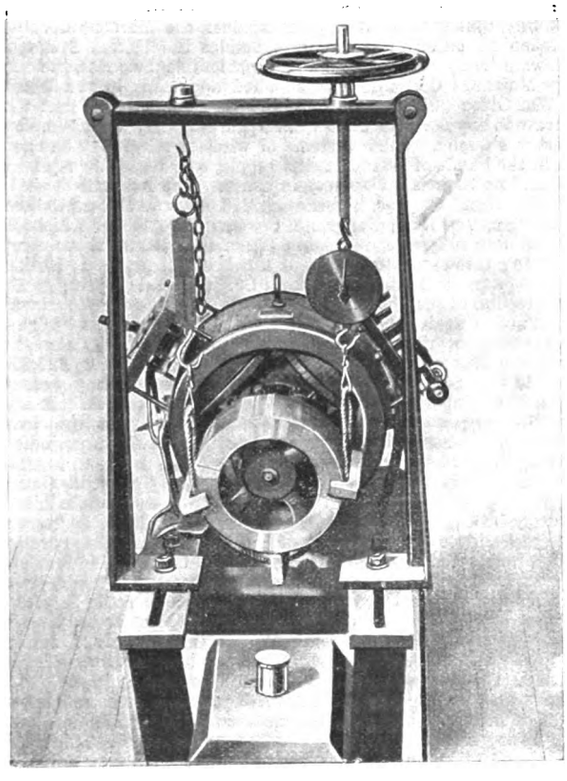
does not, as a rule, amount to more than a fraction of a minute. The glow lamp employed as a standard is so chosen that the colour of the light it gives forms a convenient mean between the yellowish tint of the ordinary low efficiency glow lamp and the whiter colour of the arc. In order, however, to make the instrument applicable to lights of every colour, specially coloured screens are provided, which can be readily substituted for either S_1 or S_2 as required. Provision is also made for measuring more or less monochromatic lights, such as the mercury vapour lamp, and so forth.

For the purpose of measuring horizontal illumination the photometer is levelled by means of the small plumb-bob inside the case, and balance obtained as previously described. This gives the horizontal illumination direct in "candle-feet." If the illumination is required, say, on a vertical plane, or at any other angle, the photometer is set accordingly by means of the plumb-bob, which moves over a graduated scale, and the measurement made as before If, instead of the illumination, the candle-power of the source of light is required, the screen S_2 is turned towards it, the correct direction being determined by means of the lens and scale, and the illumination measurement is then made. This value, multiplied by the square of the distance in feet of the photometer from the light, gives the candle-power required.

The photometer is exceedingly portable, the weights and dimensions of the apparatus being as follows: Photometer, 4 lb., 9 in. by 7½ in. by 4¼ in.; battery, 5 lb., 7 in. by 5 in. by 3 in.; and stand, 1½ lb., 19 in. by 1¾ in. by 1½ in.

COLLINS' TESTING BRAKE.

This brake, which is supplied by Messrs. Johnson & Phillips, has been designed with a view to rigidity and simplicity in working, only one attendant being required to operate the brake, at the same time taking the speed of the machine under test. As shown in the figure, the brake consists of a strip of suitable form and material,

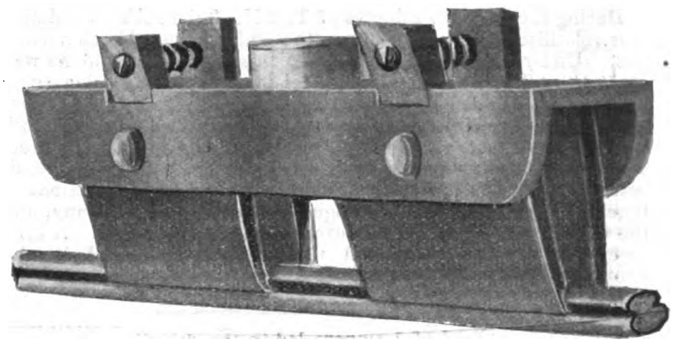


usually ropes, embracing the pulley on the machine under test; the tension on the rope being determined by a spring balance attached to each end of the brake strap, the tension of each spring being so adapted that it may be read by an index and graduated scale. The pressure on the pulley of the machine under test is adjusted by means of a screw operated by a hand wheel at the side of the brake strap which is subjected to the greater tension, so that the tension may be adjusted quickly. In the operation of this brake, should the motor under test come to a standstill, the two balances will adjust themselves to equal tension, avoiding any accident to the springs which would take place in the older form of spring balance and weight.

"I.B.F." AUTOMATIC EAR.

Messrs. Imeson Bros., Finch & Co., Stockton-on-Tees, have recently placed upon the market an automatic ear which is an ingenious invention and overcomes the difficulty experienced in the use of screwed ears.

The carriers are made of gunmetal, and the clips are made of gunmetal or malleable iron, the latter being specially made to withstand the elements. The ear is worked automatically by means of two powerful springs which are chemically prepared, not being affected by electrolysis or the atmosphere.



The weight of the whole clip is light combined with great strength. The erection of trolley wire is greatly facilitated, also time and labour is saved by the use of the "I.B.F." automatic ear, the wire being immediately released or replaced by compressing the clips. These ears are made to suit grooved and round wire of any gauge. We are informed that they have been successfully tried by several tramway companies with satisfactory results.

PATERSON'S FIREPROOF CABLES.

A sustained short-circuit on an unarmoured insulated conductor is generally made evident by a violent arc and sudden bursting of the envelope enclosing the cable, the violence of the effect depending on the energy behind the particular circuit at the moment. The sudden pressures set up by internal arcing in an insulated cable are sufficiently high to rupture the covering and to admit air which will support combustion of the insulation after current has been cut off. If means can be taken to prevent this rupture the insulation (which is always combustible) may be subjected to high temperatures but will not burst into flame nor feed any internal arc with inflammable gases. Paterson's fireproof cable is designed to preserve the insulation of a conductor intact under abnormal internal arcing or the application of external heat. In this cable the ordinary taped rubber insulation is covered with several laps of Manilla paper impregnated with a non-inflammable fluid. Over this is a strong but flexible braiding of small steel wires, covered with several more laps of the same specially-prepared paper, the steel braid being thus placed between two thicknesses of fire-resisting paper. The cable is then covered with a braiding of specially impregnated jute and finished off either in red or black fire-resisting compound.

By the invitation of Messrs. Johnson & Phillips (Ltd.) we attended yesterday a demonstration, at their Old Charlton Works, of the capacities of this special cable to resist fire, both internally and externally. The results of these tests are summarised below:—

Test 1.—Cable over Bunsen flame for half an hour, 220 volts maintained between steel protection and conductor as shown by incandescent lamp remaining alight.

Result.—After half an hour lamp still burning. Cable struck three blows with a 2 lb. hammer, no difference. Insulation resistance between conductor and steel braiding 75 megohms, with 500 volts. Cable finally short-circuited with sixth blow of hammer, the cable being quite flattened.

Test 2.—Cable over Bunsen flame as above, but not connected to electrical supply. Insulation resistance between conductor and steel protection taken at intervals.

Result.—After 12 minutes 70 megohms, after 18 minutes 75 megohms, after 26 minutes 75 megohms, after 36 minutes 75 megohms, after 40 minutes 75 megohms, each with 500 volts. Sample then tested with high tension but failed to break down with 3,000 volts.

Test 3.—Sample insulated and protected exactly as fireproof cable, but an arc lamp carbon substituted for the ordinary copper conductor; carbon is broken in the middle and an arc maintained between the two portions with about 50 amperes.

Result.—Sample tested with 60 amperes at 200 volts, after arcing for 20 minutes, cable red hot but no flame. Repeated with 90 amperes for about 5 minutes, but still no flame.

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TEST 4.—An internal arc as above maintained in sample insulated as ordinary V.I.R. braided cable.

Result.—Sample tested as above burst with loud report in less than 10 seconds.

TEST 5.—3/22's fireproof cable. Conductor overloaded with 80-100 amperes.

Result.—Conductor fused in about two minutes, but insulation and protection intact.

TEST 6.—3/22's insulated as ordinary V.I.R. braided cable. Conductor overloaded as in experiment No. 5.

Result.—After a few seconds wax compound in braid began to melt, and subsequently rubber melted off conductor. Cable in flames in about a minute and a quarter.

During the first few minutes of Test No. 3 the rubber insulation was volatilised, and exuded from the ends of the cable as a dense gas. Under ordinary circumstances this gas would find its way along the cable and through the steel braiding, as the cable would be practically sealed throughout its length. In Test No. 4 the insulation was fired by the explosion, and continued to flame until put out. We were unable to detect any flaming in the fireproof samples, and the maker's claims appear to have been amply vindicated by the tests. At the conclusion the party was entertained to lunch by Mr. S. Paterson, managing director of the company, and the works were subsequently thrown open to the visitors. A brief description of their principal products will be found in the INDUSTRIAL SUPPLEMENT published with the present issue.

CORRESPONDENCE.

THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your appreciative Editorial Notes on the first page of your last edition, of May 24th, you state that "the Central Technical College is what is known as a school of the University, and this means that it possesses certain privileges for its students; for example, the examination for the diploma of the college is accepted as the intermediate examination of the University."

As a matter of fact, any one of our students who has matriculated at the University, and has passed satisfactorily through our *first* year's course only, is ranked as having passed the intermediate examination of the University.

The diploma of Associateship of the City and Guilds Institute is of the nature of a *degree*, given at the end of a three years' course, and, if obtained in either the electrical or the civil and mechanical engineering departments, it exempts the student from sitting for any further examination for the Associate Membership of the Institution of Civil Engineers.

It does not yet obtain for him, without further examination, the degree of B.Sc. of the University of London; but seeing how large a percentage of the internal students who have gained that degree within the last year or two have been men who had been awarded our diploma the month before, we are sanguine enough to hope that, in time, the University may rise to the heights of the Institution of Civil Engineers.—I am, &c.,

W. E. AYRTON.

The City and Guilds College, May 28.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

The Select Committee of the House of Commons appointed to consider the question of the ratification of the Convention drawn up at the Berlin Wireless Telegraph Conference last year met again on Tuesday under the presidency of Sir John Dickson-Poynder.

Mr. H. CUTHBERT HALL attended and expressed a desire to put in evidence on points that had been raised by previous witnesses.

The CHAIRMAN said the Committee had decided not to hear any statement with regard to conversations between the delegates at the Conference in Berlin. They had received ample evidence from Mr. Hall regarding the effect of the Convention on the Marconi Co. He, therefore, asked witness to confine his statements to arguments on the evidence that had been given in regard to the effect the Convention might have upon national interests.

Mr. HALL said he wished to refer to the opinion of Sir Robert Hunter on the subject of the agreement between the Marconi Co. and the Post Office. He (witness) had handed in the opinion of Mr. Warmington, K.C., as to the true construction of clause 10 of the Post Office contract—viz., that if intercommunication prejudiced the company's patent rights they could not be compelled to accept intercommunication, and this had not been met by the opinions of eminent members of the Chancery bar or the Law Officers of the Crown, the only opinion quoted against it was that of Sir Robert Hunter, solicitor to the Post Office. The question of the prejudice of patent rights was considered by counsel before witness gave his first evidence, and he gave it to the Committee then, but it did not seem to have been incorporated in the report of the evidence. This opinion was by Mr. John M. Gover, and was to the effect that Mr. Babington Smith's evidence was not expressed clearly on the question of prejudice of the company's patents, but if he intended to deduce the argument that no waiver of the company's patent rights would be involved, he (Mr. Gover) considered the argument fallacious. For the Government to pledge itself to provide a non-exempted station for every exempted station appeared to be based on the assumption that there were no patents for wireless telegraphy, and even if there were strong presumptive evidence that the company had no valid patents it would be improper to enter into a binding undertaking which could only be fulfilled if the presumption were well based. There was, on the contrary, very strong presumptive evidence that the company had patents controlling all wireless telegraphy. Their first patent provided for the use of syntonised apparatus, which was also the subject of further patents. He also wished to comment upon Sir Robert Hunter's observation that the decision in the United States Courts in his company's favour and against the De Forest Co. did not seem to restrict the De Forest Co. from carrying on wireless telegraph business. Sir Robert Hunter seemed to imply that the decision only operated in New York State, but he (witness) had cabled the American Marconi Co., and they said the decision applied throughout the whole of the United States. His next point was that the decision in the De Forest case showed that there was strong presumptive evidence that the Marconi patent was the controlling patent covering the whole of wireless telegraphy. The De Forest defence was anticipation. It was alleged that the invention described by Mr. Marconi in his original patent had been anticipated. In order to prove anticipation it was not necessary to prove that the anticipation had taken place in the United States, anticipation in any part of the world would have sufficed to protect the De Forest Co. from the judgment which was delivered against them, and therefore they cited the work of men all over the world—Lodge in England, Popoff in Russia, Branly in France, and so on—as alleged anticipations. The judge said Marconi was the first to describe and achieve the definite transmission of intelligible signals by means of Hertzian waves. Sir Robt. Hunter made it a point against the Marconi Co. that they had taken no action in any country besides the United States, though there were many companies doing considerable business, including the Lodge-Muirhead Co., who had supplied apparatus to the War Office. The War Office had recently informed the Marconi Co. that they had not come to any decision as to what apparatus they would employ. Sir Robert was wrong. Other systems of wireless telegraphy had generally been in the hands of unsubstantial people, who had little capital behind them and no business of any consequence. The nominal capital of the Lodge-Muirhead Co. was, he believed, £50,000, and the capitalisation of the Amalgamated Radio-Telegraph Co. was £500,000, of which £37,500 only had been subscribed in cash. When they started these companies they were aware of the existence of the Marconi patents. He dissented from the proposition that the Marconi Co. ought to be willing to abandon the protection of their patents, and it was unreasonable to expect them to take action against persons who were doing no serious business, and who were very unsubstantial. The action against the De Forest people caused the Marconi Co. to incur expenditure of about £20,000, and owing to the financial position of the defendants they were unable to collect a single halfpenny of damages or expenses. It was immoral to suggest that an inventor should not use the invention to which his patent related except under terms which prejudiced his patent rights, and it was immoral for the Crown to use an invention in such a manner as to facilitate its infringement. The utilisation of the company's patent by the Government for intercommunication would encourage infringement, and it was contrary to public policy to compel a trader to facilitate the operations of his competitor. This question had been the subject of a decision in the Courts. Capt. Bethell had objected to general compulsory intercommunication because it would jeopardise the efficiency of the Marconi organisation, which would be valuable to the Admiralty in times of emergency, and that there would be a certain amount of disorganisation to the Marconi service, but it would settle itself easily and quickly. He gave no reasons, however, for the latter conclusion, and he differed from the views of Commander Payne and Lieut. Loring, who believed that general intercommunication would create no serious difficulty. They gave an instance of 30 or 40 ships communicating at one time with one naval station, and stated that the difficulties of communication under those circumstances were greater than would have to be met by companies. Witness said that proved his contention that general intercommunication was impracticable because it involved division of authority, and the conditions for efficient working would not exist under the Convention which Commander Payne had in his working under the sole control of the naval authorities, and the case was not made out that the interference would be only temporary. The provisions for exempted stations and stations for restricted services were absolutely inadequate for the security of scientific development. Exempted stations and ships would be liable to interference from non-exempted stations and ships, because the two classes would be under different control. The second cause of dislocation had been omitted by the Admiralty witnesses. They said that if we did not accept intercommunication we should lose the foreign ships, but witness could not find any provision in the Convention enabling ships carrying the flag of countries which did not agree to the Convention to carry on an exempted service. The Convention was

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skilfully devised for breaking up the Marconi Co.'s organisation. The Admiralty delegates said if the company did not accept intercommunication they would lose a great deal of business, and if they did accept it it would cause dislocation and disorganisation of their service. Captain Bethell had described the complicated procedure which would have to be adopted to enforce a penalty on a German ship, for instance, using American apparatus, and communicating with the Lizard station and disobeying the Convention regulations. It was suggested that that was an exaggerated statement, and that the same procedure could be adopted with regard to wireless telegraphy as was followed with regard to cable telegraphy under the Postal Telegraph Convention, but in any case it would be necessary to transmit the complaint from the Marconi Co. through the British and German post offices, the German Shipping Co., and the American company which was working the apparatus on the ship, and as some of these organisations would not necessarily be specialists in carrying out a public wireless telegraph service, this would add to the difficulty of adjusting the matter. It had also been stated that if a ship was found to cause serious and continual disturbances the coast station might refuse to accept the messages, but refusal did not stop the disturbance.

Sir GILBERT PARKER: What have you in support of the statement that the German Government desire to break the Marconi Co.?—As I stated in my evidence in chief, the German Government proposed to other Powers the drawing up of the Convention to prevent the Marconi Co. obtaining in other countries a similar monopoly to that which they had in Great Britain. There were proofs of that in a pamphlet which the company sent out to members of Parliament before the question was raised in the House.

You made a statement that exempted ships would prevent scientific development?—The provision for exempted stations will not prevent the dislocation of the traffic. The dislocation would be caused by improperly worked non-exempted stations, and our organisation would be dislocated because many foreign ships would be compelled to abandon our service, and the provision of exempted stations does not meet our statement that the Convention will hamper scientific development, which in a matter of this kind takes place in the application of the apparatus to practical work. This has been shown in regard to other departments of electrical industry.

The POSTMASTER-GENERAL: Have you recently been refused an injunction against the De Forest Co. on the grounds that the original action was in reference to a certain combination of apparatus, and that they have now ceased to use that combination?—I am not aware of that. The patent action was on the question of the earth and aerial combination. If there had been such a refusal it would presumably be within my knowledge.

You gave the Committee the impression that the Marconi Co.'s patent rights were absolutely protected in America?—I intended to convey that we obtained a sweeping judgment in the case previously mentioned, and I might have gone on and stated that we have also obtained other satisfactory judgments in America.

Mr. ADKINS: You quoted two opinions which were handed in to the Committee. Was one the joint opinion of Mr. Warmington and Mr Astbury?—Yes.

Do you consider that opinion would be relevant to the position which would ensue if the Convention were agreed to by England?—I think so. It states that intercommunication would prejudice our patent rights.

Do you think that your ability to enforce your patent will not be affected from the fact that you have taken no steps against other alleged infringers hitherto?—I do.

Do you consider the Lodge-Muirhead system worked between the Andaman Islands and Burma an infringement of your patent?—I do.

Is the reason that you have taken no steps against them because they are very small?—Yes, relatively.

Does the same apply to the work in the West Indies?—Yes.

Is there not a station at Scheveningen where you do intercommunicate?—Yes. There are no patent laws in Holland, and that is the only place where we do intercommunicate as far as I know, except in the case of distress signals.

The POSTMASTER-GENERAL: Would not the Dutch ships with your apparatus have to intercommunicate generally if the Convention were adopted by Holland?—Yes, but we have the option of terminating our agreement with the Dutch Government in 1908 if they sign the Convention.

If a ship fitted with your apparatus communicates with some other system, will not that affect your patent rights?—I should say not.

Sir EDWARD SASSOON: Would intercommunication hinder improvements in your service and also in other services?—It would hinder improvement generally. Standardisation and the application of scientific improvements are incompatible.

The POSTMASTER-GENERAL: I understand that, under your agreement with the Argentine Government you must accept any laws they may pass on the subject?—We have a concession, but if we do not choose to work under it it will be at an end.

Under Clause 10 of your agreement with the Post Office there is a reference to the prejudice of patent rights. When you entered into that agreement were you of opinion that the clause would be ineffective?—I will only say that I told the Post Office that intercommunication would prejudice our patent rights.

Can any other inference be drawn than that which I suggest?—I cannot say.

This concluded Mr. Cuthbert Hall's evidence.

Mr. Charles Bright then submitted his evidence, from which we make the following extract:—

Mr. BRIGHT: Besides being a Fellow of the Royal Society of Edinburgh, I am Associate Member of the Institution of Civil Engineers, a Member of the Institution of Electrical Engineers, and author of "Submarine Telegraphs" and other works. I have devoted considerable attention to the strategic and commercial aspects of telegraphy, and have written and lectured a good deal on this subject. I have also written on the subject of etheric telegraphy in its various aspects, but I am in no way connected with any commercial company. I do not consider that radio-telegraphy as available to-day is adapted for long distance shore-to-shore work in competition with submarine cable telegraphy, but I have a great belief in its utility for general maritime purposes, and also in times of emergency or war. I consider wireless telegraphy can be turned to useful account in conjunction with the various cable systems in emergencies, and as an auxiliary means of communication, as well as in cases where submarine telegraph cables cannot well be maintained, and where a radio-telegraph system will more suitably serve the purposes of communication. Railway signalling is another obvious use for wireless telegraphy communication between isolated places, besides general military and naval work. But whereas an electric cable is entirely under control, an etheric system is not, owing to the variable atmospheres with which it has to deal. On the subject of competition between etheric and electrical systems of telegraphy, I may say that since the first Marconi Co. came into existence about 10 years ago, about five times as much submarine telegraph cable has been made and laid as was the case during the previous period of 10 years. At December, 1887, there were 148,472 nautical miles of submarine cable made and laid; at December, 1897, 167,077 nautical miles; and at December, 1906, 251,132 nautical miles. Nearly 70,000 nautical miles have been made and laid since 1900. "The Electrician" Electrical Trades' Directory and Handbook gives further information on this subject. I am in favour of the British Government ratifying the Convention, as I consider that ship to shore and shore to ship communication by radio-telegraphy throughout the world should be made the subject of international control. The International Radio-Telegraphic Service Regulations would form a companion set of service regulations to those governing the International Telegraph Convention of St. Petersburg. Certainly telegraphy over wires and cables would never have become effective but for international control. At one time different countries had different regulations and there was no provision made for co-operation or through working, and the private telegraph companies boycotted each other by means of blocking rates. The first International Telegraph Union was called in 1865, and the meetings of this Union afforded facilities for exercising influence over the various companies in regard to landing rights, concessions and subsidies, and ultimately the Convention established uniformity of service regulations. The Governments worked together with their land lines in friendly co-operation, and the cable companies who owned the ocean cables were brought into line as units in the telegraphic system of the world. In the main, the chief lines of submarine telegraphic communication are in the hands of companies allied to each other, but the International Convention and Service Regulations, where it applies to the companies, has had an excellent effect in co-ordinating the whole network of international telegraphs, and has brought about through working between organisations in keen rivalry with each other. Just as telegraphy through wires and cables has been developed through the Convention, so I consider would wireless telegraphy be developed under similar conditions. The question of rates in regard to wireless telegraphy has been settled in advance in Article 10 of the Convention and No. XII. of the Regulations, which fix the rates for wireless telegraph messages at 6d. a word for coast messages and 4d. a word for ship messages, each Government, however, approving the actual rate to be adopted, the maximum rate being fixed by the Convention. In the early days of telegraphy it was soon found impossible to carry on the traffic without international regulation. This regulation included word counting, and this regulation would apply naturally to aerograms. The necessity for international regulation has also been shown in regard to postal matters by the adoption of a Postal Union, and this would especially apply to the regulation of international radio-telegraphy. Under the International Telegraph Convention several of the rival cable companies have to work together, but it would be inadvisable for regulations to be drawn up by anyone of these companies which would give it command over the other companies. International communication being essential, uniformity of operation can only be arrived at by conferences between the different parties interested. It is only by a system of universal wireless telegraphy that the public will be able to adequately communicate between ship and shore, and this country possessing the largest mercantile marine, it becomes of special importance that we should develop radio-telegraphy for all maritime purposes, and so regulate its use that one wireless telegraph company cannot refuse to intercommunicate with any ship or shore station fitted with apparatus other than its own. Ship to shore communication would be for the public benefit, and must be limited as regards the horse-power employed if we are to avoid confusion with other stations.

Assuming, as I do, that the Convention will be ratified by most of the other important Powers, whether Great Britain signs it or not, by our not joining the Convention ships fitted with Marconi apparatus will have to replace that apparatus by something that belongs to a company that will intercommunicate with other systems, or else these ships will have to forego all idea of communicating with the shore stations belonging to the countries adhering to the Convention and not using the Marconi apparatus. This will not apply if, when the Convention is actually ratified, the Marconi Co. withdraws from its policy of isolation. This they have already done in regard to communication with the Telefunken (Dutch) station at Scheveningen, and as regards the station in the Argentine Republic, which communicates with ships fitted with any other wireless apparatus. Without international control of some kind there will be no security that a message signalled from ship to shore will be transmitted to its destination on the telegraph system of the country con-

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cerned. I may add that until the International Telegraph Union was established in 1865, all telegraphic messages were examined when crossing a frontier, even in times of peace. On board ship it would be essential that the apparatus be easily workable by the ship's crew, and it will be quite out of the question to adopt any system whose owners insist upon working their own apparatus by means of a special staff and telegraph office on board. By the general adoption of the Convention the whole world will be for the first time in a position to utilise whatever method of etheric telegraphy is considered to be best adapted to their conditions, whereas at present many stations are unable to communicate with many ships and stations fitted with Marconi apparatus. I understand that it is compulsory intercommunication that is objected to by the Marconi Co., but a system of intercommunication dependent on both parties agreeing can scarcely prove a satisfactory arrangement. Standardisation in connection with machinery and apparatus serves as a guide to inventors, showing them definitely what is required, whilst leaving them to attain their object in any way they may think best. Doubtless there is the possibility of a certain amount of confusion at first—just as there was in the ship to shore signalling in the early days of submarine cable laying, but this would be easily dealt with by those who have the direction of affairs. I venture to think that the art will develop much more effectively if general intercommunication between different systems of apparatus is adopted then if we proceed as now. The operators will get a far more varied experience, enabling them to be prepared for all emergencies. The result of the adoption of the Convention and one of its main advantages will be that we shall be provided with operators with wide experience with different systems. As to whether the existing systems can intercommunicate satisfactorily, I believe it will be found that most of them are in reality equal to this task. It is still possible that if one system is found to be vastly superior over others for the purpose of intercommunication, such service might readily come into universal use. In the event of our Government not ratifying the Convention, I consider that foreign stations will certainly be placed in the line of the principal important trading routes and close to our territories, whereby we should not only lose the traffic that would otherwise have accrued to us, but our non-intercommunicating stations may be seriously interfered with by the working of foreign ships with foreign stations, as well as by the proximity of such foreign stations to ours. By adopting the Convention at the start, we shall have secured our own terms, and have avoided any form of combined antagonism. If intercommunication for physical reasons should be found difficult (as was insisted upon by Mr. Marconi, but denied by Mr. Cuthbert Hall), the Convention as it stands could be dropped. All we can accomplish by holding aloof from the Convention is to lose certain actual benefits and to suffer from the operation of the Convention in other hands than our own. It should be remembered that, as is provided for in the International Telegraph Convention, any country is open to withdraw from the Radio-Telegraph Convention at a year's notice if they so desire. If we should not ratify the Convention certain clauses introduced at our instigation are certainly likely to be changed. With regard to the Service Regulations appended to the Convention, I have studied these in a general way, and they appear to me to be admirably designed to meet all requirements so far as can be seen at present, and the various articles appear to be in suitable conformity with those of the International Telegraph Convention of St. Petersburg. The clause in the Convention for exempted stations, which the British delegates insisted upon, to my mind meets entirely all requirements in the nature of experiment and development with any particular system at any time. It also provides for the possibility of general intercommunication not proving satisfactory and for retaining a separate organisation of wireless telegraphy in our own hands to meet any case of confusion or dislocation by congestion of stations and traffic at important centres.

Referring to the safeguarding of our naval and military interests, Mr. Bright said he considered that the Convention provided efficient safeguards for this purpose. Turning to the question of monopoly, Mr. Bright joined with Sir William Preece in contending that the Marconi Co. had certainly shown by their actions that they were desirous of obtaining a monopoly of wireless telegraphy. They had, in fact, claimed this monopoly as a right, if only by refusal to intercommunicate. Had Mr. Marconi originated the idea of wireless signalling, as many people had been led to believe, there might be some justice in this claim, but this was not so. If they desired a monopoly, they should have attempted to have established their rights in a court of law, instead of threatening to do so if the Convention is ratified by the Government. Why had the Marconi Co. not brought an action ere this against any one of the various companies which they maintain are infringing their patents? Instead of taking this straightforward course, Mr. Bright said the Marconi Co. indulged in threats of what they would do if the Convention were ratified. The Marconi Co. had made much of the fact that theirs was the only concern with complete commercial organisation, but it should be pointed out that in the United States the two principal American radio-telegraphic companies were undoubtedly doing a substantial business, and one of them was actually engaged in attempting to span the Atlantic ocean. With regard to the Marconi Co.'s claim of only a 0·4 per cent. error in their messages, this would imply a greater accuracy and more reliable service than that of the submarine cables, but it should be remembered that in the latter service errors were calculated from the difference between the sent and the received message and not from such a comparison after the message has been sent a large number of times. In his view the true test of error was the rate at which words were correctly received without repetitions. Errors in cable messages were, as a matter of fact, chiefly errors in writing rather than in the transmission over the cables.

Mr. Bright briefly referred to Mr. Henniker Heaton's evidence, and pointed out that it was clear that the lay press regarded Mr. Heaton as an expert in wireless telegraphy. It was curious that for many years this gentleman had been engaged in a campaign against submarine cable monopolies, but was now endeavouring to secure a monopoly for the Marconi Co. in radio-telegraphy, which was in the view of some persons likely to compete with the telegraph cable companies. With regard to the voluntary statement made by Mr. Henniker Heaton that he had always refused directorships in telegraph companies, the fact that he had served on the board of the original Marconi Co. had probably slipped his memory. This fact would have some interest in view of his evidence before the Committee.

This concluded Mr. Charles Bright's evidence, but in view of Dr. Fleming's supplementary statement presented to the Committee, Mr. Bright asked that he might also be permitted to submit a supplementary statement. This supplementary statement has been presented, and we make the following brief abstract:—

Mr. BRIGHT: I wish to refer again to the idea which generally prevails, but which is quite inaccurate, that Mr. Marconi is the sole pioneer of wireless telegraphy. I attribute this idea to the "nursing" of the lay press by the Marconi Co. In this way the general public, as distinct from the scientific and technical world, have conceived the idea of Mr. Marconi's pre-eminence in this direction. After referring to the pioneers in wire telegraphy, Mr. Bright said: Following on this pioneering in what he might term "wire" section of telegraphic work, various forms of inductive telegraphy had been at various periods suggested, and were actually employed in some cases. The names of Steinheil, Morse, Gale, Lindsay, O'Shaughnessy, Dolbear, Edison, Melhuish, Stevenson, Willoughby Smith and Sir William Preece occurred to him in this connection. This inductive telegraphy (across rivers, &c.), was, of course, the precursor of Hertzian-wave wireless telegraphy. The same might be said in regard to telephony. In each of these branches the pioneering work had been done by many persons, but in regard to wireless telegraphy the public had been misled through the action of the lay press, and in this way the majority of people—probably including some members of the Committee—would, before this inquiry took place, have been under the impression that all wireless telegraphy was due to Mr. Marconi. As far back as 1863 Clerk Maxwell worked out mathematically the theory of electromagnetic waves in the æther, and their relation to light waves. In 1888 Heinrich Hertz, a distinguished German, produced, demonstrated and described them. Then Righi, a noted Swedish professor, and Mr. Marconi's tutor, and Branly, a leading French scientist, had contributed to the pioneer work. In 1894 Sir Oliver Lodge entered the field. But the first person to turn to account the various ideas presented by those whom he had mentioned was Mr. Marconi in 1896. It was true that Lodge at the time referred only to "signalling" across space, and not to telegraphy, but the first Marconi patent was for improvements in transmitting electrical impulses and "signals," and, as a matter of fact, there is no essential technical difference. The main element of difference in the Marconi apparatus was the connection with earth and the employment of an aerial wire supported on a high mast. But, as a matter of fact, there was no mention of the latter feature in Marconi's first patent, and it might be added that both the elevated antenna and the use of the earth had been previously adopted by both Dolbear and Popoff. Besides this, Lodge, as far back as 1889 ("*Phil. Mag.*," July, 1889, p. 49), specified the use of the earth in "Electric Radiation," and, in 1894, at the Royal Institution, and at the meeting at Oxford of the British Association, described the effect of an antenna in collecting the waves and bringing them to the coherer. As far back as 1895 Rear-Admiral Jackson sent wireless messages between ships. Thus it would be seen that, so far as pioneer work was concerned, there were many men at work before Mr. Marconi appeared upon the scene. In connection with the development of radio-telegraphy, Mr. Marconi aimed at spanning oceans, while Lodge had been engaged more in the work of selectivity. Slaby, Arco and Braun, in Germany, had devised what was known as the Telefunken system, and, like the Lodge-Muirhead Syndicate in this country, the owners of the Telefunken system were making numerous installations of their apparatus. There was also the De Forest system, which would be remembered in connection with the important work performed for *The Times* newspaper during the Russo-Japanese war, when many thousands of words were transmitted considerable distances at what was then abnormally high speed. Then we had the Fessenden system, owned by the National Signalling Co. of America, and this company and also the De Forest Co., are endeavouring to send wireless messages across the Atlantic ocean. The more recent system of Poulsen was, of course, somewhat distinct from all other methods previously known. There were, further, the system of Ducretet in France, and Popoff in Russia, and of Guarini in Belgium.

He had shown that a great deal of pioneering and practical work had been done by others as well as by Marconi. Coming to the question of principle, he regarded the more or less continuous, persistent (or undamped) Hertzian wave as a distinct improvement on the Hertzian wave as usually derived from discharging successive sparks. In spark telegraphy of what is called the "whip-crack" variety the waves are intermittent, and the amplitude of each, though large at the start, quickly loses its energy, which has to be successively renewed all the time. It is only the first oscillation that is really effective at the receiving station.

Mr. Bright then referred to the work of Mr. W. Duddell and of Mr. Valdemar Poulsen, who had, he said, recently, working independently, overcome this loss of useful energy in the wave, and had obtained a practically continuous train of waves with the amplitude more or less regular, necessitating, owing to the fact that the waves were, so to speak, successive, materially less power in working with them. This minimising of power reduces the chances of disturbing other neighbouring stations or ships and thus enables a larger number of stations to be worked within a given radius, especially as the facilities for accurate tuning are superior owing to the impulses being more regular. This was a feature of other systems in which the waves were made more or less continuous, such as

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the Lodge-Muirhead, which, although a spark method, is also one in which the waves are emitted in a more or less continuous form. To some extent the Telefunken system was on these lines. The transformer used by Lodge in his receiving circuit, which assists in attaining the highest speed of the Lodge-Muirhead system, was first mentioned in Lodge's original patent in 1897, and constitutes the first mention of anything of this kind for use for this purpose. Mr. Bright concludes his supplementary statement by dealing with syntony and earth connection.

During the proceedings Mr. Bright referred to an article in a German paper, in which it was asserted that if England refused to ratify the Convention it would become practically a dead letter. He considered it was unlikely that a German paper would volunteer such an admission, and he thought it must have been inspired by interested parties.

Mr. GWYNN: Do you suggest that the articles in the German press were not spontaneous?—Yes.

The POSTMASTER-GENERAL: Your general position is that the Convention would assist towards the diminution of confusion amongst the various wireless telegraph companies?—Yes. The proper organisation for an international concern is an international organisation. I do not think other countries would accept any one system unless it were proved to be enormously superior. Marconi's new system, of which we have heard, may be extremely superior, and other countries may want that system. The Convention would not stand in the way of this.

This concluded the hearing of evidence by the Committee, and the proceedings were adjourned until June 6 to enable the Committee to consider their report.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

The adjourned debate on the amendment for the rejection of this bill was resumed on Monday. (The original debate was reported in our issue of 10th inst.)

Mr. WARD supported the second reading because the bill recognised that such monopolies as electricity supply should be controlled by the London County Council and not be privately exploited.

Sir E. CORNWALL congratulated the President of the Board of Trade on having given notice of an instruction which would have the effect of giving the debate a more harmonious turn than it had on the former occasion. He looked to the Hybrid Committee, which he understood the right hon. gentleman proposed to set up, not only for a full inquiry, but for light and guidance on this difficult question. Every one admitted that the present position in London was unsatisfactory and uneconomical. If the bill failed to pass it would mean that the existing electrical systems would have to be developed, which would be the worst possible thing for London. They would have the existing companies coming to Parliament next year—they could not for all time prevent their developing their systems, and that would mean going on with small stations and sub stations, instead of working on the economical basis of a large generating station down the river, at which coal barges could deliver.

Mr. CAVE denied that the outside authorities were satisfied with the bill as it stood, or that an arrangement had been made with them.

The bill was then read a second time and referred to a Hybrid Committee.

On the motion of Mr. LLOYD-GEORGE, the committee were instructed that, if any power be conferred on the London County Council to transfer or lease to any company, local authority, body or person any of the powers, duties or liabilities entrusted to it by the bill, the conditions on which such power should be exercised should be embodied in the bill or in a subsequent bill.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited for the position of assistant engineer to the Electricity Supply department of Colchester Corporation. Commencing salary £2 per week, rising by four equal increments to £3. Applications to the borough electrical engineer (Mr. A. R. Sillar, M.I.E.E.), 36, Osborne-street, Colchester, by June 5. See an advertisement.

An electrical engineer is wanted for the Argentine Republic. Age about 30, with thorough knowledge of d.c. and polyphase currents, tramway construction and distribution with underground and overhead mains, &c. See an advertisement.

A transformer draughtsman is required for single and three-phase power transformers by Ferranti Limited, Hollinwood, Lancs. See an advertisement.

For a mechanical engineering works in London a good draughtsman is required for general work, and a man having a good knowledge of electrical work and able to get out designs for small electric hoists and controllers. See an advertisement.

An advertisement in another column announces a vacancy for a pupil, without premium, in a company's d.c. station in the south-west of London.

Acton Council require a charge engineer. Applications to Mr. J. Martin Blair, 130, Churchfield-road, Acton, by noon June 12.

Durban Corporation require a switchboard attendant. £240 per annum. Applications to Webster, Steel & Co., 5, East India-avenue, London, E.C., by June 11.

The appointment of chief electrical engineer to the city of Auckland, N.Z., is vacant. Copies of conditions of appointment from the High Commissioner for New Zealand, 13, Victoria-street, London, S.W. Applications to Town Clerk, Auckland, by 4 p.m. July 18.

The directors of the Savoy Hotel notify in an advertisement that, as 718 applications have been received for the appointment of engineer to the Savoy Hotel, they regret that they are unable to reply to these individually, but they wish to state that the appointment has now been filled.

Islington (London) Council have appointed Mr. H. H. Haywood lighting inspector at £150 a year, and Mr. D. J. Evans assistant lighting inspector at £130.

EDUCATIONAL NOTICES.

East London College.—An interesting course of six lectures on electric wave telegraphy (the production of electric waves, their measurement and their practical application) will be given by Mr. J. T. Morris, M.I.E.E., on Mondays (from 8 to 9:30 p.m.), commencing June 3. The course will be fully illustrated with experiments and demonstrations. Particulars may be obtained from the Registrar, or the Director of Studies.

City and Guilds of London Institute.—Lord Halsbury presided at the annual meeting on Tuesday and among those present were Sir John Wolfe Barry (chairman of the Executive committee), Sir W. Prideaux, Sir Edward Busk, Sir William White, Sir W. Bousfield, Lieut.-General Laurie, Sir John Watney (hon. sec.) and Mr. A. L. Soper (assist. sec.). The report gave a résumé of the negotiations with the Board of Education with a view to the Central Technical College of the institute being included in the scheme for the establishment at South Kensington of a Science and Technological Institution.

Lord HALSBURY, in moving the adoption of the report, said it contained an interesting record of good work done to promote technical training. With regard to the new Technological Institution at South Kensington, it had been made a subject of petition to his Majesty, who had referred it to the Privy Council, and there was every indication that the charter would be granted. The institute would still retain its distinctive character and they would be entitled to five members on the governing body of the new institution. The number of candidates examined last session was 22,000, about 1,000 in excess of any previous session. He thought there could be no doubt as to the valuable character of the work which the institute, with the generous assistance of the City Guilds and the Corporation, had been enabled to carry on.

Sir J. WOLFE BARRY seconded the motion, which was unanimously adopted.

Aberdeen.—The annual inspection of the electricity works at Dee Village took place on Friday last.

At the close of the inspection, in reply to the toast of "The Gas and Electric Lighting Committee," the convener (Councillor KEMP) said that when the Council first thought of going in for electricity supply, the proposal was carried in the committee only by the casting vote of the then convener. When they took the prudent step of feeling the pulse of the probable consumers, they only got seven favourable replies. Notwithstanding the apparent apathy, the Council wisely resolved to proceed. When the Cotton-street works were projected in 1891, it was thought if they were made capable of generating 150,000 units per annum that would be ample. At the close of the first year's working the units generated amounted to 72,000. At the close of the fifth year the number was 472,000. At the close of the next five years units generated were 2,987,487. At July 31, 1906, they were 4,945,198, and for the nine months of the present financial year (to April 30) they were 4,419,373, an increase of 404,398 over the corresponding period of last year. At April 31, 1906, the number of consumers stood at 1,599; at the corresponding period of this year at 1,704, an increase of 105. The total connections expressed in 33 watt lamps show an increase of 45,471. At April 30, 1906, the meters (private and hired out) numbered 506, and at the same date this year they stood at 580. There were 832 arc lamps a year ago (including the harbour lamps), and now the number was 973, or an increase of 16·9 per cent. That increase was due entirely to private arc lamps, there being no change in public lighting. They had at present installed 6,250 H.P. of plant, which included two engines of 200 H.P. each, four of 300, one of 650, four of 700, and one of 1,200. In September next they hoped to have another engine of 1,200 H.P. installed and ready to cope with next winter's load.

Dean of Guild MURRAY proposed "The Staff of the Electricity Department," and referred in appreciative terms to the capacity and engineering skill of the city electrical engineer (Mr. J. Alex. Bell), and to the care which he had always shown in selecting the members of his staff, who were all capable and painstaking employés.

Mr. BELL said that, with the broad-minded policy of the Council, they hoped to continue to keep the establishment up to date, and in a thoroughly good state of efficiency.

Abram.—The agreement with the South Lancashire Tramways Co. for the transfer of the Abram electric lighting order, of 1902, has been sealed by the Council.

Acton.—The question of applying for sanction to a further loan for free wiring has been deferred for six months.

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An Electric Target.—At the first social gathering of the Fleet Rifle Club at St. Bride's Institute on Friday, Mrs. Carr presented the club with a self-registering electric sectional target, complete with indicator, as a gift from her brother (Mr. J. A. Dickie), the inventor. In making the presentation, Mr. Carr stated that the electric target had already been warmly praised by General French for its remarkable accuracy and capabilities, while many volunteer range experts had also borne testimony to its real value as an aid to shooting.

Argentina.—It is estimated that by the end of June or nearabouts the horse-drawn cars will have disappeared from the district of Buenos Ayres. The principal electricity supply company in *Buenos Ayres*, the German company, supplied during 1906 15,410,000 units of energy.

The municipality of *Bahia Blanca* have recently introduced many great improvements in the town, including electricity supply.

In *La Plata* British capital is invested to a large extent, amongst the works owned being the electricity supply station. When the Provincial Legislature gives its sanction to the contract for electric traction to be adopted, capital is already available for the work, unless legislative sanction is too long withheld.

Asylum Lighting.—The Visitors of Fulbourn Asylum, Cambridge, have referred to the Finance committee a proposal to provide electric lighting plant at an estimated cost of £7,000.

Barking.—An inquiry was held on Monday into the Council's application for sanction to a loan of £1,500 to give a supply of current for power to a firm requiring about 100,000 units per annum.

After taking evidence, the inspector (Mr. R. H. Bicknell) said that he would report to the L.G. Board, adding that the electricity supply accounts would be considered before sanction for another loan was granted.

Blackpool.—The Tramways and Electricity committee recommend the increase of the salary of the borough electrical engineer (Mr. Chas. Furness) from £520 to £600 per annum and that of the tramway manager (Mr. J. Lancaster) from £300 to £350.

Bosnia-Herzegovina.—Col. H. Goiginger has been appointed Director-General of Posts and Telegraphs in succession to Col. L. Schleyer, promoted.

Ceylon.—The consulting electrical engineer to the Government and electrical adviser to Colombo Municipal Council (Mr. A. S. Barnard) has presented his report for 1906.

Mr. Barnard states that he made 81 inspections of electrical work in Colombo during the year and also submitted various reports relating to electricity supply and traction matters. In the early part of the year two new electric cranes were put into operation on the Plumbago jetty, making with those already in use on the Prince of Wales' and King's jetties a total of seven. During the year the Municipal Council decided to call upon the Tramways Co. to adopt automatic guards on their cars, and the work of fitting these is now being carried out. The Electricity Ordinance of 1895 has been superseded by Ordinance No. 26 of 1906. This ordinance has been drafted so as to conform as nearly as possible with the Indian Electricity Act. New regulations are being drafted and these will be, as far as possible, modelled on the Board of Trade Regulations, alterations being made, where necessary, to suit local circumstances.

Charing Cross, Euston & Hampstead Railway.—June 22 has now provisionally been fixed for the opening of this railway.

Cherbourg.—In this district, which includes St. Malo, the electric tramway between Plancoet and Matignon was worked during the summer of 1906, and when the section between Briac-Lancieux connects up the line from Lison-Lamballe to Dinard the system, as far as at present authorised, will be complete. It is likely that a further section will be authorised shortly from Minaiac to St. Servan on to St. Malo, and when this is completed communication will be greatly facilitated over a large tract of country. The Société des Tracteurs Breton is constructing an electric tramway between St. Servan, St. Malo and Paramé, the power house being situated at Talard, near St Servan, which is to be connected up by a motor boat service to Dinard. In this way a further extensive area will be looped up for service.

In the St. Malo district the telephonic system is extending rapidly. The importance of the service to the large number of fruit and vegetable growers who cultivate this district makes the extension a matter of the utmost commercial importance.

Compensation for Industrial Diseases.—In the report of the Departmental Committee on Compensation for Industrial Diseases it is stated that cases of injury to the eyes from electrical welding have occurred, injury being attributed to the intensity of the light produced in the process. The committee have had no evidence, however, that any incapacity, when it occurs, lasts for longer than a few days; and it appears that the injury can be easily avoided, and is, in fact, now avoided by the use of protective glasses by workmen. Under these circumstances, the Committee think there is no valid reason for adding this disease to the schedule of those which should be added to the Workmen's Compensation Act.

Dundee.—The city electrical engineer (Mr. H. Richardson) has submitted a report to his committee detailing proposals as to the charges for electricity supply. He recommends that the cost of current for heating, cooking, &c., which has hitherto been 2d. per unit, be reduced to 1½d., and that the following graduated system of charging for lighting be adopted:—

For each unit up to 2,500 units per quarter 3½d., 2nd 2,500 3d., 3rd 2,500 2¾d., 4th 2,500 2½d., 5th 2,500 2¼d., and all units in excess of 12,500 2d. per unit.

This proposal was unanimously approved of by the Electricity committee, and will be put into operation immediately.

A sub-committee has been appointed to take into consideration each special application for power in bulk, and to discuss with Mr. Richardson as to the price to be charged in each case. It is considered that this is a great step in advance, as regards municipal electrical undertakings, towards a more businesslike way of deciding what shall be charged to each of the large consumers taking a bulk supply.

The accounts, which were submitted at the same meeting, showed, in the opinion of the committee, that a very successful result had attended the past year's management of their electrical undertaking, and expressed appreciation accordingly.

Epsom.—The Council have received sanction to borrow £3,600 for extensions of the electricity works, but the L.G. Board have been requested to extend the period of repayment from 15 to 22 years.

Electricity in Mining.—Instead of timber it is proposed to use steel for the framework of the 300 batteries it is proposed to erect on the Simmer Deep. It is stated that this will be the first mill constructed of steel on the Rand, and the stamps will all be driven electrically.

Sheriff Shennan adjourned the case until June 20.

The Harton Coal Co. (Ltd.), of Newcastle, are putting in an extensive electric power installation. Current is to be supplied in bulk by the County of Durham Electrical Power Distribution Co. at the St. Hilda, Boldon, Whitburn and Harton collieries, and also at the quarries, staithes and pumping stations of the coal company. Three-phase current is supplied at 2,600 volts 40 cycles, and all the motors, of which 15 are already on order, are to be constructed for this voltage. Eleven motors are to be used for driving haulage and winding engines through reduction gear, while the remainder are for driving pumps and air compressors. Four of the haulage and winding motors will have a normal output of 120 B.H.P. at 400 revs. per min, and seven an output of 80 B.H.P. at 480 revs.

In connection with the fatality which occurred in December at Hawkhill Colliery, Tulliallan, Fifeshire, Mr. Thomas Borland, the manager, was indicted on Monday at Dunfermline for alleged neglect in not having a competent person on duty when the electrical apparatus was in use; in not having all persons appointed to work the apparatus instructed in their duty; also for alleged neglect in not having a trolley coupling heavily insulated, &c.

Exhibition.—The seventh Wholesale Ironmongery, Hardware and Electrical Trades' Exhibition and Market (International) will be held at the Royal Agricultural Hall, London, N., from July 9 to 19. Offices, Broad Street House, London, E C.

Fatality.—An inquest was held on Wednesday into the death of Stephen Harris, which occurred at the New Mountain Colliery, Gorseinon (Glam.), on Monday. There is electrical plant of 500 kw. for pumping, &c., and deceased received an electric shock from handling the hauling rope. The jury returned a verdict of "Death by an electric shock, accidentally received.

Germany.—H.M. Minister at Munich has sent to the Board of Trade a copy of the new Bavarian Water Right Act, which comes into force on Jan. 1 next. This law cancels and takes the place of the one of May 28, 1852. It is computed that the unused water power in the kingdom could be made to develop up to 300,000 H.P. Articles 153 to 155 of the new act regulate the compulsory surrender of private water rights to the State, Corporations, &c., for public purposes, and provide for compensation. These articles will enable the Bavarian Government to obtain the necessary water power for the electrification of the State railways whenever required. The text of the law (in German) may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

Glasgow.—The Tramways committee recommend that the salaries of Mr. L. Mackinnon, traffic superintendent, and Mr. J. Ferguson, chief engineer, be increased from £550 to £575; that of Mr. E. T. Goslin from £450 to £475, and similar increases to several other officials.

Gravesend.—An official inquiry was held here last week into the Council's application for sanction to borrow £9,500 for extensions of the electricity works.

Hackney (London).—Tenders are to be invited for wiring the Central Library.

Hampstead (London).—The Council have made a considerable reduction in meter rents.

Kilmacolm (Renfrewshire).—The electricity undertaking of the Kilmacolm Electric Lighting Co., Limited, has been at work for 3½ years, and is (we learn) making satisfactory progress. The supply is entirely a domestic one, the district being one of the principal health resorts in Scotland. About 150 consumers are connected to the mains, and 20 new houses in course of erection

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are to be wired. Cables are laid on all existing roads, and the contract for cables for new roads has been placed with Callender's Company. An extension to the generating plant at the works is under consideration.

Leyton.—The Council have decided to open a showroom in the High-road, Leytonstone, for exhibiting the latest types of electric lamps, motors, fittings, &c.

Light Railways.—Application is being made by the Llandudno & District Tramway Construction Co. (Ltd.) for an order authorising the construction of light railways in the counties of Denbigh and Carnarvon, and passing from, through or into the parishes of Eirias and Llysfaen.

L.C.C. Testing Fees.—The London County Council notifies that they propose, subject to the approval of the Board of Trade, to prescribe a scale of fees in respect of duties performed by its inspectors in visiting inspecting stations established in the county by electricity undertakers under the provisions of special acts and provisional orders. Further particulars are given in an advertisement, and objections to the proposed fees may be made by letter addressed to the Assistant Secretary (Harbour Department), Board of Trade, within one month of May 29.

Manchester.—On Wednesday the Electricity committee decided to ask the Council to take steps for borrowing £112,850 to meet the cost of new works during the next three years. The chief engineer (Mr. S. L. Pearce) estimates that £3,250 will be needed for superheaters, &c., at Stuart-street, £6,300 for new mains, £32,000 for transforming plant and switchgear for supplying large consumers, and £14,600 for additional plant at sub stations.

Motor Club.—Though scarcely seven weeks old the membership of this club stands (we are informed) at over 800, and there is a waiting list of 100.

Municipal Telephony.—At the meeting of the Hull Telephone committee on Tuesday it was reported that the consulting engineer (Mr. A. R. Bennett) and the telephone manager (Mr. T. Holme) had formulated a scheme for giving more effectual intercommunication between the Corporation and the National Telephone Co.'s systems.

The scheme had been submitted to the company, but Mr. Holme reported that the proposals put forward by the company would necessitate the installation of a transfer board, which would be equipped with clearing signals controlled by the respective subscribers' telephones, and that that system would mean the passing of the calls to two operators, instead of direct. He, therefore, recommended the advisability of uniting the best points of each proposal, which would involve the installation of apparatus in the exchange and slight additions to each instrument at a cost of between £950 to £1,000, and the writing off of apparatus recovered to the value of £236. To set against that expenditure he pointed out that the operators would be able to attend to more calls. Thus, with the increase of the system, which, on the present basis, would require three additional operators, no increase of staff would be necessary; but, on the contrary, the wages of three operators would be saved.

The report was adopted.

Oban.—Application has been made for sanction to a further loan of £2,500 for extension of the electricity works.

Overhead Telephone Wires.—At Watford on Tuesday, Judge Roberts sat as arbitrator in the dispute between the Postmaster-General and the Council. The Post Office wished to place poles for overhead wires in certain thoroughfares. The Council refused their consent, owing in the first case to heavy traffic, in the second to the narrowness of the road, and in the third to danger from the erection of the poles. They asked that the wires should be placed underground. His Honour decided that the wires must be placed underground in two of the roads, but reserved his decision in regard to the third.

Presentations.—Mr. E. J. Reindorp, charge engineer at East Ham (who is leaving for Cape Colony), has been presented with a cabin trunk.

The staffs of the Newcastle-upon-Tyne Electric Supply and the County of Durham Electric Power Companies have presented Mr. J. A. Seager with a case of cutlery on his marriage. The presentation took place in the board room of the companies, where the heads of departments met, and through Mr. J. W. Laws, who made the presentation, expressed their best wishes and esteem for their colleague.

Redditch.—An inquiry was held here on Tuesday into the application of the Council for sanction to borrow £4,000 for extensions of the electricity works and £3,500 for a refuse destructor. The total loans authorised for the electricity undertaking amounted to £34,911, and the actual capital expended to £36,758.

Rhyl.—A special meeting of the Council is called to consider Messrs. Preece and Cardew's report on the condition of the electricity works.

Salford and Eccles Tramways.—On Monday Major P. Cardew sat at Westminster Palace Hotel, London, as umpire in arbitration proceedings between Salford and Eccles Corporations to determine the price to be paid during the next five years for electric energy to be supplied by Eccles for the tramways in its own area, which are worked by Salford.

For Eccles, Mr. Vesey Knox, K.C., said his clients had had the right to supply electrical energy to Salford Corporation so far as a supply was needed in Eccles. During the five years the tramways had been running Eccles had not been in a position to supply, but they had now given notice of their intention to provide this supply, and it became the duty of the arbitrator to fix the price to be paid. Last year Salford charged 1·35d. per unit, and this year 1·3d. Under the schedule of an agreement between the two boroughs the price was to be 1½d. per unit for the first 150,000 units, and 1¼d. for all units over that amount. The approximate amount of current required was about 500,000 units per annum.

Mr. H. W. Angus, borough electrical engineer, Eccles, Mr. Philip Dawson, M.I.E.E., and Mr. C. H. Wordingham, M.I.E.E., gave evidence, and stated that a fair price would be about 1·6d. per unit.

Mr. Balfour Browne, K.C., contended that Eccles' claim was much higher than the circumstances warranted. The crux of the matter was the cost of current to Eccles Corporation. It had not taken advantage of its right to supply current hitherto, and even now had to put in new machinery in order to do so. It would be possible to put in machinery of the latest and best type, and the cost of production must be reduced considerably by doing so.

On Tuesday Mr. C. D. Taite gave evidence and stated that Eccles, with its new plant, ought to be able to supply 500,000 units per annum to the tramways at about 1·05d. per unit. He admitted that at present Salford was charging 1·3d. per unit to the tramways, or ¼d. lower than was being charged to other trade consumers. He claimed that Salford was handing over thousands of pounds every year to the rates, and was paying for new plant out of revenue instead of out of capital.

The proceedings were adjourned.

Siam.—Imports into the Western Siamese States from Penang in 1906 included telegraph and telephone apparatus to the value of £478, and a small quantity of electric light fixtures and fittings.

Walthamstow.—In future any consumer who has a free-wired installation may acquire this under a hire-purchase agreement.

In reference to the recent L.G. Board inquiry into the Council's application for sanction to borrow £26,395 for additional generating plant, the electrical engineer (Mr. G. R. Spurr) has prepared an amended scheme under which the sum has been reduced to £17,349, made up as follows: Boiler-house plant £7,480, chimney £856, engines and dynamos £3,938, condensing plant £2,270, switchboard £604, water softening and purifying plant £425, foundations for engines and condenser trenches £180, new buildings, alterations and foundations for boilers, chimney and pumps £1,174, contingencies £250, loan charges £172.

Worksop.—A sum of £2,000 is to be expended on an economiser and in extensions of the electric lighting mains.

Dinner.—The fifth annual dinner of the staff of the Middlesbrough electricity department took place on 22nd inst.

The borough electrical engineer (Mr. H. M. Taylor), replying to the toast of his health, referred to the comments made as to the provision made by the department for the future. At present he thought it would be inadvisable for the Corporation to extend their plant. The Power Co. had got rights to sell electricity in the district and could compete with them in their own area. Under their arrangement with the company, however, such firms as Dorman & Long's, which could not be supplied from the Corporation's present plant, would get their electricity at a low price. In the event of any future extension of the borough it would be quite open for the Corporation to build fresh works and compete with the company with a newer and more up-to-date plant. They were giving nothing away, but on the other hand were obtaining protection in their own district. It was untrue that their plant was destined to be consigned to the scrap-heap.

"The Electrician" in Canada.—The circulation of *The Electrician* in Canada has for many years past included a considerable number of the leading electrical engineers in the country, and most, if not all, of the principal manufacturing and supply houses. The recent changes in the postal arrangements, under which *The Electrician* can be posted to Canada for 1d. per copy, will enable us to cover a wider field in that country, and we have made arrangements by which all persons and firms engaged professionally and industrially in electrical engineering in Canada will receive copies of *The Electrician*.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Birmingham.—On Tuesday the Corporation will consider reports of the electricity supply and tramways departments for the year ended March 31. Both undertakings have made good progress during the year, and the figures are highly satisfactory.

The electricity department sold 10,887,684 units of electric energy (7,009,602 for lighting and power and 3,878,082 for traction), producing an income of £103,341, against 5,383,904 units in 1906, producing £75,094. After paying expenses the balance was £54,411. 14s. 3d., against £41,457. 10s. 4d. Interest and sinking fund charges absorbed £46,698. 4s. 9d., leaving a net profit of £7,713. 9s. 6d. (against £6,097. 11s. 9d.), which has been carried to reserve. Works costs were 1·06d. per unit against 1·454d. The net increase in lamp and motor connections during the year was equal to 63,019 16 c.p. (against 30,808 16 c.p.), the increase in motors being 2,570 H.P., against 1,508 H.P.

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The total connections represent 211,843 16 c.p., including 6,006 H.P. of motors.

The gross profit on the tramways was £52,343. 17s. 11d., and after paying interest, sinking fund, &c., the net profit was £26,660. 1s. 5d., of which £14,660 is to be placed to reserve and the balance carried forward.

Blackpool.—The traffic receipts of the tramways department for the year ended March were £54,969. 3s. 1d., and the total revenue was £56,586. 0s. 7d.

The expenditure was £31,604. 11s. 5d. and the gross profit £24,981.9s.2d. After paying interest and sinking fund (£14,939. 2s. 6d.) the disposable balance was £10,042. 6s. 8d. Capital outlay during the year was only £26. 5s. 10d., bringing the total to £281,389. 16s. 4d., towards the redemption of which there is a sinking fund of £54,623. 15s. 8,304,218 passengers were carried and 958,836 car-miles run; 1,261,946 units of electrical energy (or 1·31 per car-mile) were used, and the percentage of working expenses to total revenue was 55·85. The borough treasurer recommends the formation of a special permanent way renewal fund to which not less than £4,000 per annum should be contributed.

Chester.—The capital expended on the electricity department to March 25 was £115,183, an increase of £2,695 on the year.

The revenue from private and public lighting was £16,494. 12s. 11d., and meter and motor rentals, &c., brought in £299. 10s. 11d. Total expenditure was £8,553. 10s. 11d., leaving £8,313. 6s. 4d. £8,196. 0s. 4d. has been carried to net revenue and the balance to bad debts. Interest required £3,527. 9s. 1d. and sinking fund £3,486. 13s. 9d., leaving a net profit of £1,181. 17s. 6d., of which £500 has been voted to reserve and the balance applied in alteration to public lighting and other work. 1,793,401 units of electrical energy were generated (at a cost of £4,105. 1s. 6d.); 806,349 units were sold to private consumers, 470,471 supplied to public lamps (196 arcs and 728 incandescents) and 266,856 to the tramways. The total maximum supply demanded was 1,100 kw. There are 980 consumers, representing an equivalent of 64,652 8 c.p. lamps connected, increases of 64 consumers and 5,208 8 c.p. lamps. The works costs per unit sold were 0·717d. (against 0·676d.), and the total costs were 1·092d., against 1·110d.

The traffic revenue of the tramways department was £10,274. 0s. 7d. and the total revenue £10,606. 10s. Total working expenses came to £6,517. 2s. 10d. (including £1,945. 16s. 6d. for electrical energy at 1·602d. per unit), leaving £4,089. 7s. 2d. to meet interest (£2,317. 12s. 5d.), income tax (£117. 19s.) and sinking fund (£1,287. 7s. 10d.). The net balance (£366. 7s. 11d.) has been placed to reserve. The total capital expended is £77,662. 13s. 2d., increase £12,517. 12s. 3d. During the year 2,532,778 passengers were carried and 291,555 car-miles run, the average traffic revenue per car-mile being 8·460d. and per mile of single track £2,854. Average working expenses per car-mile (including power) 5·364d.

Elland (Yorks.).—There was a deficit of £476 on the past year's working of the Electricity department. The total income was £1,214. 4s. 9d. compared with £1,044. 18s. 3d. in 1906, and the total expenses £686. 3s. 9d., leaving a gross profit of £528. 1s., compared with £480.

Hull.—At a meeting of the Electric Lighting committee last week the chairman (Mr. E. Hanger) gave a report of the past year's working.

He stated that the net profit was £1,813, after paying all expenses, including 10 per cent. depreciation on meters. The price of current had been reduced from 4½d. to 4d. per unit, and this had affected the total income. The demand for current for power was increasing. The undertaking was badly handicapped, owing to the short periods allowed for the repayment of loans. For their borrowed capital of £325,101 they had to pay annually £8,654 for sinking fund alone.

Mr. BENTHAM pointed out that they had borrowed about £350,000, and they had in sinking and reserve funds about £90,000, or about one-fourth of their entire capital expenditure.

The report was adopted and applications from Messrs. Reckitt & Sons and Earle's Shipbuilding Co. for terms for more power were referred to the borough electrical engineer, Mr. H. Bell.

South Shields.—After paying all expenses and meeting interest and sinking fund the net profit for the past year was £3,200.

Swansea.—For the past year there was a net profit of over £200 on the working of the Electricity department.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Belfast Tramways and Electricity committee invite tenders for coal storage bunkers and electric travelling crane. Specifications from the acting city electrical engineer (Mr. Thos. W. Bloxam), Corporation Electricity Works, East Bridge-street. Tenders to Sir Samuel Black, City Hall, Belfast, by noon, Saturday, June 15. See also an advertisement.

St. Pancras (London) Borough Council invite tenders for the supply of an overhead traveller for the extension at the King's-road power house. Specifications from the Electricity Department Offices, 57, Pratt-street, N.W. Tenders to the town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras-road, London, N.W., by noon, June 12. See also an advertisement.

Dublin Lighting committee want tenders by noon June 13 for supply and erection of sub-station switchboards, transformers and accessories. Specifications, &c., from city electrical engineer (Mr. Mark Ruddle), Fleet street, Dublin. Tenders to chairman of committee, 3, Cork-hill, Dublin, by noon June 13. See also an advertisement.

Tenders are invited for the lighting by gas, oil, electricity or other illuminant of the streets, thoroughfares, &c., of the city of *Calcutta*. The city comprises approximately an area of 20 square miles, containing about 170 miles of main thoroughfares and 130 miles of smaller streets, besides several squares, markets, latrines, slaughter houses, &c., which are now lighted by gas and oil lamps. The new contract is timed to commence on May 1, 1911, and the successful tenderer will be required to have all arrangements completed and ready to begin and continue the lighting with effect from that date. Tenders should be for 10, 15 or 20 years. Further particulars are given in an advertisement, and tenders will be received by the Vice-Chairman of the Corporation up to 3 p.m. Jan. 2, 1908.

Tenders are invited for (1) 25,000 kg. 4·5 mm. galvanised iron wire, strength 40 kg. per sq. mm., coil diameter 600 mm.; and (2) 25,000 kg. 3 mm. galvanised steel wire, strength 120 kg. per sq. mm., coil diameter 400 mm., to be delivered October-December, 1907. Specifications (in Danish) and tender forms may be obtained from the Technical Department of the *Danish Telegraph Direction*, Frederiksholms Kanal 28, Copenhagen, Denmark. Tenders not later than noon July 1. Further particulars are given in an advertisement.

Belfast Tramways and Electricity committee invite tenders for a lighting switchboard to control 2,000 kw. and one motor-generator for their East Bridge-street electric station. Tenders to the town clerk (Sir Samuel Black), City Hall, Belfast, by noon June 1.

Edinburgh Corporation also want tenders by 10 a.m. June 3 for constructing sewer shaft and laying iron pipe line for condensing water for M'Donald-road station. Specification, &c., from the City Electrical Engineer or from Sir Alex. Kennedy.

Partick Corporation want tenders by June 3 for stores for the Electricity department, including cables, jointing requirements, cut-outs, meters, incandescent lamps, carbons, oils, coal, &c. Forms from the Burgh Electrical Engineer.

Swansea Corporation want tenders by noon June 4 for c.c. and a.c. arc lamps and pillars, resistances, choking coils, brackets, switch-pillars and accessories. Specification from Borough Electrical Engineer.

Bradford Electricity committee want tenders (by 10 a.m. June 7) for 12 months' supply of best steam coal. Forms from the Electricity Offices.

Penrikyber Navigation Colliery Co. (*Penrhiwceiber*, Glam.) want tenders by June 6 for supply of electric lamps and fittings, ironmongery, oils, &c.

Barnes Council want tenders by noon June 11 for erection of extension of electricity works. Forms of tender, &c, at the Council House, High-street, Mortlake.

Warrington Electricity and Tramways committee require tenders by noon June 5 for l.t. cable. Specification from Borough Electrical Engineer.

Heston and Isleworth Council want tenders (by noon June 3) for supply of electricity meters.

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London County Council require tenders by 11 a.m. June 11 for supply of electrically-operated car-traversers. Forms from the Clerk.

Bradford electricity committee require tenders (by June) for 12 months' supply of best steam coal.

The Deputy Postmaster-General, *Melbourne*, Australia, wants tenders by noon July 16 for telegraph and telephone material. Specifications from the General Post Offices, Melbourne, Sydney, Brisbane and Adelaide.

Tenders will be received until 11 a.m. June 8 for two three-phase 80 kw. 2,000 volt alternators for the *Italian Navy*. Estimated cost £1,012. Deposit required, £102. Public bids will be held at the Royal Arsenal (Contract Office), Spezia. Tenders to be on Government stamped paper of 1 lira, which can be obtained from the Italian Consulate-General, 44, Finsbury-square, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Birmingham Corporation have accepted the tender of the Phœnix Dynamo Mfg. Co. for a balancer-booster set at £692; that of the Electrical Power Storage Co. for battery maintenance for 10 years at £120 a year; and that of T. Johnson for extension of station buildings at £1,208.

Walthamstow Council have accepted the tender of G. Baker & Co. for 120 car wheels at £15. 15s. per ton; that of the British Thomson-Houston Co. for four circuit-breakers for the traction switchboard at £18. 19s. 6d.; and that of the Westminster Engineering Co. for re-winding armatures at £115.

Walthamstow Council have accepted the tender of John Spencer (Ltd.) for tramway poles at £5. 14s. each; that of Dick, Kerr & Co. for 16 bases at 16s. 6d. each; 18 sets of scroll work at 15s. 6d. per set and two sets scroll-work span carriers at 11s. 8d. each set.

The Chloride Electrical Storage Co. have in hand two batteries, each consisting of 286 cells capable of giving 1,200 amperes discharge, and two "Entz" type reversible boosters for the Hanshin Electric Railway, Japan.

Mather & Platt have recently received from Mr. F. Broadbent an order for a 430 kilovolt-ampere single-phase alternator, for use with a calcium carbide furnace.

The contract for electric motors from ½ to 4 H.P. has been placed by Govan Corporation with Electromotors Limited, Openshaw, Manchester.

Sydney (N.S.W.) Council have again placed with Electromotors Limited, Openshaw, Manchester, the contract for d.c. motors from ½ to 25 H.P.

Longton (Staffs.) Corporation have accepted the tender of the Chloride Electrical Storage Co. for 250 cells with a capacity of 420 ampere-hours.

The Metropolitan Asylums Board have accepted the tender of Buchanan & Curwen (at £31. 18s. 6d.) for wiring the pipe subway at the Fountain Hospital.

Bedford Council have accepted the tender of Mr. Chas. Franklin for 2,500 tons Newstead coal at 12s. 9d., 2,000 tons of Cotes Park at 12s. 7d., and 1,500 tons of Colliery small at 11s. 9d per ton.

Mexborough Corporation have accepted the tender of the Chloride Electrical Storage Co. for 250 cells with a capacity of 600 ampere-hours, to replace an existing battery.

Southend-on-Sea Council have accepted the tender of E Pratt & Co. for a hydraulic wheel press for the tramway department at £105.

Leyton Council have accepted the tender of W. G. Harris for the cartage of coal at 10½d. per ton.

BUSINESS NOTICES.

The Union Electric Co. (Ltd.) notify that on and after June their office for Scotland will be at 12, Waterloo-street, Glasgow. The telephone Nos. are 1910 Argyle and 2048 Central (P.O.); the telegraphic address remains "Kandus, Glasgow."

Mr. Ernest M. Sellon, M.I.E.E., who has been associated with Mr. Stephen Sellon in business for some time, is now a partner in his practice, which will be carried on as heretofore, but the title of the firm will be Stephen Sellon & Partners.

Mr. Reginald P. Wilson, of 66, Victoria-street, London, S.W., is shortly going on a business visit to the United States, and he will be absent for a few weeks.

C. W. Robertson and T. Hogg, electricians, &c., 1, Chambers-street, Edinburgh, have dissolved partnership. Debts by Mr. Hogg, who continues as Robertson & Hogg.

BANKRUPTCIES, LIQUIDATIONS, &c.

The first meeting of creditors of John Dixon Gibbs, of Linden-gardens, Bayswater, was held in the London Bankruptcy Court on Wednesday.

The statement of affairs showed liabilities £13,990, assets of uncertain value, consisting chiefly of commission notes relating to the placing of shares of the International Electric Railways & Water Power Synd., and of a company to take over certain copper mines in the Caucasus. Debtor, who anticipates receiving sufficient funds from those notes to enable him to pay his debts in full, stated that he has been connected with electrical undertakings in this country for many years, and more especially with the transforming system which he patented in conjunction with M. Gaulard. His dealings in electrical undertakings dated from 1881, and the immediate cause of his failure was a decision of the House of Lords in 1890, which held that his patent had been anticipated. He asked for an adjournment in order that negotiations which were pending with a view to the realisation of the commission notes might be matured. The meeting stands adjourned for four months.

In the public examination of Francis Williams, electrician, of Salisbury, bankrupt attributed his failure to the fact that he was the local contractor for the free wiring of premises and his reputation had been injured.

Claims against Geo. Robson and John Samson Robson, electrical engineers, Empire-buildings, Newgate-street, Newcastle-on-Tyne, and against the separate estate of Geo. Robson, are to be sent by June 13 to Mr. Thos. Lemon, 1, St. Peter's Church-walk, Nottingham.

Mr R. J. Ward, 8 and 11, Pavilion-buildings, Brighton, has been appointed trustee in the failure of Edwin J. Muddle, electrician, &c., 69, Cromwell-road and 87, West rn-road, Hove.

The liquidator (Mr. W. P. Francis) in the winding up of the McGuire Mfg. Co., Ltd., has been released.

In the liquidation of Improved Electric Supplies, Ltd., 7, Great Newport-street, London, W.C., the first meeting of creditors and contributories will take place on June 18, at Bankruptcy-buildings, London, W.C.

Arc Lamp Business for Sale.—Pursuant to an order made by Mr. Justice Warrington in the matter of the New Century Arc Light Co., Ltd. (Bush v. the Company and Others), tenders are invited for the purchase of (1) the goodwill of the business carried on at Iliffe-street, London, S.E., of electricians, mechanical engineers and manufacturers and vendors of arc lamps and accessories, &c.; (2) the benefit of contracts and orders on hand; (3) the plant, machinery, tools, fittings, &c.; and (4) the entire stock-in-trade of the company. Tenderers may offer for the goodwill of the business only, &c. Tenders (to be sent to the receiver, Mr. E. J. Palmer, Finsbury-pavement House, London, E.C., on or before June 10) will be opened at noon on June 13. Particulars and conditions of sale and forms of tender can be obtained from Mr. E. J. Palmer, or from the solicitors, Messrs. Stanley, Woodhouse & Hedderwick, Bank Chambers, 45, Ludgate-hill, London, E.C. See also an advertisement on another page.

Wanted.—A second-hand single-ended booster for 1,000 amperes, 20 volts, or double-ended booster for 1,000 amperes, 10 volts, each end (or nearest kw.) is wanted; fields preferably wound for 230 volts.

Electric Fittings, &c., for Sale.—An advertiser has about 100 electric light table standards for sale.

Messrs. Kynoch (Ltd.), Witton, Birmingham, advertise for sale a quantity of new Solar Nernst lamps, suitable for 110 or 120 volt circuits.

Business for Disposal.—An electrical contractor's business in the West End of London, with good trade connection, &c., is advertised for disposal.

Royal Naval and Military Tournament (Olympia, London).—Considerable interest has been aroused at Olympia by the brilliancy and steady burning of the "Ediswan Carbone" white flame arcs outside the main entrance during the recent tournament. These lamps, which are British made throughout (they are manufactured at the Ediswan Works, Ponders End, Middlesex) and use pure carbons, depend for their flame effect upon the improved magnetic control of the arc. If required for lighting large open spaces, such as goods yards, pit heads, sidings, &c., they can be supplied to burn impregnated carbons, thus greatly increasing the degree of luminosity. We are informed that the whole of the fittings in the Royal box, anteroom and passages were supplied by the Edison & Swan Co.

CATALOGUES, &c.

Cable Connector.—We give herewith a sectional illustration of a new type of cable connector which is intended to dispense with

SECTION THROUGH CABLE CONNECTOR AND INSULATED COVERING.

soldered joints. The view shown is practically self-explanatory, the device consisting of a double-ended cone bored out of a hexagonal brass rod. Each end of the rod is drilled and tapped to receive a special nut provided with a hole for the cable and a bevelled end registering with the projecting cones. The bared conductors are

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pushed through the hole in the nut, turned down slightly over the bevelled end of the nut which is then screwed home against the internal cone, making a good joint. The device is made in various sizes and may be insulated or not as desired. Mr. S. W. Martyn, 11, Pratt-street, Camden Town, London, N.W., is the inventor, and he is also marketing the device.

High-pressure Blowers.—A speciality is made of high-pressure blowers and cased fans for pressure and extraction work by the James Keith & Blackman Co. A new list, which is arranged on the loose leaflet plan, has just been published, and gives complete illustrated details and prices.

Ropeways.—"Recent Ropoways" is the title of the latest publication issued by Bullivant & Co., Mark-lane, London, E.C. Numerous excellent illustrations depict ropeway installations at Clacton-on-Sea, Simons Bay, Capetown, Preston (Lancs.) and Lismore (N.S.W.).

A.C. and D.C. Fans.—The latest pamphlet from the British Thomson-Houston Co. (pamphlet No. 203) has continuous and alternating-current fans for its subject. The illustrations are particularly well brought out.

Circulating Library.—Mr. H. K. Lewis' quarterly list of new books and new editions added to his circulating library at 136, Gower-street, London, W.C., during January, February and March is just to hand. We notice that a number of useful electrical and general engineering works have been included. Mr. Lewis also sends us an art circular giving illustrations and a brief description of the new extensions to his premises.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from May 18 to 28, with the ports of destination:—

Africa—Alexandria, £247 (including £84 telegraph material); Beira, £95; Cape Town, £108; Durban, £2,155 (including £1,609 telegraph material); East London, £460: Kilindini, £25: Port Elizabeth, £132; Port Sudan, £286; Suez, £41 (telegraph material). *Argentina*—Buenos Ayres, £3,771 (including £3,299 telegraph material). *Australasia*—Adelaide, £275; Auckland, £4,099; Brisbane, £62; Cairns, £510; Hobart, £140 (telegraph cable); Lyttelton, £50; Mackay, £55; Melbourne, £1,148 (including £199 telegraph material, 282 cwt. copper cable); Napier, £150; Otago, £52; Sydney, £1,617; Wellington, £1,345 (including £608 telegraph material). *Belgium*—Antwerp, £15; Brussels, £22; Ghent, £146; Ostend, £19. *Brazil*—Bahia Blanca, £453. *British Guiana*—Demerara, £50. *Burma*—Rangoon, £120 (telegraph material). *Canada*—Quebec, £83; Toronto, £285. *Ceylon*—Colombo, £24 (including £14 telegraph material). *Chili*—Valparaiso, £19. *China*—Shanghai, £167; Tientsin, £13. *Denmark*—Copenhagen, £338 (telegraph material). *Germany*—Bremen, £101 (including £35 telegraph material); Hamburg, £110. *Holland*—Amsterdam, £238; Rotterdam, £133. *Hong Kong*, £396 (including £80 telegraph material). *India*—Bombay, £4,656; Calcutta, £3,104 (including £600 telegraph material); Madras, £626 (including £191 telegraph material). *Japan*—Kobe, £16; Nagasaki, £664; Tokyo, £32; Yokohama, £564. *Malta*, £844 (including £501 telegraph material). *Mexico*—Puerto Mexico, £3,105. *Norway*—Christiania, £1,765. *Russia*—Kurch, £793; St. Petersburg, £880 telegraph material). *Straits Settlements*—Singapore, £326 (including £222 telegraph material). *U.S.A.*—New York, £124. *West Indies*—Trinidad, £21. Total (for 11 days), £35,120, against £38,557 for 7 days last year (May 23 to 29).

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Armature Construction." By H. M. Hobart and A. G. Ellis. (London: Whittaker & Co.) 15s. net.

"A Text-Book of Electro-Chemistry." By Max Le Blanc. Translated from the fourth enlarged German edition by Willis R. Whitney and John W. Brown. (New York: The Macmillan Co.) 10s. 6d. net.

"Proceedings of the Royal Society of Edinburgh." Session 1906-7. Vol. XXVII. No. 1. (Edinburgh: Williams & Norgate.) 7s. 8d.

"Dynamo and Motor Attendants and their Machines." By Frank Broadbent. 5th edition. (London: S. Rentell & Co. (Ltd.) 1s. 6d. net.

"Müller-Pouillets Lehrbuch der Physik." By Leop. Pfaundler. Vol. II. Part 3. (Brunswick: Friedrich Vieweg & Sohn.) 15m.

"La Télégraphie Sans Fil et la Télémecanique a la portée de la Monde." By E. Monier. Preface by Dr. E. Branley. 2nd edition. (Paris: H. Dunod & E. Pinat.) 2fr.

"Proceedings of the Royal Society." Vol. LXXIX. Series B. No. B531. Biological Sciences. (London: Harrison & Sons.) 3s.

"Notions Générales sur La Télégraphie Sans Fil." By R. De Valbreuze. (Paris: L'Eclairage Électrique.) 7fr. 50c.

"Essais des Machines à Courant Continu et Alternatif." By P. Bourguignon. (Paris: Ch. Béranger.) 15fr.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

March 13, 1907.

6,034 CRAMP. Single-phase alternating current motors.
6,057 BILL. Trolley wire protector.
6,064 BRECKNELL, MUNRO & ROGERS & MUNRO. Bow trolleys for electric railways and tramways.*
6,083 MORRIS & LISTER. Electromagnets.
6,092 TAYLOR. Systems of electrical distribution.
6,095 CABOT. Space telegraphy. (Date applied for, 4/4/06.)*†
6,118 WESTINGHOUSE. Cooling and ventilation of electrical apparatus.
6,133, 6,134 & 6,135 B.T.-H. Co. (G.E. Co., U.S.) Signalling systems for railways and the like.
6,139 HODDER & CARR. Turbine engines.

March 14, 1907.

6,146 MOUL. Carbon holder for arc lamps.
6,188 HERBERT & GROVE. Electrical ignition apparatus.
6,199 FOREMAN. Incandescent electric lamps.*
6,203 FESSENDEN. Electric signalling.*
6,219 DEFRIES. Construction of rheostats.
6,224 HANDCOCK, DYKES & SMITH. Protected fuses.
6,226 WILLIS. (Worthington, U.S.) Brake mechanism for elevators and railways.
6,241 B.T.-H. Co. (G.E. Co., U.S.) Generating electric current.
6,242 B.T.-H. Co. (G.E. Co., U.S.) Electrical distribution employing vapour-rectifying devices.
6,243 B.T.-H. Co. (G.E. Co., U.S.) Vapour electric devices.

March 15, 1907.

6,245 GREGORY. Rail points for electric tramways.
6,262 SPENCER. Brake mechanism for tramway and like vehicles.
6,266 BRITISH ELECTRIC PLANT CO. & OELSCHLAGER. Commutation of dynamo-electric machines, electro-motors, rotary transformers and the like.*
6,279 & 6,280 KITSEE. Improvement in telegraphy.
6,288 METCALFE. Electric trembler coils and contact-breakers.
6,289 WALTER. Controlling electric currents.
6,298 HARRAP. Switch mechanism for electrical purposes.
6,334 MADALER. Electric transmission of photographs.
6,341 BREMAECKER. Controlling electric currents.*
6,349 B.T.-H. Co. & GRAY. Electric conductors of refractory metal.
6,350 B.T.-H. Co. (G.E. Co., U.S.) Electrical methods of light and devices.

March 16, 1907.

6,358 ARNOLD & BUMPSTEAD. Electric cable sockets.*
6,367 JORDAN. Electric fuses for blasting purposes.
6,385 BERESFORD. Electric contact for electric alarm clocks.
6,390 GRIDLEY. Indicating when conductors are charged or in "live" condition.
6,408 EHRHARF. Turbines.*†
6,417 TORRENS. Electrical ignition apparatus.

March 18, 1907.

6,445 FEATHER. Supporting trolley wires.
6,449 WARREN. Primary batteries.
6,455 LEA. Tumbler switch.
6,457 FLETCHER. Magazine fuse for electric light and power circuits.
6,498 JEFFERY & JEFFERY. Electric sparking devices.*
6,502 THIROT & MAGE (called NOUGUIER). Regeneration of the electrolyte employed in extraction of copper from old bronze and bronze waste. (Date applied for, 26/3/06.)*†
6,522 NYA ACKUMULATOR AKTIEBOLAGET JUNGNER. Alloys, metallic parts of accumulators with invariable electrolyte, and accumulators constructed with such metallic parts. (Date applied for, 30/3/06.)*†
6,527 ALLGEMEINE ELEKTRICITÄS GES. Time meters. (Date applied for, 27/3/06.)*†

March 19, 1907.

6,557 BIRCH. Electrical switch for motor bicycles, motor cars and the like.
6,560 HARTLEY. Effecting the initial vaporisation in self-generating vapour lamps.
6,592 EGGER. Process for the production of leather for insulation of electrical conduits.*
6,603 TOURTEL. Coin-freed electricity meters.*
6,640 BELLISS & MORCOM & MORCOM. Guide blades and vanes for turbine motors.
6,648 B.T.-H. Co. (G.E. Co., U.S.) Vehicle wheels.*
6,649 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.

March 20, 1907.

6,675 FISCHER. Electric bells.*
6,697 BEIN. Changing intensity of direct currents by alternating currents.
6,699 MAGUNNA. Electric lamp socket with instantaneous contacts. (Date applied for, 20/3/06.)*†
6,710 MASON. Lug or take-off for secondary-battery elements.
6,715 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H. Germany.) Dynamo-electric machines and controlling same.*

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6,716 Siemens Bros. Dynamo Works and Wilson. Dynamo-electric machines or motors.*
6,725 Redman. Electrical heaters for enclosed spaces.
6,735 Triquet. Accumulators or secondary batteries.*
6,740 Todd. Incandescence lamps.
6,745 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of iron alloys.
6,751 Ravenshaw, Middleton & Townsend. Magnetic clutches.

March 21, 1907.

6,776 Hewer. Turbines.
6,784 Pearce. Fluid-pressure turbines.
6,799 Cooper. Lifeguard apparatus.
6,809 Moy, Bastie, & Ernest F. Moy (Ltd.). Starting switches.*
6,822 Davey. Steam turbines.*
6,829 Williams. Contact device for electrical ignition apparatus.
6,837, 3,838 & 6,839 Pörscke. Turbines.*
6,847 Johnson-Lundell Electric Traction Co. (Lundell, U.S.) Dynamo-electric machines.*
6,854 Schattner & Amberton. Electric controllers.
6,855 & 6,856 Warwick Machinery Co. (G.E. Co., U.S.) Governing mechanism for turbines.

March 22, 1907.

6,859 Barton & Deakin. Electro-deposition upon fabrics, leather, &c.
6,877 Lambert & Mitchell. Turbines.
6,895 Tingley. Brush-holders. (Date applied for, 4/4/06.)*†
6,899 A. P. Lundberg, G. C. Lundberg & A. Lundberg. Electrical switches.*
6,906 Keith & Tuson. Alternating-current motors.
6,912 Beattie & Barnes. Securing incandescent lamp-holders to leads.
6,925 Atkinson. Electric controllers.
6,929 Siemens & Halske A.-G. Telegraphy. (Date applied for, 22/3/06.)*†
6,932 Foster & Spoor. Electric igniting apparatus.
6,943 Davy. Arc lamps.
6,959 Gaiffe. Transformers for production of Hertzian waves.
6,966 Allgemeine Elektricitäts-Gesellschaft. Dynamo-electric machines. (Date applied for, 29/3/06.)*†
6,967 B.T.-H. Co. (G.E. Co., U.S.) Motor-controlling rheostats.*
6,968 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric transmission systems.
6,973 Kallmann. Electric brakes for electromotors.*

March 23, 1907.

6,977 Fennell. Turbine engines.
6,992 Notarianni. Electric railway danger signal.
7,011 Carter & Fletcher. Lifeguards for tramcars and like vehicles.*
7,033 Unterberg & Heimle. Adjusting device for magneto-electric ignition apparatus.*
7,048 B.T.-H. Co. (G.E. Co., U.S.) Magnetic wedges.
7,052 Stevens. Regulating voltage of the generator of petrol-electric cars.
7,053 Stevens. Ventilating the dynamo and motors of petrol-electric automobiles.

SPECIFICATIONS PUBLISHED.

1905 Specification.

25,490 Lodge & Muirhead. Wireless telegraphy.

1906 Specifications.

3,113 Reiner. Driving of turbines by pressure fluid.
5,599 Daniel. Electrical automatic bolt. (Post-dated 8/9/06.)
5,602 Bubleigh. Field magnets of dynamo-electric machines.
5,893 & 5,893A B.T.-H. Co. (G.E. Co., U.S.) High-tension switches.
6,088 B.T.-H. Co. (G.E. Co., U.S.) Electrodes for arc lamps.
6,223 Hunt & Sandycroft Foundry Co. Dynamo-electric machines.
6,224 Hunt & Sandycroft Foundry Co. Alternating-current dynamo-electric machines.
6,283 Kuehnrich. Electric furnaces.
6,454 Lea. Measuring and recording the flow of liquids or gases, and measuring and recording mechanical and electrical quantities.
6,459 Fitz-Gerald. Rotary motors for turbines.
6,477 Hollington. Apparatus for winding wire.
6,510 Brockie. Arc lamps.
6,575 Prall. (Prall.) Impact or turbine engines.
6,602 Tudor. Self-regulating installations for producing electrical power or both simultaneously.
6,803 Justice. (Deutsche Gasglühlicht A.-G., Auergesellschaft.) Glow lamps.
6,820 De Törley & Benkö. Apparatus for generating electricity.
6,833 Bastian & Calvert. Mercury vapour apparatus and the like.
7,060 Madgen & Brush Electrical Engineering Co. Motor-propelled vehicles.
7,162 Berry. Electric switch apparatus.
7,188 Bloxam. (Lux.) Incandescence bodies of refractory metals for electric lamps.
7,293 Wise. (Tischner.) Electrical connector for electric lamps.
7,566 Gardner. Signalling in local electric circuits by sound or other vibrations.
7,836 Electric Ignition Co. & Hall. Ignition systems.
7,836A Electric Ignition Co. & Hall. Magnetic ignition apparatus. (Date applied for, 2/4/05.)
8,680 B.T.-H. Co. (G.E. Co., U.S.) Systems of control for electric motors.
8,936 B.T.-H. Co. (G.E. Co., U.S.) Railway signalling systems and apparatus.
9,415 B.T.-H. Co. (G.E. Co., U.S.) Signalling apparatus.
9,706 Wainwright & Mann, executors of the late G. J. Atkins. Electrolytic apparatus.
10,021 B.T.-H. Co. (G.E. Co., U.S.) Machines for making stems for incandescent lamps.
11,317 Ulmann. Clockwork-driven commutator switch for operating signals.
11,594 Moul. Arc lamps.
11,659 B.T.-H. Co. (G.E. Co., U.S.) Automatic controlling devices.
12,385 Electric Ignition Co. & Hall. Sparking plugs.
12,735 Fullagar. Air compressors of the turbine type.
12,820 B.T.-H. Co. (G.E. Co., U.S.) Shaft bearings, especially applicable to electric railway motors.
12,907 Heideman. Operating the points of rail or tramways from vehicles thereon.

COMPANIES' MEETINGS AND REPORTS.

Callender's Cable & Construction Co. (Ltd.)

The eleventh annual general meeting of this company was held yesterday, Mr. Henry Drake presiding.

The SECRETARY (Mr. H. E. Harrison) read the notice convening the meeting and the auditors' certificate.

The CHAIRMAN said when the board last met the shareholders he mentioned that the balance-sheet then submitted gave an account of the most prosperous year they had had, but that now submitted was an advance upon last year's. In commenting upon the figures in the directors' report (abstracted in our issue of 17th inst.), he said goodwill and patents stood at nothing—that was to say, the cost of obtaining the patents had been paid out of income; money retained by Corporations and others for due fulfilment of contracts was £139,543, against £115,323 last year. The board would like to see this reduced instead of increased, because it would mean more business was being done. The profit and loss account showed profit for the year, after deducting all charges in manufacturing accounts and contracts, of £122,925, compared with £124,541. The balance carried down was £80,773, against £79,094. To this must be added £38,921 brought forward from 1905, compared with a corresponding addition last year of £23,406. After deducting debenture interest, preference dividend and depreciation, there was a balance of £82,972, which they proposed to deal with by payment of an ordinary dividend of 10 per cent., tax free, (being 10s. per share, including 5s. already paid), and a bonus of 5s. per share, and by carrying forward £56,722 compared with £13,921. He thought the shareholders would agree that this was a very satisfactory showing, and he moved the adoption of the report and accounts.

Mr. C. H. McEUEN seconded.

Mr. GEO. ALLAN also congratulated the board on their admirable report.

Mr. R. STEWART BAIN said the accounts were most excellent. Shareholders were often satisfied with looking at the amount paid in dividends, but they had something more in this case. The board were not satisfied with submitting their own valuation of the assets, but gave the shareholders, time after time, a certificate of their value. He looked upon this as of even greater moment than the excellent dividends paid year after year. A calculation showed him that they could have paid something like 35 per cent, and still carry forward a handsome sum, but they were wise in restraining themselves.

Mr. T. O. CALLENDER (managing director) said he felt very deeply what Mr. Bain had said in regard to the accounts, because there was nobody in London who had a deeper insight into electrical business methods. His many years' connection with electricity supply rendered him a most competent critic. He also appreciated Mr. Allan's remarks. The year had been a satisfactory, but none the less a trying, one to the management and the directors. They had had difficulty in maintaining their position from various causes, most of which were known to every person engaged in manufacturing. No money was available for new enterprises, and he thought that difficulty was even worse than it was last year. Added to this was the proposed legislation in regard to electricity supply, which reduced the disposition of electrical undertakers to extend into new enterprises. Finally there was the advance in price of copper. In the early part of the year copper varied from £84 to £85 a ton, but from the end of July, when it began to rise, it had reached £115. In spite of this they had not done badly. English trade had been poor, as the cables that had been used had been in existing networks rather than new contracts, but there were so many networks now in existence that these extensions amounted to a not insignificant sum. But they had devoted their attention largely to foreign work. He had himself recently returned from a lengthy voyage in India and Burma, his brother (Mr. James Callender) had been for some time in Canada, Mr. Hastings (one of their managers) had recently returned from a long trip to South America, and Mr. Petersen had on many occasions recently visited nearly all parts of the Continent with a view to introducing and extending the company's operations. Their manager in India was leaving in a few days for China and Japan. There were few parts of the world where cables were likely to be used and where their company was not fighting its battle, and, as he believed, in a satisfactory manner. They had a very fine business opening up in India. One of the causes of anxiety during the past year had been the power companies. The directors believed that there was an immense future in the supply of electricity in bulk, but circumstances had arisen which had stopped that business for the present, and their company had to a certain extent suffered in their turnover by the stoppage of business which they had anticipated. They had met the difficulty by writing down largely the shares they held in power companies, and they were satisfied that they had done what was right, that the shares stood at a proper valuation, and that before very long they would get a handsome return from the forward policy they had pursued in the past. In regard to the coming year he could only say

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they were doing everything they could to keep their business up to the high state of efficiency and profitableness which had characterised it in the past. He tendered his thanks to the staff for the assistance they had given him, and assured the shareholders that all would continue to do their best.

The motion was then carried unanimously.

At an extraordinary meeting which followed a resolution was passed that £1,200 be paid to the directors (other than the managing director) by way of remuneration, in addition to the sum already payable for the year 1906, and for subsequent years.

BIRMINGHAM & MIDLAND TRAMWAYS (LTD.)—For the past year the revenue was £92,582, compared with £116,643 in 1906, over £12,000 of the decline being accounted for by the transfer of the omnibus department to a separate company. Expenses were £44,952, against £74,465, £14,453 representing expenses connected with the omnibus department. After providing for depreciation, &c., the surplus is £48,203. The directors propose to pay a dividend of 5½ per cent. on the preferred ordinary shares, and to carry forward £552. The receipts from the tramways were £58,081, or £24,000 less than in previous year.

BRITISH ALUMINIUM CO. (LTD.)—The profit for 1906 is £155,023. 13s. 6d., and with £3,880. 1s. 11d. from the previous year, the total available profit is £158,903. 15s. 5d. The directors recommend payment of a final dividend on the preference shares for 1906, interest on the funding certificates for 1906, 5 per cent. interest on the conversion shares to Dec. 31, 1906, and a dividend of 7 per cent. on the ordinary shares for 1906, leaving £34,548. 11s. 9d. to be carried forward. During the year progress has been made with the development of the Loch Leven power scheme. By Aug. 15, 1908, all the generating plant should be installed and the aluminium factory erected and equipped. With a view to obtaining an increased production of aluminium prior to the completion of the Leven works the board acquired a partially-developed power at Stangfjord in Norway, and took steps to develop some 3,000 H.P. at Leven, which latter can be utilised without interfering with the progress of the main scheme. It is expected that the production of aluminium will commence in Norway in a few weeks' time and at Leven in the autumn. The board has also acquired concessions for a water power of considerable magnitude at Orsières in Switzerland, and intends to proceed with the construction of works without delay. These extensions involve large expenditure, and the share capital has been increased by £600,000. An agreement has been come to with the Soc. Anon. Pour l'Industrie de Neuhausen to end all outstanding provisions of the 1895 contract upon paying to the Neuhausen Co. £100, and engaging for a maximum period of 10 years from Jan. 1, 1907, not to use or permit to be used any part of the Orsières water power for the production of aluminium.

LEWES & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—At the meeting on Monday it was stated that capital expenditure during 1906 amounted to £736, making a total capital outlay of £26,234. Gross revenue amounted to £2,047, increase £90. Expenditure was £2,069, leaving a loss of £21. The demand for electricity continued to increase satisfactorily.

REUTER'S TELEGRAM CO. (LTD.)—Admiral Sir John W. Dalrymple-Hay, who presided at the meeting on Wednesday, said that the year just closed had been replete with events of a startling kind. The earthquake at San Francisco was followed by shocks in Chili and Jamaica. So great was the disturbance that cable communication was interrupted for some time. The farewell speech of Lord Cromer amounted to some thousands of words, and was one of the longest telegraph messages ever received by Reuter's. A word of praise was due to the Eastern Telegraph Co., as the entire despatch was transmitted in a little over four hours.

SOUTH STAFFORDSHIRE TRAMWAYS (LESSEE) CO. (LTD.)—At the meeting last week the Chairman (Mr. E. Garcke) said the receipts for the past year had increased by £1,300, and the number of passengers carried by 843,000. The net result was that they had been able to reduce the proportion of expenditure from 71 to 61 per cent.

TRACTION AND POWER SECURITIES CO. (LTD.)—At the meeting on Tuesday, Mr. J. H. Lukach stated that the increase in the investments was caused by further capital having been called up upon their shares in the Clyde Valley Electrical Power Co. The directors had not considered it advisable to recommend payment of a dividend at present, in view of the company's principal holdings being still in the development stage. The investments now stood in the books at £812,554. The amount of the company's holding in Mersey Railway 4 per cent. first debenture stock showed no change, and £18,297 of the stock referred to at last year's meeting had still to be taken up. He was able to report a satisfactory and continuous increase in the earnings of the Mersey railway.

NEW COMPANIES AND STATUTORY RETURNS.

NEW COMPANIES.

REED'S ELECTRICAL CO. (LTD.) (93,493.)—Reg. May 25, capital £8,000 in £1 shares, to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, manufacturers of and dealers in electrical apparatus, &c. First directors, B. Reed (chairman) and W. Ruddock.

CARIBBEAN ANGLO-COLOMBIAN CABLE CO. (LTD.) (93,464.)—Reg. May 24, capital £100,000 in £1 shares, to carry on the business of a telegraph and telephone company in all its branches, to construct, lay, maintain and work submarine and land cables and wires, &c. The subscribers (with one share each) are: M. Ross, stenographer, A. E. Cadby, clerk, A. R. Bennett, accountant, H. G. Rushen, clerk, W. H. C. Cory, secretary, A. Borer, clerk, and W. Postlethwaite, clerk. Reg. office, 84, Bishopsgate-street Within, E.C.

SOCIETE D'EXPLOITATION DES FORCES MOTRICES DE L'AVEYRON (LTD.) (93,494.)—Reg. May 25, capital £26,000 in £4 shares, to acquire a concession of Dirit et Cie. relating to the public and private electric lighting of the commune of Cordes (Tarn, France), to take a transfer of the hydro-electric works at Contillon, La Guepie (Tarn et Garonne), with its transmission lines, transformers, &c., to work the concession for the electric lighting of Cordes and its environs, and to carry out all commercial, industrial and other operations relating to the working of same at La Guepie or elsewhere, &c. First directors, G. Dirit (managing and technical director as regards the carrying on of the electrical factory), L. Daudibertieres (manager of electrical department), L. Descubes, and others to be appointed by the subscribers.

WISBECH ELECTRIC LIGHT & POWER CO. (LTD.) (93,430.)—Reg. May 18, with capital £25,000 in £1 shares, to adopt an agreement with the National Electric Construction Co., to take a transfer of the undertaking authorised by the Wisbech Corporation Electric Lighting Orders, 1901 and 1906, and to carry on the business of suppliers of electric light and power, electrical engineers, contractors for supply of electric plant, &c. First directors, W. B. Cownie, F. E. Stanley and J. T. Jervis. Reg. Office, Queen Anne's-chambers, Westminster, S.W.

STATUTORY RETURNS.

BERGTHEIL & YOUNG (LTD.)—Return to March 20 gives capital as £40,000 in £1 shares, of which 32,007 have been taken up. £8,007 has been received and £24,000 is considered as paid. Mortages and charges nil.

BRITISH ELECTRIC TRANSFORMER CO. (LTD.)—Return to April 26 gives capital as £125,000 in 50,000 preference and 75,000 ordinary shares of £1 each, of which 30,490 preference and 9,399 (?69,399) ordinary have been taken up. £1 per share has been called up on 39,889 shares, and £39,904. 12s. 6d. has been received. 60,000 ordinary shares are considered as fully paid. Mortgages and charges nil.

GUILDFORD ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to April 10 is £55,000 in 25,000 preference shares of £1 each and 6,000 ordinary shares of £5 each, of which 9,901 preference and 2,782 ordinary have been taken up. £23,813 has been received, including £2 paid on two forfeited shares. Mortgages and charges, £25,000.

HOVE ELECTRIC LIGHTING CO. (LTD.)—According to return to March 28, capital is £100,000 in £5 shares, of which 15,000 have been taken up. £5 per share has been called up and £75,000 has been received. Mortgages and charges, £44,600.

HUDSON & BOWRING (LTD.)—In return to March 11 capital is £3,300 in £1 shares, of which 3,142 have been taken up. £987 has been received and £2,155 is considered as paid. Mortgages and charges, nil.

MANN, EGERTON & CO. (LTD.)—In return to March 25 capital is £40,000 in 25,000 preference and 15,000 ordinary shares of £1 each, of which 11,669 preference and 6,007 ordinary have been taken up. £1 per share has been called up on seven ordinary and 5,500 preference and £5,507 has been received. £12,169 is considered as paid on 6,169 preference and 6,000 ordinary. Mortgages and charges, £10,000.

NEWCASTLE & DISTRICT ELECTRIC LIGHTING CO. (LTD.)—In return to March 15 capital is £300,000 in £10 shares, all of which have been taken up. £9 per share has been called up and £267,274 has been received, leaving £2,726 in arrears. Mortgages and charges £150,000.

NORTHERN COUNTIES ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to May 1 is £200,000 in £1 shares, of which 150,000 (including 10 forfeited) have been taken up. £1 per share has been called up on 146,000 and £145,991. 5s. has been received, leaving £8. 15s. unpaid on forfeited shares. 4,000 shares are considered as fully paid. Mortgages and charges, £100,000.

UNION ELECTRIC CO. (LTD.)—Return to April 29 gives nominal capital as £25,000 in £1 shares, of which 24,250 have been taken up. £1 per share has been called up on 4,250, and 1s. per share on 19,500, and £5,225 has been received. 500 shares are considered as fully paid. Mortgages and charges nil.

CITY NOTES.

MEMORANDA (May 30).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 31d.—31⅛d. per oz. Consols 84⅛—84⅜ for money, 84⅛—84⅜ for account; 2½ per cent. annuities 83—83¼. Consols Pay Day, June 3; Stocks and Shares Continuation Days, June 11 and 25, Ticket Days, June 12 and 26; Pay Day, June 13; Mining Share Carry-over Day, June 10.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—During the four weeks ended April 26, 511,662 units were delivered, against 497,922 in the corresponding four weeks of 1906.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have been asked to appoint a special settling day in and grant a quotation to 10,000 additional $100 shares of capital stock of the *Sao Paulo Tramway, Light and Power Co. (Ltd.)*, and also to allow $500,000 additional 5 per cent. $500 mortgage debentures of the same company to be quoted.

VICTORIA FALLS POWER CO. (LTD.)—It is stated that under an agreement between the Vereeniging Estates and the Victoria Falls Power Co., the latter, after it has erected a generating station of a capacity of 20,000 H.P. at a central position on the Rand, binds itself, when its orders for power amount to 80,000 H.P., to erect a station at Vereeniging of 20,000 H.P. saleable capacity.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 22	1,306	+ 77	51	69,974	+ 1,803
Airdrie	,, 17	234	+ 7	19	4,259	+ 6
Anglo-Argentine	,, 27	16,662	+ 2,011	21	347,253	+ 30,918
Ashton-under-Lyne Corp	,, 25	489	+ 171	9	3,574	+ 604
Ayr Corporation	,, 25	285	+ 9	2	406	...
Baker St. & Waterloo Ry.	,, 25	2,580	+ 1,197	11	25,915	+ 9,043
Barnsley	,, 17	171	+ 6	19	3,068	- 54
Barrow	,, 17	231	+ 3	19	4,274	+ 12
Bath Electric Trams, Ltd.	,, 22	1,127	+ 330	21	14,960	+ 317
Birkenhead Corporation	,, 26	1,097	+ 78	...	...	...
Birmingham Corporation	,, 25	6,976	...	8	47,334	...
Birmingham & Mid.	,, 10	812	...	18	13,810	...
Blackburn Corporation	,, 22	1,349	+ 503	§8	9,624	+ 1,160
Blackpool Corporation	,, 23	1,757	+ 1,241	7	5,966	- 433
Blackpool and Fleetwood	,, 26	1,483	+ 1,084	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 26	2,994	+ 1,022	8	17,955	+ 1,129
Bournemouth Corporation	,, 22	2,083	+ 695	¶7	12,851	+ 748
Bradford Corporation	,, 18	4,547	+ 296	8	37,169	+ 1,966
	,, 25	5,464	+ 1,231			
Brighton Corporation	,, 26	1,217	+ 406	8	7,170	- 7
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 24	6,472	+ 1,571	15	73,033	- 1,397
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 25	1,369	+ 235	8	8,473	+ 221
Burton Corporation	,, 26	328	+ 49	8	2,256	- 99
Calcutta Tramways Co.	,, 25	R14,396	+ R3,124	20	R1,014,247	+ R14,798
Camborne-Redruth	,, 25	176	+ 66	21	2,374	+ 138
Cardiff Corporation	,, 18	1,998	+ 102	8	16,468	+ 794
	,, 25	2,559	+ 668			
Cavehill	,, 17	87	+ 1	19	1,367	+ 46
Central London Railway	,, 25	5,473	- 991	21	128,765	- 13,716
Chatham & Dist. Lt. Rys.	,, 23	853	+ 262	¶20	13,691	+ 4,241
City & South London Rly.	,, 26	3,057	+ 500	21	62,051	+ 2,016
City of Birmingham	,, 17	2,931	...	19	52,125	...
Colchester Corporation	,, 22	279	+ 90	...	...	...
Cork Electric Trams Co.	,, 23	493	- 11	21	8,775	- 197
Croydon Corporation	,, 24	1,653	+ 278	‡8	11,130	- 288
Devonport & Dist. Trams	,, 17	446	- 13	19	8,425	+ 127
Dover Corporation	,, 25	280	+ 57	8	1,758	- 66
Dublin & Lucan Railway	,, 24	170	+ 61	21	2,123	+ 53
Dublin United	,, 24	6,768	+ 1,984	†21	102,839	+ 6,240
Dudley Stourbridge	,, 17	823	- 9	19	15,345	- 89
Dundee Corporation	,, 22	1,099	+ 101	1	1,099	+ 101
East Ham Council	,, 25	1,082	+ 261	8	7,300	- 108
Exeter Corporation	,, 24	404	+ 151	‡8	2,482	+ 346
Falkirk and District	,, 22	273	...	8	2,306	...
Gateshead & Dist. Trams	,, 17	1,026	+ 70	19	18,877	+ 720
Glasgow Corporation	,, 25	18,192	+ 1,282	51	872,866	+ 70,579
Glossop	,, 25	147	+ 20	21	2,827	+ 94
Gravesend—Northfleet	,, 17	245	+ 9	19	4,285	+ 130
Great Northern & City Rly.	,, 25	1,689	- 23	21	38,345	+ 104
Gt. Northern, Piccadilly, &c.	,, 25	4,300	...	21	81,019	...
Greenock & Port Glasgow	,, 17	699	- 8	19	11,983	+ 131
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 17	283	+ 10	19	4,899	- 246
Hastings Elec. Trams Co.	,, 23	1,336	+ 729	21	17,620	...
Hong Kong	,, 25	$7,519	+ $1,346	8	$161,410	...
Huddersfield	,, 25	1,879	+ 467	8	12,783	+ 1,146
Hull Corporation	,, 25	2,676	+ 478	8	18,799	+ 1,381
Ilkeston District Council	,, 22	183	+ 72	8	1,151	+ 193
Ipswich Corporation	,, 25	475	+ 117	8	3,067	- 6
Isle of Thanet Co.	,, 25	764	+ 384	34	10,635	+ 614
Jarrow	,, 27	135	...	19	2,177	...
Keighley Corporation	,, 23	177	+ 42	47	7,107	+ 592
Kidderminster & District	,, 17	101	- 14	19	1,863	- 71
Kilmarnock Corporation	,, 25	167	+ 18	¶1	273	+ 37
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 23	1,240	+ 393	21	22,342	+ 4,734
Lancashire United	,, 22	1,427	+ 571	§21	23,839	+ 6,720
Leamington	,, 17	143	- 6	19	2,677	- 127
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	,, 27	2,606	+ 507	21	45,956	+ 999
Leith Corporation	,, 25	506	+ 13	†2	807	- 21
Lincoln Corporation	,, 25	129	+ 21	8	919	- 12
Liverpool Overhead Rly.	,, 26	1,754	+ 344	21	29,986	+ 686
Liverpool Corporation	,, 18	10,897	+ 425	20	208,981	+ 3,605
*London County Council	,, 18	31,763	+ 5,520	7	208,621	+ 24,901
London United	,, 24	9,034	+ 3,240	†21	119,750	+ 7,163
Lowestoft	,, 25	219	+ 91	31	5,261	+ 776
Maidstone Corporation	,, 25	117	+ 21	8	866	+ 27
Manchester Corporation	,, 25	17,869	+ 4,977	8	115,500	+ 11,369
Mersey Railway	,, 25	1,948	+ 279	21	38,541	+ 1,985
Merthyr	,, 16	206	+ 7	19	3,886	+ 224
Metropolitan Dist. Railway	...	...	...	...	...	...
Metropolitan Elec. Trams	,, 17	4,993	+ 1,288	19	78,688	+ 18,775
Middleton	,, 17	368	+ 6	19	6,205	+ 124
Nelson Corporation	,, 25	152	+ 22	9	1,305	+ 125
Newcastle-on-Tyne Corp.	,, 25	4,206	+ 409	8	32,357	+ 1,162
Newport (Mon.)	,, 25	847	+ 267	8	5,337	+ 519
Northampton Corporation	,, 25	559	+ 179	‡8	3,111	- 159
Oldham, Ashton & Hyde	,, 17	610	- 27	19	11,236	+ 681
Oldham Corporation	,, 26	1,968	+ 238	9	17,438	+ 1,838
Perth (N.B.) Corporation	,, 22	165	+ 6	1	165	+ 6
Perth (W.A.) Elec. Trams	,, 21	1,232	- 152	21	30,882	- 718
Peterborough	,, 17	136	+ 17	19	2,159	+ 41
Portsmouth Corporation	,, 25	2,330	+ 752	8	15,090	+ 632
Potteries	,, 17	1,892	+ 88	19	35,218	+ 549
Preston Corporation	...	...	...	...	...	...
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 23	785	+ 352	‡8	4,375	+ 915
Rothesay	,, 17	117	- 5	19	1,689	- 12
Salford Corporation	,, 27	6,261	+ 1,962	8	38,192	- 2,904
Sheerness	,, 15	56	+ 2	19	971	- 16
Sheffield Corporation	,, 26	5,961	+ 644	9	49,346	+ 3,293
Singapore Trams	,, 25	$9,740	+ $1,715	8	$79,047	+ $13,775
Southampton	,, 22	1,105	- 239	...	...	...
Southend Corporation	,, 22	472	+ 156	8	2,561	+ 42

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
South Metropolitan	May 17	803	...	19	13,676	...
Southport Tramways	,, 17	270	+ 1	19	4,615	- 249
South Staffs	,, 17	880	+ 76	19	16,810	+ 1,311
Stalyb'dge, Hyde, &c., Jt. Bd.	,, 25	1,064	+ 390	8	6,439	+ 564
Sunderland Corporation	,, 12	1,358	+ 98	8	10,936	+ 436
	,, 19	1,364	+ 155			
	,, 26	1,537	+ 260			
Sunderland and District	,, 22	623	+ 323	21	8,826	+ 1,404
Swansea Trams	,, 17	840	+ 30	19	15,485	+ 437
Swindon Corporation	,, 15	175	- 15	...	...	...
	,, 22	179	+ 15			
Taunton	,, 17	39	- 5	19	769	- 56
Tynemouth and District	,, 17	211	- 1	19	3,278	- 365
Tyneside Trams Co.	,, 22	504	+ 158	21	8,583	+ 858
Victoria, Elec. Supply Co. of	April 21	797	- 536	4	4,250	+ 436
Wallasey District Council	May 25	994	+ 270	7	1,437	+ 455
Walsall Corporation	,, 18	509	- 11	21	10,039	- 243
	,, 25	691	+ 219			
West Ham Corporation	,, 23	2,597	+ 537	8	19,245	+ 1,495
Weston-super-Mare	,, 15	80	- 4	19	916	- 58
Wolverhampton Co.	,, 17	454	+ 39	19	8,090	+ 226
*Wolverhampton Corpn	,, 22	1,362	+ 616	18	16,403	...
Worcester	,, 17	266	+ 2	19	4,781	- 84
Wrexham	,, 17	97	+ 2	19	1,851	- 22
Yorkshire W.R. Trams	,, 26	1,577	+ 724	21	23,247	...
Yorkshire Woollen District	,, 17	1,002	+ 76	19	17,853	+ 1,20

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., May 29.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO MAY 29. Highest.	Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	7⅞—7¹⅞	5 2 6	Ap, Oct	7¹¹⁄₁₆	7⅞
£	2/9	Do. 5% per Cent. Cum Pref.	5¹¹⁄₁₆—5¹³⁄₁₆	4 12 3	..	5¹³⁄₁₆	5¹¹⁄₁₆
St.	6%	Do. Permanent 6% Deb. Stock	135 —136	4 8 8	..	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	104 —107	4 13 6	..	105	..
5	..	Brisbane Electric Trams. Invest. Ord.	2¹³⁄₁₆—3¹⁄₁₆	3 5 6	..	3	2¹⁵⁄₁₆
5	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5¼	4 18 9	..	4¼	4¼
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	98 —102	4 8 0	..	98	..
St.	7%	British Columbia El. Ry. Df. Ord.	123 —127	4 14 3	..	..	..
St.	5%	Do. Pref. Ord. Stock	106 —111	4 10 0	..	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	102 —1 6	4 14 3	..	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	99 —10	4 8 0	..	..	..
100	4½%	Do. Vancouver Power Debs.	102¼—1 4¼	4 6 0	..	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	3¼—3⅜	4 0 0	..	3¹⁷⁄₃₂	3¹³⁄₃₂
5	3/0	† Do. 6 per Cent. "A" Cum. Pref	4¼—4⅜	5 11 6	..	..	..
5	3/0	† Do. "B"	4¼—5¼	5 14 0	..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	..	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	..	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	98 —101	4 19 0	..	..	..
10	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	100 —104	5 5 9	..	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	100 —105	5 14 0	..	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7¼—8	5 0 0	..	7¹⁵⁄₁₆	7⅞
100	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5¼	4 7 6	..	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	103 —108	4 3 3	..	..	..
8½	..	Cape Electric Tram Shares	⅝ ⅞	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	90 —100	5 0 0	..	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 - 90¾	5 11 0	..	88	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 —95	5 5 0	..	..	..
5	6%	Do. 6 per Cent. "B" Ditto	81 - 85	7 1 0	..	84	83
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅛	3 9 6	..	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	5 1 0	..	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb	98 —101	4 19 0	..	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —101	4 19 0	Ja, Jul	96	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 —104	4 6 6	..	..	..
St	6%	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	..	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	123 - 128	3 2 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	£5%—£7%	5 3 0	..	£6	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¾—5¼	5 14 0	..	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7¼—8⅜	5 15 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 —98	4 11 9	..	97	..
5	5/3	Calcutta Elec. Supply Ord.	7½ - 8½	5 2 0	..	8¼	8¼
5	2/3	† Do. £4 paid	6 —7	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	..	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2¾	..	..	..	..
St.	5%	Do. 5 per Cent. Deb Stock	88 —92	5 8 6	..	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 — 98	5 2 0	..	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 —109	5 10 0	..	..	..
1	0/7½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	13 13	..	..	13	13
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½—97½	5 2 6	..	..	..
1	1/6	Rand Electric	1⅝—1⅞	..	..	..	..
1	0/6	†River Plate Electricity Co. Ord.	1⅝—1⅞	..	..	1⅝	1⅝
1	1.2½	† Do. 6 per Cent. non-Cum. Pref.	4—4¼	6 0 0	..	4¼	..
St.	5%	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	..	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	..	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101¾	4 19 0	..	99½	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., May 29.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO MAY 29. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	9⅛—10⅛	6 16 6	..	10⅛	1⅞
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝—10⅝	4 9 0	..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10½—10⅝	5 11 8	..	10⅝	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	101 —104	4 6 6	..	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜—5½	5 5 0	..	..	..
St.	4½%	Do. Do. 1st Debs.	97 —99	4 11 0	..	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 — 9	5 11 0	..	..	..
5	3/6	Do. 7 per Cent. Pref.	7½—7⅝	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4½ Guar. Db. Stock	100 —103	3 17 6	..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	2½—4	6 5 0	Feb, Aug	3⅜	..
5	2/3	Do 4½ per Cent. Pref.	4 —4½	5 0 0	Feb, Aug	4⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	98 - 99	4 1 0	..	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜—4½	5 9 0	..	..	..
5	2/3	Chelsea Electric Supply Ord.	3½—4½	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	104 —107	4 4 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord...	9¾—10½	5 17 0	Feb, Aug	9⅜	..
10	6.0	Do. 6 per Cent. Cum. Pref.	11½—12¼	4 16 0	Jan, July	12⅜	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 —124	4 0 9	June, Dec	123	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 —100	4 10 0	..	99	96⅜
5	5%	County of Durham Elec. P.D. Ord.	4½—5	4 7 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅝—5	5 4 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅜—8⅜	5 17 6	..	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10½—11½	5 4 0	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)....	106 —109	4 2 6	..	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	95 —98	4 12 0	..	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜—5⅜	5 2 0	..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	..	..	..
St	4½	Do. 4½ 1st Deb. Stock (red).....	97 —100	4 10 0	..	..	..
5	5/0	Hove Electric Lighting Ord.	7 —7½	6 0 0	..	7⅛	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼—9½	5 5 0	..	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½—7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 —100	4 0 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 - 102	3 13 0	..	..	..
3	2⅓	London Electric Supply Ord.	1⅞—2⅛	5 13 0	..	..	..
5	3.0	Do. 6 per Cent. Pref.	4⅝—5¼	5 14 0	..	4⅝	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	95 — 98	4 2 0	Mr,Jn,S,D	..	..
5	4.0	Metropolitan Electric Sup. Ord.	6 — 6⅜	6 3 0	April, Oct	6⅜	6
1	2/3	Do. 4½ per Cent. Cum. Pref.	5 — 5½	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	106 —109	4 2 9	June, Dec	1 6½	103
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	90 — 93	3 15 3	..	9⅛	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 —98⅞	4 12 0	..	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8½—9½	5 0 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 —103	4 10 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7½—7⅝	5 8 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 — 6	4 7 9	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 —100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 —1⅛	2 16 6	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 —101	4 10 0	Jan, July	..	..
10	9.0	Notting Hill Electric Ord.....	12 —13	5 15 0	March ..	..	..
5	4/6	Oxford Electric Ord.	6 —6⅝	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 — 99	4 1 6	..	..	..
5	5.0	St. James' & Pall Mall Elec. Ord	7⅜—7½	6 1 6	Feb, Aug	7⅜	..
5	3/6	Do. 7 per Cent. Pref.	6⅜—7⅜	4 18 0	Feb, Aug	6⅜	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	88 —91	3 15 3	..	90	..
5	..	Smithfield Markets Electric Sup. Ord...	1½—2½	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 —77	5 4 0	..	..	..
5	3.0	South London Electric Supply Ord.....	2½—2⅝	6 8 0	..	2½	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝—¾	3 6 9	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	4 15 0	..	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 —103	4 7 6	..	..	..
5	2/6	Urban Electric Supply Ord.	1⅛—2⅛	10 0 0	..	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	2⅜ - 3⅜	7 3 0	..	3⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 — 97	4 12 9	..	..	..
1	6.6	Westminster Elec. Sup. Ord.	9⅛ 1⅜	6 8 0	Mar, Sept	9⅛	..
5	2.3	Do. 4½ per Cent. Cum. Pref.	5⅛—5⅜	8 13 3	..	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 —95	4 4 0	..	90	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜—⅞	5 14 0	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—1	5 0 0	..	⅝	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 - 99	4 11 0	..	..	..
St.	4%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 - 99	4 11 0	..	..	..
10	9½	Bristol Tramways & Carriage Ord.	14½—14⅝	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 —9½	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 - 102	3 18 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅜ - 3⅛	12 0 0	..	3⅛	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6⅛ 7	8 11 0	Feb, Aug	6⅞	6⅝
St.	5%	Do. 5 per Cent. Perpetual Debs.	93 —103	4 13 0	..	100	98⅛
St.	4½	Do. 4½ per Cent. 2nd Deb. Stock	79 —82	5 9 6	..	..	..
St.	4%	Central London Ordinary Stock.....	69 —71	5 12 6	June, Dec	71⅛	69
St.	4%	Do. 4 per Cent. Pref. Stock	92 — 94	4 5 0	..	93⅛	..
St.	4%	Do. Deferred Stock	50 — 53	7 10 6	..	..	..
100	4%	Do. 4 per Cent. Debs.	103 — 106	3 15 6	..	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db Stk.	83 —86	4 13 0	..	83	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½—5	5 0 0	..	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 —101	3 19 0	..	..	..
St.	2%	City & South London Rly. Con. Ord. ...	40 —42	4 15 0	Feb, Aug	41⅛	40⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 —121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 —118	4 4 9	..	..	..
St.	5%	Do. (1901)	115 —118	4 4 9	..	16⅛	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 —105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½—14½	4 2 9	..	..	..
10	6/0	Do. 6 per Cent. Pref.	13 —14	4 5 9	..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2½—2⅝	..	..	2⅛	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 —7	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 —88	4 11 0	..	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ 1 b. St	93 —101	4 9 0	..	93⅛	..
10	9%	‡ Imperial Tramways Ord.....	12 - 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 —11½	5 6 6	Mar, Sept	..	..
St.	4½	‡ Do. 4½ per Cent. Debs.	99 - 101	4 9 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 — 1⅛	..	..	2⅛	2⅛
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 — 73	5 9 6	..	..	..
St.	47/6	Lancs. Utd. Trams 5 · Prior Lien Db. St.	95 —98	..	..	..	..
10	..	Liverpool Overhead Railway Ord.	1⅜—1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 — 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 —90	4 9 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	7⅜—8⅜	5 14 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	85 — 89	4 10 0	..	85⅛	..
St.	..	Mersey Con. Ord. Stock	2 —4	—	..	2⅜	..
St.	..	Do. 8 per Cent. Perp. Pref.	7 —10	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅛—⅜	..	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜—½	5 3 0	..	..	..
St	4½%	Do. 4½ per Cent. Deb. Stock	96 - 99	4 11 0	..	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜—1⅜	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	5⅞—6⅛	6 8 0	..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 —7⅛	6 18 3	Feb, Aug	..	..
St.	4½%	† Do. 4½ per Cent. Deb. Stock	96½—99½	4 19 6	..	..	..
1	3/6d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	3⅜—1⅝	5 16 6	..	..	..
St.	3½%	Do. 4 per Cent. Deb. Stock	82 —86	4 13 0	..	..	..
100	5	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	86 —90	5 11 0	..	..	..
..	5%	Underground Elec. Rys. Co. of London ...	74 — 77	6 10 0	..	..	..
5	..	Yorkshire (W. R.) Elec. Trams. Ord.	1⅛—1⅜	—	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅜—3⅝	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 —94	4 15 9	..	..	..

SHARE.	LAST DIVIDEND	NAME.	Price Wed., May 29.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO MAY 29. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅜—½	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜—½	8 0 0	..	⅜	..
1	2/4½	Babcock & Wilcox Ord.....	3⅜—4	5 0 0	..	3⅝	3⅜
1	0/7½	Do. Pref.....	1⅜—1⅝	8 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6½—7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅜—6½	4 16 0	Jan, July	..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —1 5	4 5 9	..	..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 - 96	4 14 3	..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 —1½	..	..	..	1⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	64 —68	5 18 0	..	..	..
2	..	Brush Electrical Engineering	⅜—⅝	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	1 —1⅛	8 0 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 —92	4 13 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 —78	5 14 6	Jan, July	..	..
5	5/0	Callender's Cable Con. Ord.....	10⅛—11⅛	6 13 3	Jan, July	10⅝	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 7 0	Jan, July	5⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106⅜—108½	4 3 0	Nov, May	..	..
1	0/9⅜	†Castner-Kellner Alkali Co.	1⅜—1⅝	5 14 0	..	..	1⅜
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 —102	4 8 0	..	..	..
1	0/9⅜	Chadburn's (Ship) Telegraph Ord.	1⅜—1⅝	7 5 0	..	..	1⅜
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	5 4 0	..	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 61,000).....	1½—2⅛	3 12 9	Jan, July	1⅝	1⅝
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	99⅞—99⅞	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅞—1⅞	6 8 0	Sept	1⅞	—
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 - 105	4 5 6	..	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1 —1½	10 2 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2½—2⅝	4 11 6	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	85 —87	4 12 0	June, Dec	..	..
St	5%	Do. 5 per Cent. 2nd Deb. Stock	89 —92	5 8 6	..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅜—1⅛	10 0 0	H'lf-yearly	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅜—2⅛	..	..	1⅝	1⅜
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	85 - 90	5 0 0	..	..	..
2	..	Electric Construction Co.....	⅜—⅞	..	July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅜—2	7 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	79 —83	4 16 3	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8⅜—9⅜	5 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 - 95	4 4 0	..	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅜ 12⅜	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5⅛—5⅜	3 18 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	107 —109	4 2 6	..	..	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15 —16	6 5 0	Feb, Aug	15	..
100	4%	Do. 4 per Cent. Debs. (red.).....	98 —100	4 0 0	..	98	..
1	1/2⅜	Richardsons, Westgarth & Co., Ltd. Ord.	⅜—⅝	7 6 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅜—1	6 0 0	..	⅝	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 —100	4 10 0	..	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	30½—31½	5 14 3	Mar, July	30⅝	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	100⅜—103⅛	3 17 0	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	6 1 0	..	2⅛	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1⅜	4 1 0	..	1⅜	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 —117	4 5 6	..	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 —104	3 17 0	..	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 —107	4 4 0	..	105	..
10	6.0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½—10	5 0 0	..	..	..
5	..	Willans & Robinson Ord.....	1⅛—1⅜	..	Apr, Oct	1⅛	1⅛
5	..	Do. 6 per Cent. Cum. Pref.	3⅞—4⅛	..	Apr, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	79 — 83	4 16 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 —3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 —91	5 10 0	..	..	..
St.	15/0	Anglo-American	61½—64½	6 0 6	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	107½—108½	5 11 0	F,My,Ag,N	108	107
St.	15%	Do. Deferred	19⅜—20⅜	4 5 9	F,My,Ag,N	20⅜	19⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	93½—94½	4 4 6	Jn,Ap,Jy,O	93⅝	92⅛
10	5.0	Cuba Submarine Ord.....	7⅛—8⅛	6 1 9	Feb, Aug	8	..
10	10/0	Do. Preference 10 per Cent.....	15⅞—16⅛	5 19 6	Feb, Aug	16⅛	..
5	2/0	Direct Spanish Ord.....	3⅜—3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅞ 9⅛	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝-103⅝	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	15⅜—15⅝	5 17 6	Ja, Ap, Jy,O	15⅛	15⅜
100	4½%	Direct West India Cable 4½% Bg. Db. (rd.)	100 —104	4 8 0	June, Dec	..	..
St.	65/0	†Eastern Ordinary .....xd & bonus	137 —142	4 18 0	Ja, Ap, Jy,O	141	138½
St.	17/6	† Do. 3½ per Cent. Pref. Stock	89 —91	3 17 0	Ja,Ap,Jy,O	90	8⅝
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104⅛—105⅜	3 15 0	May, Nov	..	..
10	2/6	Eastern Extension	13⅜ - 14⅛	4 17 6	Ja, Ap, Jy,O	14	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock	101½—106⅛	3 15 0	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 —101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	£8⅞—100⅞	4 0 0	May, Nov	..	..
10	3.0	G.N. (of Copenhagen), with Coupon 70...	34 —36	6 19 0	Jan, July	34⅜	34⅛
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.	100 —102	4 8 0	June, Dec	..	..
25	£2/6	Indo-European..... ex all	56 — 58	5 1⅜ 0	May, Nov	..	..
100	4%	Mackay Companies Common	71 —73	5 8 6	Jan, July	..	..
100	4%	Do. Preference	69 —71	5 13 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜—⅝	..	..	..	..
100	4%	Pacific & Europe'n Tel. 4½ Guar. Dbs. (red.)	£1⅜—100⅜	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 —10⅛	3 16 0	..	..	..
2½	1/3	†West Coast of America	1⅜- 1⅝	3 12 9	..	..	..
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅝—1⅛	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅜—8½	7 5 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅜—7⅜	..	May, Nov	7⅛	..
100	5%	* Do. 5 per Cent. Debs.	100 —103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	14 —14½	4 18 6	Mr,Jn,O,D	14⅜	14
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 —105	3 16 0	..	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 —94	4 5 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 —101	4 19 0	..	..	..
5	3 0	Chili Telephone	6⅞—7⅛	5 11 0	August ..	..	..
1	0/4⅜	Monte Video Telephone Ord.	1⅛—1⅛	4 14 0	..	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞—1	5 0 0	..	..	..
St.	6%	National Co. Pref. Stock	108 —110	5 9 0	..	109	108
St.	5½%	Do. Def. Stock.....	105 —107	5 2 6	..	106⅛	104⅜
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11½—13½	4 9 0	Feb, Aug	12	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —12	5 0 0	Feb, Aug	11⅞	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ..	5⅛—5⅜	4 10 0	Feb, Aug	..	..
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	95⅜—97½	3 11 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —102	3 18 0	..	100⅜	..
1	0/9⅜	Oriental	1⅜—1⅞	4 17 6	April, Oct	1⅞	..
1	0 7⅛	Do. 6 per Cent. Cum. Pref.	1⅜—1⅛	4 16 0	..	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 —98	4 2 0	..	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	99 —102	4 7 0	..	..	..
5	3/0	United River Plate.....	6⅞—7½	5 9 6	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	June, Dec	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	109 —112	4 9 3	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	4 —5	6 0 0	..	..	..
10	2 0	Globe Telegraph & Trust.....	10⅞—11½	4 19 0	Ja,Ap,Jy,O	11	10⅛
10	3/0	Do. 6 per Cent. Pref.	13⅝—14½	4 5 0	Ja,Ap,Jy,O	14⅜	13⅛
10	6%	Submarine Cables Trust (Cert.).....	127 —130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these

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An Aspect of the Isolated Plant Problem.

THE chief excuse raised to disarm criticism of the inefficiencies of electricity supply plants in the early days was the small size of the units employed. "Build us larger units," said the supplier to the manufacturer, "and we shall mutually benefit." The capacity of single units has accordingly been constantly pushed upwards, and 10,000 H.P. plants are not now regarded as in any way abnormal. The halo of economy surrounding the large generating unit is probably responsible for the appearance in the great industrial areas of "power in bulk" supply undertakings, which generate and distribute cheap electric power on an extensive scale. The conditions contributing to the laying down of these plants do not seem to be conducive to their satisfactory operation. Makers of large dynamos or steam engines are under no obligation not to supply smaller units for installation in the area of a company giving an electric power service from the larger machines which they (the makers) provided. Although they furnish generating plant to the power in bulk company they still compete for business in the power area. Discrimination, to the extent of giving preference to the electric power service, can hardly be expected of manufacturers of electrical and allied machinery. But were some sort of co-operation in force it would probably redound to the advantage of both parties. Isolated plants may bring in business for large dynamos and steam engines, but they appear to bar the way to the extension of the power in bulk service, with a correspondingly greater amount of business in motors. Many industrial establishments will not entertain electric driving because some similar works are motor-driven from isolated plant which is supposed to give greater economy than the supply service. Until the management can sanction the outlay on their own generating station they leave electric driving severely alone and ignore the supply service altogether. The dynamo maker then gets neither generator nor motor orders. We are not referring to isolated plants generally, but to those within the area of a supply authority capable of taking most of the power load.

Up to the present no kind of co-operation appears to have been considered between power in bulk (to take an instance) and manufacturing concerns to mitigate the competitive consequences to both in the area served by the power company. If the undoubted advantages of a concentrated electric power service are to be more generally appreciated, and the many industries in need of them are to reap the benefits they can confer, it would appear advisable that an arrangement be come to between the parties chiefly concerned. On the one hand there are companies exploiting, with the assistance of manufacturers, such financial value as there is in great generating units, and on the other are the same manufacturers ostensibly counteracting the value of the companies' main asset, and one which they themselves furnished. The mutual arrangement suggested would have its limitations and be applicable as circumstances permitted. If it were entered upon it would tend to remove what must appear to power users as an incongruous state of affairs—namely, the keen competition existing between isolated plants and the power in bulk service, a competition encouraged by the very makers whose plant figures prominently in each particular case.

The subject is worthy of investigation, and doubtless interesting figures could be furnished of isolated plants operating in competition with electric power supply, and the extent to which that competition might be averted by the co-operation suggested above. We have not hitherto seen any statistics bearing upon this phase of the isolated plant problem.

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Some Products of Johnson & Phillips, Ltd.

A MANUFACTURING establishment which has been in existence over a period of 30 years naturally witnesses many changes. An undertaking devoted to the production of electrical plant and apparatus is singularly subject to change. In fact, unless the works are conducted on progressive lines—new designs being put forward and old patterns modified to conform to modern requirements—stagnation inevitably sets in, and the reputation of the firm sinks below its former high level.

General. Although Messrs. Johnson & Phillips have been established over 30 years in the electrical industry, they have, judging by our recent inspection of their extensive works at Old Charlton, Kent, maintained the same activity as formerly in their various departments. We need hardly recall the details of the pioneer work done by the firm in the early eighties when electric lighting installations were first put down in the large towns of the United Kingdom. With most of these, either in the matter of dynamo electric machinery, cables, transformers or arc lamps, the company was identified. In the battle of the systems a.c and d.c. waged for some years, J. & P. products figured impartially, as the works were able to supply plant and apparatus for both sides.

Cables and their Machinery. At the present time practically the same departments are kept busy at the works as in the early days, and the principal productions are in the main identical with those of past years. A large section of the works is devoted to the manufacture of cable-making machinery, an extensive business being done in this both for the home and foreign trade. Machines for the production of every known type of cable, whether for electric light and power or for telegraphs and telephones, are manufactured, supplied and erected. These include also the preparing machinery for rubber cleaning, washing, mixing, calendering, &c. Such finishing plant as vulcanisers, vacuum driers and impregnators, lead presses, &c., are also designed and manufactured. All the heavier machinery required for stranding, taping, braiding and steel armouring complete a fine group of products from this important department, which lack of space prevents us from dealing with in detail.

Fireproof and other Cables. A perfectly natural complement to the production of cable-making machinery is the manufacture of cables and wires. This is another particularly active section of the works. At the time of our recent visit almost every known type of cable, insulated and otherwise, could be seen in the making. Light V.I.R. cables and wires passing rapidly through insulating machines a dozen or more at a time, and heavy single cable slowly taking up accurate proportions of pure rubber, coated tape and braid, each represented the limits of a large range of intermediate conductors, all of which could be turned out with economy and dispatch. The paper-insulating and bitumen-covering machines were alike interesting to watch busily active in another department. In remarking that the products of the cable and wire section are only limited by present-day knowledge of the art of cable-making, we sum up in a few words the capacities of this department of the works. We may naturally look for specialities among the cable products,

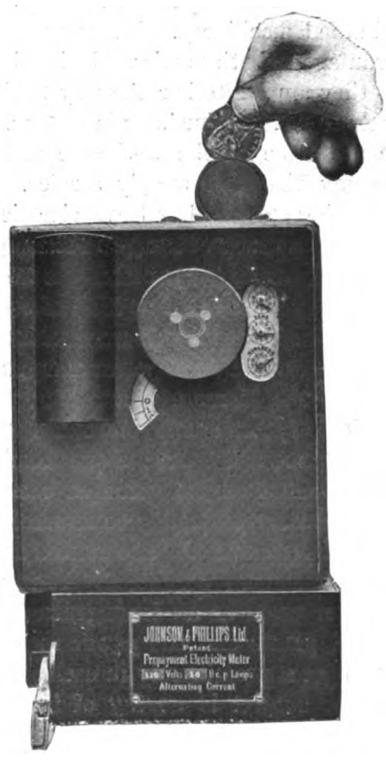

Fig. 1.—View of Prepayment Meter with cover in position and coin being inserted in trap.

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and these are to be found in a fireproof cable (Paterson's patent) and a flexible-braided conductor for shot-firing cables. The first-mentioned is built up with a flexible steel reinforcing cover, which prevents the bursting of the cable insulation under the pressure of internal arcs and effectually protects it also from the action of external heat. We are informed that under severe short-circuit conditions in the cable itself there have been no external signs of flaring or rupture of the protective covering.

The shot-firing cables are composed of an extremely flexible conductor and an equally flexible armouring. The conductor is made up of a number of thin wires twisted into a flexible which forms the basis of the cables required. A number of these flexibles is arranged into a large complete cable which is very pliable and can be twisted into almost any desired position. The outer wire covering, which obviously must contribute to rather than detract from the flexibility of the cable, is put on to prevent bursting of the insulation by the concussion of the exploding charge. Experience with heavy guns has provided conclusive evidence of failure of the firing cables from this cause. The flexible cables are made to any desired size for use in electric power work in which flexible armoured conductors are needed.

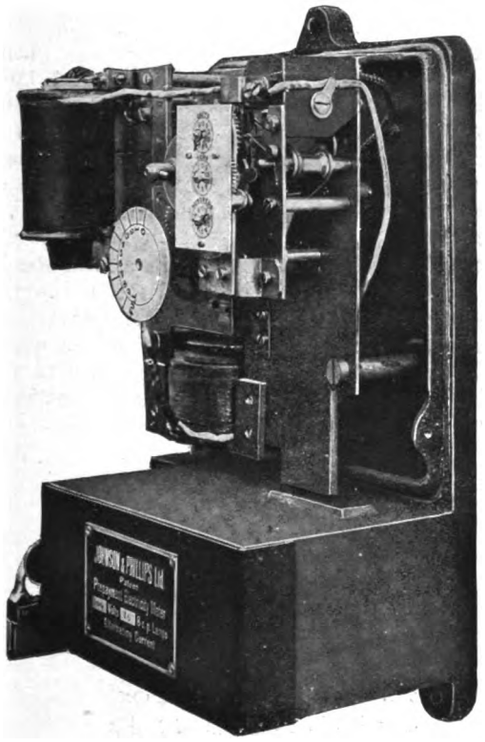

Fig. 2.—Interior View of Prepayment Meter showing Dials.

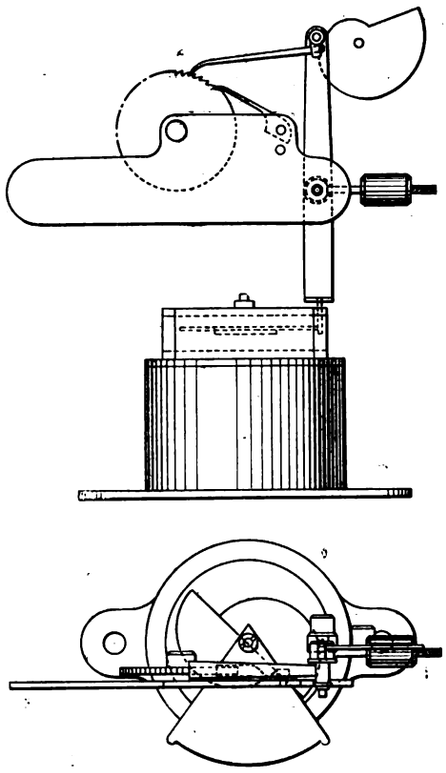

Fig. 3.—Diagrams showing Ammeter Coil and Snail Controlling Return Movement of Epicyclic Gear in Prepayment Meter.

Joint Boxes. Prominent among the other productions of the cable section are joint boxes and feeder and switch pillars. The former are built to all standard cable requirements, as well as for special purposes. The latter are more favoured by mains engineers now than formerly, and the designs of the firm conform to the regular needs of distribution networks for this type of apparatus. A large number both of joint boxes and feeder pillars is now in use on the systems of network at present in vogue.

Dynamo Electric Plant. Dynamo electric machinery of every description is the product of another large section of the works, and one which is as well known as the cables just referred to. Among the pioneer generators built in this country, Johnson & Phillips' polyphase alternators figured prominently, and the earliest colonial transmission plants were put down by the firm. We need only briefly refer to this department by stating

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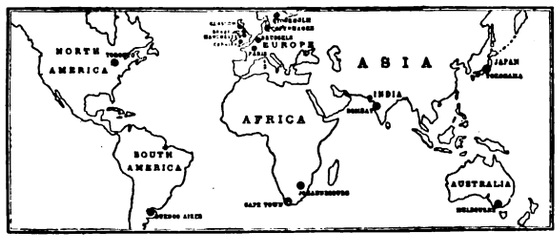

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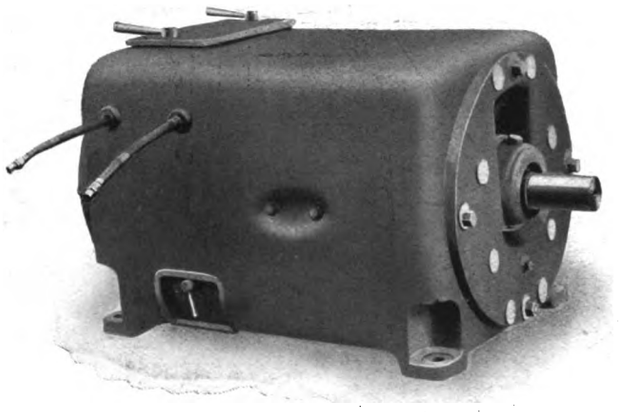

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that all modifications and improvements in the design and construction of generators and motors for both alternate and direct currents have been closely followed and introduced into all types admitting of or requiring alteration. For example, the recognised advantages of interpoles have not been lost sight of and d.c. generators and motors are now fitted with these. Electrical and mechanical details receive careful attention from the building up of the core and windings to the assembling and testing of the complete machine. For the latter a special testing shop is provided, with a full complement of instruments, and here running and insulation tests are strictly carried out.

Transformers. For many years past static transformers for air and oil cooling have been built at the Charlton works. The oil-cooled type is recommended for arduous service because the insulation can be maintained at a high figure and the dissipation of heat is more readily assured. Overloads can also be carried more regularly than by the air-cooled type. The core yoke is in one piece, to allow of easy dismantling for access to the primary and secondary windings.

The list of heavy products of the works may be said to be completed by switches and switch gear for high and low voltage duty and for both alternate and direct-current circuits. The ordinary or special needs of electricity control can be met and gears of any size and capacity constructed and erected on site.

Arc Lamps. The arc lamp specialities of the company have been well known now for many years, more particularly the "Ark" enclosed pattern for direct and alternate-current circuits. The latest production of this department is a vertical carbon flame lamp, as distinguished from the more common converging carbon pattern. We saw one of these burning on test at the works. The mechanism, we were informed, is somewhat similar to that of the standard open type lamp, the chief difference in the lamp being the employment of special flame carbons. Currents as low as 3 amperes may be used and five lamps can be run in series on a 220 volt d.c. circuit. The diffusion of light from vertical carbons is generally good in a horizontal direction, and this feature is claimed as a special point in favour of vertical carbons with a flaming arc. We were not shown any light curves of the lamp, but we understand that the efficiency is high and the burning hours are well maintained. The lamp is certainly an interesting outcome of considerable experiment with flame arcs.

Prepayment Meters. The meter department is chiefly concerned with the manufacture of hot wire and moving coil instruments for all circuits, capacities and voltages. Edgewise, sector pattern and round case instruments are all made, and among the hot wire type is a range of special portable instruments.

We were particularly interested in a new prepayment meter which we saw in process of manufacture in this department. This meter has been designed for use on small installations where the load cannot exceed 10 8 c.p. lamps. The instrument consists of a clock (which is wound by the customer automatically each time a coin is inserted), a switch and an ammeter. A handle projecting through the front of the case (see Figs. 1 and 2) cannot be turned unless the mechanism is released first by the insertion of the coin inserted in a slot, which admits it to a cylindrical trap the front end of which can be depressed to move the penny towards a slot connecting with a notch in the barrel which actuates the switch and clock-release mechanism.

The coin frees the mechanism and allows the operator to wind. The switch is put in circuit at the same time and an epicyclic gearing is moved a certain distance for each coin inserted. When current is switched on, the clock is started by an electromagnet which clamps the balance wheel of the clock movement when no current is passing. The clock is a regular timekeeper and revolves a snail

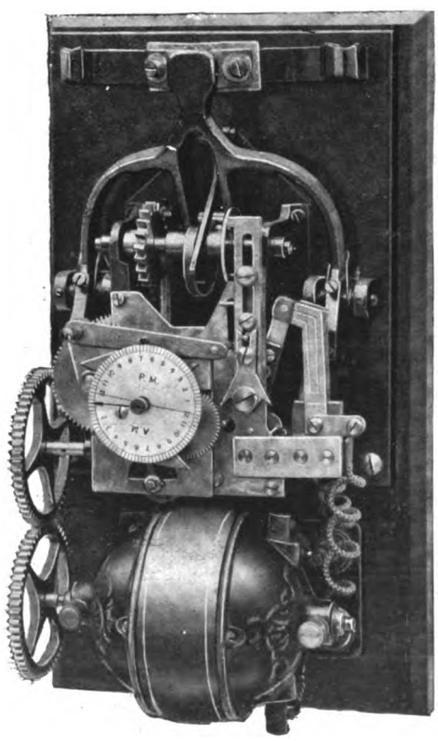

Fig. 4.—Motor-operated Time Switch in the "on" position and Motor Switch shown closed.

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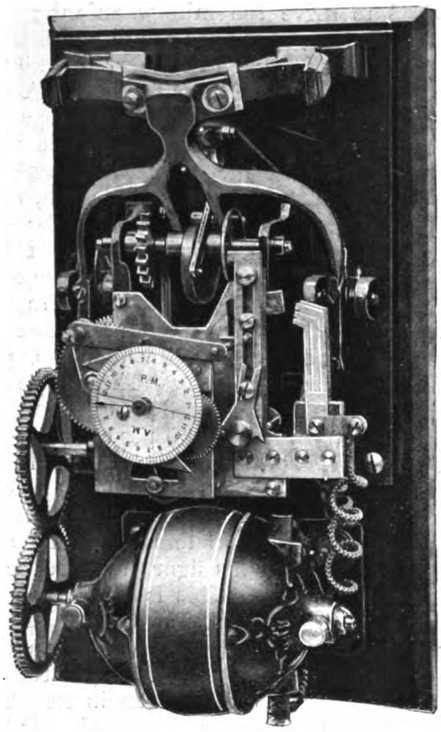

Fig. 5.—Motor-operated Time Switch in the "off" position and Motor Switch shown open.

which causes an arm to take up, at regular intervals of five minutes, a definite position against the aluminium scale of the ammeter, which position is governed by the current passing. The arm having a greater or less movement, racks a small disc an exactly proportional distance as shown in Fig. 3. This disc being directly connected to the epicyclic gearing spindle, moves the gearing in the opposite direction to that in which it was wound by the operator, and when the prepaid amount of energy is used, the gear arm cuts out the switch. The change in the price per unit is a simple operation consisting only of an exchange of two change wheels.

The arrangement of the parts makes up a compact meter, and the mechanism is of substantial construction to admit of rough usage. The switch controlling the lamp circuit has a positive make and quick break, and the tripping mechanism appears certain in action. The meter is supplied for both a.c. and d.c. circuits and is already in use in several towns in the provinces.

Time Switches. Another very interesting product of the meter department is a motor-operated time switch for any capacity circuits. Illustrations of this are given in Fig. 4 and 5, which show the switch in the "on" and "off" positions. The device comprises a small motor (a.c. or d.c., as the case may be), a clock movement, a motor switch and the main switch. The latter is single break single pole, and is fitted with carbon breaking points. The motor is spur geared to a horizontal spindle connected both with the barrel of the clock spring and the mechanism actuating the main switch. The clock drives a dial to which two horn plates are attached, and in the path of these is a pin fixed to a lever controlling the motor switch. This may be seen on the right of the illustrations above the turns of flexible cord. At a given time one horn trips this switch, starts the motor, and the main switch is moved in by a snail and held in by a locking lever against the pressure of a spring. The motor continues to run until a trip motion is brought into action, which opens the switch, keeping it in circuit. The other horn comes round in due course and again closes the motor circuit, but on this occasion the motor is only in circuit two seconds, as compared with seven seconds for the closing of the switch. Each time the motor runs the clock is wound, and a slipping clutch prevents over-winding or injury to the spring. From our inspection of the switch we observed that the motor switch mechanism, upon which the duty of the device really depends, is very positive in action. The switch is opened or closed by a falling weight, which gives a smart blow to the switch arm during each operation of opening and closing. The switch we inspected at present will deal with circuits up to 60 amperes capacity and up to 400 volts pressure. The clock face is engraved 12 hours a.m. and 12 hours p.m., and the horns referred to are directly behind this face, being clamped to turn with it by a large milled nut. The slackening of this is the only adjustment required to set the opening and closing of the switch. The device can, of course, be employed for any duty calling for a time switch, particularly the switching on and off of street lamps, either arc or incandescent. In this capacity it will save both labour and time, very important items in the conduct of the average electricity works.

In the space at our disposal we have been able to give only a faint idea of the many electrical products of Johnson & Phillips. The majority of these are naturally standardised and well known in the industry, and for this reason we have confined ourselves to detailed descriptions of new and interesting specialities which the company is engaged in developing.

We are indebted to Mr. F. S. Paterson, Managing Director, by whose permission we went through the works, and our thanks are also due to Mr. A. P. Pope, Sales Manager, who kindly conducted us round the various departments referred to in this article.

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Electric Drive in Cotton Mills.

THE good cause of electric power for the textile industries is receiving a well-deserved advertisement in Lancashire at the present time. For several weeks past, columns of the "Manchester Guardian" have been devoted to the subject of cotton-mill driving, and the arguments for electricity, gas and steam power have all appeared with various classes of adherents to champion them. The writers of these letters are evidently drawn from different industrial and commercial grades, and this fact is mainly evident from some of the effusions as the individuals themselves prefer to remain anonymous. We commented in our last issue upon the concoctions being served up, doubtless for speedy consumption and assimilation by textile manufacturers. It is a matter for considerable gratification that the subject is being well ventilated. No better proof of this is required than the appearance on the scene of gas engine advocates, who seek to divert attention from the main issue to their own particular type of prime mover. For the moment, however, they must be disregarded for the "stick to steam" partisans.

An unsigned article entitled "A Defence of Steam" has recently been published, which contains many remarkable assumptions and palpable contradictions. The writer unconsciously repudiates his own claim for the greater efficiency of steam driving in sentences following closely upon each other. He says in one sentence: "The power required to drive a *modern* (our italics) spinning mill, including engine main rope drive, mill shafting and belts, but not cotton machinery, is about 20 per cent. of the power required to drive the mill when fully at work." Presumably this means that with a mill and machinery of the class mentioned the total loss incurred is 20 per cent., but it is not worded in this particular way. A few lines later it is stated that "the loss in the main rope drive, between the engine shaft and mill shafting, is seldom more and often less than 5 per cent." We ourselves should have added this 5 per cent. loss to the 20 per cent. referred to above, and set the total loss at 25 per cent. for steam and rope driving. Not so the specious advocate of steam. He fixes attention on the fact that the loss between engine and mill shafting (that is, the loss in the main rope race) is 5 per cent., and at once proceeds to enumerate the losses between a steam dynamo and the motors which it supplies for ordinary group driving in a mill. "These are from 17 to 18 per cent. (5 per cent. generator, 3 per cent. cables, 10 per cent. all motors) as against 3 to 5 per cent. for the plain rope drive." A millwright in reading this would lay down his paper convinced that electric driving is a very costly business and had better be left severely alone. He will not think to place the writer's *total* loss figure of 20 per cent. for steam and ropes beside his figure for electrical operation of 17 to 18 per cent. This is the real comparison which should have been drawn.

Having given the method of driving its quietus, he endeavours to slay the dead by turning upon the increased production claims of the electrical engineer. These are mildly put at 7 to 12 per cent., and sneered at as the result of comparison with old mills previously equipped with obsolete machinery. But, thrusting these claims roughly aside, he declaims that "the same result can be obtained by speeding up the steam engine." Here, again, the argument is self-contradictory, for the losses of the electric drive are based upon the greater speeds at which motor-driven shafting is run to give the increased output claimed for electric driving. Consequently, speeding up the steam plant, even if it can be accomplished, is also accompanied by increased loss for the steam and rope drive. In the case of the electric drive this loss is already included and has not to be added to the figures given. But the anonymous advocate of steam remains discreetly silent on this important difference. His other arguments contain numerous flaws, but for our purpose the above are the most flagrant error he has perpetrated.

Another writer (A. A. Buss) appears to favour the electric drive, but is uncertain what form of drive will best suit the purpose. He proceeds to consider the respective merits of three forms of drive: (1) single large motor, (2) smaller departmental motors, (3) individual motors on each machine. His discussion of the first two seems sound enough, but in considering the third a glaring error has been made. The carding room is taken as an instance. "There lies a plan before me of a concern which works 120 carding engines, by no means the largest plant. Each of these machines consumes on the average ¾ I.H.P. and makes some 180 revs. per min. Now imagine 120 small motors put down, each costing easily £35 without the necessary wiring, and we have the nice little expenditure for the cards alone of some £4,200 and all the upkeep, repairs as well. Then these small motors happen to race away at something like 2,000 revs. per min. and the speed relationship to the machine to be driven is more than 11 to 1. Assuming a pulley of 6 in. diameter as practical for efficient driving by belt, we get a pulley on the machine of some 66 in. diameter, a monstrosity and expense which I leave the spinning machinery makers and manufacturers to contemplate."

This writer may be zealous for the cause of electric power, but his zeal should be tempered with wisdom. Had he consulted the price list of any maker of polyphase motors he would have found that a 1 H.P. machine to run at *1,000 revs. per min.* could be bought singly for just half

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the amount he has given, namely, £17. 10s. Even a 1½ H.P. motor only costs £20. The makers would doubtless be delighted to book an order for 120 motors at £15 a-piece. On this basis the imaginary £4,200 shrinks to £1,800. Even this we regard as an excessive figure, and, moreover, it is not correctly comparative, because it is doubtful if a single department, such as a card room, would be individually equipped. We rather think that the entire mill should be considered in a case like this, and the cost per motor would then probably be below even the figure we quote above. Obviously it is unfair to take an isolated case like this and to regard it as applicable to the entire equipment. In any event, the criticism should be based upon accurate figures, and not upon prices taken haphazard from unreliable sources.

We are pleased to see Mr. C. D. Taite, of the Lancashire Electric Power Co., entering the lists on behalf of supply from a central source. He points out the advantage of turbo-driven plant, such as is now installed in large central stations, and the steady character of the drive obtainable. Also he emphasises the fact that stand-by plant is available at the central station, whereas in most mills generating their own energy reliance is placed upon one power unit only. Mr. Taite says: "A turbo-electric mill with isolated plant and no stand-by must always be a very risky proposition."

Some contributors to the controversy appear to labour under the impression that when power is taken from an outside source the transmission cables must be paid for. One writer says: "The alternative method is to obtain electrical energy from an outside supply. The capital charges have still to be paid (in most cases), although they would be reduced, so far as the power generating plant is concerned, on account of the increased scale of production. The cost of the transmission cables and gear will, however, generally offset any saving thus obtained. The result is, therefore, that the cost of the power equipment is in any case about doubled by adopting the electrical drive." Statements of this kind, once made, are difficult to catch up with, and they usually become magnified in being handed from one man to another.

The gas engine, as we remarked at the outset, has been dragged into the controversy, and here again opinions are generally conflicting. A writer appears to sum up the case against the gas engine in a few words: "The gas engine for driving machinery has as its greatest defect a lack of reliability. In the combination of producer, scrubber and engine no one part can go out of action without entailing an almost immediate stoppage of the engine." The importance of continuous running is also emphasised: "The mere fact of a late start—say, half an hour lost—will swallow up all the saving in the coal bill by the gas engine for that day at any rate." In reply to this a champion of gas argues somewhat lamely that gas engines are reliable and not difficult to manage. In one statement he touches more nearly upon the crux of the gas engine problem: "The gas engines as built in England, with the hit and miss governors, high initial pressures and enormous flywheels, do well enough for electric lighting provided that the dynamos are properly wound to counteract the cyclical variation due to the governing. There is, however, little doubt that mechanically they are a second-rate article, and, judging from the number of new firms who are starting to build Otto cycle gas engines of the Continental design, their day will soon be over." But why the textile manufacturer should choose the gas engine to drive his mill in preference to the electric motor we cannot for a moment think.

Still, we cannot but feel that a great deal of good will come out of the discussion, and we hope that the columns of our Palatine contemporary will remain open some time yet to permit the matter to be thoroughly thrashed out.

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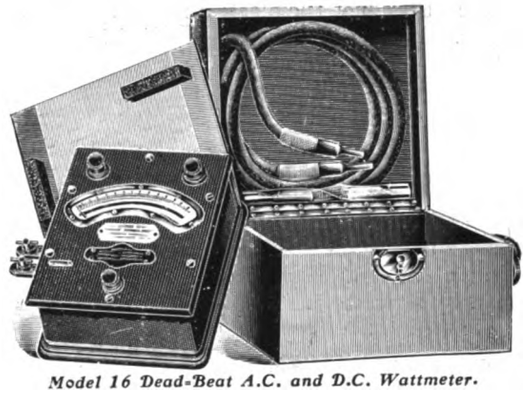

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Electric Power at 50s. per Horse-Power-Year.

THE Ontario Power Commission is about to conclude a contract with the Ontario Power Co. for the supply of electric power at the rate of £2. 10s. per horse-power-year furnished at the transformer station at Niagara. A minimum of 10,000 H.P. is to be kept available for the use of the Commission, and on 30 days' notice being given this amount can be increased to 30,000 H.P. The contract is to be concluded for 10 years, with the option of renewal for 40 years. Up to 25,000 H.P. the price is to be £2. 13s. 4d. for 24 hours' use. Presumably the Commission acting as a selling concern for the Ontario Power Co., so that these prices are not likely to obtain at the consumers' terminals. It reserves to itself the right to purchase power from other sources, and penalty clauses are to be included in each contract in case of non-continuity of service. The rights of the Ontario Power Co. include power to generate 180,000 H.P. from the Niagara Falls, and one-third of this may be exported. It will be interesting to hear what the selling price to the consumer will be. The undertaking responsible for the generation of the electrical energy evidently does not care to burden itself with any heavier task, and the Power Commission will accordingly contract with it for "large blocks" of power. The disposal of this to consumers is a matter really requiring a separate organisation, and it will be instructive to observe how the plan operates in practice.

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Paper Making by Electric Power.

SLOWLY but surely paper makers are beginning to realise that the electric motor has a special use for them in the driving of the various machines employed in the production of paper. The readiness with which the power can be subdivided among the machines in the mill and the fact that most of these machines are adaptable for operation by individual motors, favour the introduction of electric power at the outset and strengthen its case for all similar plants. For the operations which begin with the hoisting in of the raw material and end in the shipping of the finished product, the electric motor is practically indispensable. It can, moreover, be applied in efficient sizes which ensure a high aggregate economy for all the machines driven. Most paper mills are situated in districts remote from a central source of electric energy, and it is, therefore, usual to instal special generating plant for the purpose.

From such information as we are able to gather paper makers are favourably disposed towards the electrical operation of their plant. There are two interesting installations in this country which have put down their own generating plant and drive the mill and its subsidiary machinery by separate motors. The Abbey Mills, Holywell, of Messrs. Grosvenor, Chater & Co., a leading London house, are an instance of one of these plants. A 165 kw. steam generator has been put down for supplying power to one 75 H.P., one 35 H.P., three 24 H.P. and several smaller machines about the mill. Fig. 1 is an illustration of the paper mill looking towards the wet end. In the foreground will be seen one 35 H P. motor for driving this mill. This is fixed to the floor independently of the mill base plate and drives a large spur wheel through a raw-hide pinion. The spur-wheel shaft is fitted with a rope pulley wheel and from this the drive is taken in both directions to the main wheels of the mill. This is a very interesting example of electric driving and one which is well depicted in the illustration, which is from a photo taken while the mill was actually running. At the left of this same view of the mill room may be seen a 24 H.P. motor geared to a countershaft from which the backwater, vacuum pumps and mixers are driven by belts. At the back of this portion of the plant is another 24 H.P. motor driving the press-pate through gearing. The cables feeding these machines are run on insulators fixed to the roof girders and the illustration shows what a neat job this method makes.

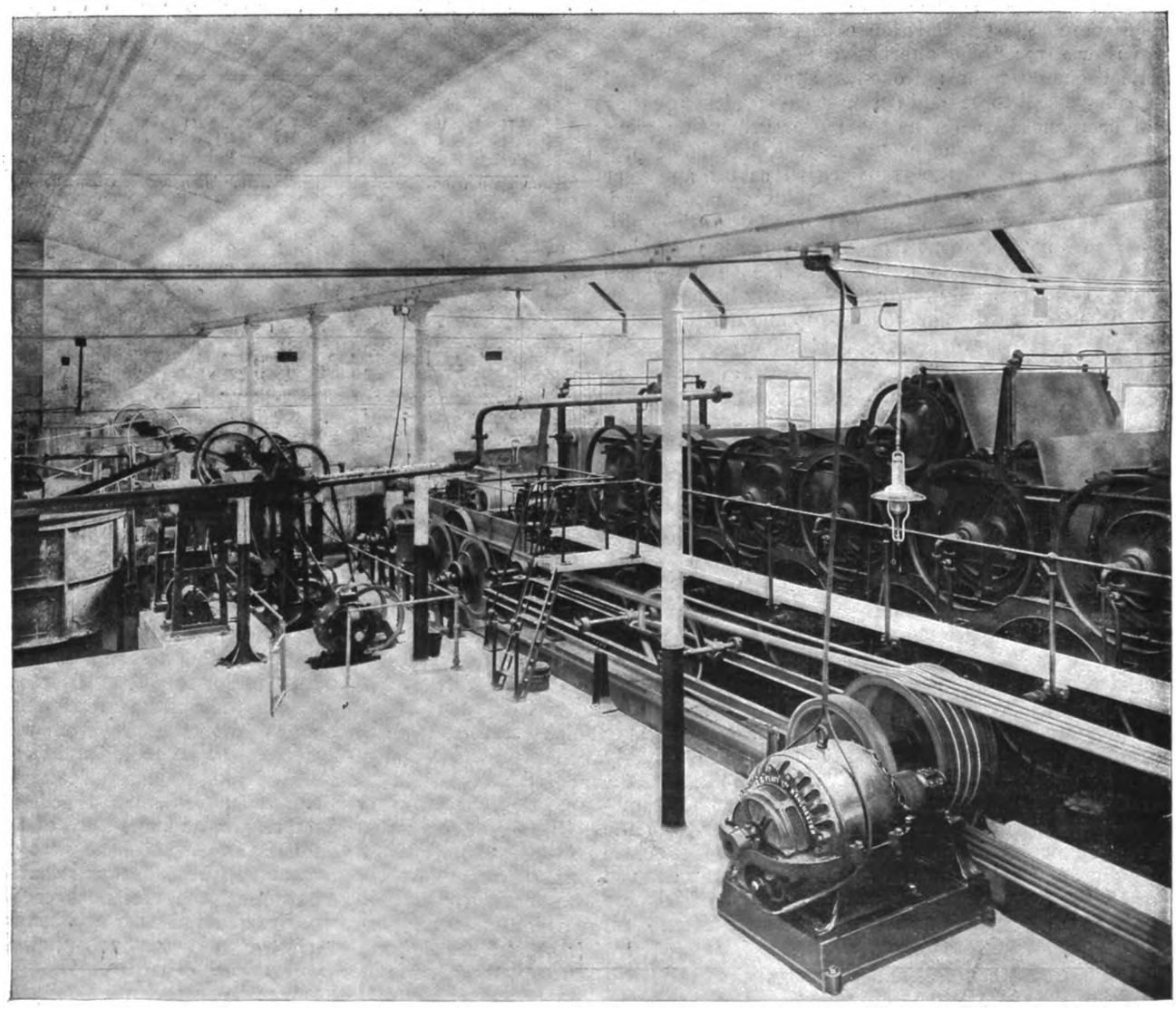

Fig. 1.—75 H P. Motor driving Large Paper Mill. In the background a 25 H.P. Motor is shown driving Mixers and Stuff Mill.

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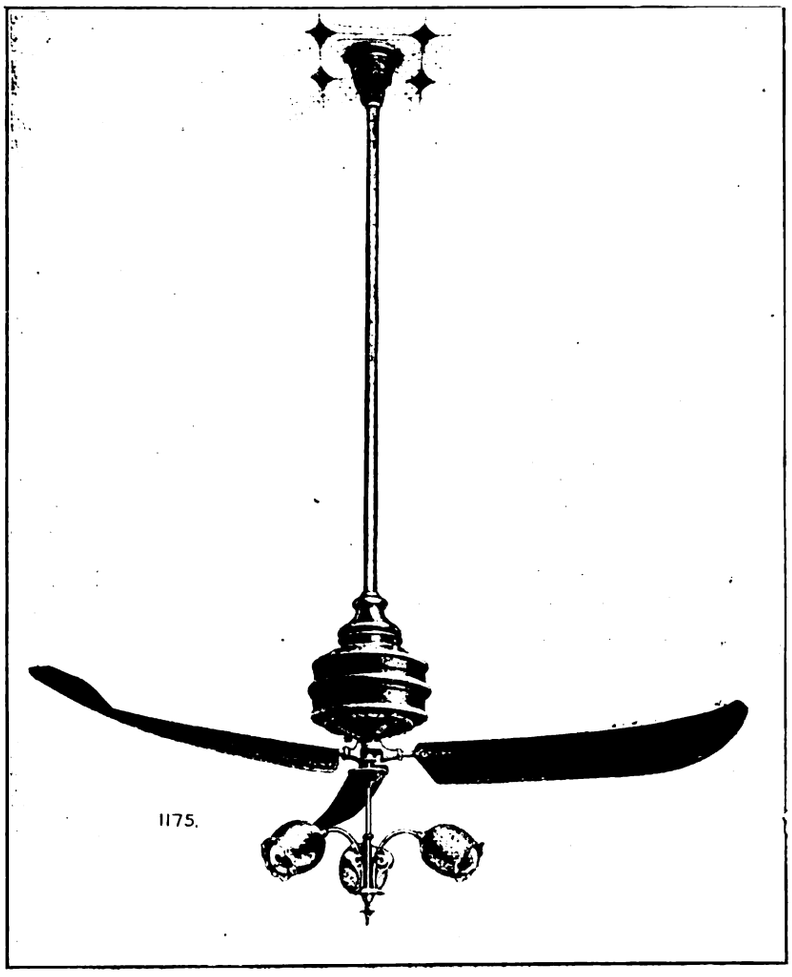
ELECTRIC CEILING FANS.



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In another part of the mill there is a grass duster driven by a 24 H.P. motor. The breaking engines, which are of the conical type, are operated by a 35 H.P. motor, geared down to a countershaft from which the engines themselves are operated. Two paper-cutting machines are each driven by 6 H.P. motors and the same size motor is employed driving a reeler. Ventilation is not lost sight of, and is almost naturally entrusted to electric fans. Two of these are installed in the paper house and one in the duster house, in the latter being a cyclone dust catcher and collector, which withdraws the dust and gathers it in a special receptacle.

Another installation of electric power in a paper mill in this country is at the Rishton Paper Mills of A. M. Peebles & Co., another London house of high repute. Two 190 kw. generators are installed here, and a large number of motors is supplied with power. In the esparto warehouse is a motor-driven hoist which is fitted with arrangements for keeping the bales in tension during transport. Another hoist, also electrically driven, serves to carry esparto bales across the yard. Another motor is direct coupled to a grass duster. The two breakers illustrated in Fig. 2 are independently motor driven through gearing. The motor may be seen on the left of the illustration, together with the large spur wheel which it drives. The small belt at the side of the machine is not the main drive but an auxiliary drive to a lay shaft for rotating the large drum. This same plant contains several calenders driven by independent motors. Fig. 3 illustrates a view of one of these taken in position in the mill. The use of a separate motor adds very little to the floor area of the machines driven, and dispenses with wasteful and cumbersome shafting.

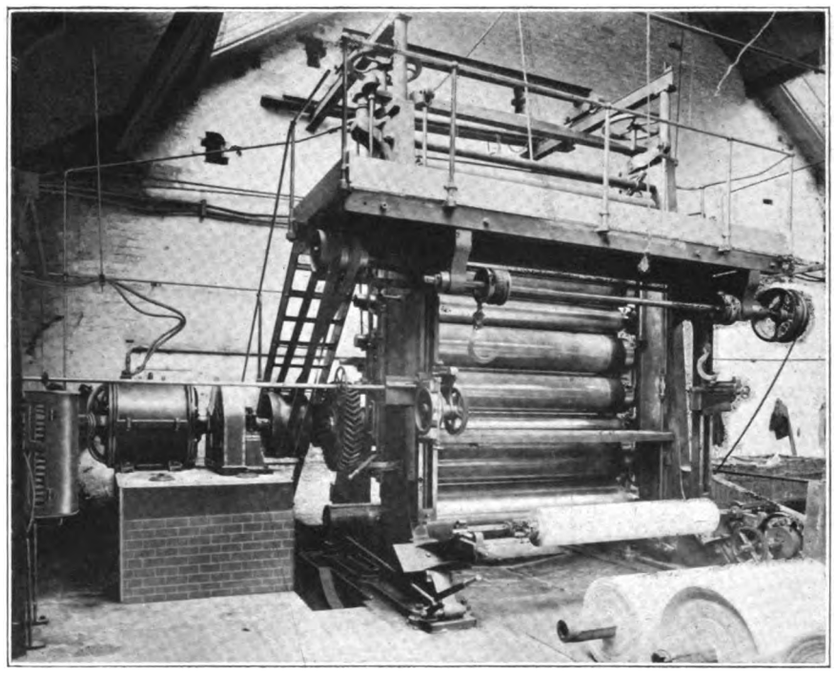

Fig. 3.--Super-Calendering Machine Driven by Individual Motor.

Both the above installations have been in operation for some months past, and are, we understand, giving every satisfaction. The plant is direct current in each case, and was built and installed by Messrs. Mather & Platt, to whom we are indebted for the illustrations of the various machines.

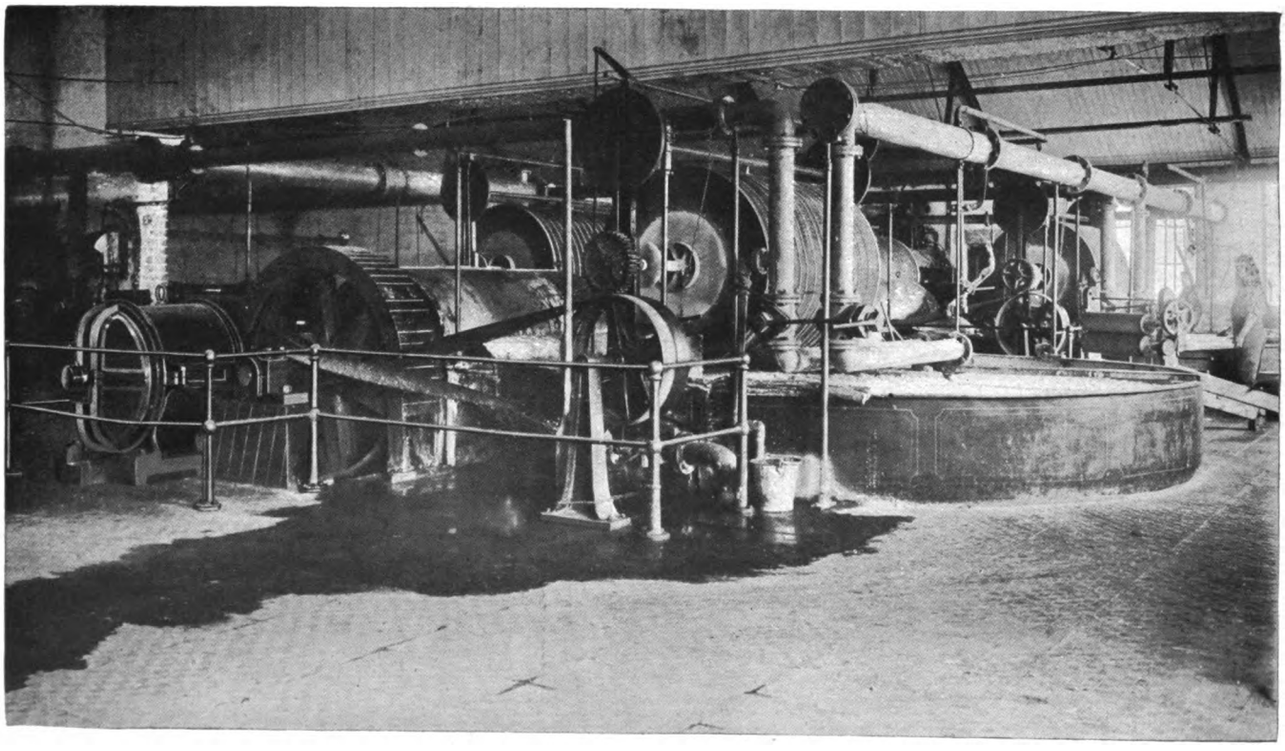

Fig. 2.—Two Breaking Machines Driven by Direct-Geared Motors.

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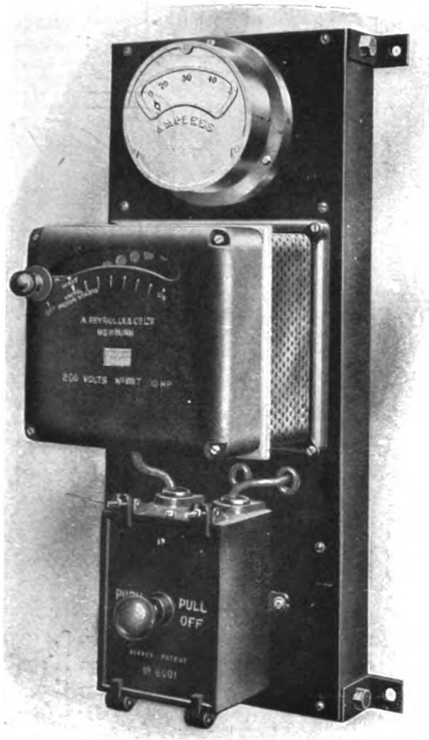

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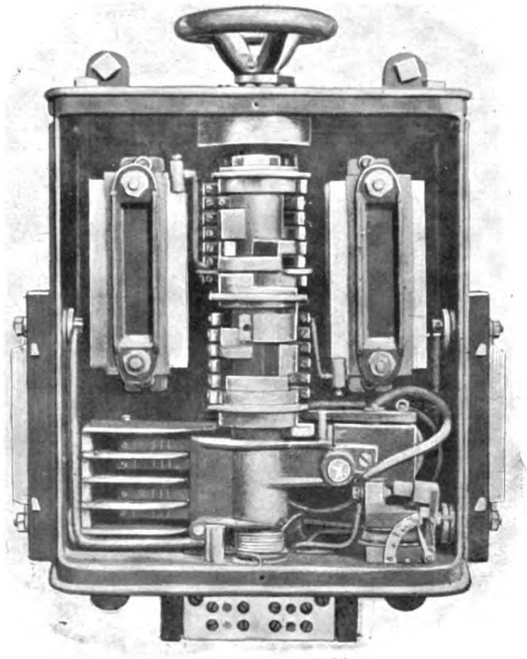

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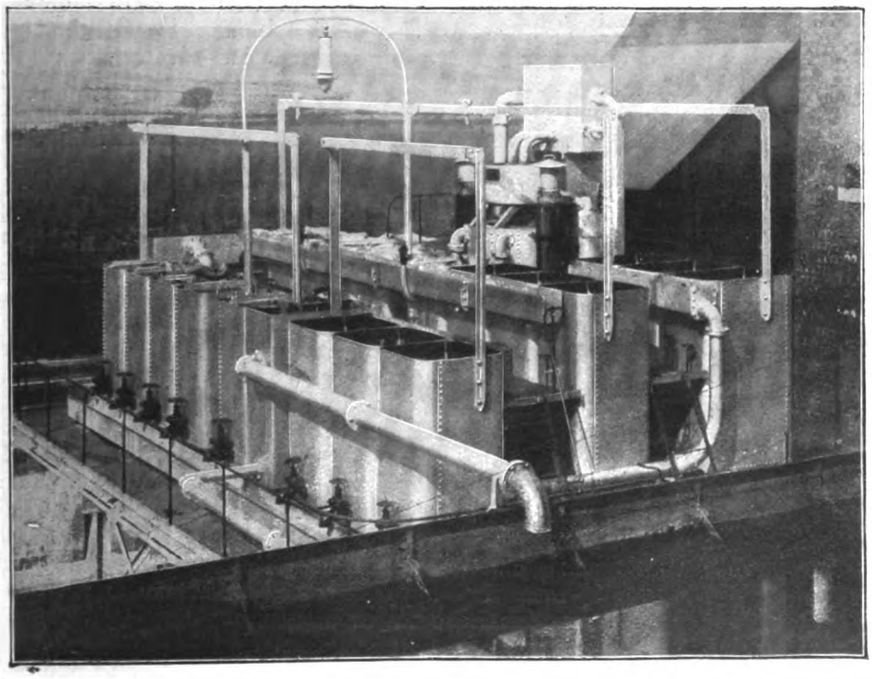

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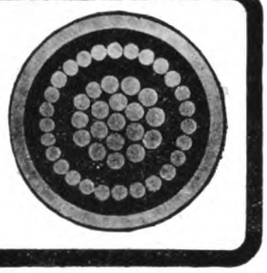

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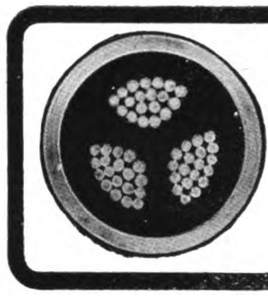

Electric Jib Cranes.

THE use of small motors for the operation of the various motions of jib cranes has produced numerous interesting examples of this type of lifting device. At one time single motors were fitted to cranes of this class, and the motions were driven through gearing put in and out of action by clutches or fast and loose pulleys with belt drive. This method has, however, been abandoned in favour of a number of independent motors for each distinct motion of the crane.

An interesting example of a five-motor crane of the travelling jib type is depicted in Fig. 1, this being one of a number of 4 ton cranes supplied by Applebys Limited to a large steel works in Sheffield. It is employed to charge and discharge the soaking pits in these works. As will be seen by the illustration, the headroom for the cranes is limited, the actual distance being 13 ft. 6 in., measured from the rail head. This restriction necessitated the building of a special frame, more particularly as high speeds were required and the total lift for the crane was only 11 ft. from the rail. Four motions of the crane are required: (1) Travelling, (2) hoisting and lowering, (3) slewing and (4) derricking. The first of these is accomplished by two motors, one coupled to each axle. To one axle a powerful electric brake is fitted, and buffing beams and draw gear are arranged to suit the rolling stock in the steel works, for obviously the crane can ply as a locomotive. The lifting and lowering drum is driven through gearing with single and double purchase, and the motor spindle carries a special electric brake. Both the slewing and derricking motions are also independently driven by small motors. Series-wound motors are used, and the control is by special liquid controllers. Owing to lack of headroom, the trolley pole for the supply of current to the motors had to be designed and built specially. In the open yard it runs under a trolley wire at a much higher elevation.

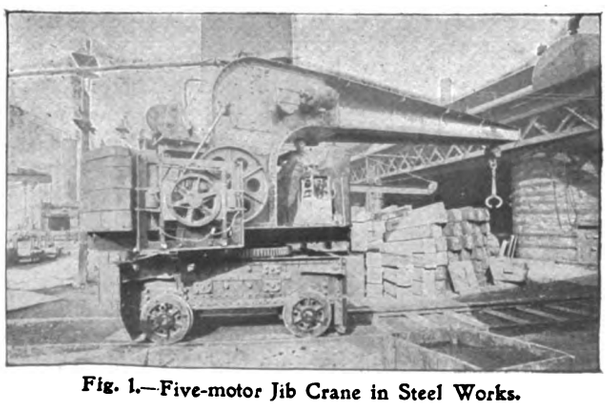

Fig. 1.—Five-motor Jib Crane in Steel Works.

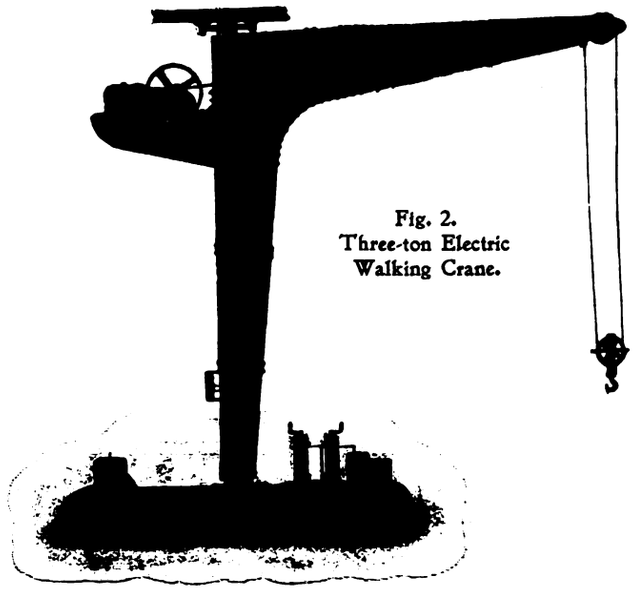

Fig. 2. Three-ton Electric Walking Crane.

Fig. 2 illustrates another design of travelling jib crane run on a single rail and known as a "walking" crane. It has a lifting capacity of 3 tons, and is one of three supplied for a large engineering firm in Glasgow. The crane carriage runs on a single rail embedded in and level with the floor, and is steadied at its upper extremity by a small trolley run between steel girders fixed to the ceiling rafters some 21 ft. above the floor. Of the three motions of slewing, hoisting and travelling the last two are motor-operated, the first being easily accomplished by hand (without gearing). Although this is a comparatively small crane it has been found better to use two motors instead of one for the power motions referred to. Series-wound reversing ventilated motors are utilised, and the lifting and travelling motors have respective capacities of 10 B.H.P. and 5 B.H.P. Drum-type controllers also are used and an electric brake is fitted to the lifting and lowering motion. The travelling motion has a powerful strap brake operated by pedal lever on the driving platform. The working speeds are: Lifting 30 ft. per minute with full load, travelling 200 ft. per minute with full load. The jib has a 15 ft. forward radius and 5 ft. 6 in. tail radius. The jib is built up of well stiffened steel plates, and the entire crane with motor equipment weighs 9½ tons. It is a type of crane for which many users can be found in warehouses, engineering workshops and other places where floor space is comparatively limited. It constitutes another instructive example of the flexibility and general convenience of the electric drive.

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Workshop Driving.

ENGINEERING workshops afford one of the best instances of the economy of the individual drive by electric motors. The operating conditions appear to favour the use of single motors, even up to large sizes. Railway workshops especially are interesting as furnishing useful and reliable data regarding the individual operation of machine tools. Some interesting figures were presented at a recent meeting of the Southern and South-Western Railway Club of the United States, comparing electricity and steam for driving railway shops. An instance was quoted in which the average output of 300 H.P. of a steam-driven plant when driving by belt was reduced by approximately half when the electric drive with separate motors was installed. By dispensing with long lines of shafting and taking advantage of the latest types of motors for machine-tool operation the efficiency of a modern railway shop can be largely increased. Attention was also directed to the enormous advantages conferred by the increase in the head room provided with the electric drive. The overhead electric crane could be operated under much better conditions on account of the absence of obstructive shafting. Some experiments carried out on individually driven tools were also quoted at the meeting referred to. Two 72 in. cast-iron discs were cut down to a minimum diameter of 6 in. in two machines driven respectively by belt and electric motor. The belt-driven tool, using three-step cone pulleys, required 59 minutes to complete this task. With an electrically-driven tool, operated by a variable speed motor, the work was done in 31 minutes, representing a saving of 90 per cent. in time alone for the electrically-driven tool. The advantages of the interpole motor giving from 100 to 400 per cent. speed regulation were also emphasised as being superior to those of motors running with double armatures on multi-wire systems. The use of flywheels was recommended with compound-wound motors on such machines as punches, shears, planers and similar tools. The flywheel also has a particular value where slow, intermittent and heavy cuts have to be made by the motor-driven tool. The average amount of power consumed by a steam-driven machine shop in driving unnecessary shafting and belting was stated at this meeting to be seldom less than 40 per cent. of the total capacity of the plant. The subject was also discussed at the May meeting of the Cleveland Electric Club when it was stated that at a steamship dock in New York 3 tons of coal per day were required to run shafting alone. The sweeping economies effected by the individual motor in machine-shop operation cannot be always realised in other industries, but it may be taken as indicative of the advantages derived from dispensing with wasteful shafting and other methods of mechanical power transmission. Many of the great workshops in this country are now driven by electric power, but there is still a tendency to adhere to line shafting and group driving from large motors. Machine tools are singularly well adapted to operation by separate motors, a fact which the makers themselves are now beginning to realise, as they provide in their designs for direct motor operation. But, like many other changes, that required by the introduction of the single electric motor drive comes slowly, though, judging by progress so far made, it is surely making headway and will before long become firmly established.

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Editorial.

The Driving of Paper Mills.

In a previous issue we presented a number of illustrations of electric motors operating paper making machinery, and we have recently been supplied with views taken of two typical British installations, which we give in this number, and which will doubtless be of interest. In each of the mills so far described the electrical energy was derived from a special plant laid down expressly for the purpose. We do not at present know of any large mill in this country taking power from an outside source. The conditions of paper making are in themselves peculiar, because heat is necessary in one of the processes, namely, that of drying. Where steam boilers are used the provision of this heat is a comparatively simple matter; but if steam plant is dispensed with entirely it becomes a rather serious item. For this reason it is probable that the electrically driven paper mills in this country will continue to furnish their own energy rather than take a supply from any conveniently located company in their vicinity. Similarly, those plants at present operated by steam, but which have conversion to electric driving in contemplation, will probably put down also their own generating units or arrange that the existing steam engines shall drive the new dynamo-electric machines. From what we are able to gather, paper mills are generally located very considerable distances from the ordinary source of power, consequently they are not likely to become consumers of a supply company, even assuming it were possible for them to do so.

Crane Head Room.

An important consideration often overlooked in advancing the claims of the electric drive for workshops, engineering or otherwise, is the clearance afforded under the travelling and fixed cranes owing to the absence of shafting. The most casual inspection of any modern factory electrically equipped will at once reveal the marked difference between the open appearance of the aisles and bays and the tangled masses of belting and shafting so common with the steam drive. This circumstance emphasises the necessity for judicious arrangement of shop methods with a view to co-ordination and smooth working. While much time and money may be saved with high efficiency tools and systematic methods in the shops, all this good may be undone by inadequate transport facilities between departments. Electric driving, in ridding a shop of the bulk of its shafting, not only contributes to rapidity of production, but adds considerably to the economic handling of material and parts passing through the various productive processes. Crane head room is worth more than at first sight may appear, and it is an excellent point in favour of electrical operation of factories of almost every kind. The disposition of individually or group-driven tools leaves the space swept by the crane hook absolutely clear, and, as a consequence, a minimum of manœuvring is needed when the crane is at work. This applies equally well to jib cranes fixed to the shop columns. If the latter were crowded with shafting there would be no room for lifting devices of any kind. Manufacturers who are familiar with shops resembling forests rather than factories would be astonished at the difference in the "sky space" available in an electrically-driven shop. All things considered, it is one of the most valuable recommendations which electric driving can have, this amplification of upper shop space for the crane.

Textiles and Electric Power.

In another column we comment upon some correspondence on cotton mill driving now appearing in a prominent daily paper published in the Lancashire textile district—the "Manchester Guardian." While strongly approving of discussion of so important a subject, we deplore the widespread publicity being given to gross misstatements of the case for steam and rope driving of cotton mills. If our "friends the enemy" have no better weapons with which to meet and buffet the newcomer in the shape of electric power, they should acknowledge credit where they recognise it as due, and refrain from deliberate, or apparently deliberate, perversion of the facts. We think that electrical engineers are apt to be too sanguine of the capabilities of electric motors applied to any industry, and in consequence overstate their case, but sheer optimism is recognisable as such and due allowances may be made for it. On the other hand, it is difficult, if not impossible, "to overtake a lie." Experience up to the present appears to favour the employment of electric motors in textile mills, both for group or floor driving and for the individual operation of single machines. If steam engineers do not like the turn matters seem to be taking, let them defend their case like men, without recourse to methods which only tend to aggravate such grievance as they feel they have against the newer methods.

We admit that there is much yet to make known from our own standpoint on this important subject, and we hope that electric power engineers will withhold none of the real facts whatever they may be. The two main claims of electric driving are increased efficiency and production. By efficiency we mean economy in operating and improved

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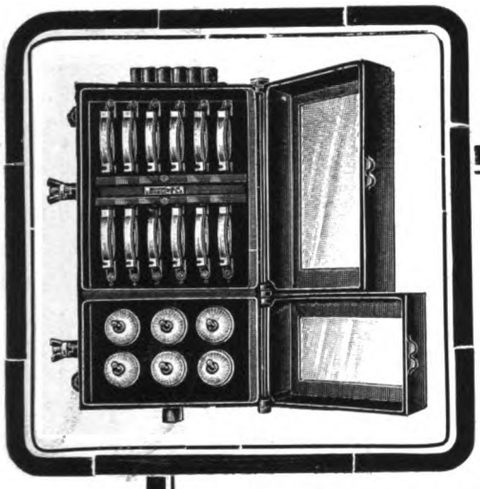

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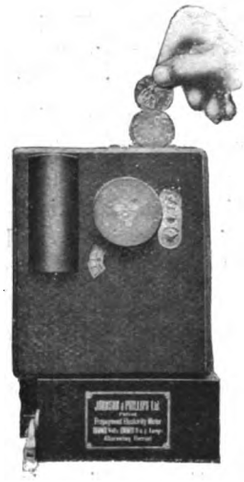

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quality of product by reason of steadier running. The principal data relating to these are not difficult to obtain, and they should be fearlessly published, in order that they may be placed in comparison with the figures of steam driving under similar conditions. We want less generalising on hypothetical efficiences of this or that section of the equipment and more special details, culled from extended practical experience in both fields of operations. Figures for steam should be available at any moment. As to electric power, a few more months' running of mills already equipped should enable a reliable and accurate comparison to be made.

New Creative Ideas.

In the current issue of "Cassier's Magazine" Mr. B. A. Behrend writes on the subject of the "Coming of Age of Electrical Engineering," and considers, among other things, what he calls "natural" and "forced" ideas. He says: "The natural idea may be likened to a plant growing under favourable conditions and adapting itself to its environment; the forced idea may be likened to a plant raised in a hothouse, with the exclusion of such conditions as might have a tendency to prevent its development. The natural idea will survive, the forced idea will go to the wall; but it is often only after extended experiments conducted on a large scale have been laboriously completed that we realise that an idea has been followed out which could have lived only under particularly favourable conditions, such as are not usually found in practical operation."

"In contemplating the history of the development of the utilisation of alternating currents, the single-phase system has appeared to be an almost ideally simple system. The experience gained during the past 15 years with polyphase currents and the many opportunities afforded the engineer for comparing the single-phase machinery, generators and motors with their polyphase cousins, have led to an attitude of scepticism towards single-phase current. The very much reduced output of both generators and motors if operated single-phase, the reduced efficiency, the impaired regulation, the increased heating, and the lesser stability of single-phase motors and generators, connected with the increased cost as produced by the greater amount of material required—these form the main reasons for inducing me to call the recent attempts which have been made in the utilisation of single-phase currents a forced idea. Fifteen years ago the possibilities of polyphase systems were clearly seen by engineers competent to judge, although the apparatus developed at that time was still rather inefficient. Our attitude towards apparatus generating and utilising single-phase currents is slightly different. Our efforts have not been crowned with success as regards the building of economic single-phase generators and motors whose characteristics may be favourably compared with those of polyphase machines. If single-phase currents are to be used successfully, a new creative idea must be introduced which will do away with some of the disadvantages peculiar to the present single-phase apparatus."

Mr. Behrend then refers to the apparent future need for new creative ideas which will remove the difficulties and solve the problems which confront us at the present time. There is certainly truth in the fact that some drastic change is needed to enable the main obstacles presented by single-phase systems to be surmounted.

Industrial Topics.

A CONSIDERABLE amount of money is annually diverted from the advertising colums of technical journals to the publication of leaflets and pamphlets by manufacturers who have an appeal to make to prospective buyers. At one time one and two-page display announcements were common enough in the technical press, and manufacturers in purchasing space had faith in the media through which, in this particular manner, they cried their wares. Of recent years probably the same annual expenditure has been devoted to publicity, but the spaces have dwindled to much smaller dimensions, and the money once allocated to press publicity is spent in leaflets, &c. These are prepared in an attractive way and are punched carefully with holes for filing in a more or less substantial case which retains its contents handy for reference. Literature of this description is costly to prepare, print and distribute. Pamphlets and leaflets, per se, are attractive enough to deflect attention for a brief period. Then they are cast aside or hurriedly mixed with other papers from which they are seldom disentangled. The publicity pamphlet and its containing file are excellent, and would remain so if they were not overdone. If one firm could retain the monopoly of the method and exploit it widely most effective publicity would be secured. Every interested client would keep the handsome file on his desk, and it would loom largely in his daily round. But each manufacturer must have his booklet and file and confusion thus becomes confounded, and most of the efforts at well-directed publicity are frustrated. "Another of these files in the mail this morning," says the pestered client, and into the W.P.B. it goes, probably without even being scanned. The question is a very vexed one and needs thorough ventilation. Only firms who spend huge sums annually on publicity of this kind can fully appreciate what the outlay really means. Probably also they will be familiar with the paucity of the return from the expenditure incurred. Journal advertising is, in the nature of things costly, mainly on account of the lack of general support given to technical papers, however ably conducted. But space outlay, if properly purchased and wisely filled, would probably run the specialised circular very close for efficiency and even for effective display. We much question if the fashion, for it seems nothing else, of file publicity will last always. Improvements in colour printing and, in fact, in printing generally, have tempted the manufacturer to invest in elaborately-prepared publications, and to avoid running the risk of these being cast aside he has taken up the loose leaflet and file to secure publicity for his products. He himself knows if the system pays. What new direction methods of securing publicity will take we cannot definitely predict, but we feel sure that when the manufacturer becomes both introspective and retrospective he will effect comparisons which will not be altogether flattering to some of the methods which now prevail.

File Publicity.

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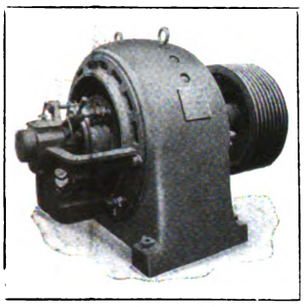
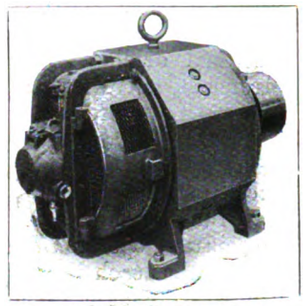
THE ELECTRIC CONSTRUCTION Co. LTD.

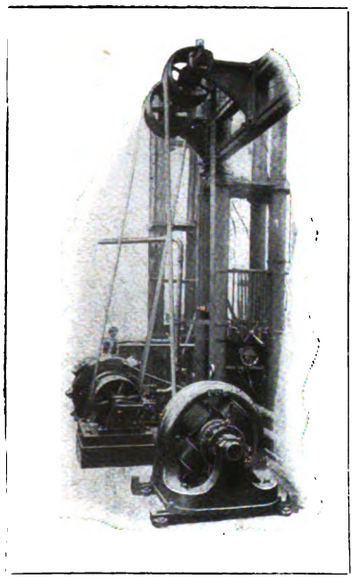


Continuous-Current Motor or Dynamo for Rope Drive.

ELECTRICITY FOR POWER PURPOSES

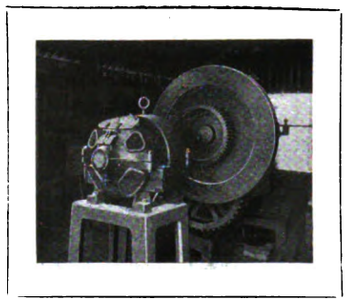


Continuous-Current Enclose Ventilated Motor.

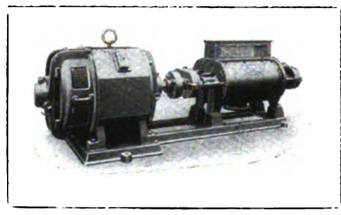


Motor Driving Shafting by Belt.

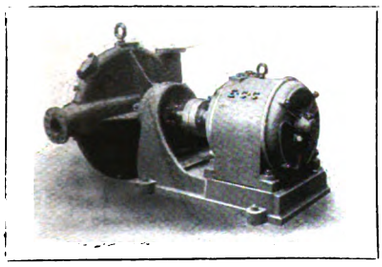
E.C.C.



Motor Driving Cold Shear in Steel Works.



Motor Direct-Coupled to Root's Blower.



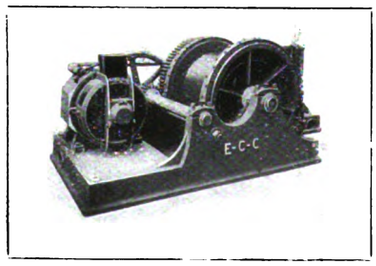
Direct Connected Motor-Driven Centrifugal Pump.

MANUFACTURERS OF

MOTORS

OF

EVERY DESCRIPTION.



Motor-Driven Winch.

HEAD OFFICE:- DASHWOOD HOUSE, 9 NEW BROAD STREET. LONDON, E.C.

WORKS:- BUSHBURY, WOLVERHAMPTON.

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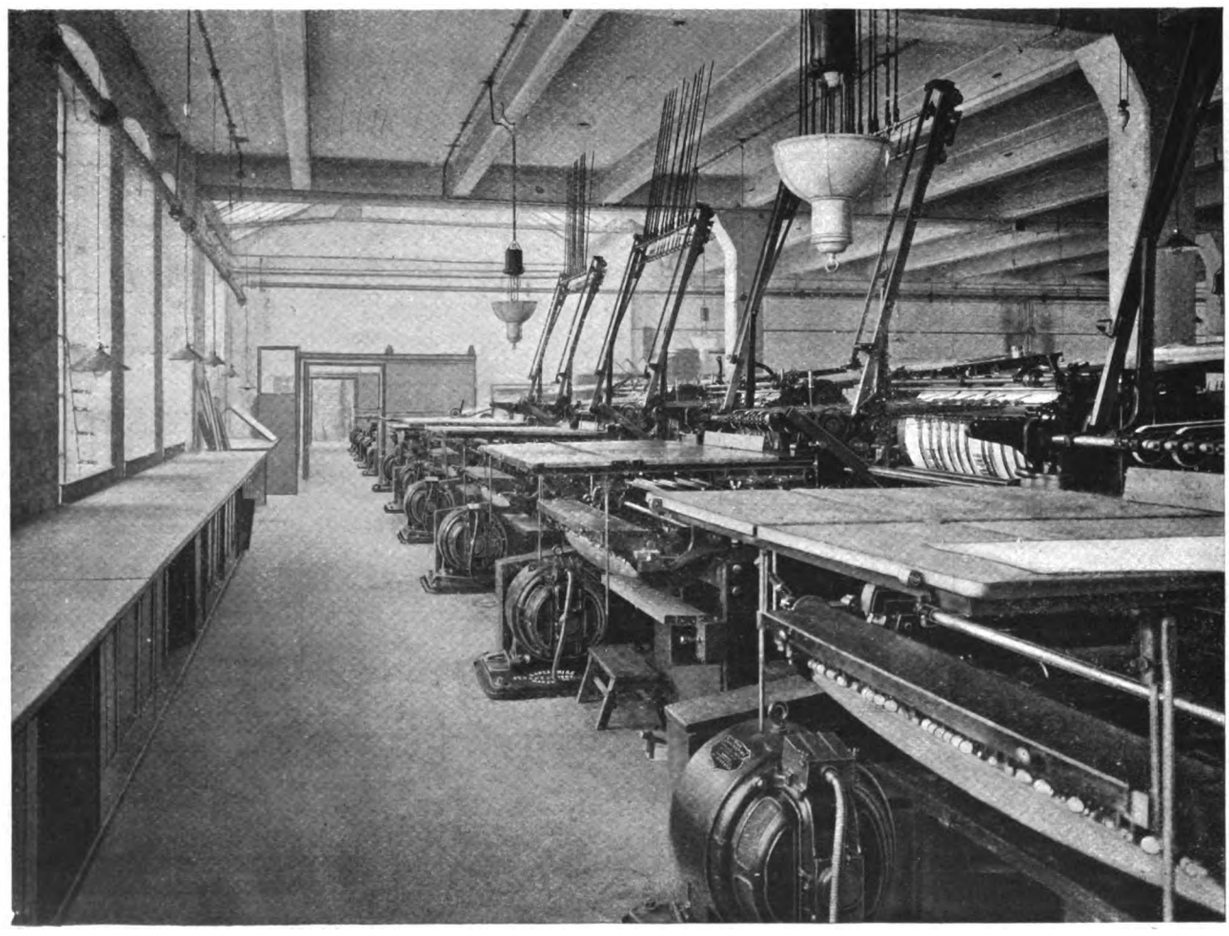
A Typical Electric Printery.

THE flexibility, convenience and economy of the individual motor drive are strongly brought out in the many applications of electrical energy now made to printing machinery. The fact that machines are required to run at different times, and more or less independently of one another, favours the employment of separate motors, and up to the present printers who have adopted electrical driving have taken every advantage of this arrangement. Through the courtesy of Messrs. Hudson & Kearns, Stamford-street, London, S.E., we were recently afforded an opportunity of inspecting the electrical equipment of their printing works. We are also able to give an excellent illustration of the application of individual motors to a range of large printing presses which they have had in constant operation for the past two years. It will be noticed that each press has its own motor, and that each driving unit occupies a comparatively small amount of space. In fact, in many cases the motor does not extend beyond the ordinary base line of the printing press. In the majority of instances a belt drive is employed on to the main shaft of the press, and any speed regulation required is effected on a rheostat in the field circuit of the motor.

The illustration is one of those happy instances, which are unfortunately very rare in printing works, in which an excellent photograph can be taken of a large number of machines. This in itself is excellent testimony to the size of the machine rooms, the manner in which they are lighted and the absence of overhead shafting which renders the illumination obscure. The works themselves are electrically driven throughout, power being purchased from the local supply company. Upwards of 45 motors, made and installed by the Lancashire Dynamo & Motor Co., Trafford Park, Manchester, are employed driving the various machines in the works, ranging from heavy presses to light ruling machines. These motors aggregate upwards of 180 H.P., the sizes varying from $1\frac{1}{2}$ to 6 H.P. The installation seems to us to be a typical example of what can be done with electric driving, and we are pleased to have the opportunity of presenting the illustration of one of the main portions of it to our readers.

We noticed during our round of inspection that the wiring had been carefully carried out in steel conduit and practically every inch is enclosed. Even behind small boards carrying starting switches the tubing was run and the practice of bringing loose ends from the back of boards into switches and starters has not been followed. An installation of this kind cannot fail to be a source of gratification to the proprietors and also a means of economising power while increasing the output of the plant. The enterprise of the management in adopting electric driving is doubtless now finding complete justification in the results obtained.



General View in aisle of Machine Room in Hudson & Kearns' Printing Works, showing row of Presses driven by Lancashire Dynamo Motors.

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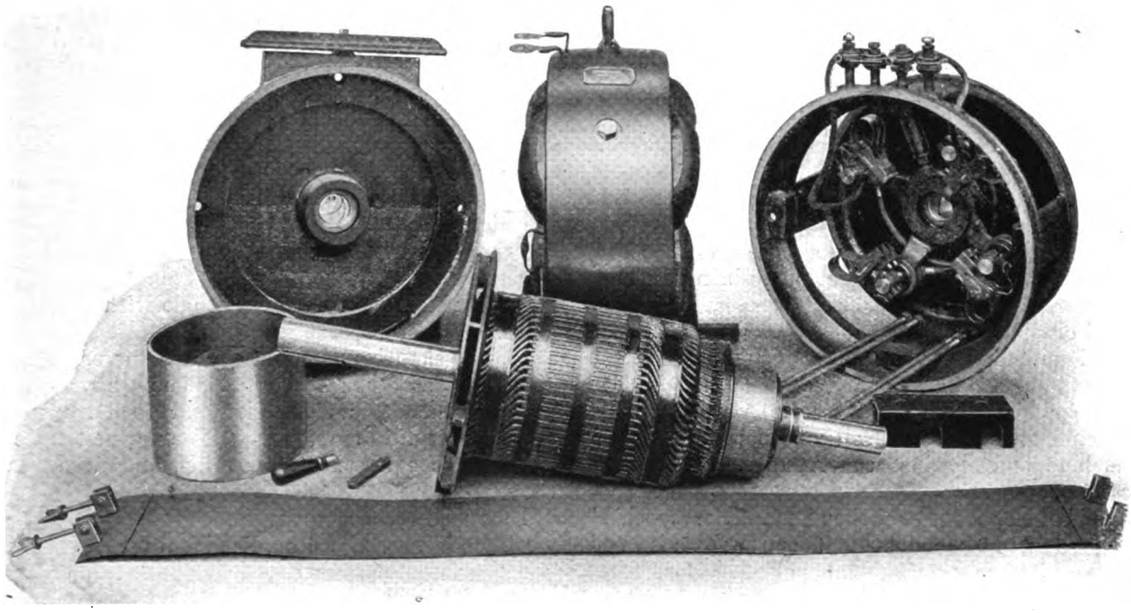
LOOK RIGHT INTO THE QUESTION BEFORE YOU DECIDE. THIS SHOWS THE VITAL PARTS OF A UNION MOTOR & SHOWS THEM ALL GOOD FOR A LONG LIFE.



MOTORS from ¼ to 1,400 H.P.
Usual Sizes in Stock.

Union Electric Co. Ltd.
PARK ST. SOUTHWARK. LONDON, S.E.

Notes and Observations.

VIII.—Textile Tangles.

"YOU know nothing about textile machinery. How can you tell me how to drive it?"

"I can tell you how you should drive it, but you don't want to listen."

Textile machinery and millwrights are two of the most cussed things I have yet been up against. The machinery can't be directly blamed. The millwrights simply beggar description.

Old Higginbottam, for instance, whose remark opens this note, reckoned he knew the last thing on the driving of a cotton mill, and all the pneumatic hammers of persuasion and electric drills of argument would have no effect on him.

"I don't care a tinker's cuss what other mills are doing; I shall keep running by steam as long as the boilers will hold water."

"Why did you put in steam?" I inquired casually.

"Nothing else for it."

"For just that reason you will go over to electric."

"Oh! and when, pray?"

"Soon as prejudice gets worn off and steam engineers can't tell any more lies about electric driving."

"I don't see the object in motors taking the place of shafting or a rope race."

"Because, my dear sir, you are unable to appreciate the difference between the mechanical and electrical transmission of power."

"What's the difference? Perhaps you'll tell me."

"The loss in ropes, belts and shafting is, mildly, 20 per cent. of the total engine output. With electric cables it is about 2 per cent."

"Yes, but what about dynamo and motor losses; they amount to something?

"About another 10 per cent. for the two; so you save, roughly, 8 per cent. of power on the drive alone."

"And get your money back into the bargain, I suppose," he suggested ironically.

"Well, your output increases also," I replied, disregarding his sneers. "Your machinery can be run nearly 10 per cent. faster with motor drive."

"But we can speed up the steam engine and get level there."

"Not so fast," I said, stopping him. "What about your shafting losses? They will climb up with the increase in speed."

"So they will with your motors."

"Granted," I said; "but it happens that the 10 per cent. increased output takes account of whatever losses there are in the faster motor drive. It's just there where we keep ahead of you all the time."

"Maybe you can, but I'll be hanged if I'm convinced. You none of you know what you're doing. Some say, Have your own dynamo. Others say, Buy outside. Here the cry is, Away with gearing; there it is said that gearing must still be used. You can't wonder I stick to steam amidst so much uncertainty and confusion."

"It may seem confusing to you, but take each case on its merits, and your difficulties will cancel out."

"Take the power problem."

"Have I not dealt with that often enough? For months I have sat on your doorstep almost with the cables in my hand wanting to give you a supply. All the while your

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beastly gearing has made day and evening hideous, and your beam engine has kept bumping along. What more zeal do you want? I'd give you the motors if we made them, but we only supply the 'juice,' and at ⅝d. a unit you get it dirt cheap."

"Yes, but the cables are at the top of the road half a mile away. A pretty penny they will cost me to bring down to the mill," he remarked.

"Not a red cent," I answered.

"I was told we had to pay for the transmission line," he started.

"More fool you for believing it, second or third hand. On no occasion have I offered to sell you more than power. How it gets here is up against us. At any rate you know now and can't excuse yourself."

"Why should I buy from you when I can make myself?"

"Why spend £10,000 when you can avoid it?" I answered him at once. "You will pay £10 for every horse-power you want to drive the mill. We can save you that and much more. Therefore, buy from us."

"But you are miles away. Suppose you break down. What shall I do?" he asked, only naturally.

"We take care of that. Our plant is in duplicate, and we take great precautions. We have not let any one down yet," was my reply.

"Too risky," he said.

"Not any more so than with your steam plant. You've stopped now in the weaving sheds owing to a gear wheel breaking," I remarked.

"How do you know?"

"Looked in as I came past. It does not take long to find things like that out."

"Well, you can talk till you're blue in the face, and you won't move me into any electric driving," he said, rising and waving me towards the door.

"There's only one alternative," I replied, without getting up.

"What's that?"

"Extinction, my friend; your competitors will get ahead of you. The quantity and quality of your product will go down, and you will not make up the difference with steam."

"Oh, yes, in another 20 years,"—he began.

"Five," I shouted, interrupting him. "You can't see the thing in the way I can. Electrical manufacturers are just falling over one another to equip every industry under the sun with electric motors. Competition is deadly keen. Prices will fall. Textile manufacturers will have to adopt electric driving whether they want it or not."

"Rubbish! All stuff and nonsense! Don't come here with any tall talk."

"As a matter of fact they do want electric driving, and badly, very badly, to compete with new rivals," I went on.

"What new rivals?" he asked, as I paused for his question.

"Oversea rivals, Colonial, Continental and American," I answered.

"What the deuce have they to do with Lancashire?" he cried.

"More than you think—a heap more. They are beginning where you leave off. They have cheap water power, transmitted electricity, and good transport. They are near certain markets, too. Your own textile machine makers are equipping their mills, and in a year or two they will laugh at you."

I stopped for a moment, and he said:

"Sounds very alarming, but it's a long way off."

"Nearer, much nearer, than you think," I said, "and unless British textile men can see it this way now, in a year or two it will dawn upon them too late." Don't forget that most other countries near cotton fields have cheap power almost for the asking. It's there and only wants developing. The cry in every industry is for machinery, and when that is made it must be driven. If cotton can be spun where it is grown it will be.

He remained silent and sat down again. I resumed at once.

"One more thing. Don't forget the workers. In Lancashire they haven't got any too rosy a time. Smoky towns, dismal streets, dreary unwholesome dwellings. Overseas there is less of this and with electric power it is done away with altogether. That's one of the reasons I want you to buy from me. Our power station is at the pit's mouth. We cut off short the smoke at your stack and all those around. Before long you can start cleaning up this little town. It will be better to live in. You set an example which others will follow."

"Yes, I can see it somewhat in your way now," he said after a long silence, "but it will take a precious long time."

"I said five years. By that I meant that a great change would have been made. And it will be so."

"But why?" he queried.

"Because," I answered, "once a fair start is made the rest will follow with a rush. There will be an electric boom in textiles as there has been a steam boom, and your name on the list now will go a long way towards giving the movement an impetus."

"I'll think about it; seriously I will," he said, and he shook me heartily by the hand at the mill lodge.

W. E. W.

BRITISH ENGINE, BOILER & ELECTRICAL INSURANCE CO., LTD.
Head Office ... 12, KING STREET, MANCHESTER. | Glasgow Office ... 65, Renfield Street.
London Office ... 49, Queen Victoria Street, E.C. | Newcastle office ... Standard Chambers, Neville St.
DYNAMOS, MOTORS, ENGINES, BOILERS, PIPES, &c., Insured, Inspected and Tested.
PLANS AND SPECIFICATIONS PREPARED. SUPERVISION DURING CONSTRUCTION.
Chief Engineer: MICHAEL LONGRIDGE, M.A., M.Inst.C.E., M.I.Mech.E. *Elec. Engineer:* LLEWELLYN FOSTER, A.M.I.C.E., M.I.E.E.
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Telegraphic Address: "OERLIK LONDON."
Telephone: No. 4167 Gerrard.

Commercial Development of Central Stations.

STATION managers who endeavour to "boost" business by conducting a properly organised publicity department do not appear to take kindly to newspaper advertising. Probably the outlay is regarded as disproportionate to the results anticipated, and rather than incur the risk of loss the subject is left severely alone. Wholesale advertising in newspapers cannot be recommended to British station engineers, because the public appealed to are unlikely to be greatly interested as regular readers, and the style of advertisement inserted will also probably fail to compel the attention desired. Newspaper advertising needs to be undertaken with extreme caution. There is good to be done by its aid, but only a carefully "plotted" campaign will do it. Daily papers should be avoided for large display announcements. They certainly have a wider circulation than weeklies, but, for the object in view, quality rather than quantity of numbers distributed is wanted. A weekly of repute will give greater promise of result than a half-dozen dailies, and first experiments should be made with this. The purchase of space requires some little deliberation. The advertisement manager of the journal in question may advise on this, but his selection of a position should not be accepted first hand. Obviously the main matter to be kept in view is the *kind of appeal* which is to be made. This should govern the position taken. In the columns of one paper the number of appeals can be many and varied. For this reason the space purchased can easily be spread over different sections of the reading matter. "Wants," "For Sale," "Apartments and Houses to Let," are read regularly by every class of newspaper buyer, and make admirable positions for the insertion of "catchy" advertisements. The rates also are comparatively low. Where bona fide advts. only are inserted in such columns some position at the head or foot of them may probably be obtained. The "copy" to fill the space purchased should be carefully prepared. Preferably some distinguishing and distinctive border or catch line should be adopted, and the matter in or below this should be constantly changed. It is waste of money to fill costly spaces with cheap copy. Better to leave newspaper advertising alone entirely. A little reflection will, however, show that some good may come of a judicious investment in newspaper space. In another issue we hope to give further details.

Newspaper Advertising.

Curtain Advertisements.

Who attending a music hall has not been amused, annoyed, or mayhap aggrieved, at the advertisement curtain displayed to view once or oftener during the performance? Many traders will be cajoled into making use of this space with little subsequent result. That the "position" has some value may be judged by the absence of empty spaces and the presence of names well worn in the advertising campaign. We have never yet noticed an advertisement of electric lighting, heating and power on any of the curtains it has been our fortune, good and ill, to gaze upon. Without knowledge of the rates prevailing for the spaces on these curtains we should commend them as "live" positions to the station manager. His appeal to the public may be surrounded by Bosco's Beef, Weekly's Whisky, Pulper's Jams and Garlick's Pickles, but what does that matter? The consumption of each and all of these is rendered more enjoyable in the "limpid light of a glow lamp, or the browsy breeze of an electric fan." It is not a location in which the matter can be constantly changed, but for keeping the name "always there" it has few equals. As we have intimated, it has its value, and the station manager should not buy the space for more than its real worth.

"Ideal" Petrol Electric Sets.

SMALL combined engine and dynamo sets are becoming more popular for country-house lighting, and the supply of these compact units has in itself created a distinct demand. Messrs. R. J. Nicholson & Co., Corporation-street, Manchester, have equipped quite a number of country houses with their "Ideal" petrol electric units, and they inform us that they give every satisfaction. In the sets themselves the engine and dynamo are coupled together and fixed to the same bedplate, all belting is dispensed with and the space occupied is small. All parts in both engine and dynamo are made to gauge and are interchangeable. The engine is petrol-driven, vertical, two-cycle in action. The design eliminates all moving valves, the passage of the piston opening and closing the ports admitting and discharging the gases. This design is said to entirely overcome the vibration nuisance Governing is by means of a horizontal centrifugal governor actuating a valve on the piston side of the carburettor, which throttles the mixture. Simultaneously with this throttling is a variable regulation of the air admission. A lever is provided by means of which the gas may be regulated by hand while the engine is running; this permits of a speed adjustment at will. The engine is started with a handle and free clutch in the same way as a motor-car engine. Lubrication is effected by "splash" in the crank case to the crank and connecting rod. The piston is lubricated from a sight-feed lubricator fixed on the cylinder head, and the ignition is electrical, with induction coil and accumulator.

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polyphase Induction Motors.

THE large number of power stations furnishing alternate currents, either two or three phase, for power purposes has increased so much of late years that a corresponding demand for induction motors for these circuits has been created. Although it labours under several disadvantages—such as speed inflexibility and low starting torque—the polyphase induction motor has a distinct field of utility, and up to the present it has filled it well. The design of motors of this type differs considerably, and the various makers have their own special features to commend them. Messrs. Marples, Leach & Co. have just issued particulars of their standard machines for all kinds of a.c. circuits, and some details will doubtless be of interest.

The motors are built in two styles: (i.) with short-circuited rotors, and (ii.) with slip rings. The former is the simpler

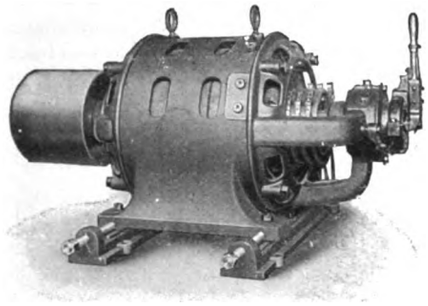

Fig. 1.—Three Phase Motor with special short circuiting device for slip rings.

machine, but above certain sizes and for certain duties it is not used, a machine of the slip-ring pattern being employed. We are informed that the rotor of the short-circuit type of machine is built up without joints in the conductors, either mechanical or soldered, the windings being cut from a single piece of solid metal. This is a valuable feature, as, in case of overheating, there is no likelihood of conductors coming loose and doing damage by flying out of the machine.

The slip-ring machines, above a certain output, are provided with a form of short-circuiting device, which cuts out the starting resistance, raises the brushes from the slip-rings and at the same moment closes the rotor circuits as if they were solid, as in the case of the short-circuited type. A three-phase motor with this arrangement fitted is illustrated in Fig. 1. It will be noticed that a handle is provided outside one of the main bearings, and this is coupled to a lever by which the brushes are lifted from the rings and the windings coupled up without the starting resistance. At first sight this might appear an unnecessary complication, but the raising of the brushes obviously decreases the wear and tear, both of them and the slip-rings. The risk of stoppage of the machine through defects in the brush gear is at once removed, and also the possibility of sparking occurring is practically eliminated. An improvement in the efficiency is also claimed.

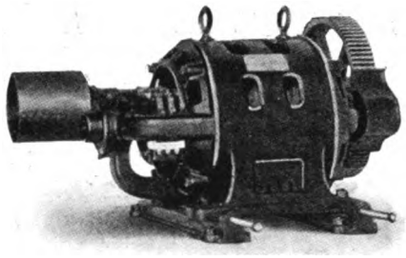

Fig. 2.—Slip Ring Motor with Speed Reduction Gear.

These motors are also built with speed-reduction gear, forming part of the motor carcase. Fig. 2 illustrates a slip-ring motor, without the special short-circuiting device, fitted with reducing gear. Standard ratios of reduction are 3 : 1, 4 : 1, 5 : 1 and 6 : 1. The gear wheel and pinion can be enclosed in a dust-proof casing.

A line of single-phase motors is also included in the company's standard range of a.c. motors.

The standard frequency for all machines is 50 periods. Motors for other frequencies are also built. The starting torque of slip-ring motors is said to be $2\frac{1}{2}$ times full-load running torque. The machines are made to withstand 25 per cent. overload for half-an-hour, 40 per cent. for three minutes and momentary overloads of 2 to $2\frac{1}{2}$ times full load without injury. Liquid starters are supplied, but these are not suitable for speed regulation. Fig. 3 illustrates a type of these with worm drive.

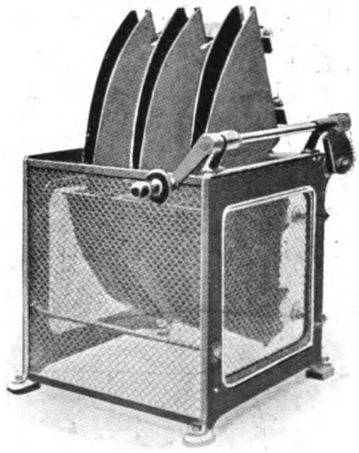

Fig. 3.—Liquid Starter with worm operating gear.

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An Electrically Wound Time Switch.

THE ordinary pattern of time switch with eight-day clock labours somewhat under the disadvantage of requiring winding up periodically. To obviate this difficulty arrangements can be made for winding the clock electrically from the circuit in which the switch is placed. The Reason Mfg. Co., of Brighton, make a type of switch which is entirely automatic in action. Figs. 1 and 2 illustrate this switch, viewed from the front and side, with covers removed. At the top of a stout metal base the switch contacts are fixed on insulated bases and are bridged by brush laminæ carried at the end of a swinging arm, which is actuated by a separately wound spring at the back of the plate. The switch is tripped by the clock mechanism, which releases the spring holding the switch in the "on" position. The time for switching, both on and off, can be set on a dial at the front of the switch by the simple movement of a milled screw.

The electrical winding of the clock is effected by a solenoid at the back of the supporting base, the circuit of this coil being closed by a small carbon break switch which may be seen to the left of the illustration in Fig. 1. This same switch is shown open in the side view, Fig. 2, and as carbon contacts are used it will safely break the solenoid circuit. Across the terminals is a non-inductive resistance to reduce sparking and to take the inductive "kick" of the solenoid when switching off.

The switch is made in three types: (i.) Fitted with s.p. switch up to 15 amperes capacity, with carbon break, for 250 volt circuits. This type is also made up for two-rate meters and as a change-over switch for arc and incandescent lamp circuits. (ii.) Fitted with d.p. carbon-break switch up to 15 amperes capacity for 500 volt circuits, which can also be used for change-over purposes. (iii.) Fitted with separate switch box containing solenoid-operated d.p. quick make-and-break switch actuated by local circuit which is opened and closed by a small time switch. This is made for capacities up to 100 amperes for 500 volt circuits. The switches are suitable for a.c. and d.c. circuits, and we are informed that they only require about 1 unit of energy per annum to operate them. Features of the switch are the use of ample power to operate the switch mechanism, the independence of the clock motion of the switch parts as far as operating is concerned, and the substantial construction of the current-carrying parts. In the larger patterns of switch magnetic blow-outs can be supplied in addition to carbon breaks.

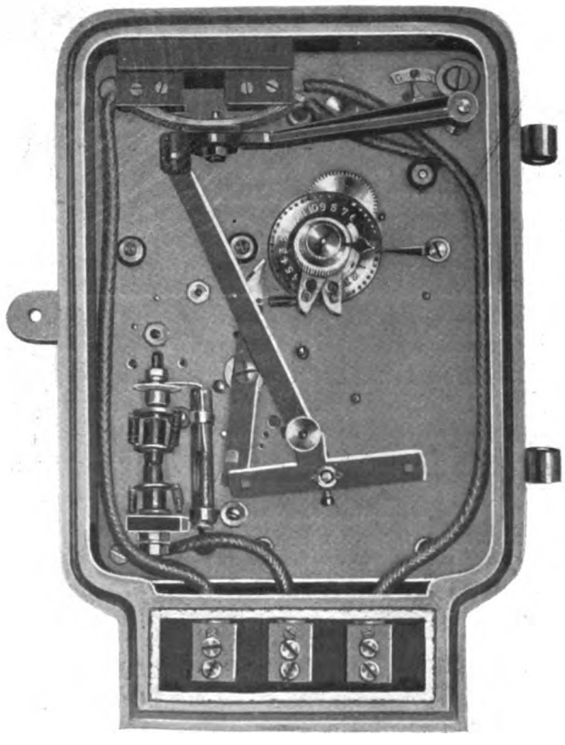

Fig. 1.—Front View of Time Switch with cover removed.

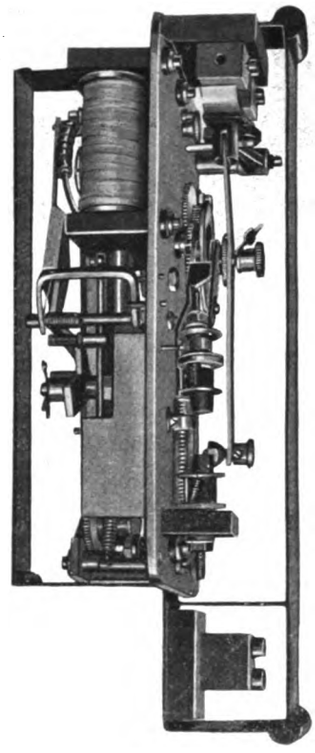

Fig. 2.—Side View of Time Switch showing working parts.

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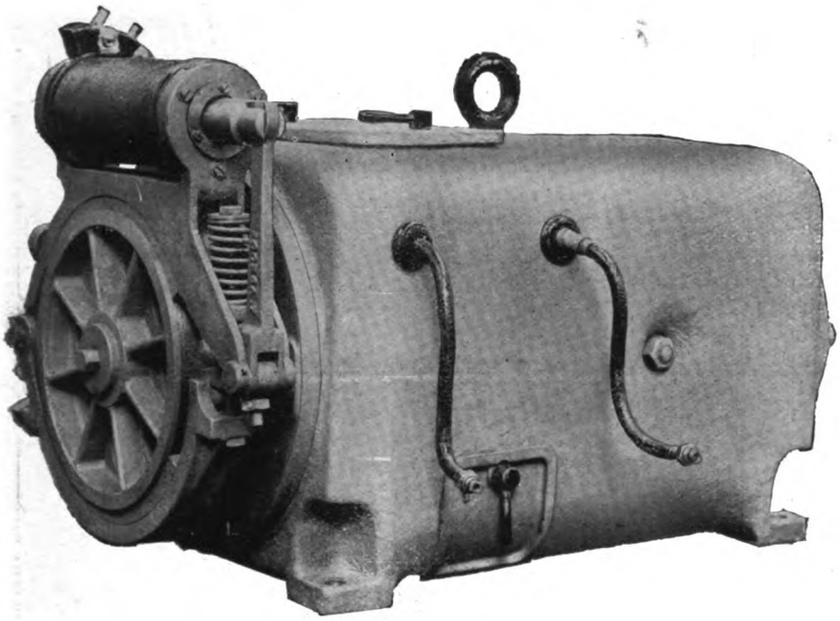
Crane Motors.

THE demand of crane makers for motors having a special rating for high-duty service has now to be met by motor manufacturers with machines built expressly for the purpose. Siemens Bros. Dynamo Works (Ltd.) inform us that they supply crane motors for all outputs, speeds and voltages, and in the alternate-current types for all frequencies. As such motors are called upon to operate in confined spaces they are built up on compact lines and are also completely enclosed. A rectangular cast-steel frame is used for the field carcase, and cast-iron end shields, bolted on to large circular seats, serve as supports for the bearings. By rotating these shields the base of the motor can be set for a horizontal, vertical or overhead support to suit the type of drive required. This adjustment is an interesting and valuable feature of the motor, as in crane operation it is frequently necessary to drive by gearing from several positions. On the crab of an overhead travelling crane, for instance, the motors may be fixed on horizontal bases. For traversing the motor will be bolted vertically against one of the span girders of the crane, while for travelling the motor may have several positions. With jib, pillar and dock cranes the motors will also require to drive from a variety of positions. An illustration of the motor is given herewith. The bearings are ring-lubricated, and the field coils are so disposed as to be removable from any pole without disturbing others adjacent. The armature is of standard build, and the motor is fitted with a self-contained magnetic brake.



Exterior View of Crane Motor with Magnetic Band Brake.

The Pinion Drive.

WE referred several months back to the impetus given by electric motors to the use of pinions for the direct driving of machinery, and specially mentioned the value of paper pinions for this purpose. The British Insulated & Helsby Cables (Ltd.), who are makers of the Prescot paper pinion, have recently published an exhaustive booklet on the subject, in which some interesting data of these pinions are given. The makers state that the strength of a tooth of compressed paper is equal to that of cast iron of the same dimensions, but is more elastic. The maximum safe speed for the pinions is 3,500 ft. per min. Under treatment with a special graphite lubricant, and after being in service some time, the compressed paper assumes a highly polished surface, and the friction between the paper and metal teeth is considerably reduced. The best results are obtained with the spur wheel engaging with the paper only and not with the metal shrouds. The paper portion of the pinion is, accordingly slightly wider than the spur wheel. One paper pinion should be used in each pair, or every alternate one in a train. The pinions materially reduce the noise so common to metal gears. The teeth are machine cut in each case, and customers can be supplied with blanks in which to cut teeth as desired. The centre of the pinion is always metal bushed. Special plant has been laid down at the Prescot works for the making of these pinions, and in the latest publication issued some interesting illustrations of the pinions in use are given. One of these is a 16 ft. boring mill, operated by an independent motor, an example which represents a fairly constant but heavy load on the driving mechanism. The largest pinion illustrated is one of 24 in. diameter. The standard shape of teeth is involute Brown and Sharpe. It is interesting to recall the fact that the makers first introduced these pinions into their own works, having experienced considerable trouble with ordinary pinions and spur gearing. We understand that the prices compare favourably with rawhide, but the life is stated to be greater with the paper pinion.

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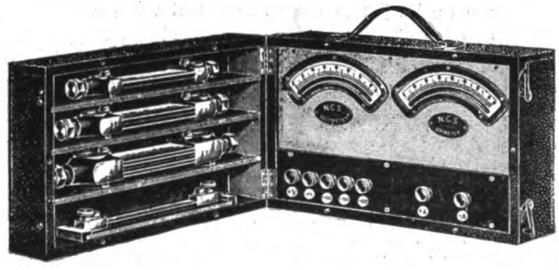

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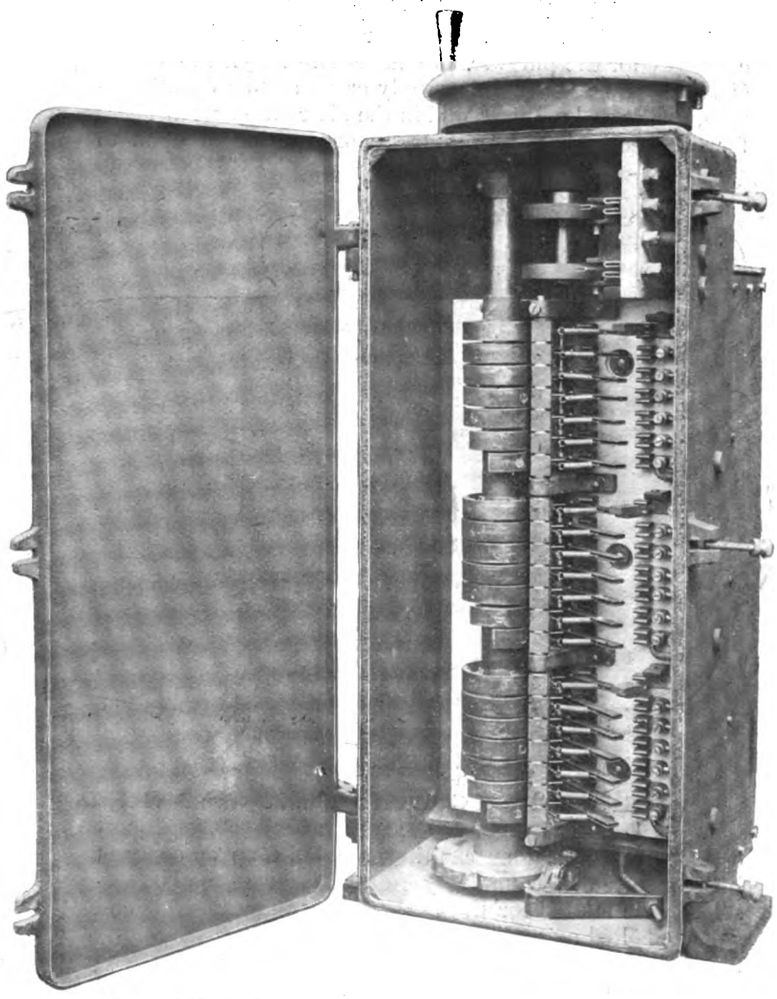
A New Drum Type Controller.

DRUM type controllers are now usually employed for the control of large a.c. and d.c. motors because of their compactness and ease of handling. The general practice adopted in the design of these controllers has been to employ a number of fixed contact fingers and change the connections to them by means of metal rings or sectors spaced apart on the controller drum. For control of heavy capacity d c. circuits powerful magnetic blow-outs are fitted to extinguish the arc at the moment of breaking, this being generally intense on account of the slow break provided by the movement of the drum. Heavy arcing also takes place in large drum-type controllers for a.c. service.

We give an illustration of a new pattern of controller which retains the main features of the drum-type as far as appearance is concerned, but which has been designed to afford a quick break at each switching point. It will be observed that knife switches are fitted in a horizontal position to an insulating base, being pivoted thereon and controlled by strong springs. Extensions of the switch blades at the back of the hinged support serve as heels against which the cams on a controlling drum engage and press each switch into its clip contacts. The cams on the drum are arranged to give independent action to each switch, so that as the barrel is moved round either for switching on or off, each drops into or snaps quickly out of its contact.

The controller illustrated is in use on a 30 H P. a.c. haulage gear fixed in the workings of a fiery mine. It controls the rotor circuits of a 500 volt slip-ring motor and is built to give six speeds in either direction. The reversing switch may be seen at the top of the controller below the cover. It is operated from the main handwheel by gearing, and is a plain throw-over switch for reversing the connections of two of the phases. The three sets of switches below are in the legs of the rotor windings. They cut resistance in and out of circuit to give the speeds required, and the cams on the drum are so placed that one switch in each set (of the three legs of the rotor) is cut in or out simultaneously. The feature of the controller is the prompt cut-out of the knife switches at all times irrespective of the speed at which the handle is moved.



View of Knife Switch Contacts, and operating Cam Drum in New Controller.

The lower end of the drum is fitted with a disc having V-notches in its rim, the position of these corresponding to the switching points of the controller. A spring-actuated roller drops into these notches securely holding the drum on the point and allowing the handwheel to be released. As will be seen from the illustration, the handwheel is substantially made and of large diameter. It is fitted with a shrouding ring which encloses the gear used for driving the cam drum. This gearing is necessary because the handwheel moves through a half circle, clockwise and counter-clockwise for the forward and reverse positions of the controller. For each ½ revolution of the handwheel in either direction the cam drum makes one complete revolution.

The controller casing is of cast iron, with hinged door making a gas and water tight joint, an important feature for colliery service. In addition the resistance units are an integral part of the controller and are enclosed with it as part of the casing. The connections between these and the switches are consequently quite enclosed, and, moreover, are neatly made without having recourse to loose and straggling cables.

These controllers are made in standard sizes for a.c. and d.c. circuits and for any voltage or capacity by Engineering Instruments (Ltd.), 272B, Upper-street, Islington, N.

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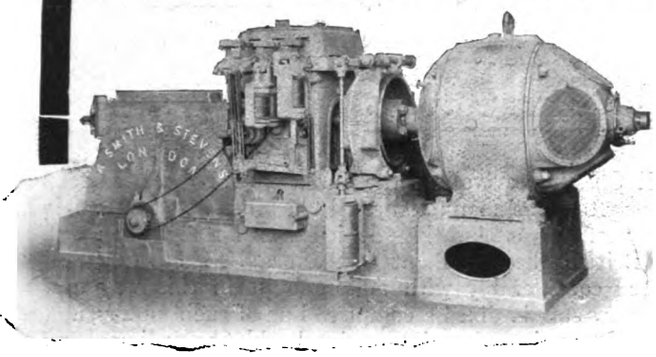

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Photographic Arc Lamps.

PROFESSIONAL photography has profited considerably by the introduction of electric lighting, more particularly with arc lamps, and the last few years have witnessed the development of numerous devices for use in photographic printing rooms. The enclosed arc lamp is greatly in demand for work of this kind because of its long burning hours and the medium strength of the light which it emits. The diffusion of the light is also good, and by the aid of reflectors it can be directed to any desired spot. The Union Electric Co.'s pure carbon lamps are made specially for photographers' use, and in addition to supplying the lamps, a number of useful fitments can be furnished. We illustrate a convenient travelling carriage designed to run on overhead rails and also to carry one or more arc lamps. The latter are supported from small two-wheel trollies the brackets of which are fitted with a swivel pin. On this a frame, carrying the lamp attachment, is made to turn so that a large combination of movements is possible with the trollies and pivot suspension. The standard pattern of carriage has 8 ft. 2½ in. centres, but carriages for greater spans can be provided as required. The lamp-holders are also pivoted and the supporting frame is telescopic to give adjustments in a vertical plane. The lamps shown on the frame in Fig. 1 are for direct-current circuits only.

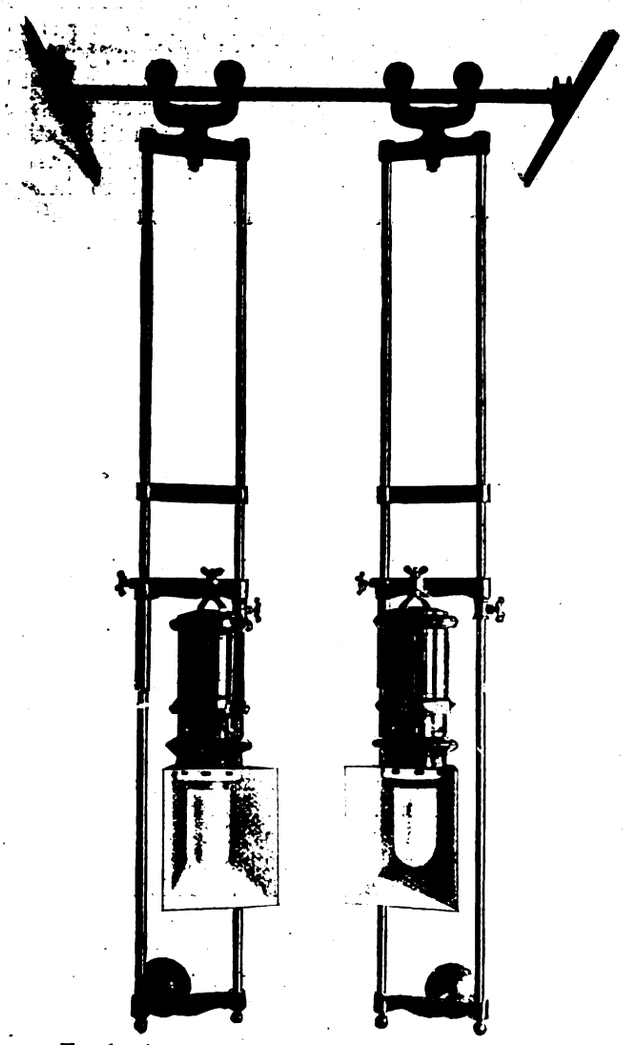

Fig. 1.—Adjustable Hanging Frame with Two Lamps.

Fig. 2 illustrates another method of supporting two copying lamps with reflectors from the floor. The same style of frame is used, but a floor carriage is fitted with castor wheels for convenience in transport. A complete range of lamps for photographic work is supplied by the Union Electric Co. In addition to the enclosed patterns illustrated, an open-type lamp is supplied with special parabolic reflector for the concentration of the light of the arc. The series of lamps also includes transformers and choking coils.

Fig. 2.—Adjustable Stand with Two Enclosed Lamps.

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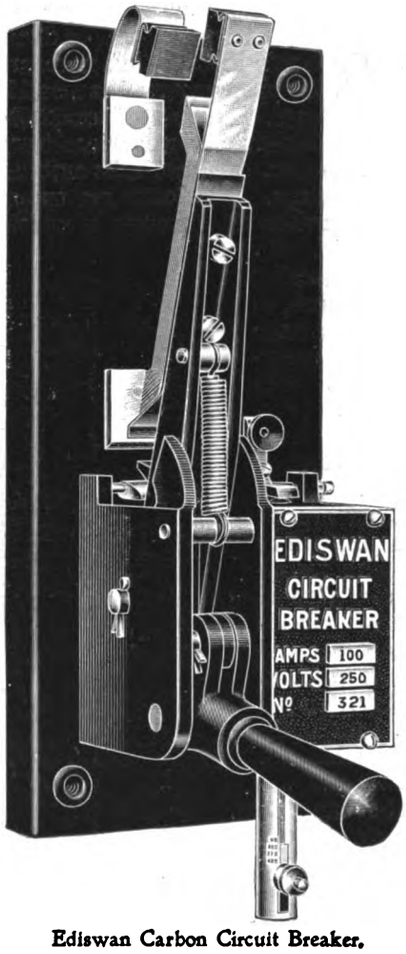
A New Circuit Breaker.

FUSES are now subjected to more severe competition with automatic protective appliances for electric circuits, the number of which is constantly on the increase. A worthy addition to the ranks of circuit breakers is a new pattern which the Ediswan Company are making at their Ponders End works. An illustration of the latest arrival is given herewith and a glance will be sufficient to give the idea of compactness in the design and simplicity in the construction of the breaker. A substantial and "springy" brush contact of the self-cleaning pattern is fitted and the final break is made on carbon blocks, attached to light springs, well above the main contacts. The carbon blocks can be easily renewed, as the illustration shows. The principal supporting parts are stout castings, stove enamelled, to give a neat finish to the assembled elements. The handle is loose and independent of the movement of the switching



Ediswan Carbon Circuit Breaker.

arm, so that the breaker cannot be held on the line with an abnormal current passing. The switch is held in by a knuckle lever against a dead centre which is "tumbled" by the tripping coil through a suitable latch. A powerful spring brings the switch smartly out. The main brush cannot be jarred from its position by even excessive vibration. The overload coil is attached to the switch base at the side, and the plunger, which is gravity controlled, knocks up a short lever connected with the trip latch in the switch mechanism. This lever can also be hand operated from a push button above the main coil. The breaker is being made for capacities up to 800 amperes and pressures up to 250 volts. A complete pamphlet giving full details and prices will be issued shortly.

Compensated Variable Speed Motors.

SINCE the revival of the interpole for direct-current motors the manufacture of machines fitted with this useful compensating device has largely extended. The British Electric Plant Co., Alloa, N.B., have experimented considerably with motors built in this way and have now standardized a complete line of such motors, and recently have issued an interesting booklet regarding them. They state that the machines they have adapted for this special service have proved to be completely stable under speed variations up to 1 : 5. Even at the top speed, which is fixed by considerations of mechanical safety only, any overload up to three times the normal can be applied momentarily without sparking. The auxiliary poles are wound so as to counteract the re-action of the armature and to create a commutating field large enough to balance the reactance voltage, and by this means to suppress sparking. The main field coils, as well as the auxiliary coils, are wound on formers, are insulated, taped and baked, and then slipped over the pole limbs. There is no crossing of windings. With regard to the output of a certain size, this is fixed by the lowest speed. If, for instance, a 230 volt motor of $7\frac{1}{2}$ H.P. with a 4 to 1 range be required, and it is considered that a top speed of about 1200 must not, for mechanical reasons, be exceeded, then one has to select a motor which will do slightly less than $7\frac{1}{2}$ H.P. at 300 r.p.m. Motors of this type are specially applicable to driving machine tools, paper printing presses and for calico printing and other machines and fans in the textile and paper-making trades. Also for reversible motors, as on cranes, hoists, capstans, for motors subjected to heavy variations of load and even overload, like rolling mills, colliery winding and hauling gears, and for high speed centrifugal pumps.

Lampholder Fans. . . .

THE use of a lampholder as a point from which to distribute cooling breezes is frequently overlooked by the average consumer of electrical energy. Perhaps it is that he is unfamiliar with the existence of fan motors sufficiently small to insert in the place usually occupied by a lamp bulb. A series of diminutive motors fitted with fan blades is manufactured by E. Figueras & Cie., Rue Pajol, Paris, which possesses points of novelty. The motor is little larger than an ordinary lamp bulb, and is built with due regard to economical operation and cool running. It is a two-pole machine with a tiny slot-wound armature. The commutator has radial bars and horizontal brushes of carbon press against its working face. It is claimed that the energy consumption is about one-fifth that of a 16 c.p. lamp. The lampholder plug is interchangeable for use in either a bayonet or screw-socket holder. The motor can be placed in any type of fitting, either for pendant, standard, bracket or desk use. The fans are made for any of the voltages now commonly supplied.

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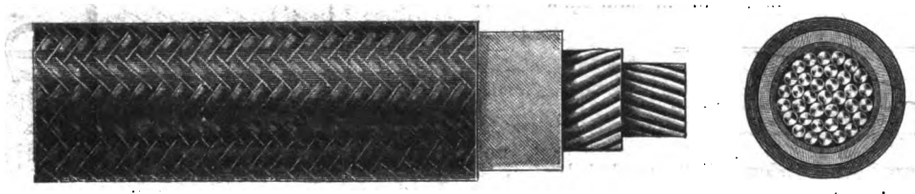
"Silvertown" Cables



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THE ELECTRICIAN:

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NOTES.

Undamped Oscillations.

SINCE the advent of undamped oscillations, as produced by POULSEN'S electric arc, it has generally been supposed that the oscillations are not only undamped but also normally uninterrupted; but at his recent Friday evening discourse at the Royal Institution, Prof. FLEMING showed an experiment proving that these oscillations are actually interrupted at times, although the interruptions may be extremely brief. To most people the effect of moving an object illuminated by an alternating-current arc to and fro is quite familiar; the effect obtained is that of a number of images separated more or less by dark spaces, owing, on the one hand, to the persistence of vision, and, on the other hand, to the fluctuations of the light. Prof. FLEMING showed a corresponding experiment in electrical oscillations by moving or rotating a Neon tube about a line perpendicular to its axis near a helix carrying such oscillations. If the tube is stationary it glows brilliantly, but upon rotation the disc of light is not uniform, presenting the appearance of radial dark bands and dark spaces. Another interesting experiment shown by Prof. FLEMING was the effect of undamped oscillations in a closed wire circuit containing capacity and inductance shunted across a Poulsen arc. Such a circuit acted very powerfully on a similar closed and syntonic secondary circuit at a considerable distance, and Prof. FLEMING expressed the opinion that the use of undamped oscillations in that way might once more bring forward the possibility of so-called wireless telegraphy by electromagnetic induction, which was attempted with some success many years ago by TROWBRIDGE, PREECE, LODGE and others, but was abandoned in favour of wireless telegraphy as we know it to-day.

Electricity in Farming.

IT is a common complaint that the farmer has a hard time, though it is sometimes hinted, rightly or wrongly, that he is by no means up to date in his methods. In America, where people are up to date as a matter of course, the farmers alongside electric railways running through agricultural districts have been taking advantage of facilities offered to them by the railway companies, and utilising electrical energy for agricultural purposes, such as the driving of chaff-cutters, churns and other appliances. In this country, the farmer who is fortunate enough to live in the neighbourhood of the mains of the Durham Electric Power Supply Co. is about to have the same advantages placed at his disposal, for it is reported that the Company is offering to supply current to such consumers at the low rate of 0·55d. per unit. It will be interesting to see if the farmer will take advantage of this offer, and so convert what is generally regarded as an unsatisfactory position into something more rosy; it is quite possible that the enterprise of a few successful farmers may create an industry advantageous to both sides, for not only are there agricultural implements requiring power, but it is a question whether the application of electricity may not yet be brought prominently forward as a means of increasing the fertility of the ground.

Light Railways.

DURING the last two or three years there has been a decided drop in the number of applications made to the Light Railway Commissioners. Such applications have to be made during May or November, and, in looking over past years' records, it is noticeable that, although the applications in May, 1898, were 35, and in May, 1899, 40, they have steadily dropped since that time. The number this May has fallen to 11, and, judging from the last two years, the applications in November are not likely

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to be much greater. Of these 11 applications, four are for extensions of time or amendment of existing powers, and one is for an additional mile of line, so that only six new schemes are proposed. It, therefore, appears that the object of the Light Railways Act has been more or less accomplished, and that very few agricultural districts remain which are sufficiently tempting, from the financial point of view, to induce the promoter to put down a light railway. The time seems to have come when the Light Railways Act should be amended and its scope enlarged, and the Commissioners should have powers conferred upon them to refer such schemes as appear to them to be useful direct to Parliament for final decision. At present engineers and promoters are indisposed to waste time and money in preparing light railway projects owing to the unsatisfactory state of the law, and to the opposition of railway companies and local authorities. We hope, therefore, that the Government will find time in the 1908 Session of Parliament to submit proposals for the much-needed amendment of the Light Railways Act, and for a similar amendment of the Electric Lighting Acts.

Electrical Equipment in Workhouses.

So much evidence has been given at recent L.G.B. inquiries regarding the extravagant systems of electric lighting adopted in some workhouses that it is gratifying to hear of one in which the adoption of electric power and light is bringing about a considerable saving. In this issue we give a short description of the plant which has been installed for supplying electricity to the Brownlow Hill Workhouse at Liverpool. Although this plant is only of small size, very good results are being obtained; the works cost per unit during the first six months' running amounted to only 0·59d. on a total output of 190,398 units, so that the estimated saving of £700 per annum is likely to be realised. The load factor is made as high as possible by power applications, and not only is the laundry electrically worked but the paupers are electro-medically treated as well.

Street Sweeping.

DURING the last few years several proposals for utilising electric tramway equipments during the hours when they would be otherwise standing idle have been brought forward, and in some cases adopted. With this object in view an interesting experiment was made early one morning last week at Aberdeen. Two large rotary brushes belonging to the Streets Department of the Corporation were fitted on to one of the Corporation tramcars, and were arranged so that any width of street from 7 ft. to 14 ft. might be swept. We understand that the experiment proved very satisfactory, so that further developments may be expected if the innovation shows a genuine reduction in the expenditure on street sweeping as a whole.

Cripples and Crutches.

WE have received from Messrs. Bemrose & Sons (Ltd.) a copy of "Crutches to help Cripple Children," which is published this week in aid of the Lord Mayor's Cripples' Fund. The publication, which is sold at one shilling, cannot be described as electrical; in fact, we doubt if its excellent pages have even a passing reference to electricity; but we are sure that electrical engineering, like all other professions, has its cripples who are only too anxious to secure financial crutches, and we therefore commend to our readers this effort to help those who have the misfortune to find life unusually hard from the very start. As a publication, we may say that its 60 pages include many interesting contributions in prose and verse by popular authors, and coloured reproductions of works by well-known artists, as well as drawings in lighter vein. The honorary editors, Sir DOUGLAS STRAIGHT and Sir JAMES D. LINTON, R.I., for the literary and art sections respectively, are to be congratulated upon the result of their efforts, and anyone investing a shilling in this publication will certainly receive good value in return, and will derive satisfaction from aiding a good cause.

Engineering Conference, 1907.—It is announced that the discussions on the subjects, "Superheated Steam for Locomotives," "High-temperature Determination" and "Electric Furnaces," have had to be abandoned.

Royal Institution.—A general monthly meeting of the members of the Royal Institution was held on the 3rd inst., when the special thanks of the members were returned to Mr. Oswald Lewis for his donation to the fund for the promotion of experimental research at low temperatures.

Oxford University.—Amongst those on whom it is proposed to confer honorary degrees at Commemoration on June 26th are: Sir Norman Lockyer, Sir William Ramsay, Sir William H. Perkin, Mr. T. A. Edison, Mr. Ludwig Mond and Prof. W. C. Röntgen.

University of Manchester.—For some time past the need has been felt for more room in the engineering laboratories of the University of Manchester. Plans have been prepared for an extension, and building operations will shortly be commenced on the north side of Coupland-street, near the physical laboratories. A main laboratory, lecture rooms, drawing office and boiler house are to be erected.

Electrical Surveyors' Society.—The third meeting of this society (consisting of surveyors attached to the various fire insurance companies) was held on May 27th, when a lengthy discussion took place on the subject of "Flexibles." On the opinion of the meeting being taken, it was unanimously agreed: "That the use of flexible cord in places where hard wiring in conduit or wood casing could be used should be very strongly discouraged."

American Institute of Electrical Engineers.—At the annual meeting of the American Institute of Electrical Engineers, held on May 21st, the following members were elected as officers: President, H. G. Stott; vice-presidents (for a term of three years), L. A. Ferguson, J. G. White, W. C. L. Eglin; managers (for a term of three years), B. G. Lamme, H. W. Buck, P. H. Thomas, M. Brooks; treasurer, G. A. Hamilton; secretary, R. W. Pope.

Wireless Telegraphy Notes.—The *Neue Freie Presse* states that experiments have lately been carried out in Vienna with the object of introducing a system of regulating public clocks by means of wireless telegraphy. These experiments, which are stated to have been successful, have been under the direction of Prof. Reithoffer and Herr Morawetz. A clock controlled on this principle was tested and was found to be quite uninfluenced by stray radiations and kept perfect time with the regulating clock, 3·72 miles away.

Cable Interruptions.	Date of Interruption.
Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907

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Personal.—Sir William Ramsay, K.C.B., has been granted permission by the King to wear the Order of Commendatore della Corona d'Italia conferred on him by the King of Italy.

At the conference of the South-Eastern Union of Scientific Societies to be held at Woolwich on Wednesday, June 12th, Prof. S. P. Thompson, F.R.S., will deliver the opening address.

Electric v. Steam Traction.—The *Giornale del Genio Civile*, in comparing the cost of electric and steam traction on the Varese Railway, states that there was an increase of net revenue in the year 1902-3 over the year 1897 of about £15,758 in favour of electrical working. Probably part of this increase is due to the normal development of trade; but it is worth noting that the proportion of expenses to revenue has fallen from 67·5 per cent. with steam working to 65·5 per cent. with electrical working. At present power costs 1·08d. per unit, but when a water-power plant now under construction is completed, it is estimated that the cost per unit will fall to 0·45d. per unit, with a consequent improvement in the economic results.

A New Arrangement for Trimming Arc Lamps.—*L'Electro* gives an account of a new arrangement by which arc lamps may be more easily raised or lowered. This apparatus is characterised by the suppression of the usual suspension with winch or counterpoise, and the lamps are suspended by chains passing over pulleys. For trimming the lamp a bamboo rod ter minated by nippers is used, together with a long leather strap fitted with a hook. This hook is placed in an eye at the end of the suspending chain, so that the strap forms a continuation of the chain. By a slight jerk the chain is detached from the pin on which it is fixed, and the lamp is allowed to descend, the extra length of suspension necessary being supplied by the strap. As soon as the descent begins the current is cut off. When trimming is finished the lamp is raised by pulling on the strap; the last link of the chain is then fixed on the pin and the belt detached. Current is switched on directly the lamp reaches its proper place. An automatic brake prevents a fall or too sudden a movement.

Electrically-driven Paper Mill in Japan.—The *Western Electrician* gives an account of an electrical installation which will shortly be erected in a paper mill at Hokaido, Japan. Current from a hydro-electric station will be transmitted 15 miles, at a pressure of 46,000 volts and a frequency of 60, for driving the motors. At a sub-station, near the mill, the voltage will be stepped down to 2,200 and 2,100 volts. In the paper mill five 750 H.P. 2,000 volt induction motors will be used to drive the pulp grinders. These motors have an external resistance in the armature circuit and controllers to vary the speed. Each motor will have an extended shaft and will be so placed between two pulp grinders that both grinders can be driven directly without belting. Each of four beater machines will be driven by a 350 H.P. induction motor, operating at a potential of 2,000 volts. A fifth will be driven by a 200 H.P. induction motor, and all will be operated on the rope-drive system.

Iron and Steel Institute.—It is announced that the autumn meeting this year of the Iron and Steel Institute will be held in Vienna on Monday, Tuesday and Wednesday, September 23, 24 and 25. The route to Vienna has been arranged via Zurich and Innsbrück, in each of which towns a day will be spent to allow places of interest to be visited. During the three days' stay in Vienna papers will be read and discussed, the meetings being held at the headquarters of the Vienna Society of Engineers and Architects. The members will be received by the Burgomaster, and a special performance will be given at the Imperial Opera House. On September 26th three excursions will be made, to the Prager Eisen Gesellschaft and to the works of the Böhmische Montangesellschaft, to the Alpin Montangesellschaft and to the Witzkowitzer Gewerkschaft and the Oesterreichische Berg- und Hütten-gesellschaft. The travelling arrangements are in the hands of the Tourist Agency of the Great Northern Railway, 2, Charing Cross, S.W., to whom members should apply for further information.

Deposition of Copper on Aluminium.—The *Mechaniker* describes a process of obtaining a permanent coating of copper on aluminium, which is due to an American inventor, Mr. A. Giroux. The bath consists of a solution made up as follows: 9·46 litres of distilled water, 241 gr. of sodium carbonate crystals, 198 gr. of sodium bisulphate crystals, 241 gr. of neutral copper acetate, and 241 gr. of potassium cyanide. The sodium carbonate is dissolved in 6·6 litres of warm water, and the sodium bisulphate added, from time to time, in small quantities. The copper acetate is then finely powdered and added in small quantities, while the solution is stirred vigorously. The potassium cyanide is dissolved in 2·8 litres of water, and when the solution is cold it is added to the first. The whole is then stirred, heated and filtered. A bath made up in this way will give a thick coat of copper if care is taken not to use a current greater than 0·4 ampere at 3 volts for every 96 sq. cm. of aluminium treated. Mr. Giroux finds that the preliminary treatment of the aluminium is quite as important as the proper composition of the bath. The scraping should be done as quickly as possible, for the aluminium oxidises very quickly. To do this the aluminium is plunged for an instant into a solution of potassium cyanide, then it is rubbed all over with pumice stone. Directly it is quite clean it is placed in a hot solution of potash, and is left there till it gives off bubbles of gas. It is then washed in cold water and in a solution of bichloride of mercury and potassium cyanide dissolved in water. This operation is repeated, and the aluminium is then placed directly in the bath.

Society of Engineers.—At the meeting of the Society of Engineers, held at the Royal United Service Institution, Whitehall, on June 3rd, a Paper was read on "Working Experiences with Large Gas Engines," by Mr. Cecil A. St. George Moore. In his Paper the author dealt with the relative advantages of the two and four-stroke cycles, the Körting and the Oechelhäuser engines being taken as the most prominent examples of the former type. The author considered that the thermal and mechanical efficiencies of the Körting type of engine were lower than in the case of the four-cycle type, and he gave results of tests bearing out this conclusion. He also gave some details of the design of the piston and cylinder of the Körting engine, and mentioned several defects in those parts which had given trouble, and described modifications in design that had been adopted to overcome those defects. After noting the essential points of a satisfactory packing, the author described a form of packing that he had found to work well in practice. Reference was made to the theory of stratification of the working mixture as applied in the Körting engine, and an account was given of some curious effects noted on changing the position of the point of ignition in the cylinder. After noticing the utilisation of the waste heat of the exhaust, the author concluded by considering the properties of producer gas and its suitability for use in large engines. He laid great stress on the necessity for thorough cleaning of the gas, and mentioned the effects of tarry gas when supplied to an engine. He arrived at the conclusion that a percentage of about 27·0 of hydrogen in producer gas was not too great for its satisfactory use in large engines.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 7th (to-day).

ROYAL INSTITUTION.

9 p.m. Meeting at Albemarle-street. Lecture on "Studies in High Vacua and Helium at Low Temperatures," by Prof. Sir James Dewar, F.R.S.

SATURDAY, June 8th.

JUNIOR INSTITUTION OF ENGINEERS.

Visit to the Works of Messrs. Kodak (Ltd.), Harrow.

FRIDAY, June 14th.

PHYSICAL SOCIETY.

8 p.m. Meeting in the Pender Electrical Laboratory, University College, Gower-street, W.C. Papers on "Observations on the Electric Arc," by Mr. W. L. Upson; on "The Poulsen Arc as a Means of Producing Electrical Oscillations" (with experiments), by Dr. J. A. Fleming, F.R.S.; and an "Exhibition of a Direct-reading Conductivity Bridge for Rods," by Mr. R. Appleyard.

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ON RECORDING TRANSITORY ELECTRICAL PHENOMENA BY THE OSCILLOGRAPH.

BY J. T. MORRIS.

About a year ago, during the course of a research on the oscillatory discharge of condensers, it became of importance to devise a simple and easy method of obtaining a photographic record of a single train of electric oscillations by means of the Duddell oscillograph. A single train usually lasted in these experiments for any time from a twentieth to a two-hundredth part of a second. This requires a switch to be operated while the falling photographic plate has the beam of light from the oscillograph falling on it. So far as the author is aware, the methods which have been employed to record phenomena such as occur during the moment of switching operations, with any fair measure of success, have been of two kinds: The first consists in endeavouring to get the phenomenon to repeat itself periodically, if possible, by means of some form of commutator. This was done by Prof. A. Hay in 1895 when studying current rushes in transformers, for which purpose he recorded the phenomena by means of a Joubert revolving contact. More recently Dr. J. A. Fleming, F.R.S., in his investigations on oscillatory discharges of condensers recorded the oscillations by means of the Duddell oscillograph, using the synchronous motor and thereby enabling the oscillations to be seen as well as recorded.*

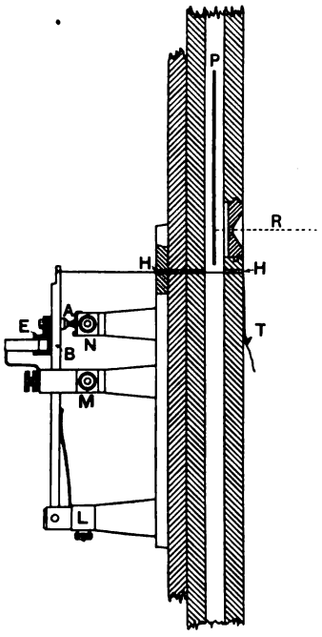


FIG. 1.—ARRANGEMENT FOR TRIPPING SWITCH.

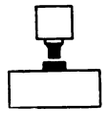


FIG. 2.—TAPPING KEY CONTACT.

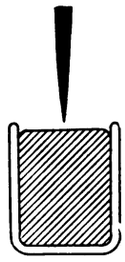


FIG. 3.—MERCURY POOL AND NEEDLE POINT CONTACT.

The second method is to set a kind of cinematograph film rapidly revolving in front of the oscillograph and at once actuate the switch which causes the required phenomenon to take place, immediately afterwards stopping the rotating film. The film then has to be developed, and the small portion containing the desired record picked out. This method has been employed by Mr. Duddell (*Jour.* Inst. Elec. Eng., Vol. XXXVI., pp. 139-141) for examining switching operations of cables. At its best, however, it is clumsy and expensive, though under certain conditions it may be impossible to use any other arrangement.

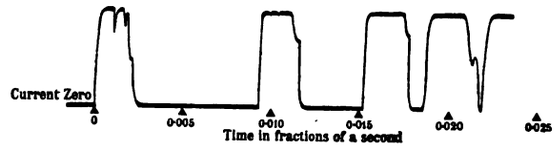
Other methods have been adopted at various times, including that in which the Braun vacuum tube is used, but as far as the author is aware these methods fail to give a sufficient degree of accuracy.

It occurred to the author that in the falling plate type of oscillograph the action of the falling photographic plate might be utilised to trip the switch which would cause the phenomenon to take place; and he has employed this method and found it to work well.

* A good series of oscillograms taken by this method is given in Dr. Fleming's book, "The Principles of Electric Wave Telegraphy," p. 238, plate I.

Method.—The arrangement is as follows: A suitable kind of switch is screwed on to the outer case of the oscillograph box (shown in Fig. 1), and is held in its first position, against the tension of a spring, by means of a strong linen thread (H) tightly stretched, which passes across the tube down which the plate (P) falls. The photographic plate in its descent cuts this thread and so releases the switch, which springs at once into its second position, thereby causing the required oscillation. It will be observed that in the passage of the switch it breaks the circuit LAN, and makes the circuit LBM.

Difficulties encountered with the Switch Contact.—For the study of such effects as the growth of current in a slightly inductive circuit, or the starting of a current through an incandescent lamp, it is highly desirable that the switch used should operate with precision. In certain cases investigated it has been found that a switch will take possibly a fiftieth of a second to com-



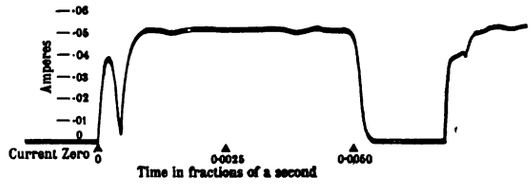
CURVE I.—TAPPING CONTACT. CURRENT STARTING OSCILLOGRAM.

plete contact—*i.e.*, from the time that contact is first made to the time the circuit is finally closed. Many of the effects which it was desired to investigate are of shorter duration than this interval of time, and therefore it became imperative to find some form of contact which would close the circuit practically instantaneously.

Forms of Switch Contacts employed.—Several forms of switch contacts were tried, and it will be of interest briefly to indicate what form they took and what difficulties were experienced in their use. The following four were tried in succession:—

Tapping key contact.
Mercury pool and needle point.
Ordinary knife blade contact.
Modified knife-blade contact.

Tapping Key Contact.—An ordinary single-pole condenser discharge key was used (*see* Fig. 1) for testing this form of contact, in which a platinum stud attached to the lever of the



CURVE II.—MERCURY MAKE AND BREAK CONTACT. CURRENT OSCILLOGRAM.

switch closes the circuit by striking a fixed platinum contact (*see* Fig. 2). On releasing the trigger of the switch, by means of the photographic plate and thread a record was obtained which gave a means of judging how this contact operates (*see* curve I.). The result clearly shows that the contact rebounded four times, permanent contact being only obtained after 0·023 of a second, thus rendering it useless for the present purpose of the experiment.

Mercury Pool and Needle Point.—In this form of contact the circuit is closed by means of a steel needle or copper wire suddenly plunging into a little pool of mercury (Fig. 3). The steel needle was carried by a very light framework made of aluminium wire attached to the lever, which, as before, was released by the breaking of the thread. The needle acquired a considerable speed before it entered the mercury, but here again the contact was not perfectly sharp, though vastly better than the preceding. Contact was completed in from 0·002 to 0·001 of a second. The circuit during the time of completing the contact was actually broken (curve II.), as in the preceding case, but apparently only once, this being possibly due to the formation of a ripple on the surface of the mercury.

Ordinary Knife-blade Contact.—The contacts in an ordinary knife-blade switch were next used (Fig. 4) and here, though

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the brass blade was moving with considerable rapidity at the moment of entering the brass spring jaws of the switch, faulty switching invariably occurred. An examination of the oscillograph records leads one to the conclusion that the blade, on striking the jaws of the switch, and thereby making contact for the first time, causes them to rebound slightly before again

FIG. 4.—KNIFE BLADE CONTACT.

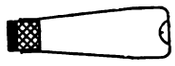
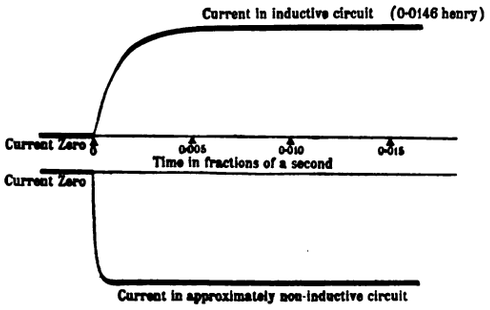


FIG. 5.—MODIFIED KNIFE BLADE CONTACT.

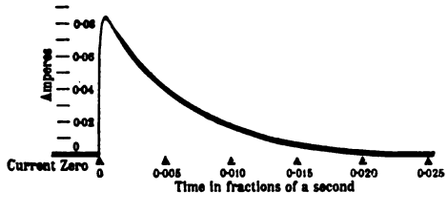
closing on to the blade—thus either completely breaking the circuit for an extremely short interval of time, if a very low voltage is employed, or with a higher voltage causing a small arc to draw out. In general the time taken to complete the contact in this case was of the order of 0·002 of a second.

Modified Knife-blade Contact.—The previous result at once suggested the use of a modified form of the contact used above.



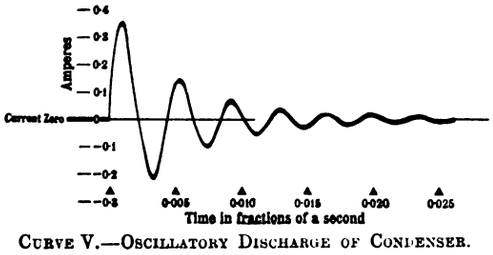
CURVE III.—CURRENT GROWTH OSCILLOGRAMS.

On the brass blade of the switch an extension of ebonite was fitted having exactly the same width as the blade itself (Fig. 5, also E in Fig. 1). As the ebonite extension was already in the jaws of the switch before the switch was tripped, when the brass entered the jaws of the switch it quickly glided in without any jar at the moment of electrical



CURVE IV.—CHARGING CURRENT OSCILLOGRAM OF CONDENSER.

contact. As far as the records taken with this form of switch contact go, it appears to work absolutely instantaneously, but certainly within 0·0001 of a second. Needless to remark, the contacts must be moderately clean, and an ordinary working pressure of the jaws is necessary. Only on one occasion was there any failure recorded (*see* curve VII.), and this was due to the switch contacts not being clean.

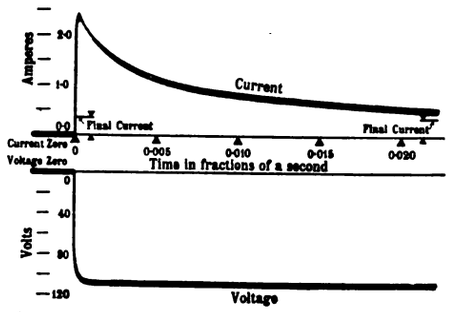


CURVE V.—OSCILLATORY DISCHARGE OF CONDENSER.

Results Obtained.—It is proposed here to give a few of the results obtained by the method, these being selected with a view to illustrating its application to various cases. The author hopes to present at some future date a number of other results obtained and a discussion of them in detail.

Curve III. shows the growth of current in a circuit which was approximately non-inductive, and also in a circuit having an inductance of 0·0146 of a henry.

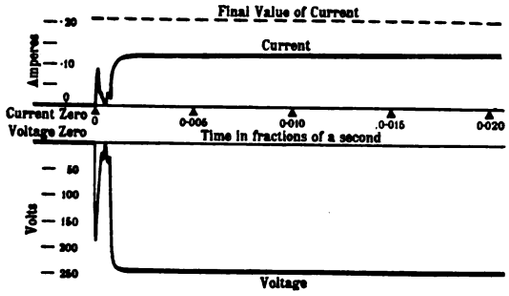
Curve IV. shows the charging current of a paraffined paper condenser of capacity 4·35 mfd. when charged with a voltage of 127 volts through a resistance of 1,410 ohms. It will be



CURVE VI.—OSCILLOGRAM OF STARTING CURRENT IN A 110 V. 32 C.P. OSRAM LAMP.

observed from the oscillogram that the initial current is 0·084 of an ampere, and if the current started absolutely instantaneously this should be 0·09—*i.e.*, 127÷1,410—a fairly close agreement considering that it is not possible to get a circuit absolutely non-inductive, and incidentally illustrating how nearly perfect the high-frequency oscillograph is.

Curve V. shows an oscillatory discharge of a condenser, capacity about 10 mfd., resistance 2 ohms, the inductance being



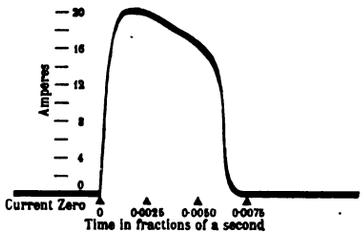
CURVE VII.—OSCILLOGRAM OF STARTING CURRENT IN 220 V. 5 C.P. CARBON FILAMENT LAMP.

NOTE.—Only case of failure recorded of switching device.

the 100 volt winding of a 2½ kw. Packard transformer, the charging voltage being 26.

Curves VI. and VII. show the starting currents taken by an Osram and a carbon filament lamp.

Curve VIII. This illustrates the current through a fuse while "blowing." No. 46 bare copper wire was used which has a normal fusing current of 1·2 amperes, and the oscillogram shows that a maximum of 20 amperes was reached before the fuse melted, when an arc started which lasted for five or six thousandths of a second. The fuse was blown on a 120 volt direct-current circuit.



CURVE VIII.—OSCILLOGRAM OF CURRENT THROUGH FUSE AT TIME OF "BLOWING."

Curve IX. shows how the arrangement can be used for studying current rushes into alternate-current transformers. The switching device in Fig. 1 was so connected that as the switch arm sprang across it broke the circuit at A and almost instantaneously re-made it at B. These two contacts operated in curve IX. at the times indicated by F and G respectively. The transformer was working normally up to point F, leaving the core magnetised; then on re-starting at G the current attempts to force the magnetisation up to unusually high induction densities and consequently low permeability, resulting in a current rush of possibly some 25 amperes in a transformer which normally takes 1 ampere as a maximum. In the oscillogram the current rush was so great as to carry

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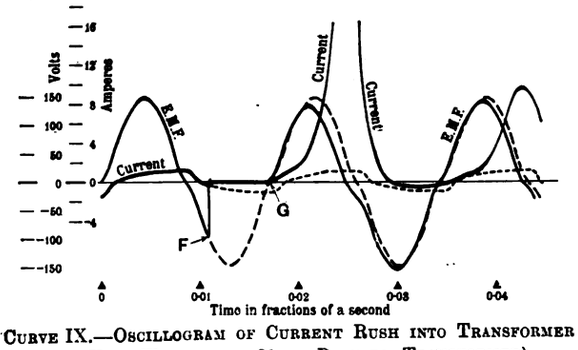
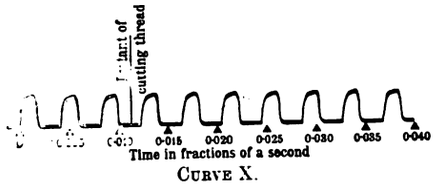
the spot of light a long way beyond the edge of the photographic plate; hence the current line is incomplete. The dotted curves have been drawn in to show normal voltage and current waves throughout the whole period under examination. The deformation is apparent in the voltage wave brought about by the excessive current during the "rushes."



CURVE IX.—OSCILLOGRAM OF CURRENT RUSH INTO TRANSFORMER (100 VOLT WINDING OF 2½ KW. PACKARD TRANSFORMER).

Curve X. gives the result of an attempt to determine the variation of speed of the photographic plate caused by its cutting the thread in its fall, by the use of a smoothly-running contact breaker. Careful measurements from the actual oscillogram show that the speed of falling is not affected to the



CURVE X.

extent of 1 per cent. in this case, although subsequent work has shown a speed reduction of between 1 and 2 per cent. in certain cases.

In conclusion, the author desires to acknowledge much valuable assistance given him by Mr. A. G. Warren and also by Mr. W. B. Medlam, both senior students of the East London College.

THE GENERATING STATION OF THE BROWNLOW HILL WORKHOUSE, LIVERPOOL.

Brownlow Hill Workhouse, Liverpool, is one of the largest, if not the largest, poor law institution in this country, having an inmate population of about 4,000, apart from the officers and nurses. It has a hospital capacity of about 2,000 beds, and is the largest nursing training school in Great Britain.

The buildings, some of which have been converted from ordinary workrooms to hospital wards, are mainly old; until recently the whole of the building, except the nurses' home, was lit by gas, and the laundry, which is a large one, dealing with 50,000 articles per week, was driven by a steam engine.

The members of the select vestry, realising that it would certainly be more satisfactory and probably more economical to have an electrical generating plant, decided to seek advice on the matter, and instructed Messrs. T. L. Miller and Wilson, to submit a report on the subject

The report when prepared showed that, allowing for an expenditure of £10,000, and after providing for all capital charges on this amount, that a saving of about £700 per annum might be anticipated if the buildings were lit and motive power supplied from a central generating station.

Acting upon this advice, the consent of the Local Government Board was obtained and work commenced in January of last year, the plant starting operations in September of the same year.

The results have been most satisfactory, and during the six months ending March 30, 1907, a total output of 190,398 units was generated at a works cost of 0·59d. per unit, distinctly better than the estimated figure. The coal consumption per

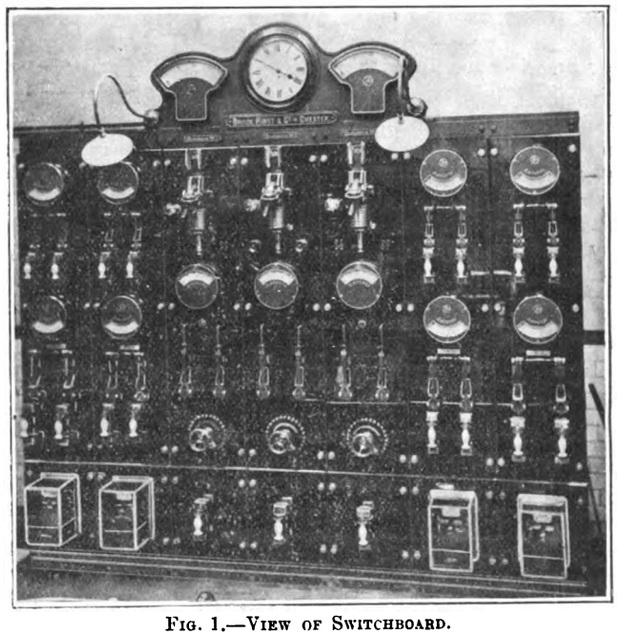


FIG. 1.—VIEW OF SWITCHBOARD.

unit was about 7 lb., which with small sets working non-condensing may be considered very satisfactory. About 32,000 units were supplied for the laundry motors, the remainder being utilised for lighting and electro-medical apparatus.

The generating plant, which is seen in Fig. 2, comprises three high-speed steam sets, consisting of 120 H.P. enclosed type Brush-Falcon engines direct connected to three 85 kw.

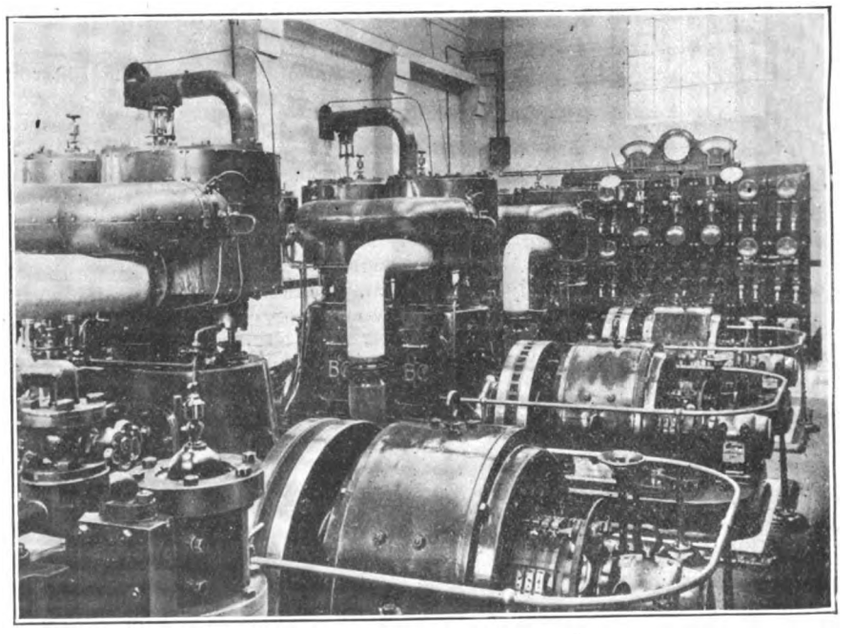


FIG. 2.—INTERIOR VIEW OF GENERATING STATION.

Brush generators These machines give a normal output of 370 amperes at 230 volts.

The steam raising plant consists of two 28 ft. by 7 ft. 6 in. Lancashire boilers by Messrs. Galloway of Manchester, each boiler having a downtake superheater of the "Easton" type. The boilers work at a pressure of 120 lb., and steam is delivered to the engines at about 100 deg. superheat.

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The feed pumps and feed tank are at the far end of the engine-house, the pumps being of the "Cameron" type. The steam piping is arranged so as to allow either boiler to supply any engine, and the valves are so placed as to render a total stoppage impossible.

The switchboard, an illustration of which we also show (Fig. 1), consists of three generator panels in the centre of the board, and four feeder panels—two on either side.

The system of mains supplying the various blocks consists of bare copper conductors laid solid in "Carbolite" in wood troughing and has given every satisfaction.

The lighting installation comprises 27 arc lamps, some of which are used for outside lighting, and about 3,000 16 c.p. incandescents, the bulk of the wiring being done in wood casing.

In the operating theatres and hospital wards a considerable amount of electro-medical apparatus has been installed, including a large number of electrically-heated sterilisers.

The laundry installation, which is very interesting, comprises five motors of 16 H.P. at 400 revs. per min., built by the British Electric Plant Co., electrically heated finishing machines, and a large number of electrically heated irons. Very great benefit has been derived from the abolition of the gas-heated irons previously used.

The generating and steam raising plant are located in a substantial brick building, divided into two rooms of equal size, the main dimensions being 50 ft. by 21 ft. each, and the main flue leading to a brick chimney 90 ft. high.

The result of the first six months' working showed that the anticipated saving of £700 should be realised, and great credit reflects upon Mr. W. P. Elliott (the engineer-in-charge) for the economical running of the station.

The contractors for the wiring were the Alliance Electrical Co., of Birmingham, and for the switchboard and motor-starting panels Messrs. Brook Hirst & Co., of Chester. The pipe work was carried out by Messrs. E. H. Williamson & Co., of Liverpool.

The whole of the work was executed under the supervision of Messrs. T. L. Miller & Wilson.

THE ELECTRICITY GENERATING STATION OF THE GREAT EASTERN RAILWAY CO.

Although up to the present time the Great Eastern Railway Co. have not experimented with electric traction on any of their lines, they have had for many years a generating station for supplying electric light to Liverpool-street Station and the adjoining offices, hotel, &c. For this purpose a station was put down at Norton Folgate in 1893, giving a supply at 220 and 110 volts pressure. Current was supplied to 345 arc lamps, and the equivalent of 15,300 8 c.p. incandescent lamps, as well as to 40 small motors. The load factor on this station was very high, being over 30 per cent. The company, fully appreciating the advantages of electric light and power, proceeded to lay down a large generating station at Stratford. This station commenced to supply current about three weeks ago, and already a considerable load has been connected up.

In addition to supplying current to Liverpool-street and Fenchurch-street stations and offices, &c., the majority of the suburban passenger stations are also being wired. At present it is proposed to adopt electric lighting in all stations as far as Canning Town, Goodmayes and Walthamstow. The wiring of these stations is being carried out by the company's own electrical staff, under Mr. Skeates, the distribution engineer. Later on it is expected that power will be used for working the electric cranes at Parkeston Quay and the use of electric driving in the company's shops will be increased.

The power station at Stratford was designed by Mr. H. W. Firth, who was at that time assistant to Mr. Wilson, the chief engineer of the railway company, but who has recently been appointed electrical engineer to the company. In the design and carrying out of the scheme, Mr. Firth was assisted by his chief assistant, Mr. W. James. The building consists of galvanised iron on three sides, the fourth side, against which

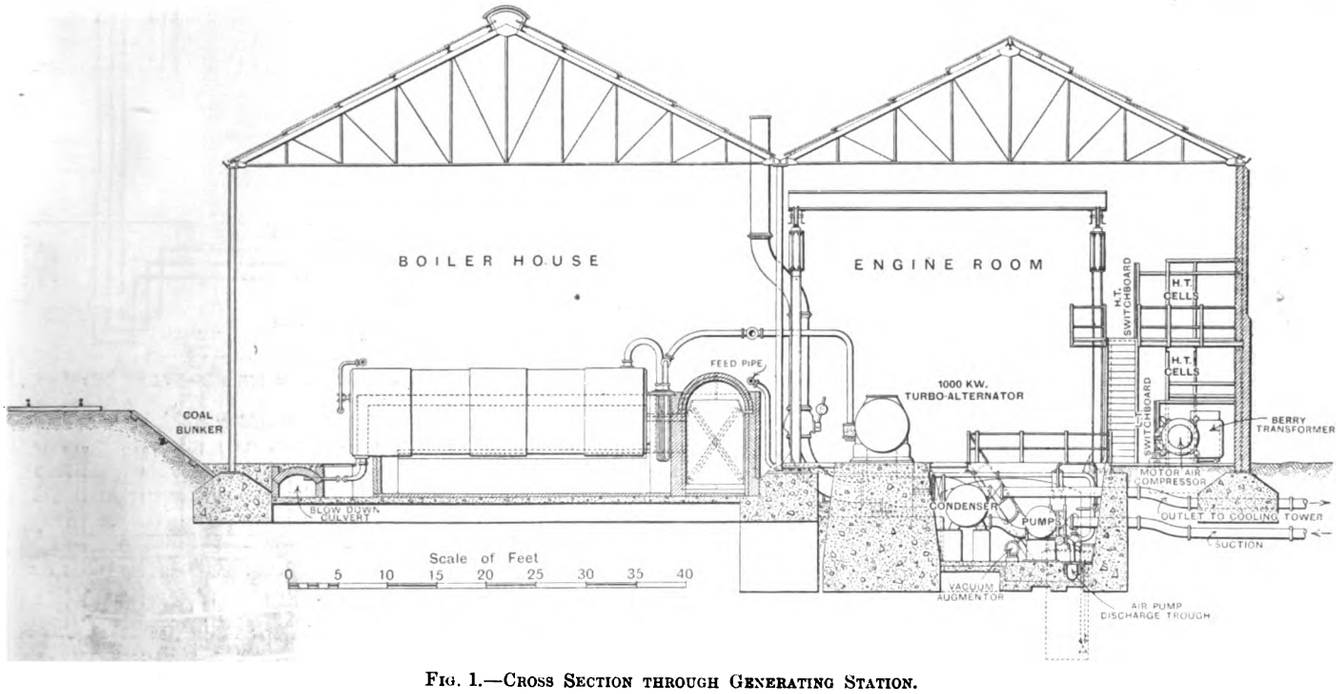

FIG. 1.—CROSS SECTION THROUGH GENERATING STATION.

are situated the switchboards, consisting of a brick wall, in order to prevent any possible trouble due to damp.

The general arrangement of the generating station will be seen from the sectional elevation (Fig. 1) and Fig. 3, which is a view from one end of the engine room. The boiler house contains nine 8 ft. 6 in. by 30 ft. Galloway boilers, working at 160 lb. pressure. These boilers have Galloway patent furnaces and are also fitted with Galloway superheaters. These superheaters are fixed about 24 ft. from the firebox bridge, and therefore do not receive the hot gases at the highest temperature. This, however, ensures a more uniform working, and no regulating is required. A superheat of about 100°F. is obtainable, and this does not decrease more than 20 deg.

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whilst the fires are being cleaned. Each boiler is provided with a blow-off cock, but there is only one handle for operating all these, and this handle can only be removed from a blow-off cock when the latter is closed. This prevents any loss due to the blow-off cocks being left partly open. The boiler fittings are of Messrs. Hopkinson's well-known type. A Green economiser consisting of 480 tubes has been installed, and space is provided to allow of the addition of another 240 tubes when desired. The scrapers for the tubes are driven by means of a small motor. Water is obtained from an artesian well, which has a capacity up to 10,000 gallons per hour. The water is passed through a Stanhope water softener which has been transferred from the old Norton

Feed water is supplied to the boilers by means of two compound feed pumps made by Messrs. Hall, of Peterborough, each capable of delivering 6,000 gallons of water per hour. These are situated in the basement of the engine-room, but are controlled from the boiler house.

Coal is obtained from a railway siding running parallel and immediately behind the boiler house. By means of a simple wooden structure the coal is emptied straight from the trucks and slides down into the boiler house adjacent to the boilers. In this way a cheap and efficient method of delivering the coal has been obtained without conveyors or other apparatus, and as hand firing is adopted there should be little trouble experienced in the boiler house.

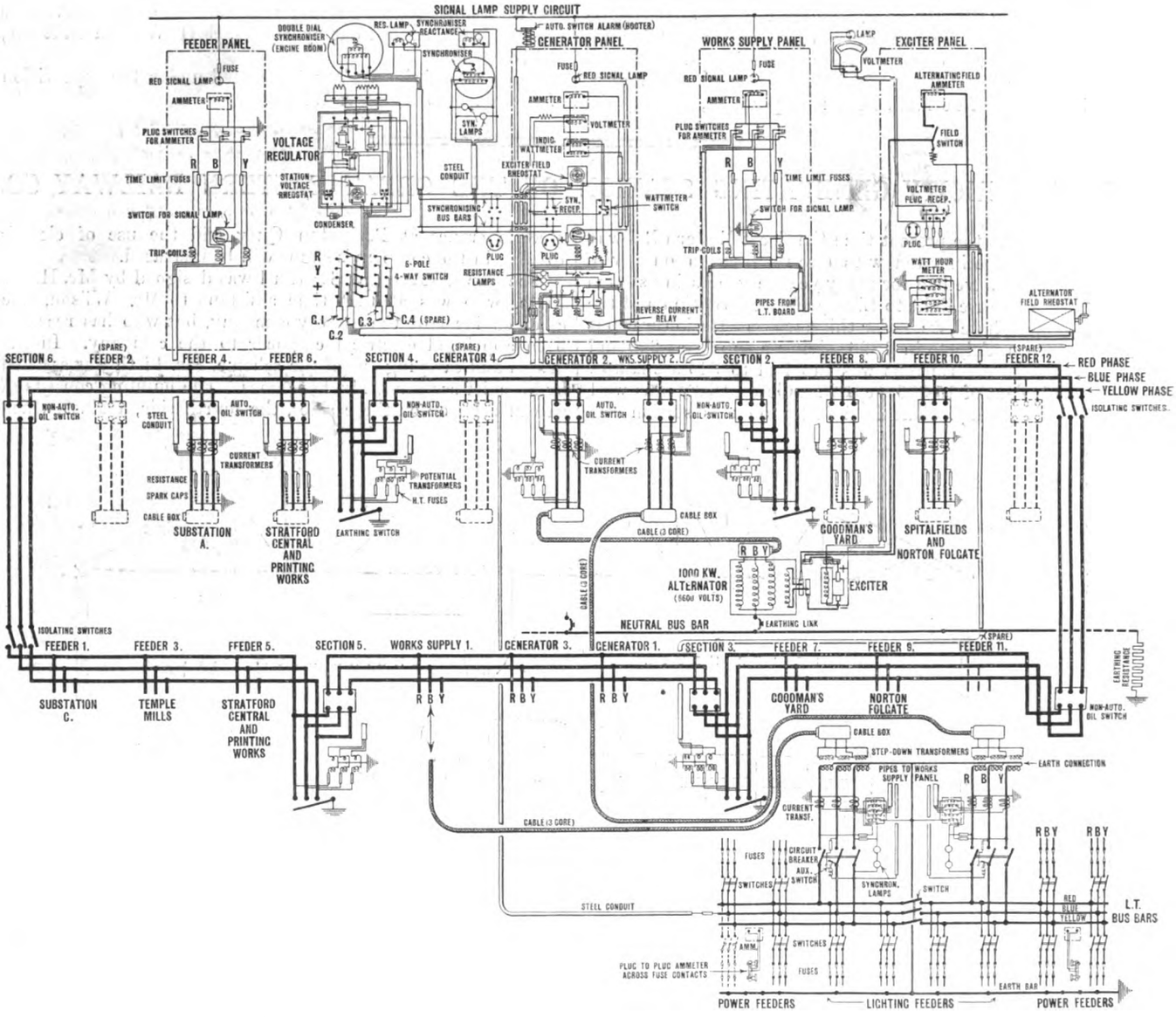

FIG. 2.—DIAGRAM OF CONNECTIONS. (VIEWED FROM THE FRONT OF THE BOARD.)

Folgate generating station. For raising the water in the artesian well an electrically-driven air compressor, supplied by Messrs. Isler, has been installed; there are in addition two steam-driven compressors, made by the Westinghouse Brake Co., which would be utilised for starting up when the 'bus bars are "dead." The three compressors mentioned are situated at one end of the engine room, adjacent to which is he artesian well.

Induced draught is used for the boilers, four fans driven by four 17·5 H.P. British Thomson-Houston motors being installed. A couple of these motor fans are placed at the base of each chimney, of which there are two, respectively 50 ft. and 75 ft. high, each 8 ft. 6 in. diameter. The bearings of the motor fans are cooled by means of circulating water.

The pipe work has been carried out by Messrs. Spencer, of Wednesbury, and the steam, feed water, and safety valves have been supplied by Messrs. Thos. Noakes & Sons.

One point in connection with the pipe work is especially worthy of notice—namely, that as far as possible every length of pipe connected with any plant has been made interchangeable with the corresponding pipes connected to the remainder of the plant.

This same object has been kept in view in designing the whole of the plant installed in the generating station, and no doubt the result will be found exceedingly satisfactory. The recommendations of the Engineering Standards Committee have been rigidly adhered to, and all contractors have been compelled to adopt standard flanges, &c., the result being that,

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as regards standardisation and interchangeability, the generating station is probably equal to any in this country.

The steam pipes from the boilers deliver into a common header, which can be split into sections, when desired, by means of isolating valves.

The generator sets, which are three in number, as seen in Fig. 3, are turbo-alternators of Messrs. Parsons' well-known type. The normal load of each is 1,000 kw., but, as we have mentioned on several occasions recently, these machines are capable of very large overloads without much drop in efficiency. These turbo-alternators run at 1,500 revs. per min., and the exciters are placed at the ends of the shafts.

The condensers are situated in the basement, below the engine-room floor level, and as Messrs. Parsons' vacuum augmentors are in use there is little difficulty in obtaining a vacuum of 29 in. All the small gear in connection with these turbine sets is interchangeable, and even the exciters can be interchanged if at any time it is found necessary to do so.

The air pumps, which are of Messrs. Parsons' own type and manufacture, are electrically driven, spur wheels being used, whilst the circulating water pumps, which have been made by Messrs. W. H. Allen, Son & Co., are coupled direct on to the shafts of the same motors. The water from each condenser is taken to a separate section of a large Balcke cooling tower. Each section of this is capable of dealing with 1,000,000 lb. of water per hour.

It will be noticed that the complete unit system has been adopted throughout, and each generating set is entirely independent of the others, this, of course, providing for the greatest reliability.

Three phase current is generated by the turbo alternators at 6,200 volts and 50 frequency. This current is distributed by means of nine feeders, and Berry transformers are, in all cases, used for reducing the pressure to 390 volts between phases for distribution purposes. This latter pressure enables incandescent lamps to be used between each phase wire and the neutral, at a pressure of 225 volts, whilst the motors are connected across the three phases.

The feeders have been supplied by W. T. Henley's Telegraph Works Co., and, where underground, have been laid on the solid system in bitumen.

Current for use on the works for lighting and power purposes is obtained from two 150 kw. Berry transformers, which are placed behind the low-tension switchboard situated on the engine-room floor. This switchboard controls the various circuits for fan motors, pump motors, lighting, &c.

Like the remainder of the equipment, the switch gear has been designed to avoid unwarranted complications, the ingenuity and engineering ability usually devoted to the development of complicated apparatus being devoted in this case to the perfection of comparatively simple apparatus.

The accompanying diagram (Fig. 2) gives an idea of the general system of connections of the electrical circuits in the power house, together with every detail connection to and through each winding of every instrument or other device, together with all signal circuits and other auxiliary circuits, with the exception of the switchboard lighting, which is separate from the switchboard itself. The connections appear from this diagram more complicated than they are, owing to the fact that the diagram follows the actual wiring of the panels with the complete route of each lead through conduits or otherwise, in order that it may be of value in locating the conductors corresponding to the connections.

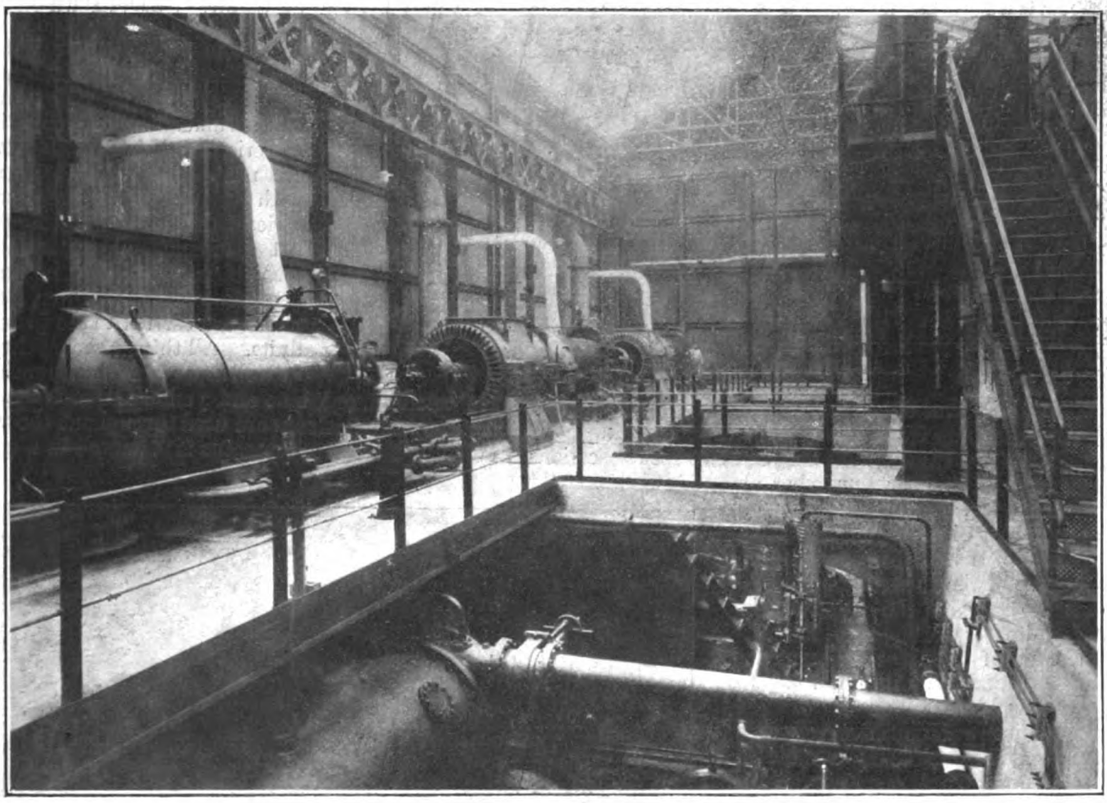

Fig. 3.—View of Engine Room.

The arrangement of the switchboard will be seen from the end view (Fig. 4) and end elevation (Fig. 6), whilst a front view of the panels is given in Fig. 5.

The main extra-high-tension three-phase 'bus bars are arranged on the "ring" system, divided into six sections—two for generators and four for feeders. In general each sub-station is supplied through duplicate feeders, one connected to a 'bus-bar section in the upper row and one to a corresponding section in the lower row. This makes it possible to divide the load if it ever becomes advisable, and run either both right-hand feeder sections from one generator section and both left-hand from the other, thus putting part of the sub-stations on one pair of generators and part on the other; or the two upper feeder sections may be supplied from one generator section, and the two lower from the other, making it possible to divide the load at the sub-stations between power and lighting services, or otherwise, as may be desired. This gives all the flexibility usually required of duplicate 'bus bars without the complica-

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tions of transfer switches. The division of the 'bus bars into six sections also makes it possible to do away with isolating switches between the 'bus bars and the oil switches, since any one section may be shut down, for work on an oil switch, without suspending supply from any part of the network. Two of the oil switches, each located between two feeder sections, are provided with isolating switches on one side, since work on one of such oil switches would require the shutting down of two sections of the 'bus bars, suspending service to some of the sub-stations.

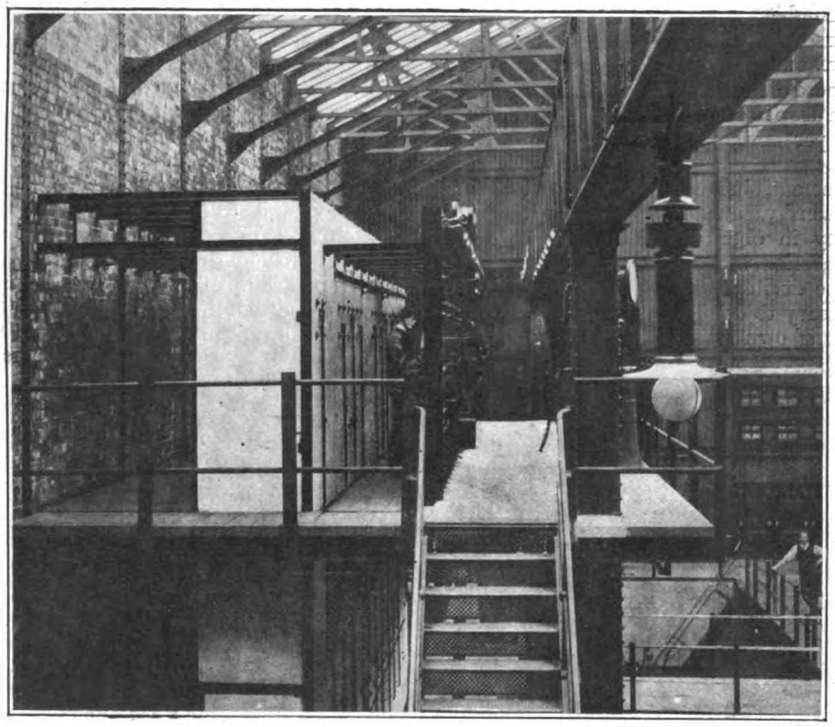

FIG. 4.—END VIEW OF SWITCHBOARD.

In order to improve the action of discriminating devices throughout the network in case of faults, the generator neutrals are connected through links to a neutral 'bus bar which is earthed through a cast-iron grid and mica resistance on suitable porcelains, having a value of 14·2 ohm and capable of carrying the full load of about 250 amperes at about 4,000 volts, which would be impressed upon it in case of a heavy fault to earth for a period of 10 seconds without rising in temperature more than 200°C. This resistance prevents any solid earth from being a short-circuit, and limits the flow of current in the case of a breakdown to earth to an amount at which the discriminating devices can select the circuit at fault and clear the same without setting up heavy rushes of current throughout the network which will affect other apparatus. The generators are provided with triple-pole reverse-current relays of the differential type, while all feeders have direct-acting trip gear supplied from series transformers, with secondary fuses in parallel with the trip coils to give the time-limit effect. These avoid the complications of intermediate time-limit relays between the current transformers and the trip gear.

Each feeder is equipped with one ammeter of the H.E. type, with a jack, by means of which it can be inserted in the secondary of the current transformer in any one of the three-phases. Each generator is equipped with one ammeter, one voltmeter and one indicating watt-meter, provided with a switch, such that it can be used at will to measure the lagging or leading component of the machine output instead of the energy component. Recording watt-hour meters are also provided for the generators, and sector type illuminated dial voltmeters for the 'bus bars. Synchronising is accomplished by duplicate synchronisers of the revolving dial type, one having double dials 18 in. diameter, swivelled, so that one of them can be turned toward any part of the engine-room for the benefit of the turbine attendants.

One three-phase potential transformer per generator supplies all synchronising, watt-hour meter, relay and other potential circuits, and three current transformers per generator or feeder—one in each phase—supply all current instruments and automatic gear, the current transformers of similar ratio being interchangeable without reference to variations in the number of instruments or other devices connected in series to their secondaries. Thus there are no potential transformers in parallel with each other, or current transformers in series with each other throughout the gear. All current and potential transformer secondaries are star-connected with earthed neutrals and with three terminal leads, which are carried to the panels in steel conduits. All this secondary three-core wiring, as well as all extra-high-tension cable cores, are coloured red, blue and yellow respectively, and the same distinguishing colours are used throughout the whole system.

All high-tension apparatus is mounted in a number of cells of artificial stone moulded in place with the steel framework of the cell structure holding the false work, thus making the structure one integral concrete unit. These cells are located

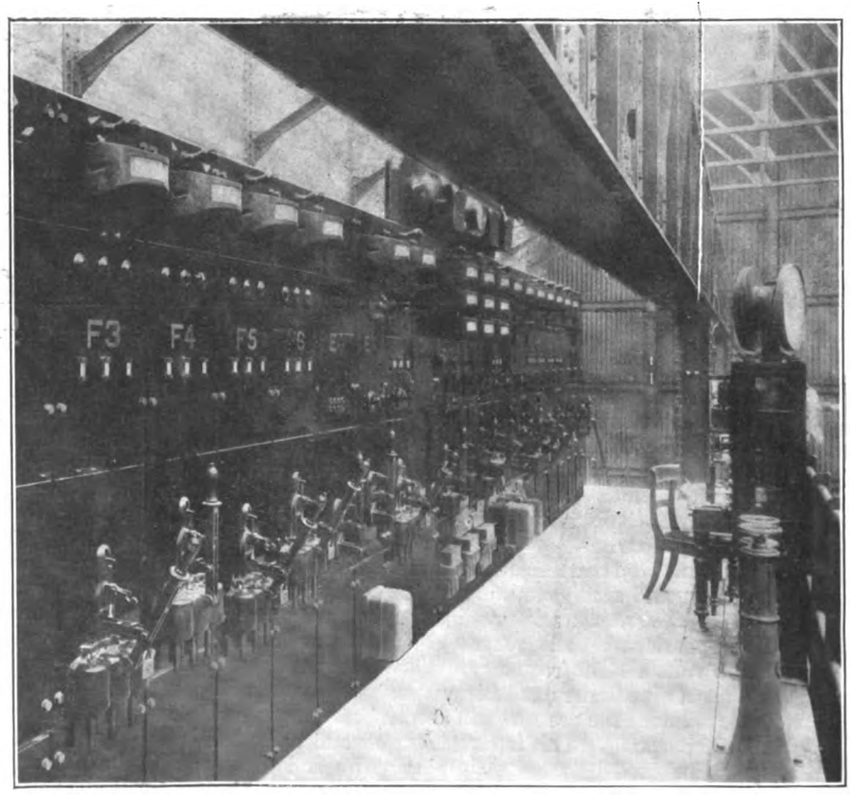

FIG. 5.—FRONT VIEW OF SWITCHBOARD.

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in part on the engine-room floor level and in part on a gallery above, the two ends being joined vertically by other cells, thus forming a cellular ring in a vertical plane corresponding to the ring system of 'bus bars. Each switch cell is 32 in. in width, while each panel is 16 in. in width, thus making the two panels for the upper and lower cell occupy the same width as the cells themselves, avoiding lateral offsets in the operating gear and pipe connections. All extra-high-tension inter-connections between cable boxes, current transformers, oil switches and so forth are made up of bare copper rod. The exciter field rheostats are mounted on the back of the generator panels, while the main field rheostats are hung below the operating gallery and operated through wheels on vertical pedestals.

An interesting addition to the usual power station equipment consists of an automatic voltage regulator made by the B.T.-H. Company. In the present case the voltage regulator can be switched on to any of the three turbo-alternators, and is connected in the exciter field circuits. It periodically short-circuits part of the resistance in such field circuits, the duration of such short-circuiting being controlled by the voltage of the alternator. This instrument obviates any attention on the part of the

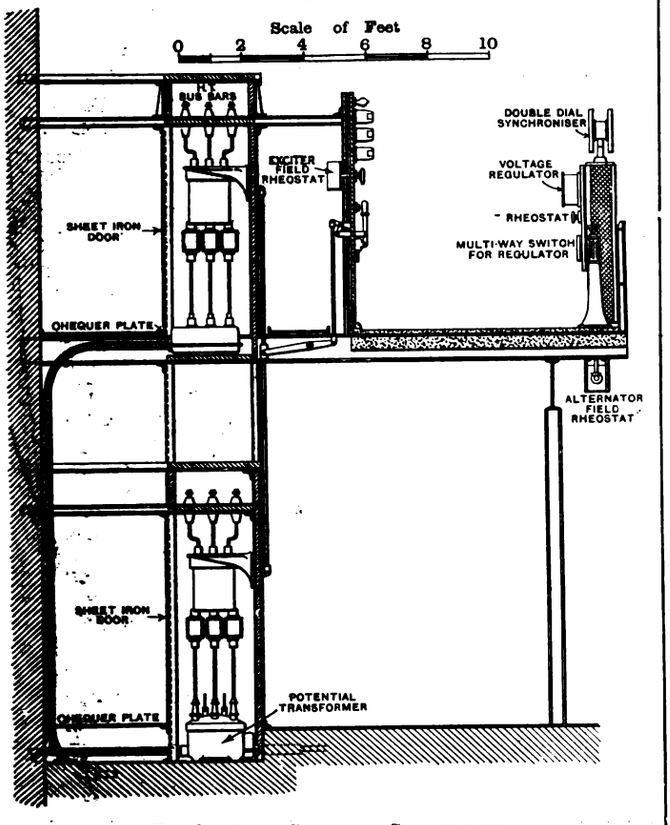

FIG. 6.—CROSS SECTION OF SWITCHBOARD.

switchboard attendant to voltage regulation and is a distinct improvement in any up-to-date power station. As we mentioned previously the high-tension feeders are looped into Berry transformers which are fixed at all the suburban passenger stations, and by utilising different phases as far as possible a satisfactory system of balancing has been ensured.

All the lighting is thus on the alternating-current system with the exception of Liverpool-street Station, with its adjoining hotel, offices, &c. This station, as we mentioned above, was previously supplied from the Norton Folgate generating station with continuous current at 220 volts, and as the alterations to the hotel wiring, necessitated by a supply similar to the other stations, would have required a very considerable outlay, since it would have meant practically re-wiring the buildings, it was decided to instal motor converters, the existing steam plant being shut down. Three 300 kw. La Cour converters have been supplied by Messrs. Bruce Peebles for the Norton Folgate generating station, and the supply to Liverpool-street Station, &c., has thus been unchanged.

We are indebted to Mr. H. W. Firth, the electrical engineer to the Great Eastern Railway Co., for the opportunity of obtaining the information and illustrations contained in this description, and also to Mr. W. Watson, resident engineer at the Stratford power station, for the information he has placed at our disposal. The description and diagram of connections of the switchboard have been kindly furnished us by the British Thomson-Houston Co., to whom also our thanks are due.

THE ELECTRIFICATION OF THE NEW YORK, NEW HAVEN AND HARTFORD RAILWAY.

The electrified section of the New York, New Haven and Hartford Railway between Grand Central Terminus and Stamford presents some features of special interest at the present time. From New

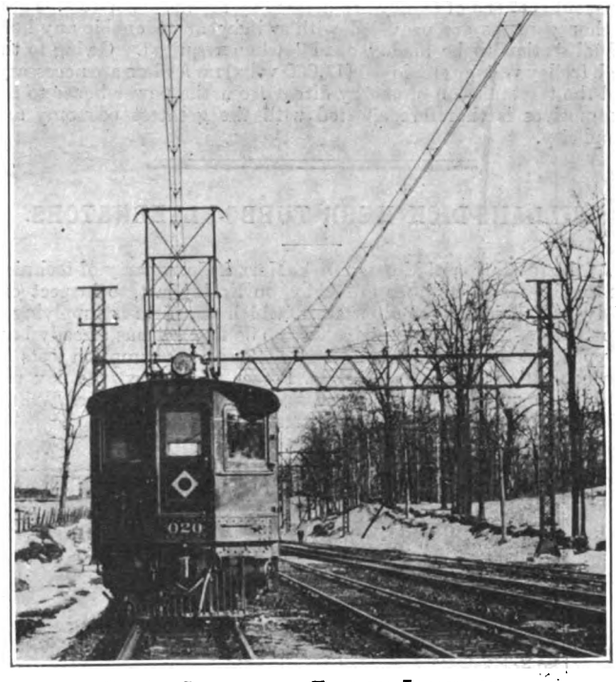

FIG. 1.—SINGLE-PHASE ELECTRIC LOCOMOTIVE.

York to Woodlawn, a distance of 11 miles, the trains run over the New York Central Railway system, which is equipped with ordinary third-rail supply at 600 volts, direct current. Between Woodlawn

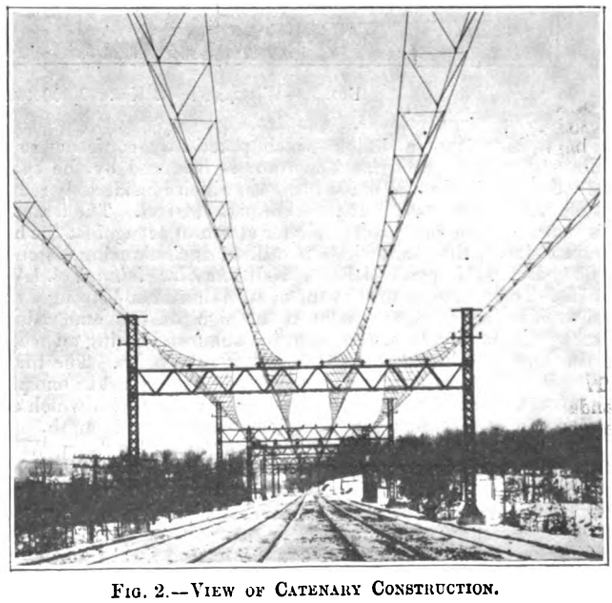

FIG. 2.—VIEW OF CATENARY CONSTRUCTION.

and Stamford, a distance of about 22 miles, the New York, New Haven and Hartford Railway use their own permanent way, which is equipped with overhead trolley construction for 11,000 volt,

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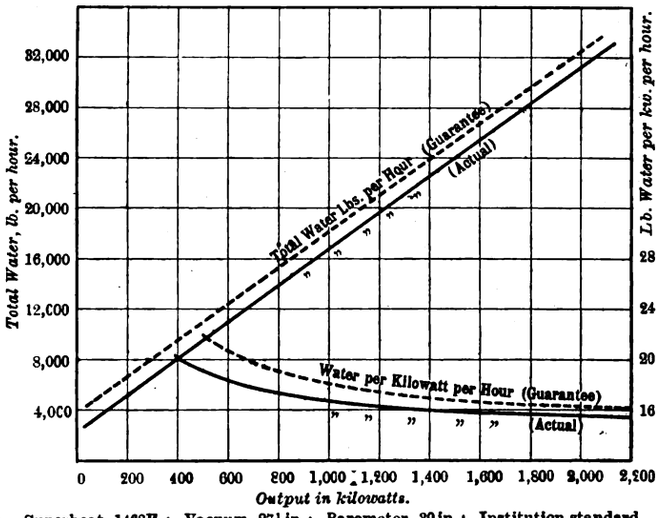
single-phase, alternating current. The locomotives have, therefore, to work both on this high-tension, alternating current and on 600-volt direct current. These widely varying conditions are met by the use of Westinghouse compensated series single-phase motors and electro-pneumatic unit switch type control, the high-tension alternating current being collected by pantagraph bow trolleys from the overhead line, and the 600-volt, direct-current supply being taken from the third rail by collector shoes carried on the bogies.

One of these locomotives is shown in Fig. 1, which also shows the type of trolley construction used. This consists of a 4/0 B. & S. grooved copper wire, suspended centrally over each of the four tracks. The trolley wire is supported, at intervals of about 10 ft., from two steel suspension cables at a height of about 22 ft. above the rails. The suspension cables are carried on insulators, mounted on steel lattice gantries, which span all four tracks, and are spaced about 300 ft. apart. At intervals of two miles a heavy gantry is placed, to which the trolley construction is anchored on both sides, and at which the adjacent sections of trolley are divided by section insulators. These anchor gantries are provided with switchgear to enable any individual section to be made "dead" when required. Owing to the high trolley voltage employed (11,000 volts) no feeders are necessary, and the transmission of energy direct from the power-house to the locomotives is therefore effected with the greatest economy and simplicity.

WILLANS-DICK KERR TURBO-ALTERNATORS.

At the invitation of Messrs. Dick, Kerr & Co. a party of technical journalists travelled down to Rugby, on Friday last, to inspect one of two 2,000 kw. turbo-alternators, which that firm is supplying to the Sydney (N.S.W.) municipality. The first set has already been shipped and the second had undergone steam consumption tests for the consulting engineers (Messrs. Preece & Cardew) the day previous to our visit. The turbines have been built by Messrs. Willans & Robinson, at whose works the tests were carried out.

The slots in the blade rings are also cut on special machines. These comprise a circular table which can be tilted at any angle and which has shallow circular rings of diameters corresponding to the different



Superheat, 146°F.; Vacuum, 27½ in.; Barometer, 30 in.; Institution standard output efficiency ratio = 0·68, taking steam condition at first row of blades.

FIG. 2.—CURVES COMPARING GUARANTEE AND TEST FIGURES OF SYDNEY 2,000 KW. TURBO-ALTERNATOR.

sizes of blade rings required. Into one of these the half of a ring is placed and clamped. Attached to a headstock is a sliding carrier supporting the bearings of a high-speed circular saw, the pulley for which

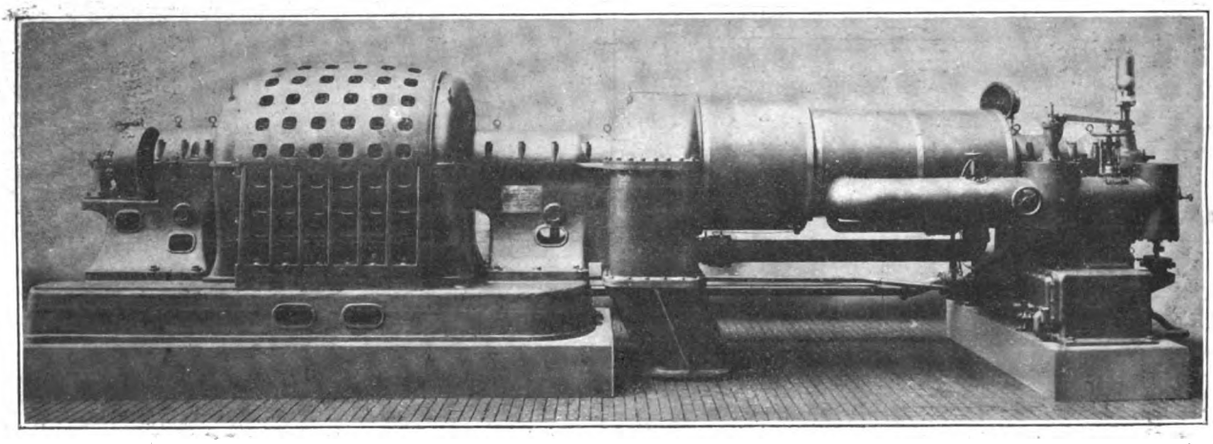


FIG. 1.—WILLANS-DICK KERR 2,000 KW. TURBO-ALTERNATOR FOR SYDNEY MUNICIPALITY.

The turbine is of a design which practically conforms to the Willans standard pattern. The rotor is balanced by the special method adopted in all Willans turbines, which considerably reduces the diameter of the casing at the high-pressure end. The feature of this method is the provision made for steam to act against the high-pressure end of the rotor, which is utilised as a balancing piston (*see* Sydney Baynes' Paper, I.M.E.A., 1906, *The Electrician*, Vol. LVII., p. 372). The system admits of the use of a shorter and stronger shaft and avoids a large balance piston at the high-pressure end, reducing thereby the liability to distortion in the shaft and casing on account of the high temperature of the steam at that point. The turbine casing is built up in three sections instead of being cast in one piece, the advantage claimed being the greater accuracy with which each section can be machined separately than in one solid length.

The blading of the turbines has been carried out on Willans standard shroud-ring system, which is now well known, and which, we understand, has given excellent results in practice. Reference may be made to *The Electrician* (Vol. LV., p. 211) for complete details. We were given an opportunity of witnessing the various stages in the process of making the blades and inserting them into the rotor and casing. The stock-blading section is most carefully inspected in stores for size errors and surface flaws. Gauges having a 0·004 in. limit either way are passed over each stockpiece, and any length failing to pass this test is rejected. Special punches and presses are at work cutting up the stock to suitable sizes and forming the "tang" at one end for insertion in the rotor or stator blade ring. is belt-driven from overhead countershafting. The motions of the machine provide a reciprocating movement of the saw carrier and a notching round of the circular tilting table carrying the blade ring. The saw cuts a slot in the ring on the outward and return strokes, the table carrying the ring notching round to correspond. Forty slots per minute can be cut in a brass ring and six per minute in steel. Other machines in the same department were shown bending the blade and shrouding-ring stock to the desired diameters, and punching the holes in the shroud-ring channel. These holes receive the blade tips. On another machine the completed blades were being buffed, the polished surface being advantageous in reducing skin friction between steam and blade. The caulking in of the blade ring is carried out by hand with hammer and drift. In turbines for operation under a high degree of superheat the caulking strips and blade rings are of steel at the high-pressure end. This precaution has been found advisable on account of the high temperatures employed. With steel rotor and brass blade rings and strips the difference in the expansion coefficients of the two metals has caused the caulking strips to work loose and give trouble through rubbing. We may remark at this juncture that the blade ring grooves in both rotor and casing are of dovetail section, and the process of caulking causes both blade ring and caulking strip to entirely fill the groove. The dovetail section retains both in position under the action of centrifugal force.

Examination of the completed rotor or casing shows the blading to be particularly rigid. The method of construction is also con-

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ducive to interchangeability. The bladed rotors are turned true within 0·001 in. in a lathe, and similarly the casing in a horizontal boring machine. By this means clearances between the rotor and stator can be more readily guaranteed. In the smaller sizes of turbine the top half of the casing is hinged to the lower half, and as there are no obstructing steam inlets or outlets the upper part can be easily opened for the inspection of the turbine blades.

The Sydney turbines are arranged to give an overload of 20 per cent. for periods of two hours and to obtain the full load non-condensing they are fitted with pass valves. The normal working boiler pressure is 150 lb. per square inch and steam is superheated between the limits of 85°F. and 145°F. The normal speed is 1,500 revs. per min. Fig. 1 illustrates the complete machine and Fig. 2 is a curve showing the steam consumption at various loads.

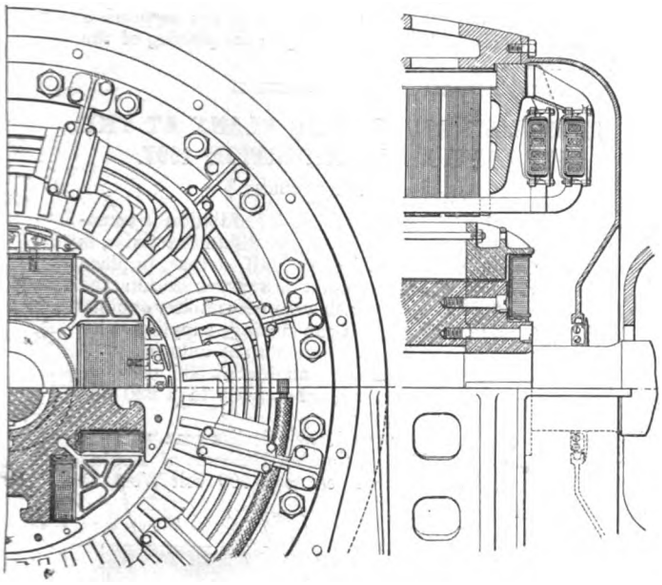

FIG. 5.—DETAIL OF POLE WEDGES ON DICK-KERR STANDARD TURBO-ALTERNATORS.

The complete condensing plant for the two sets has also been built by Messrs. Willans & Robinson (Ltd.) and maintains a vacuum of 27½ in. at the normal full load of the turbine, and a vacuum of 26 in. at the overload, the temperature of the circulating water being 70°F. The air pump is built on the Edwards principle and is of the three-throw type running at a speed of 108 revs. per min. It is driven through single reduction gearing by a three-phase 22 B H.P. motor running at 585 revs. per min.

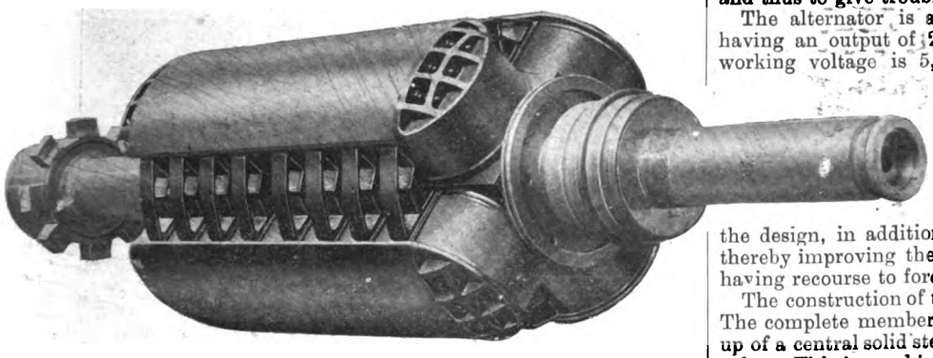

FIG. 4.—ROTOR OF LATEST TYPE DICK-KERR TURBO-ALTERNATOR SHOWING MODIFIED FORM OF WEDGE BETWEEN POLES.

The circulating pump has been built by Messrs. Gwynnes, and is capable of circulating 2,950 gallons per minute when working against a head of 22 ft. The pump in question is driven by a three-phase 35 B.H.P. motor running at 580 revs. per min. Fig. 3 is an arrangement of the condensing plant with a Willans turbine, and it will be seen that in an engine room with lofty switch gallery the turbine can be raised to the gallery level and the condensing plant is fixed to the floor so that extensive excavations are not necessary. The copper expansion pipe between the turbine and the condenser is not fitted with the Willans condensers, adjustments for expansion being made by powerful springs upon which the barrel is supported.

A decidedly novel form of emergency governor is now fitted to Willans & Robinson turbines. Its chief feature is its extreme simplicity. At the high-pressure end of the turbine a special helical spring is laid in a grooved collar on the shaft. The ends of the spring are coupled by a short link so that the coils completely encircle the shaft. The spring is made and tempered to take up a normal annular position in which it is at rest. It retains this position also at certain speeds, but above a limit which can be exactly predetermined the coils take up a larger diameter, due to centrifugal force, and in so doing knock up a light lever which trips a butterfly valve in the main steam feed pipe. The speed of the machine is then checked within safe limits.

In the governing of the turbine oil, and steam relays are omitted, and an ordinary centrifugal governor acts direct on to a throttle valve. Other features in the turbine are: An oil tank with water circulating through it forms the end-bearing pedestal, and contains the necessary oil for the different bearings. The rotary oil pump for circulating this oil is driven by a spindle actuated by worm gear from the main shaft. The steam chest, with the necessary valves, &c., is arranged separately on one side of the turbine, and in no way tends to distort the casing of the turbine proper by being attached to it.

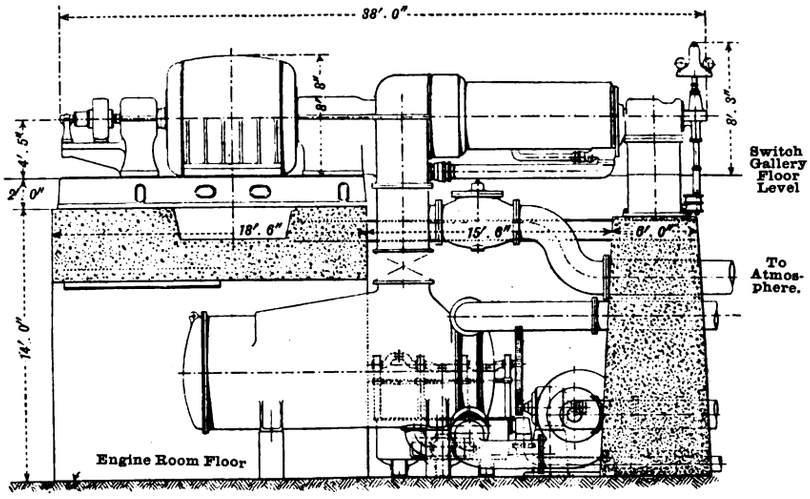

FIG. 3.—TYPICAL CONDENSER ARRANGEMENT WITH WILLIANS & ROBINSON STEAM TURBINES Dimensions are for a 3,000 kw. set.

The end shaft on the steam end of the rotor is forged solid in one piece with the rotor itself in all except the largest sizes of turbine. The usual practice is to force the end shaft into the rotor. Messrs. Willans & Robinson consider this objectionable in view of the high temperature prevailing at the steam end, the difference in temperature between hot and cold tending to loosen the shaft in the rotor, and thus to give trouble at the joint.

The alternator is a standard Dick, Kerr three-phase machine, having an output of 2,000 kw. with a power factor of 0·85. The working voltage is 5,200 and the frequency is 50 cycles. The principal features of the machine are well known, but the latest types embody a number of improvements. The rotor is of the radial pole pattern as distinguished from the cylindrical construction common to Continental machines. The makers claim lower magnetic leakage and better regulation for the design, in addition to getting more copper into the field and thereby improving the efficiency. Ventilation is obtained without having recourse to forced draught.

The construction of the rotor contains numerous points of interest. The complete member is illustrated in Fig. 4. The body is built up of a central solid steel casting cast under pressure with projecting poles. This is machined and bored out to a diameter larger than the shaft and two cross-shaped pieces are fitted at each end to carry the rotor on the shaft. The pole tips are laminated and dovetailed in the poles of the steel casting. Special end pieces, also dovetailed on the steel casting, retain the laminated tips in position by bolts passing lengthways through the laminæ, and at the same time act as checks against centrifugal force to keep the spools in position.

The field winding is built up of solid copper strip wound on edge, insulated between turns with paper and mica, and supported in a special copper bobbin with heavy insulated flanges. The windings, after being formed and insulated, are subjected to hydraulic pressure in the axial direction of about 50 per cent. over the pressure to which they would be subjected from centrifugal action in normal running. The copper turns bear flat on the insulation, thus avoiding any danger of cutting. The terminal leads of each spool are carried out on the bottom of the spool, and are composed of very thin and flexible copper strips. Between the spools special gun-

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metal wedges are provided against the horizontal component of the centrifugal force, which tends to open the spools. The constructional details of these wedges are shown in Fig. 5, which clearly brings out the method adopted for retaining the wedges in position. The spools are finished on the outside surface, where otherwise the copper would be bare, with a special oil and waterproof varnish, which presents a very hard and glossy surface, making it easier to clean the machine. The shaft is of special pressed steel and finished all over, and the rotor is pressed over it with about 100 tons pressure.

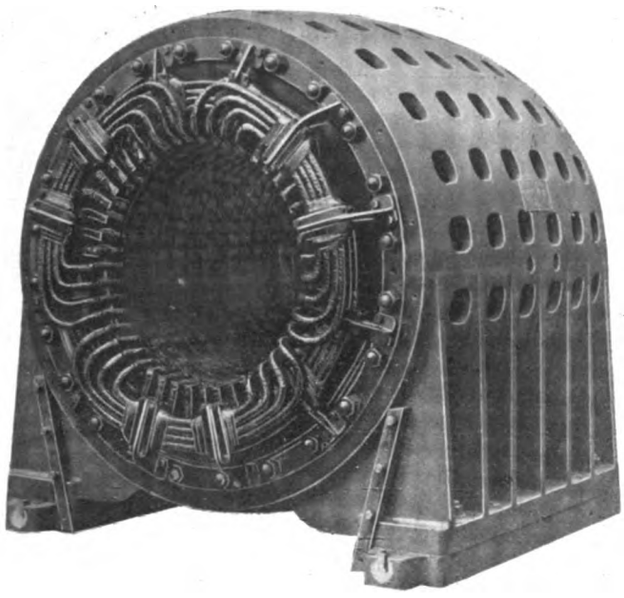


FIG. 6.—STATOR WINDINGS OF ALTERNATOR SHOWING INSULATED SUPPORTS.

The collector rings are of special cast iron fixed over a solid-steel sleeve, the collector rings being shrunk hot over micanite rings. The connections to the collector rings are protected by a cap, which is easily removable for inspection purposes. The collector rings and rotor body have no loose connections or projecting parts, making it possible to keep the machine clean when running. The brushes are of high conductivity low-friction coefficient graphite, having ample contact surface. They may be adjusted or placed when running if necessary.

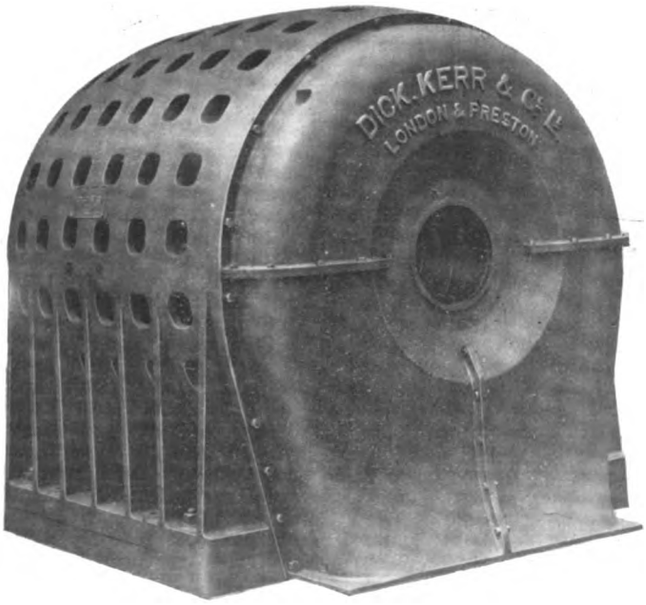


FIG. 7.—VIEW OF END SHIELD OF ALTERNATOR.

The stator, which has no special points of interest, is illustrated in Fig. 6. The solid character of the supports for the ends of the coils may, however, be noted. To reduce noise and prevent the entrance of an undue amount of dust the alternator is provided with end shields, similar to those shown in Fig. 7. The stator can be moved along a special sole plate in a direction parallel to the rotor to admit of inspection.

The placing of the Sydney contract with Messrs. Dick, Kerr & Co. is a matter of some interest, in that the engineer to the municipality, Mr. T. Rooke, personally inspected the manufacture and running of turbo-generators in America, on the Continent and in in this country. That his selection rested on a home firm may be taken as flattering to British enterprise, more especially as national competition in this branch of manufacture is particularly keen. We take this opportunity of tendering our thanks to Mr. H. Scholey, of Messrs. Dick, Kerr & Co., and to Mr. E. J. Fox and Mr. Izzard, of Willans & Robinson, for their kindness and consideration on the occasion of the visit. We may also compliment the respective organisations upon the circumstances leading to the placing of the business in their hands.

ELECTRIC LIGHTING AND POWER PLANT AT THE IRISH INTERNATIONAL EXHIBITION 1907.

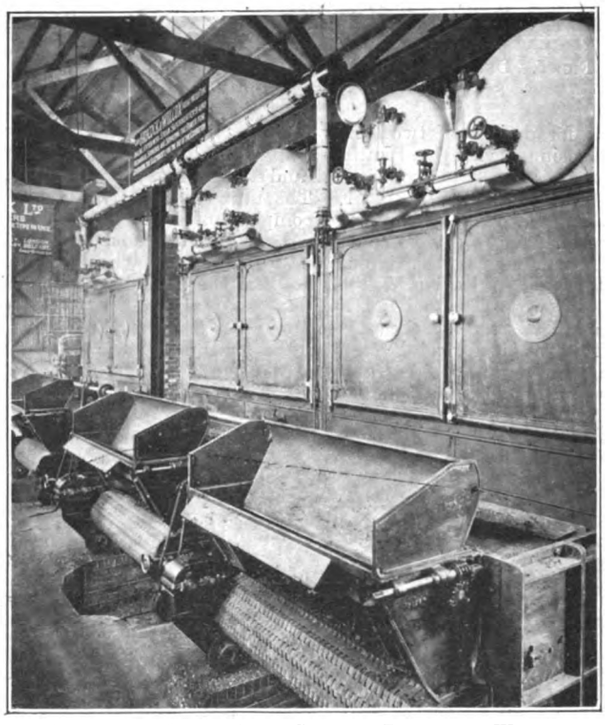
[FROM OUR OWN CORRESPONDENT.]

The power plant at the Irish International Exhibition is somewhat unusual in that the plant, consisting of dissimilar units, is made part of the exhibits in the Machinery Hall, so that, in place of the ordered arrangement of similar units in a power station, the various units are arranged as though each were an ordinary exhibit.

The steam plant, which is all non-condensing, supplied with superheated steam at 160 lb. pressure, is made up as follows:—

One 630 I.H.P. vertical triple-expansion engine at 330 revs. per min. by Combe Barbour, of Belfast, direct coupled to a 230 volt Westinghouse direct-current generator.

One 450 I.H.P. vertical cross compound, with Corliss gear, running at 90 revs. per min., also by Messrs. Combe, Barbour, of Belfast, direct-coupled (between the cylinder lines) to a 500 volt Westinghouse direct-current generator.



BOILERS AND CHAIN GRATE STOKERS, BABCOCK & WILCOX.

Two 120 I.H.P. vertical compounds running at 550 revs. per min., by Messrs. Workman, Yeames & Co., of Belfast, direct-coupled to G.E.C. direct-current dynamos, one at 230 volts, the other at 460 volts.

In addition there are the following gas driven units:—

One 175 B.H.P. single cylinder Crossley gas engine, running at 180 revs. per min., and belt driving a 220 volt direct current dynamo.

One 350 B.H.P. two cylinder "National" gas engine, running at 210 revs. per min., direct-coupled to a 220 volt "Siemens" direct-current dynamo.

The curiously mixed voltages were obviously not a matter of choice but of necessity, and the ingenuity with which the plant has been utilised is creditable to the ingenuity of the engineer, Mr. P. S. Sheardown, the hon. consulting engineer, Mr. G. M. Harris, the resident engineer, and the contractors, Messrs. Wm. Coates & Son, of Dublin and Belfast. The 220 volt dynamos are utilised for general lighting and power. The 460 volt dynamo feeds 90 10 ampere arc lamps run nine in series in the Central Palace. The 500 volt dynamo feeds all the lamps used in outlining the buildings

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and bridges by incandescent lamps run five in series and also (with resistance) acts as a spare for the 460 volt dynamo.

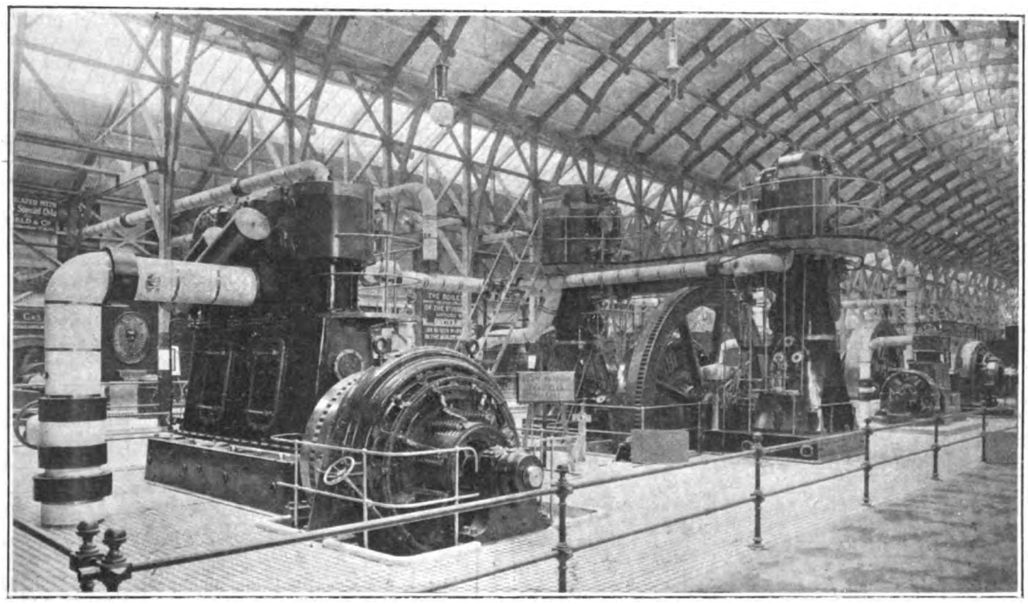
The 230 volt dynamo supplies the motors in the Machinery Hall.

There is nothing new in the steam engines, which are all well-known types embodying the practical details which long experience of the types has shown to be necessary. They are fine, well-designed engines, highly creditable to their builders, and are giving the greatest satisfaction in operation.

The Crossley gas engine is of this firm's well-known type, but embodies some new and valuable features. The connection between the wires and outer shells at the breech-end is specially designed to obviate fracture from expansion and contraction, the exhaust valve is balanced to save wear and tear of valve and gearing, the main bearings are ring-oiled and the barring gear is particularly neat and effective.

Upon this set, installed long before the others, has fallen all the work of lighting before the opening, and testing the circuits, and spent in tuning-up and adjusting, should have taken up its share of the load.

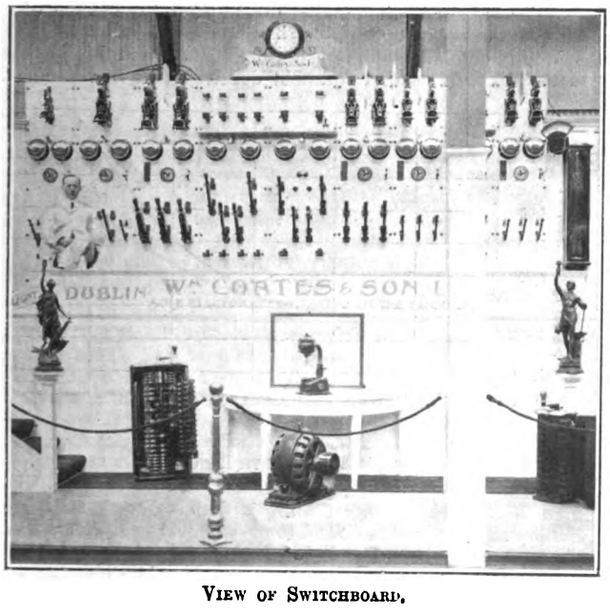
It will be seen that the power installation is not of any great magnitude, and the units are small, but looking back to the days, some 15 or 16 years ago, when small units in central stations were common practice, and when the gas engine was scarcely considered seriously by engineers except for the smallest power, we cannot but think that the co-operation in the same service of the gas and steam-driven plants is significant as suggesting the problem as to the motive power of the future.



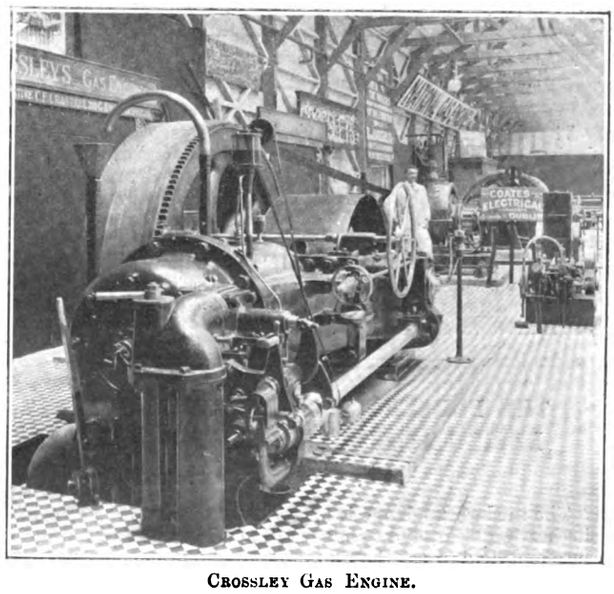
General View of Electrical Plant.

A turn round the boiler house does not decrease the significance of the casual juxtaposition of the two systems of prime movers to the engineer who is thinking, as we all are, of this problem of power production as a whole—*i.e.*, from pound of coal to kilowatt-hour.

In the boiler house are installed three B. & W. boilers, each having 3,580 sq. ft. of heating surface, and each capable of evaporating 12,000 lb. of water per hour at 200 lb. pressure. Each is fitted with



View of Switchboard.



Crossley Gas Engine.

now its convenient size, the ease with which it can be started—thanks to a compressed air starter driven by a 1½ B.H.P. engine—and its reliability, keep it continuously at work.

The "National" engine is the first built by the company to a new design. It reflects no small credit on the designers and builders that, furnished too late to admit of assembling and testing at the works, it should have been erected for the first time upon its bed at the exhibition some time after the opening, and, after a few days

superheater and with the latest improved type of B. & W. chain grate stoker, and is an example of up-to-date plant for steam production by a firm which has taken a large part in the advances made in steam generation for many years. Recalling the modest power, low pressure, absence of superheating and simple hand-stoking of one of the first batteries of B. & W. boilers erected in England—that at Manchester-square central station for the Metropolitan Electric Supply Co.—one has a very vivid impression of the de-

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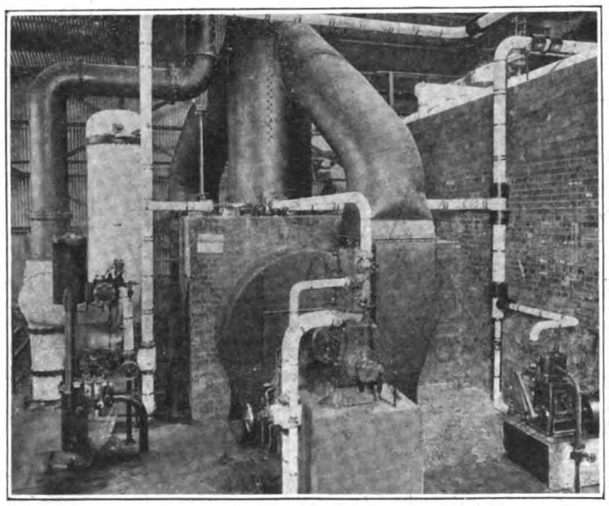
mands of the engine builder and electrical engineer upon the boiler-maker; these demands have been met, but obviously not without adding considerably to the first cost, to the upkeep costs and to the complexity of the steam-raising plant. In fact, the engine in its most highly developed form has been simplified into the pure rotary turbine type; but this simplification of the engine has necessitated —in order to develop its highest economy—a higher pressure, a higher temperature and a lower vacuum, and the net result has been that simplification of the engine has meant complexity in the boilers and condensers.

As the result of these years of strenuous engineering effort, the cost of steam-raised power on a large scale has been considerably reduced; but it is noteworthy, as bearing upon the problem suggested by our subject, that even now a quite small producer and gas engine will give a better return in power per pound of coal than the most complex and up-to-date steam plant.

The problem is essentially one of increasing the size of the units possible with the gas-driven plants, and, unfortunately, English engineers—at least those who are not specially interested in gas engines—are for the most part unaware of the progress made abroad — especially in Germany—in this direction.

The danger of this attitude is that it may lead English engineering into a hopeless pursuit of fractional economies in steam power production, while the larger economies possible in the production of power by internal combustion engines, coupled with recovery of the bye-products, are left to the exploitation of German chemists and engineers—for the problem of how to get the utmost out of a pound of coal needs the collaboration of both.



FEED WATER HEATER, INDUCED DRAUGHT, FEED PUMP AND ENGINE DRIVING MECHANICAL STOKERS.

The demands of the electrical engineers of this country have, during the past 20 years, led to the development in steam power production, which we all recognise. Their demands, in the next 20 years, will equally determine the main direction in which engine builders will work. There appears to us to be a fair probability that most profit lies in the solution of the newer problem, and our excuse for having looked at the Irish Exhibition plant from the point of view of its suggestiveness on this head is that, without in any way depreciating its value in other respects, we believe this to be its most valuable aspect.

THE PRESENT STATE OF DIRECT CURRENT DESIGN AS INFLUENCED BY INTERPOLES.*

BY F. H. PAGE AND F. J. HISS.

The modern tendency is to work electrical machinery right up to its heating limit, and by means of ample ventilation in both armature and field to use the minimum amount of copper and iron compatible with good mechanical design and running. The temperature rise allowed is not quite so strict, 70° F. replacing the 60° F. more commonly specified a few years back, and signs are not wanting to indicate a general movement towards 80° F. for revolving machinery, all these temperatures being measured thermometrically.

With the advent of turbo machines a new phase of electrical development was entered upon. Successful operation was impossible without some special device for ensuring sparkless commutation, with the result that compensating windings and auxiliary poles were re-introduced. The success which attended these old and previously discarded devices has led first to their adoption on variable speed d.c. motors, and latterly on constant speed machines, and they are especially valuable in cases where generators are required to do duty both on a traction and lighting load.

The authors will endeavour to show how the development of the interpole machine has led to a better mechanical design which ensures a more efficient ventilation, to a lower works cost due to the greater saving in material, and finally to an improved efficiency curve and commutation over the whole range of loads.

THE OUTPUT LIMITS OF D.C. MACHINERY.

Heating in Armature.—An accurate predetermination of the armature temperature rise is not an easy task owing to the great differences found between the calculated and the actual iron losses. It will be found that the question of agreement or disagreement depends to a great extent upon the amount the slots are touched up

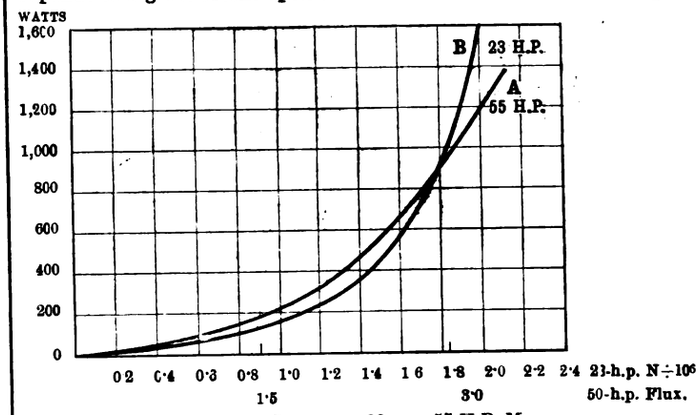


FIG. 1.—IRON LOSSES OF 23 AND 55 H.P. MOTORS.

with a file or milled out, or, in other words, how much the discs are burred over and shorted on one another. The hysteresis and eddy current losses when separated out invariably give one result, the hysteresis being approximately as calculated, the eddy loss being several times greater than that obtained by a transformer test. The value of this multiplier is not constant for any given armature, but increases with increase of flux, and appears to be due to a breaking down of the insulation between the discs at the burred edges.

In Fig. 1 are curves of the measured iron losses in two machines, A being for a 55 H.P. motor in which the core was carefully built up, and B for a 23 H.P. motor in which the slots were touched up with a file and the plates not so carefully assembled. The iron losses are actually greater in the smaller machine, and the shape of the two curves at once shows wherein the difference lies.

With a carefully built up armature the above multiplier is approximately 10 with normal full-field densities, but it will rise to 20 or

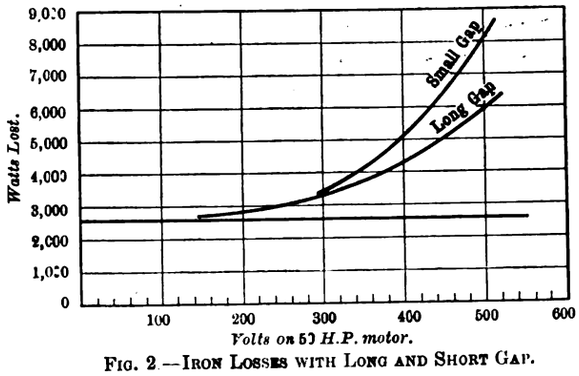


FIG. 2.—IRON LOSSES WITH LONG AND SHORT GAP.

even 30 if much milling or filing is done. Results calculated with the lower value will be found to agree fairly well with the empirical curve proposed by Parshall and Hobart.

Eddy Loss in the Copper.—In addition to these actual iron losses, those losses must be taken into account which, often classified as iron losses, are yet in reality eddy losses in the copper bars in the slots. They may be ascribed either—

1. To the increased fringe cutting the tops of the armature bars when the short air-gap is used, or

2. To the varying reluctance of the magnetic circuit, the variation being greater the shorter the gap and the higher the density.

Fig. 2 shows the measured iron losses of an armature with an air-gap of 2 mm. and 3·5 mm. The magnitude of the increase fully illustrates the importance of taking these details into consideration. To

* Abstract of a Paper read before the Institution of Electrical Engineers.

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reduce these losses to a minimum it is advisable not to increase the tooth density above 21,000, and to work with gaps at least as large as those given in Fig. 5.

Estimation of Temperature Rise.—In calculating temperature rise for an armature the following formula has been used by the authors:—

$$\text{Temperature rise} = \frac{K \times W}{A \times (1+0{\cdot}1v)}$$

where K = constant, W = watts lost in the armature being the sum of the iron and copper losses, A = cooling surface in square decimetres, v = peripheral speed in metres per second.

The accuracy of the results obtained with this well-known method depends entirely upon the cooling surfaces taken into account. Fig. 3 shows these, the dark lines indicating the surfaces taken.

A table is given by the authors showing a series of results calculated by this method and the temperature rise obtained on test. A diagram is also given showing a series of curves, which illustrate how this constant varies with the actual temperature rise of the machine, being higher the greater the rise and vice versa. This shows the higher the actual temperature rise, less watts per square decimetre per unit degree rise can be radiated.

Heating in Field Coils.—A diagram and similar list of results for field coils, the whole surface being considered, are given.

Commutation Limits in Constant Speed Machines.—The sparking limit of a machine is determined by the reactance voltage and the ratio of armature ampere-turns per pole to ampere-turns per pole for gap and teeth. If the reactance voltage is sufficiently low, the latter ratio can be neglected, dependence no longer being placed on the

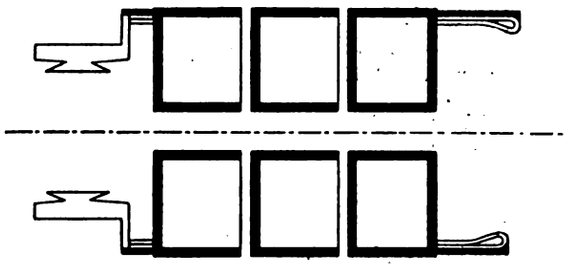

FIG. 3.—COOLING SURFACE OF ARMATURES.

magnetic fringe to reverse the current under the brush. Whilst this may be done with boosters and other low-voltage machines, it is impossible to obtain the same state of affairs in a 500 volt generator. As the strength of the armature—ampere bars per centimetre of armature periphery—is increased, so must the gap or teeth ampere-turns in proportion be increased to ensure a fixed brush position from no load to full load. This entails a further expenditure of copper on the fields to provide the necessary extra ampere-turns, and a limit is reached about 260-300 ampere-bars per centimetre of periphery, beyond which it is not economical to increase the output.

The greater the core length the higher will be the value of the reactance voltage, owing to the decreased magnetic reluctance of the path of the short-circuit flux. This in large machines considerably restricts the choice of armature length, compelling the choice of a larger diameter and smaller length than the most economical design would have given. The saving which is effected with the smaller diameter is considerable, owing to the decreased size of the overall dimensions of the machine.

Commutation Limits in Variable Speed Machines.—Variable speed shunt motors, with wide speed variation by alteration of the shunt field alone, had been successfully built by a number of firms before the introduction of commutating poles, relying entirely upon the brush resistance to effect the reversal of the current, the brushes being placed in the geometrical neutral position, so as to minimise the effect of armature reaction. Such machines, if a great range of speed variation be required, must be designed with a very high field strength obtained by the use of long air-gaps in conjunction with a normal armature reaction, and a smaller ratio of pole arc to pole pitch than is employed with the standard type of machine. Up to 250 volts it was possible to obtain variations of 3 : 1 or even greater, but such machines were necessarily expensive, and with a 500 volt motor the great difficulty of obtaining a sufficiently low reactance voltage rendered the possibility of obtaining such a variation of speed entirely out of the question.

CALCULATION OF THE INTERPOLE DIMENSIONS AND WINDINGS.

Reactance Voltage.—In calculating reactance voltage and the turns required on the interpole, one of the authors has used either of the following methods, each of which has given satisfactory results, although the second one appears more rational.

The first method is due to Dr. Breslauer.* He takes as his basis the reactance voltage formula:—

$$e_r = \tfrac{1}{3} b^x \cdot m_c \cdot m \cdot i \cdot n \cdot 10^{-8} \text{ volts},$$

where e_r = reactance volts, b^x = 0·1 mean length in centimetres + net iron length, m_c = conductors per armature coil, m = conductors in series on armature, i = current (total in armature), n = revolutions per minute of machine.

From this he deduces the following formula:—

$$AT_c = AT_2 + \frac{ASb_c}{2} + \frac{AS.6.\delta b^x}{l_c},$$

where AT_c = total ampere turns on commutating pole, AT_2 = armature ampere-turns per pole, AS = ampere bars per centimetre of periphery of armature = $m \cdot i \cdot / \pi d$, δ = interpole gap, b_c = breadth of commutating pole, l_c = axial length of commutating pole.

The second term of the above equation requires some explanation. The auxiliary pole, being placed exactly over the coils undergoing commutation, tends to reduce the magnetic reluctance of the path of the short-circuit flux. The second term was introduced to take this into account. In practice, however, it will be found that, owing to the damping effect of the eddy currents induced in the solid interpole shoes, this increase is to a great extent nullified. If laminated shoes are used, increased ampere-turns will be required. In spite of this, good agreement will be obtained with this method between the calculated and the required interpole turns, as these ampere-turns provide the additional flux necessary owing to leakage.

The second method, which has also been found very reliable, is based on exactly the same principles as the above, the differences

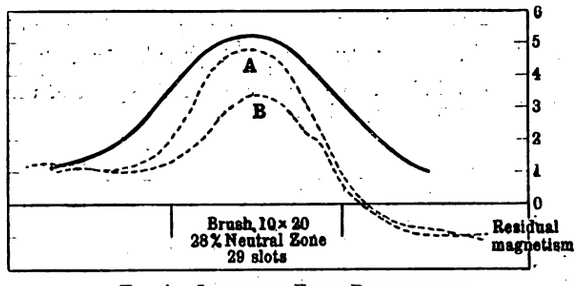

FIG. 4.—INTERPOLE FIELD DISTRIBUTION.

being in the calculation of the reluctance of the air path, and in the reactance voltage formula used. Prenzlin's formula has been employed, and this is as follows:—

$$e_r = \frac{M_c}{2} AT_2 \frac{n}{30 \times 10^8} \frac{p}{\left(2-\frac{p}{a}\right)a} \left\{ I_a \left(1{\cdot}68 \frac{N_t}{N_b} + 3{\cdot}68 \log \frac{I}{N_b} \right) + I_f \left(0{\cdot}1 + 0{\cdot}92 \log \frac{D_a}{pN_b} \right) \right\},$$

where p = number of pairs of poles, $a = \frac{1}{2}$ number of circuits D_a = armature diameter, L_a = net length of armature iron, I_f = free length of conductor, N_t = slot depth, N_b = slot width, I = neutral zone.

$$\text{AT required} = AT_2 + \frac{ASb_k}{2k} \times \frac{p}{\left(2-\frac{p}{a}\right)a} \{\text{a constant}\},$$

where $1/k$ = magnetic reluctance of the air path, in centimetre units.

Interpolar Arc.—It is evident that a machine with a very narrow interpolar arc has many points in its favour. Owing to its comparatively small leakage coefficient, the machine will be able to stand heavy overloads without the interpoles becoming saturated, and the commutating field will be more closely proportional to the armature current. In addition, there will be more space between the auxiliary and main field coils, ensuring a lower temperature rise—with the same watts dissipated per unit of exposed surface—owing to the improved air circulation.

In Fig. 4 is shown the curve of interpole field distribution, with a machine where the arc is equal to the slot width. The dotted lines are the curves taken on test, the full lines are the calculated ones. The curve A was taken with 800 ampere-turns, curve B with 416 ampere-turns, on the interpole. The arc subtended on the armature circumference by the brush is shown below.

It is obvious that part of the coils which are undergoing commutation must lie outside the influence of the interpolar field. By using brushes with a very high cross resistance it is possible even to obtain fair results with this narrow pole, but when a wide speed variation is desired on a 500 volt supply, or where the reactance voltage is higher than 3, it is impossible to obtain even this fair result.

* *Elektrotechnische Zeitschrift*, Vol. XXVI., 1905, p. 640.

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It is not, then, so much the question of coils commutating outside the auxiliary field as it is the rapid variation of the field itself. The magnetic reluctance of the interpolar flux path will vary considerably as the teeth pass under the pole. To obtain fair results one has to take an average value for the commutating flux and then determine the ampere-turns required to produce this value with the average position assumed for the tooth. It will be usually found that a machine with a narrow pole arc is very sensitive to brush position, being very liable to hunt or flash over with a sudden variation in load or speed.

Arnold has stated that the width of the pole arc should be at least equal to two slot pitches, but this is not necessary with ordinary variable speed machines where the reactance voltage, calculated by Prenzlin's formula, does not exceed 8 to 9. An arc equal to a slot pitch plus a tooth width will be found sufficient; expressed in terms of a slot pitch this is equivalent to 1·5 to 1·7 times the pitch. It must not occupy too great a percentage of the neutral zone if leakage, and, consequently, the interpole copper, is to be kept within reasonable limits. For this reason 35 to 45 per cent. of the neutral zone will be found to be the average figures representing modern practice in this respect.

Axial Length.—The axial length of the auxiliary pole-shoe will be determined by the conditions which the machine has to fulfil, being dependent to a large extent upon the density employed in the air-gap. In high speed machines, or machines having a wide variation of speed, one must work with low average densities of from 5,000 to 9,000 lines per square centimetre in the air-gap, whilst with constant speed machines working at full field strength 10,000 to 12,000 will be perfectly satisfactory. It is best to cut down the axial length as much as possible, as thereby the leakage from the pole is reduced.

Pole-shoes.—Several firms have made a very special feature of the pole-shoe of the interpole. The utility of skewed pole-shoes depends upon the strength of the main fields; with variable speed machines they are of no avail, but they may have a certain sphere of usefulness with large constant speed generators.

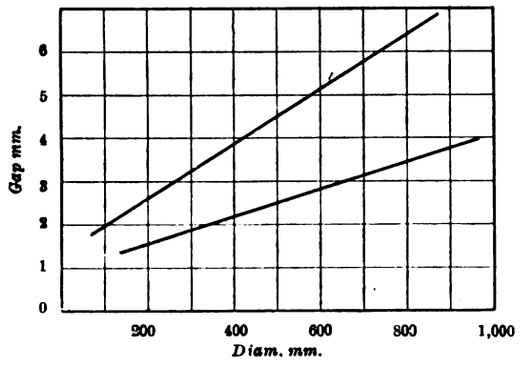

FIG. 5.—AIR-GAPS AND ARMATURE DIAMETERS.—INTERPOLE AND NON-INTERPOLE MACHINES.

Pole-core.—The pole-cores should be made circular in secton wherever possible owing to the saving which can be effected in copper; this is not always possible owing to lack of room.

Number of Interpoles to be Employed.—With a series wound armature, the number of interpoles used need not be the same as that of the main poles, the improved ventilation obtained by such a construction being a great advantage.

THE EFFECT OF THE INTERPOLE UPON D.C. MACHINERY.

It is evident that the heating limits will remain the same whether interpoles are employed or not, and it is only by a better distribution of the losses and a different proportioning of the various parts of the machine that an economy can be effected. For the very small sizes it is probable that it will not be found of much advantage to adopt commutating poles as a standard. The extra labour cost entailed in fitting commutating poles is of considerable consequence, the available space between the poles is constricted, the total number of field coils would be doubled, and, as the heating limit is reached before the sparking, advantage cannot be taken of the saving in material which is effected in large machines by a reduction in the length of the air-gap and so forth. Only machines above 40 kw. to 50 kw. output will therefore be considered.

Poles.—The extensive adoption of interpole windings will probably decide once and for all the question of the shape of the main poles. The authors are of opinion that the cheapest designs are obtained by the use of round poles in bipolar and four-pole machines, but rectangular ones for all machines with a larger number.

Number of Poles.—It does not appear desirable to increase the number of poles with the new designs. Although on paper by so doing a considerable saving may be effected in amount of material used, yet the general sensitiveness of a machine with an abnormal number of poles fits it rather for laboratory experiments than for practical working, especially under adverse conditions.

Armature Length.—At first sight it would appear that a considerable saving could be effected in field copper by slightly increasing the core length of the machine and reducing the high flux-densities in the teeth. This is possible, as one is no longer restricted in length by commutation conditions. A limit is, however, soon reached, beyond which a further increase in length is not economical. If this be exceeded it will pay to increase the densities again until the increased cost of copper as a per cent. of the total cost just balances the per cent. increase in output. This density seems to be about 19,500 to 20,500 lines per square centimetre.

Armature Strength.—It must not be forgotten that increased armature ampere-turns will necessitate more interpole turns and that therefore there must be a certain point beyond which it will not pay to increase the rating even if there is ample room in the slot. This limit is reached when there are from 300 to 360 ampere-bars per centimetre of armature circumference, the figure to be taken depending on the size of the machine.

Windings.—In the choice of windings one has now a much freer hand; a series winding can often be employed where formerly commutating conditions would necessitate a parallel one. With interpole machines preference should always be given to a series winding, as its self-equalising properties are very valuable with the short lengths of air-gap employed. Another important feature is that the variation in commutating flux is less with the series winding.

Series parallel windings should be avoided, as they usually lead to heavy equalising currents flowing under the brush from winding to winding. The only time when they can be employed with good results is with eight or a larger number of poles, a doubly re-entrant or a duplex winding having been used with excellent results by one of the authors on several occasions. A doubly re-entrant winding is best with an 8, 12, or 16 pole machine; a duplex with a 10, 14, or 18 pole.

Air-gaps—The curves in Fig. 5 represent the air-gaps which have been employed in ordinary non-interpole machines compared with air-gaps which the authors consider will be approximately adopted by most manufacturers who will take full advantage of the designs with commutating poles. Below these figures it is not advisable to go, for mechanical reasons, and above them the machine will be costly in amount of copper used.

Commutators.—The authors do not believe that the commutator diameter will be much affected. A ratio of 60 per cent. between commutator and armature diameters being most satisfactory.

Conclusions.—The question which faces the manufacturer is whether auxiliary poles should be regarded merely as adjuncts to a standard line of machines, or whether new designs should be got out.

For large machines the works cost will be cheapened owing to—(*a*) The higher armature reaction employed. The extra cost of the interpole copper and winding being more than offset by the increased output obtained and the saving on the main field, no ampere-turns being required for armature reaction. (*b*) The smaller air-gap. This still further reduces the amount of copper required. (*c*) The armature can be made longer and of smaller diameter, thus effecting a great saving in the mechanical design and labour costs. (*d*) A smaller commutator, giving a better ventilated armature and a cheaper mechanical construction.

The Paper concludes with a number of examples showing the modern practice in d.c. interpolar design. Dimensioned illustrations are given of the machines of a number of well-known makers.

Two appendixes give respectively a method for calculating the interpolar air-gap reluctance, and for experimentally determining the flux curve.

[We hope to give an account of the discussion on this Paper next week.]

HOT-WIRE WATTMETERS AND OSCILLOGRAPHS.*

BY J. T. IRWIN.

(*Concluded from page 267.*)

Summary.—In this Paper the author describes a new type of hot-wire instrument, which can be used for measuring voltage, current and power. He also shows how it can be adapted for use as an oscillograph, and also for recording B – H curves.

Voltage Curves.—One of the first machines for which the voltage curve was obtained was the Pyke and Harris inductor alternator at the Central Technical College. Voltage curves obtained by the author's instrument coincide exactly with those obtained with a Duddell oscillograph.

In connection with the hysteresis curves, it would be well to describe the arrangement of drawing rectilinear curves adopted by the

* Abstract of a Paper read before the Institution of Electrical Engineers

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author. There have been rectilinear curves drawn by a moving spot of light for hysteresis and other curves, by having, say, two oscillographs, one indicating flux, and the other P.D. with the plane of the mirrors normally parallel and their axis of rotation at right angles, or the equivalent of this obtained by rotating the plane in which a beam of light reflected from the mirrors would vibrate by a reflecting prism as shown by Morris and Catterson-Smith* and by Witteman.†

There is, however, no necessity to go to the trouble of fitting up this special arrangement, as by the simple arrangement shown in Fig. 11 the curve can be drawn. A is a source which gives a beam of light on M_1, the mirror on the oscillograph. This mirror, which has a deflection proportional, say, to the magnetising current of a transformer, reflects the beam on to the mirror M_2, which has its axis of rotation at right angles to M_1. If the mirror M_2 is oscillated by a synchronous motor, and if the phase of the displacement is exactly in phase with the flux in the transformer, then the beam of light will draw out a hysteresis curve on the screen S. To effect this an eccentric E is placed on the shaft of a two-pole synchronous motor and a lever L (which oscillates the mirror M_2 about its centre) is kept pressed against it. The lever is fairly long in comparison with the throw of the eccentric, so the motion of the mirror is nearly simple harmonic. A sine wave P.D. is impressed on the transformer, then the back E.M.F. must be also a sine wave and the flux a sine wave; therefore if one can vary the position of the eccentric on the shaft until its maximum throw corresponds with the maximum flux in the transformer, and if the mirror M_1 has a deflection proportional to the magnetising current, then the beam of light will draw out the hysteresis curve.

There is another method of drawing hysteresis loops where the E.M.F. wave does not compel the magnetising current to be nearly a sine wave—namely, by putting a large self-induction without iron in the core in series with a small magnetising coil wound on the test piece of iron. A hot-wire oscillograph is connected across this magnetising coil or across a secondary. Since the deflection of the oscillograph is proportional, if the frequency is high, to the quantity, it will be proportional to the flux, therefore one has only to make the deflection of mirror M_2 proportional to the magnetising

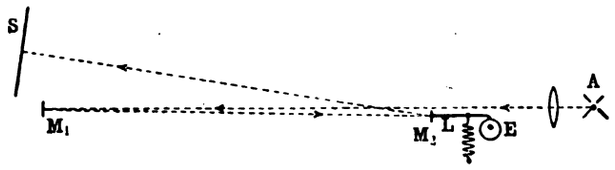

FIG. 11.

current and the hysteresis loop will be drawn out. The objection to this method is that there is no exact method of compensating the strips for their difference in rate of losing heat, since to secure compensation would require a current proportional to the flux as well as to the rate of change of flux to be flowing through the instrument at every instant.

HOT-WIRE WATTMETER TESTS.

The instrument on which these experiments were carried out was arranged in tubular form, so as to be able to go inside the tubular airtight casing, and was constructed on the same principle as the hot-wire oscillograph except that the small plane mirror was replaced by a concave mirror $\frac{3}{8}$ in. in diameter. An ideal hot-wire wattmeter should have the following properties:—(1) High sensibility.‡ (2) Deflection proportional to the difference in the rate of heating of the two strips and independent of the actual heating of the strips.

If condition (2) is fulfilled then it should be possible:—(*a*) To pass a current of any value that would not damage the instrument through the two wires in series without producing any deflection. (*b*) To apply any voltage within limits across the two strips in parallel without producing any deflection. (*c*) To have a deflection proportional to the square of the current through one strip only.

The following particulars of the instrument may be of interest:—

Total effective length of wire for each strip ..	10 cms.
Diameter of wires	0·005 of a cm.
Distance apart	0·15 of a cm.
Material platinum, silver	
Resistance of strips	10·39 ohms. / 10·30 ohms.

The natural period of the instrument was $\frac{1}{50}$th of a second at first, and on account of it being so high it was liable to get in phase with the variation of heating in the instrument on alternating current. The mirror was weighted with lead to stop this movement.

Sensibility, 290 mm. deflection at a scale distance of 1 metre for a current of 0·2 of an ampere through one strip; that is an expenditure of power of 0·4 of a watt. The author would suggest as a sensibility factor for hot-wire wattmeters the term—

$$\frac{\text{deflection}}{\text{scale distance} \times \text{difference in watts dissipated}}$$

The factor in the present case comes to 0·72, but could easily be increased to a higher value by employing finer wires in the instrument, by using longer wires not tied back so far, or by putting the wires nearer together.

DISCUSSION.

Mr. A. CAMPBELL said that one could learn a great deal from the instruments described in the Paper, a very interesting point of which was the application of the hot wire to the oscillograph. One peculiarity of the hot wire was its sluggishness, but Mr. Irwin had got over that difficulty. Having reviewed the many ingenious points of the instrument used by Mr. Irwin, he referred to an experiment he had carried out recently of using a hot wire to make a telephone. He had used a mica plate with a thin wire in the middle. If an alternating current were sent through this wire the roar of the current could be distinctly heard.

Mr. W. DUDDELL said that the use of a hot wire to make an oscillograph by Mr. Irwin was certainly ingenious. As to the watt curves shown, it would be interesting to have the zero line shown. The hysteresis loop mentioned in the Paper was very interesting, and of the utmost importance. He was very anxious to obtain some easy method of recording these hysteresis loops. With regard to Mr. Campbell's hot-wire telephone, if he had polarised his instrument he would have heard nothing.

Dr. C. V. DRYSDALE said the most striking thing in the explanation given by Mr. Irwin of his instruments was the use of the condenser. With regard to thermal lag, all kinds of lag when dealt with electrically came to the same thing as self-induction.

THE ACOUSTIC EFFICIENCY OF THE TELEPHONE.*

BY H. ABRAHAM.

1. The currents received by a telephone set the diaphragm vibrating, the diaphragm moves the air, and a portion of the energy of these vibrations reaches the ear.

What relation is there between the sound energy utilised by the ear and the electric energy furnished by the line?

A sufficient estimate of the energy furnished by the line may be obtained by default by multiplying the resistance of the apparatus by the square of the current. A maximum of the other factor may be estimated by excess, and thus a superior limit may be obtained for the efficiency.

2 The latter estimate may be made by seeking the maximum power available for the diaphragm for a sound of given pitch, say 200 periods per second, and for a current of known strength.

It must be remarked that in order to avoid resonance phenomena it is necessary to let the proper pitch of the diaphragm be notably higher than the sounds of the speaking voice. Hence, in the equations of motion of the membrane, we may neglect the terms of inertia, and reduce our equations to the type

$$Ax + B\frac{dx}{dt} = C \sin \omega t,$$

where Ax represents the elastic force, while $C \sin \omega t \pm$ is the force exerted by the electromagnet, and $B\frac{dx}{dt}$ represents the resistance on which the diaphragm works.

We deduce immediately from this equation that, when there is no resonance, the maximum power available for the membrane is $C^2\omega/4A$.

The two quantities to determine are therefore C/A—*i.e.*, the flexure produced on the diaphragm by a known force, and C the force exerted by the electromagnet on the diaphragm for the given current.

These two determinations may be made by statical experiments which present no particular difficulty.

3. Here are the results of an experiment made with a telephone of the usual sensitiveness:—

Resistance of the telephone	13 ohms.
Current	$\frac{1}{300}$ ampere.
Displacement of the diaphragm	$\frac{1}{4}$ micron.
Corresponding elastic force	100 dynes.

For an alternating current of frequency 200, having a maximum strength of $\frac{1}{300}$ ampere, we should therefore have:

Electrical power spent (min.)	700 C.G.S.
Power available for diaphragm (max.)	1 C.G.S.

It follows from these figures that, however sensitive the telephone may actually be, it is only a very indifferent receiver.

Apart from cases of resonance, the best telephone does not transmit to the ear one-thousandth part of the energy it receives.

* Translated from the *Comptes Rendus*, April 29, 1907.

* *Journal* of Inst. of Elec. Eng., Vol. XXXIII., p. 1,019.
† *Elektrotechnische Zeitschrift*, Vol. XXV., p. 885.
‡ Not so desirable if a pressure transformer is used.

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THE RADIO-TELEGRAPHIC CONVENTION.

The present moment is a critical one in the history of wireless telegraphy. The report we are awaiting from the Committee appointed to inquire whether the International Wireless Telegraph Convention, as approved by our delegates at the Berlin conference of November and December last, shall or shall not be ratified by Great Britain and her Colonies, must exert a great influence on the universal adaptation of the art to the purposes of the navigator. On the one hand, if this country signs the Convention the whole world will enter on a period of fuller use than ever before of wireless telegraphy, while if the ratification is withheld a period more or less protracted must follow, wherein one part of the shipping world will find itself in isolation from, if not in conflict with, the other part. It may seem at first sight strange that this country has found it necessary or possible to hesitate in the matter. The sole cause of this hesitation is undoubtedly the powerful position here and abroad of the various Marconi Companies.

The official translation of the full text of the Convention and the associated documents was published in our issues of December 14th and 21st last. Broadly, the Convention is intended to encourage and to regulate the use of wireless telegraphy for communicating between ship and shore. Its provisions may be summed up very briefly. First, all shore stations having public telegraphic business with ships must be authorised by the Government of the territory

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concerned and must be connected with the ordinary telegraphic system, and, together with all ships availing themselves of the facilities offered, must be registered at the International Bureau. In the next place, all such shore stations must intercommunicate without regard to the system of apparatus installed. Further, certain rules are laid down for the conduct of traffic—for instance, it is provided that signals of distress shall take precedence over all others—and certain regular charges for messages are to be enforced. The final protocol, besides fixing certain details of future Conferences, provides for the exempting at any time of a coast station from public work, and makes allowances for systems so special that they cannot intercommunicate with more ordinary systems. The Service Regulations published with the text of the Convention demand that ships must be licensed by their Governments, and that their apparatus must be syntonised. The wave-lengths are fixed for coastal communication at 300 and at 600 metres, and a limit of 1 kw. is put on the power usually to be employed by ships. All radio-telegraphists must be certificated by their Governments. In addition, regulations are laid down to ensure prompt transmission of telegrams, and to avoid confusion. This last is ensured by putting the coast stations in command of the telegraphic traffic they are concerned with at any moment, and by rules regarding the method of calling, and similar details for the guidance of operators.

In reviewing the evidence put before the Committee for and against ratification of the Convention, it must be borne in mind that the only opinions adverse to ratification were offered by the Marconi Company and its experts. The truest view of the situation is therefore obtained by devoting most attention to their evidence. The case against the Convention was opened by the managing director of the Marconi Company. He stated three main objections. The first rested on his statement that his Company alone did any appreciable telegraphic business, which implied that they only, or at any rate chiefly, were affected; and he submitted that they did not want the Convention. The second objection was that the Marconi Company have a number of contracts with various lines of ships already embodying the principle of non-intercommunication. And his third objection was that intercommunication was impracticable, and that it would disorganise the whole of the service his Company had already erected; it would, he said in illustration, be like a telephonic system wherein everyone could call anyone, with chaotic results. The first objection, based on relative bulk of business, was disproved at a later stage by statistics specially gathered by the Secretary of the Post Office, statistics that tended to show that a larger volume of business was actually being transacted on the United States coasts. That this American business was spread over a number of intercommunicating rival companies is a fact to be set against the third objection put forth above. To the second objection it might be said that the existing contracts referred to as containing clauses barring intercommunication might be greatly mended by the removal of the detested and harmful proscription. How harmful to public interest such clauses are is well illustrated in Capt. INGLEFIELD'S evidence, where the tale is told of an American ship, finding a derelict, being barred from communicating with a passing liner because of the latter's Marconi contract. The third objection, that the excellent though limited Atlantic service organised by the Marconi Company would be injured, is one that may gain sympathy, and we are inclined to agree that it is rather hard on the Company to see the service they have so patiently fostered for their own profit thrown open at once to all comers.

Dr. MARCONI was the next witness offering evidence against the ratification. He contended that scientific and technical progress would be hindered by the regulations, which made practically impossible the introduction of great improvements for trial at any station. The secrecy, he hinted, without which inventors will not invent, will be lost. Further, there was no provision for experimental licences on ships. It should be noticed, however, that the Convention does not apply to coast stations not doing public telegraphic work. Private experimental stations, if not on a ship, are still possible, and Nauen, for instance, if not registered as a public station, may, so far as the Convention goes, disturb whomsoever it pleases. This may be found a weak point in the Convention. With respect to Dr. MARCONI'S objection that private experimental ship stations are impossible, we are bound to agree that this is a serious hindrance to inventors, who will necessarily now be driven to the cold charity of a Navy in order to carry out experiments at sea. Dr. MARCONI'S vague reference to "amplitude" and its neglect by the Convention was made a little more lucid by Prof. FLEMING later. If it was meant to lead up to the complaint that inventors of non-intercommunicating systems will be discouraged by the Convention, we have to say that such systems will, from their nature, be discouraged more emphatically still by the navigator—the Navy (whither the Convention does not reach) is the place for such systems.

Prof. FLEMING was the third witness against the Convention. He complained that the Convention looked at the present and not to the future. Now the Convention is designed for the regulation of such intercommunication as is daily useful to mariners and sea-travellers, and it should be remembered that the simpler and even cruder forms of apparatus will long be the most useful on board ship. Taken in the broadest possible way the argument would have impelled the Marconi Company itself to refrain from standardising any of the apparatus it supplies—but we trust it has not. But the most important part of Prof. FLEMING'S evidence dealt with MARCONI'S deserts as an inventor and the consequent commercial expectations of the companies that own his patents. On the first point we can go a long way with Prof. FLEMING. The second point affords the first indication we meet in all the evidence of the true views and aspirations of the Marconi Company. Put plainly, the view of the Company is that they alone possess the right to send messages through the ether by Hertzian waves; or, in the words of Mr. HALL, the managing director of the Company, in giving his supplementary evidence at a later stage, "there was very strong presumptive evidence that the company's patents controlled *all wireless telegraphy*." The struggle reduces to one between the interests of the Marconi Company and the interests of all the world.

This stupendous claim, it must be mentioned, is logically enough based by Prof. FLEMING on the fact that practically

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all wireless telegraphy (except, perhaps, Prof. FLEMING'S own newly announced system) is accomplished by the use of antennæ directly or equivalently earth-connected, and that the master patent for this use is possessed by the Marconi Company. It has, of course, been long known that the Company held this view mildly, but since they have never yet ventured to win or lose all in the Law Courts, we doubt if they have ever been taken quite seriously. The fact explains, however, the attitude of the Company through much of its past history, and in particular gives the explanation of its policy of ignoring other wireless apparatus, that is of the principle of non-intercommunication. Nevertheless, we cannot agree that the ratification of the Convention by this country will debar the Company from entering the Law Courts. But it is very plain now that not to ratify would afford support to the Company in its claim, and would help them to crush their English rivals by enabling them to continue their comparatively inexpensive boycotting policy.

The issue has narrowed to this: Is it good for the national interest and for the future of wireless telegraphy that the Convention should be signed at once? First, it must be noticed that some of the earlier arguments of the representatives of the Marconi Company do now, in the face of this threat of a monopoly of the ether, react against the Company. To recall one argument only—namely, that the Convention by imposing (so far as it goes) a certain uniformity of apparatus would make it harder for inventors to test and to introduce improvements, and would hinder scientific and technical progress—this argument is surely infinitely more telling against the state of things threatened by the Company's vast ambitions. But more important than this is the fact that every witness not connected with the Marconi Company spoke emphatically of the perfect safeguarding, nay, the increased fostering, of our national interests under the Convention. As Mr. GAVEY said, our well-being is more fully protected with the Convention than it could be without it. In the first place, in the words of the Secretary of the Post Office, "in the shaping of the Convention the interests of the Admiralty and the War Office were paramount." Quite apart from the public services, and ignoring what we might suffer if we do not ratify, the Convention is anticipated to be more beneficial to shipping, mercantile as well as naval, in the English Channel than in any other place in the world. Strategic benefits, of course, will be proportional to the number of ships fitted, and we have the largest marine. Merely from the point of view of wireless traffic accruing to our shores under the Convention it was conclusively shown that we are certain to gain, while it is so very palpable that the Convention will administer so great a stimulus to the fitting of ship and shore stations that it seems clear that even the Marconi Company may, if it will, benefit pecuniarily. Beyond and above all these considerations there is the prospect, indeed the assurance, that the adoption of the Convention, by its promise of universal intercommunication, will bring to the mariner—and for him alone the Convention is conceived—a boon of such prospective value as has never before in the history of navigation been tendered to him.

RECENT CONTRIBUTIONS TO ELECTRIC WAVE TELEGRAPHY.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

(*Continued from page 273.*)

There are at least three ways in which these undamped oscillations can be created. The first is a mechanical method, viz., by a high-frequency alternator. Assuming we possess an alternating current dynamo giving a current of a sufficiently high frequency we can connect one terminal to earth and the other to a radiating antenna and then on setting the machine in operation high-frequency undamped currents would be created in the antenna and corresponding waves radiated. To secure the best results it is necessary, however, to syntonize the free time period of the antenna circuit and the natural frequency of the alternator. The chief difficulty, however, is to construct a machine which shall give alternating currents of sufficiently high frequency and voltage with sufficient power and current capacity. Sixteen or seventeen years ago Prof. Elihu Thomson and Mr. Tesla built dynamos giving an alternating current of 10 amperes at a frequency of 10,000 to 15,000 and an output of about 1,000 watts. Mr. Duddell exhibited to the Physical Society in April, 1905, an alternator capable of a frequency of 120,000 but its power output was not more than 0·2 watt. I have on the table a small alternator made by Mr. S. G. Brown giving an alternating current having a frequency of 12,000, an E.M.F. of 20 volts and a power of about 50 watts. Prof. Fessenden has recently given a description of an alternator made for him having a frequency of 60,000 with an output of 250 watts running at a speed of 10,000 revs. per min. and giving an E.M.F. of 60 volts. Since steam turbines of the Leval type are now made to run at 500 revolutions a second it is not difficult to construct an inductor alternator having a frequency of 50,000 to 100,000. Such a type of alternator has, however, always a large fall in terminal P.D. if called upon to give out current. For this reason a type of machine without iron in the armature is to be preferred, but then it becomes more difficult to balance the moving parts for very high speeds. In

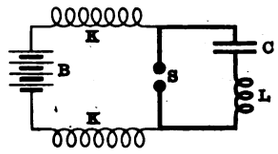

FIG. 8.—ELIHU THOMSON'S METHOD OF PRODUCING OSCILLATIONS.

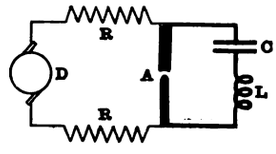

FIG. 9.—DUDDELL MUSICAL ARC.

spite of some attempts, the difficulties of making and driving a high-frequency and high-potential alternator, of any considerable output, say 10 kw. size, have not yet been overcome. Even if we could secure a frequency of 50,000 this corresponds to a wave of 4 miles in length, and special antenna arrangements are necessary to radiate and receive such waves. Hence the alternator method of electric wave production will certainly not supersede the spark method, although in some cases it may be practicable and useful.

In the next place, we have the electric arc method to which so much attention has lately been directed, employing a continuous-current arc with a condenser and inductance placed in series across the terminals of the arc. As in many other cases, the seeds of this invention were sown in the form of discoveries by several workers. In July, 1892, Prof. Elihu Thomson filed a United States patent, No, 500,630, in which he proposed a method for creating high-frequency alternating currents by connecting a condenser and inductance to a pair of spark balls, and this spark-gap was also connected through two other inductances with a source of continuous-current supply such as a storage battery or dynamo (*see* Fig. 8). An air blast or magnetic field was employed to continually extinguish the continuous-current arc formed. The operation of the arrangement was thought to be as follows: When the arc is blown out or before it is formed the condenser is charged by the dynamo.† When the arc is re-established the condenser is discharged with oscillations. In the above specification nothing is said about the use of a continuous-current arc between carbon poles, but Prof. Thomson asserts that oscillations with frequency up to 50,000 could

* A Friday Evening Discourse delivered at the Royal Institution of Great Britain, Friday, May 24, 1907.

† An interesting and not very dissimilar device has recently been described by Mr. S. G. Brown; he employs a revolving aluminium wheel against which a copper spring presses lightly. The spring and wheel are connected through an inductance and resistance with a source of direct-current supply and also by a circuit consisting of a Leyden jar in series with a coil of wire. When the wheel revolves an arc is formed at the loose contact and high-frequency oscillations are set up in the Leyden jar circuit (see *The Electrician*, November 23, 1906, Vol. LVIII., p. 201).

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be obtained. In 1900 Mr. Duddell showed that, if a suitable condenser and inductance was shunted across the poles of a continuous-current arc formed with solid carbons, high-frequency alternating currents were set up in the condenser circuit and the arc emitted a musical sound (*see* Fig. 9). Much discussion subsequently took place as to the causes of the effect and as to the highest frequency of oscillation it was possible to secure by this method. Duddell and others based their explanation of the phenomenon upon the known fact that a small decrease in the current through the carbon arc is accompanied by an increase in the P.D. of the carbons. The continuous arc with solid carbons was said, therefore, to have a negative resistance.*

The explanation of the manner in which the continuous-current arc maintains undamped oscillations in the condenser circuit is then as follows. If a condenser and inductance are shunted across the arc, the condenser begins to be charged, and this robs the arc of some current. This change, however, raises the P.D. of the carbon poles, and the charging of the condenser, therefore, continues When the condenser is full the arc current is again steady. The condenser then begins to discharge back through it, and this increases the current through the arc and, therefore, decreases the P.D. of the carbons. The condenser, therefore, continues to discharge. The action resembles that by which the vibrations of the column of air in an organ pipe controls the behaviour of the jet of air from the mouth which impinges against its lip, forcing the jet of air alternately into and outside the organ pipe and so maintaining stationary oscillations in it. The jet of air from the mouth of the pipe corresponds to the continuous-current arc, the closed or open pipe associated with it is a resonant circuit and corresponds with the condenser and inductance.

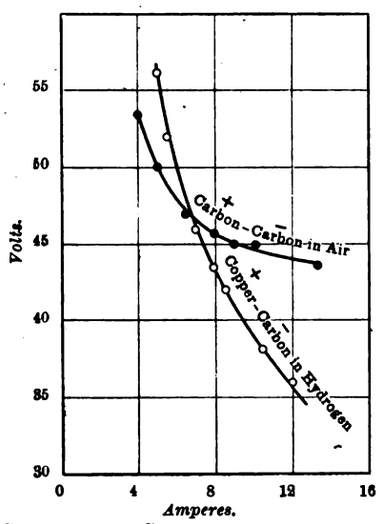

FIG. 10.—CHARACTERISTIC CURVES FOR CONTINUOUS-CURRENT ARC IN AIR AND HYDROGEN (UPSON). Arc length = 1·25 mm.

Consider the state when the oscillations have been set up in the condenser circuit. We must assume that there is a stream of electrons from the negative terminal of the arc making their way across the interspace to the positive terminal. If, then, we consider the state at the instant when the condenser has reversed its charge so that the coating connected to the negative arc terminal is positively charged, we see that there is a tendency for the stream of electrons to enter the condenser and supply the deficiency represented by the positive charge on that plate. They are, so to speak, sucked into the condenser. Accordingly this action either annuls or reduces the current in the arc. When the condenser is charged to the P.D. then existing between the terminals of the arc no more electrons enter it, and they then all travel across the arc. This increase in the arc current is accompanied by a fall in the electronic density difference or the P.D. of the arc terminals and the condenser then begins to discharge across the arc and still more reduces this P.D. Owing to the inductance in series with the condenser, or, in other words, in consequence of the kinetic energy of the moving electrons, the condenser is not only discharged but charged up again in the opposite direction.† It parts with the excess of electrons forming the negative charge on its plate in connection with the negative arc terminal, and that plate is left with a deficiency of electrons, that is, with a positive charge. Then the process repeats itself over again. Two conditions seem necessary for the automatic continuance of this process. First, the arc must be formed between terminals of such nature and in such surroundings that rapid variations of current through it must cause correspondingly rapid and large changes in the P.D. of the terminals in an inverse sense, that is, as H. T. Simon has shown, there must be a steep falling characteristic curve for the arc* Secondly, the arc must have the power of re-starting itself if entirely extinguished for a short time, but this should not take place until the P.D. between the terminals exceeds a certain value—that is, it must not take place too easily or at too low a voltage. If the arc is formed between solid carbon terminals then it appears that these conditions are only fulfilled up to a certain frequency—that is, when employing a rather large capacity in the condenser circuit. We then obtain Mr. Duddell's musical or singing arc, which emits a sound because the rapid variations of current through the arc by varying the energy expended in it expand and contract the column of incandescent vapour forming the true arc, and therefore the layers of air next to the arc, and hence send out air waves which are heard as sound. Frequencies up to 10,000 or so are possible, although many physicists, such as Banti, Corbino, and also Maisel, contend that much higher frequencies can be obtained. In 1903, Mr. Poulsen introduced a further improvement. He found that by enclosing the arc in a vessel containing hydrogen or coal gas, and forming the arc between a cold metal terminal, which is the positive, and a large carbon terminal which is the negative, the arc being also traversed by a strong magnetic field, much higher oscillation frequencies could be obtained than with the double carbon arc in air (*see* Fig. 11).

He also found it an advantage to rotate the carbon terminal.

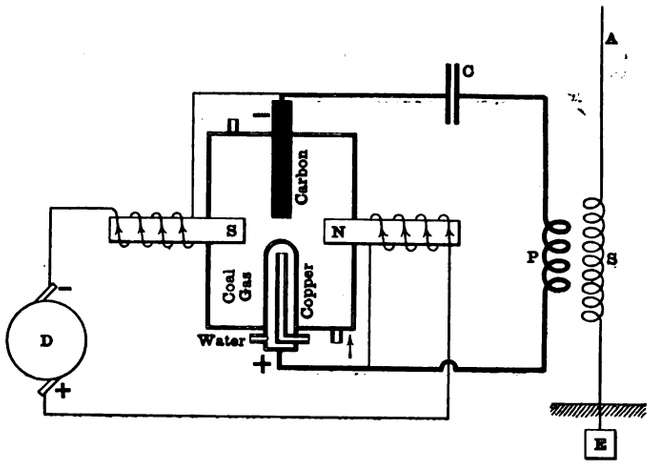

FIG 11.—POULSEN'S APPARATUS FOR CREATING UNDAMPED OSCILLATIONS.

When this arc is shunted by an appropriate small condenser in series with an inductance we can obtain in this last circuit electric oscillations having a frequency of a million or more, depending on the capacity and inductance used. If a suitably tuned antenna is connected to one terminal of this condenser, and one arc terminal to the earth, as shown in the diagram, we are able to radiate from the antenna undamped trains of electric waves. I have before me an apparatus of this kind with which much work has been done, in my laboratory, during the last few months. It consists of a water-jacketed brass cylinder with marble ends through which project at one end a thick carbon rod kept in rotation by a motor, and at the other, a water-cooled brass tube with copper beak on its extremity. An electric arc is formed with 400-500 volts between these terminals taking 6-10 amperes.

The terminals are connected by a sliding inductance and by a condenser. Then, in addition, a long helix of wire is connected to one terminal of the condenser. This helix is tuned to the condenser circuit and may be taken to represent the antenna when the apparatus is used in wireless telegraphy. If we start the arc, then high frequency oscillations are produced in the helix and by the

* The term negative resistance is a very inappropriate term. It is better to call the curve for an electric arc showing the relation of current through the arc to P.D. of the electrodes or poles the *characteristic curve* of that arc, following a usual nomenclature in connection with dynamos. This characteristic is a curve sloping downwards when the current is taken as abscissa and the P.D. as ordinate.

† The amplitude of the P.D. of the condenser terminals may and does become very much greater than the mere steady P.D. of the electrodes between which the arc is formed. Thus with a P.D. of 220 or 300 volts across the arc the R.M.S. of the condenser plate may reach 1,000 or 1,500 volts.

* A careful study of the phenomena of the electric arc between metal and metal and carbon terminals in air and hydrogen has recently been made in my laboratory, under my direction, by Mr. W. L. Upson. It has been found that for an arc taken between a cold metal and a carbon terminal in hydrogen for the same length of arc, the rate of decrease of terminal voltage with increase of current is always greater than for an arc in air between two carbon terminals; in other words, the volt-ampere characteristic is steeper (*see* Fig. 10). Also it has been found that in the case of a carbon arc in air the currents can be interrupted for a much longer time without permanently extinguishing the arc than is the case for the metal-carbon arc in air or hydrogen.

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action of resonance the potential at the free ends becomes large enough to create an electric brush discharge. There is, of course, a strong oscillatory electric field outside the helix, and vacuum tubes held there, particularly Neon tubes, glow brilliantly. It has been contended that these oscillations are undamped and continuous, but I can show you a simple experiment with a Neon tube which proves that they are not always uninterrupted. If I hold a Neon tube near the helix and move it rapidly to and fro you see a broad band of light due to persistence of vision, but this is cut up by dark lines and spaces. In the same manner, if a Neon tube is rotated near the helix it does not produce a uniform disc of light, but the disc presents the appearance of radial dark bands and bright spaces. The same effect is seen with a vacuum filled with any other gas provided the tube is sufficiently narrow in the bore. It appears to me that this proves incontestably that the oscillations are not uninterrupted but are cut up irregularly into groups of various lengths.*

To obtain these high-frequency oscillations the various contributory factors, strength of magnetic field, length of arc, supply of coal gas, have to be carefully adjusted with reference to the capacity and inductance used and the voltage on the arc. This discontinuity of the train of oscillations seems to depend to some degree upon a want of perfect regularity in the rotation of the carbon terminal. It may also be brought about by the energy transferred to the condenser circuit being radiated or dissipated faster than it is supplied.

No one who has worked practically with the apparatus can say that it is a simple and easy one to use. A very little want of exact adjustment causes the arc to be extinguished or else fluctuate greatly in current, and compared with the extremely simple appliances required for spark telegraphy the advantage in ease of working is largely on the side of the spark.

But we have to consider whether there are not counterbalancing advantages as a generator of telegraphic electric waves which make up for the increased difficulty of working and greater complexity of apparatus. The claim made for it is that if the transmitter produces undamped continuous oscillations these can be reduced to such small amplitude that they will not affect other neighbouring wireless non-syntonic receivers, even if only a little out to tune, but can by the cumulative effects of resonance actuate their own corresponding or exactly syntonised receiver at the same or a greater distance. This claim is based on the known fact that for certain types of receiving circuit the current created in them can be largely increased by increasing the number of oscillations in the incident train of waves, so that if oscillations or waves are undamped they can make up for feebleness by their persistency. This, however, depends essentially upon the nature of the receiving circuit, and is only true within certain limits.

When electric waves radiated from one antenna fall on another syntonised or tuned secondary circuit they set up oscillations in the latter of the same period. It might be thought that if these impinging waves are undamped we should have an infinitely large current produced in the secondary circuit. As a matter of fact we do not. The electromotive impulses from the sender only increase the secondary current up to a certain point. The secondary circuit necessarily possesses resistance and other sources of energy dissipation which rapidly increase with the current induced in it. Moreover, when the secondary circuit has an antenna attached, this itself radiates part of the energy it absorbs. Hence it follows that beyond a certain point the energy thrown on to the secondary circuit is no longer utilised to increase the current in it, but only just suffices to maintain it. The case is exactly analogous to that of a body being warmed by radiant heat. A thermometer exposed to full sunshine only rises to a certain height.

A comparison between the damped and undamped radiation to be valid must be made as follows. Assume that we have two wireless transmitting stations side by side, one sending out intermittent trains of feebly damped oscillations, the other continuous trains of undamped oscillations, and let them be so adjusted that the transmitters take the same mean power to work them. Let the frequency of these damped and undamped waves so radiated be the same. At a distance let there be a suitable movable receiving station—say a ship—with receiver tuned to the same frequency. Then the principal question at issue is, whether the undamped waves can affect this receiver at a greater distance than the damped waves of the same integral energy. Otherwise, at the same distance, can the undamped wave station affect the receiver when using less power than the damped wave station. Since, however, by assumption the undamped waves from one station have the same integral energy as the damped waves from the other, the latter will have a higher initial value in each train to compensate for their decreased value and intermittent cessation. Hence we may ask another question, viz., what will be their relative effect on receiving stations in their neighbourhood not quite in tune with the emitted waves. Can we bring the undamped waves nearer into tune with these outlander stations without disturbing the latter, than we can in the case of the damped waves, and if so, within what ratio of wave length? Claims have been made for a great superiority in this respect in the case of undamped waves, but we are still awaiting quantitative confirmation. Amongst other assertions it has been stated that the undamped waves are less easily "tapped," to use a newspaper expression. This is a fallacy. With proper experimental appliances a receiving circuit can be gradually adjusted to any electrical frequency, and when it comes to the right frequency it must be affected just as much as the true receiving station for which the waves are intended. It is all a matter of apparatus and skill. To illustrate the first point, viz., the effect of the nature of the receiving circuit, we may take an instance from optics. When we look through a telescope at the stars we can see a certain number down to some limiting magnitude. No amount of prolonged gazing when using the eye as a wave receiver increases the effect produced by a just invisible star. If, however, we use a photographic plate the effect on it is cumulative, and we can by a sufficiently long exposure obtain impressions of invisible stars in countless numbers. The photographic film is a wave detector of quite a different kind to the retina. In the case of the film it can make up by time what is wanting in intensity in the wave motion. In the case of wireless telegraphy it is clear, therefore, that the nature of the receiver has a great deal to do with the possible advantages of undamped waves, and it is not merely a question of the tuning or the transmitter,* Again the ordinary 10 in. induction coil and spark transmitter as used on ships takes up ½ H.P. when in full work, and can send wireless messages 200 miles or more when an appropriate receiver is used. I find it very difficult, if not impossible, to obtain sufficiently high-frequency oscillations by the arc method unless at least 1 H.P. or 1½ H.P. is being expended in the arc. Hence for short-distance work, on the point of economical working as well as simplicity of apparatus and ease of working, the spark method has advantages denied to the arc. We were told not long ago by an eminent electrician that the arc method of creating undamped waves sounded the death knell of spark telegraphy. It is always advisable to exercise some caution in issuing obituary notices of well-tried inventions prior to their actual decease, and in this case, although the power to create continuous trains of electric waves will doubtless greatly assist space telegraphy, it does not follow that their generation by the arc method is the best or final method.

In the production of continuous oscillations we are not limited to the arc method. Mr. Marconi has for some time past been engaged in developing an ingenious method of creating undamped electric waves for telegraphic purposes which involves neither an arc nor alternator, but is a new mechanical method of great simplicity.

This method is capable of producing astonishingly large alternating currents of very high frequency—in other words, so-called undamped or persistent oscillations. I have recently witnessed some of his experiments, and was surprised at the results obtained. Long distances have been telegraphically covered with every prospect of great efficiency. Unfortunately, the incomplete state of certain foreign patents prevents me from entering into details of this method now, but I hope he himself will be able to do so soon.

(To be continued.)

* Previous experimentalists seem to have been satisfied with examining in a revolving mirror the flaming arc or brush produced at the secondary terminals of a transformer, the primary of which forms the inductance in the condenser circuit, and finding the image drawn out into a band of light concluded that the oscillations were continuous. The Neon tube is a more delicate test and reveals the discontinuity mentioned above.

* In order that he may take the utmost advantange of the principle of resonance, Mr. Poulsen uses in the receiver a device he calls a "ticker." This serves to keep the condenser-inductance circuit of the receiver closed until resonance has exalted the oscillations to the utmost. The ticker then opens it at intervals and inserts the particular oscillation detector, whether electrolytic or other, which makes the audible or visible signal. In his syntonic receiver Mr. Marconi has always adopted a similar plan, for he keeps the coherer terminals joined by a condenser which closes the secondary circuit of the receiving jigger. A point of interest not yet considered is whether we do need absolutely undamped waves to gain all the possible practical advantages derivable from them. It may be that very slightly damped trains containing, say, 50 oscillations per train and following each other several hundred times per second will, with an appropriate receiver, give us all that we can obtain from the use of forced undamped waves.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.

"Drahtlose Telephonie." By Ernst Ruhmer. (Berlin: Ernst Ruhmer.)

"Das Problem der Schwingungserzeugung mit besonderer Berücksichtigung schneller elektrischer Schwingungen." By Dr. H. Barkhausen. (Leipzig: S. Hirzel.) 4m.

"Science Abstracts," May, 1907, Vol. X. Part 5. Section A—Physics. Section B—Electrical Engineering. (London: E. and F. N. Spon.) 1s. 6d. each.

"Proceedings of the Royal Society," Vol. LXXIX. No. B. 532. Series B—Biological Sciences. (London: Harrison & Sons.) 3s. 6d.

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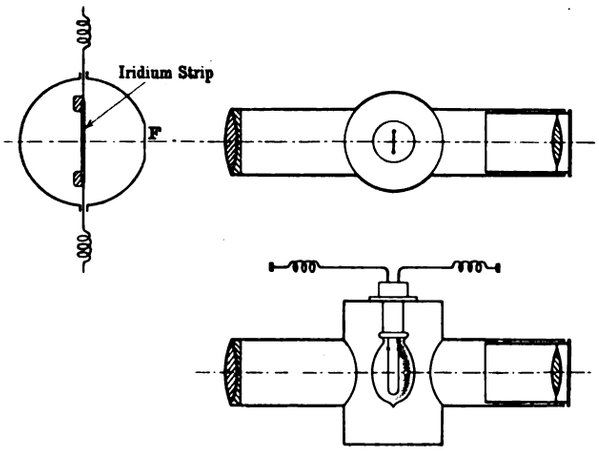
THE TEMPERATURE AND EMISSIVITY OF CARBON, OSMIUM, AND TUNGSTEN FILAMENTS.*

BY A. GRAU.

Many investigations have been made to determine the temperatures of carbon and metallic filaments. In 1892 H. F. Weber stated that the temperature of an ordinary carbon filament was between 1,565°C. and 1,580°C. Lombardi applied Weber's formula to osmium lamps, and found that at 1·5 watts per Hefner candle-power the temperature was 1,435°C. (See the *Elektrotechnische Zeitschrift*, p. 41, 1904.) Bailey ascribed the efficiency of the osmium lamp to its higher temperature. (See *The Electrician*, Vol. LII., p. 646, 1904.) Lummer and Pringsheim, by bolometric methods, have fixed the temperature of a carbon filament, taking 3 watts per Hefner candle-power, at something between 1,602°C. and 1,827°C., and of a Nernst lamp at 1,927°C.-2,177°C. (See *Verhandlungen der Deutschen Phys. Ges.*, Vol. I., 1899.) Nernst has published figures relating to the emissivity of his lamp at different temperatures in the *Phys. Zeitschrift*, p. 881, 1906. Hartmann, by means of the thermopile, arrives at lower figures for the Nernst lamp, and concludes that its temperature lies between 1,505°C. and 1,535°C. (See *The Electrician*, Vol. LVII., p. 579, 1906.) Waidner and Burgess give a "black" temperature of 1,860°C. to a carbon filament taking 3 watts per candle-power and 2,135°C. to a tungsten lamp taking 1 watt per candle-power. (See the *Electrical World*, Vol. XLVIII., p. 915, 1906.) It will, therefore, be obvious that further tests are necessary before any definite conclusions can be reached.

For the purposes of the following experiments filaments of carbon, osmium and tungsten were prepared by Kremenetsky & Co. and by the Auer-Osmium Co., the lengths and diameters of the various filaments being very exactly determined. The work was carried out, in so far as the figures relating to temperature are concerned, before the publication of the results obtained by Waidner and Burgess, and as the conclusions do not altogether agree with theirs, they may be of some interest. The filaments were as follows, viz. :—(1) A_2, a carbon filament, 155 mm. long and 0·1 mm. in diameter; (2) A_3, a tungsten filament, 136 mm. long and diameter 0·0932 mm.; (3) A_4, a tungsten filament, 136 mm. long and diameter 0·08 mm.; and (4) A_5, an osmium filament, 136 mm. long and 0·115 mm. in diameter. The temperature of the filament is found by means of a Wanner pyrometer, which was previously calibrated by means of a "black" body. This was done by means of a strip of iridium, which is heated by passing a current. The "black" temperature of the iridium strip is therefore known under given conditions, and is the temperature which a "black" body would have, emitting the same radiation. The iridium strip is shown in Fig. 1 at I, and is observed through an opening, F, by an instrument similar to a Kurlbaum pyrometer. This consists of a telescope with a cylindrical cross-piece in the middle. The cross-piece has a cover which can be removed in order to receive the lamp to be tested. The lamp filament is seen as a dark line against the bright background formed by the iridium strip. The current through the filament is then adjusted till it disappears against its background. The filament will then be at the same temperature as the iridium strip, and this can be measured by means of the Wanner pyrometer. At the higher temperatures a red screen was used for determining the exact moment of disappearance. The following tables show the results of the measurements.



* Abstracted from the *Elektrotechnik und Maschinenbau*, April 14, 1907.

"Black" temperature in degrees centigrade.	Current in amperes.	Volts.	Watts.
	Carbon Filament. A_2.		
1230	0·1580	57·5	9·085
1340	0·1823	58·0	10·573
1420	0·2020	64·5	13·029
1534	0·2409	77·0	18·549
1675	0·2790	89·0	24·831
1762	0·3440	111·0	38·184
	Tungsten Lamp. A_3.		
1208	0·9379	4·40	4·127
1334	1·0844	5·75	6·235
1410	1·1948	6·60	7·886
1524	1·3897	8·40	11·673
1675	1·6222	10·95	17·762
1762	1·8180	13·00	23·634
	Tungsten Lamp. A_4.		
1208	0·8184	4·50	3·6828
1340	0·970	6·00	5·82
1420	1·0736	7·00	7·515
1534	1·2397	8·85	10·971
1675	1·4111	11·00	15·522
1762	1·6325	13·55	22·120
	Osmium Lamp. A_5.		
1200	0·9844	4·70	4·627
1310	1·1370	5·91	6·720
1400	1·2816	7·18	9·202
1524	1·5110	9·22	13·931
1657	1·7440	11·45	19·969
1762	2·0068	14·30	28·697
1850	2·2400	17·40	38·98

Further tests were made to find the candle-power and the watts per candle-power at various temperatures. From the known dimensions of the filaments their "longitudinal cross-section" (*i.e.*, the apparent illuminated area, as seen by the observer) can be calculated, and from this we can deduce the emissivity at any temperature in Hefner candle-power per square millimetre of apparent cross-section for the different substances. The following tables summarise these results :—

"Black" temperature in degrees centigrade.	Current in amperes.	Volts.	Watts.	Hefner c.p.	Watts per c.p.	Hefner c.p. per sq. mm. of longitudinal cross-section.
			Carbon Lamp. A_2.			
1230	0·1580	57·5	9·085	0·2473	36·73	0·0159
1340	0·1823	58·0	10·572	0·6209	17·03	0·04000
1420	0·2020	64·5	13·029	1·257	10·36	0·081
1534	0·2409	77·0	18·549	3·121	5·943	0·201
1675	0·2790	89·0	24·831	6·815	3·643	0·439
1762	0·3440	111·0	38·184	23·69	1·61	1·52
			Tungsten Lamp. A_3.			
1208	0·9379	4·40	4·127	0·1428	28·91	0·01116
1334	1·0844	5·75	6·235	0·5304	11·76	0·0418
1410	1·1948	6·60	7·886	1·000	7·886	0·0788
1524	1·3897	8·40	11·673	2·882	4·05	0·227
1675	1·6222	10·95	17·762	8·477	2·095	0·669
1762	1·818	13·00	23·634	16·90	1·39	1·333
			Tungsten Lamp. A_4.			
1208	0 8184	4·50	3·683	0·1199	30·72	0·0110
1340	0·970	6·00	5·82	0·5122	11·36	0·0470
1420	1·0736	7·00	7·515	1·059	7·097	0·0974
1534	1·2397	8·85	10·971	2·864	3·830	0·263
1675	1·4111	11·00	15·522	7·182	2·161	0·660
1762	1 6325	13·55	22·120	17·60	1·28	1·59
			Osmium Lamp. A_5.			
1200	0·9844	4·70	4·627	0·16	28·91	0·0102
1310	1·1370	5·91	6·720	0·5304	12·67	0·0339
1400	1·2816	7·18	9·202	1·059	8·69	0·0677
1524	1·5110	9·22	13·931	3·384	4·11	0·216
1657	1·7440	11·45	19·969	8·517	2·34	0·544
1762	2·0068	14·30	28·697	20·03	1·43	1·28
1850	2·2400	17·40	38·98	35·70	1·09	2·28

If curves are constructed for each of the four lamps with the watts per candle-power as abscissæ and the corresponding temperatures as ordinates, the curves for the metallic filaments practically coincide; but the curve for the carbon lamp lies above them, showing that at a given temperature the efficiency of the metallic lamp is greater than that for carbon. The two curves, however, approach one another towards their upper extremity, and all the efficiencies are probably the same at a temperature which is between 1,800°C. and 1,850°C. After this point the efficiency of the carbon lamp

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becomes greater than that for tungsten, but at these temperatures instability sets in. The curves show that with a carbon filament the temperature of 1,660°C. corresponds to 3 watts per Hefner candle-power, and this agrees well with the result obtained by Lummer and Pringsheim. With tungsten a temperature of 1,850 deg. corresponds to 1 watt per candle-power. From this it appears that the greater efficiency of the tungsten lamp is due to its higher temperature. Lummer and Kurlbaum have stated the law connecting temperature and candle-power as follows—viz.,

$$\frac{\phi_1}{\phi_2} = \left(\frac{T_1}{T_2}\right)^x,$$

where ϕ_1 and ϕ_2 are the candle-powers corresponding to temperatures T_1 and T_2, and x is equal to 12 for temperatures above 1,900 deg. absolute. Let us suppose that the same amount of energy is consumed by a tungsten filament at 1,850°C., or 2,123 deg. absolute temperature, and in a carbon filament at 1,660°C. or 1,933 deg. absolute. From the above tests we see that the light emitted by the tungsten lamp is three times that of the carbon filament. By Lummer and Kurlbaum's law the ratio should be $\left(\frac{2,123}{1,933}\right)^{12}$—*i.e.*, 3·07. This seems to show that the figures obtained under test agree well with the results of theoretical calculations.

CORRESPONDENCE.

CORRUGATIONS IN TRAMWAY RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to "Road Inspector's" letter, when I said I believed the Overhead Railway was centrally driven I meant I was not certain. However, as it is end driven, I presume the conditions are somewhat similar to tramways, and I gave my ideas on the subject in my first letter. He also says by observation he finds that the inner wheel holds to the rail and the outer one does all the slipping and skidding. I think, if he reads my letter again (pp. 190-1), he will find that that is exactly what I said. I also said in that letter, "In curves of shorter radius the slips and relief must take place at shorter intervals," which statement perhaps needs an explanation, as the whole question of pitch is dependent thereon, and I believe my theory reduces the matter of pitch of corrugations, in some instances, to a matter of simple calculation. I have measured the pitch to about 2¼ in. on a radius which was, as near as I could make out, 160 ft., which works out to 5,409 corrugations for the complete circle, and as the difference in length between the inner and outer rails for this (or any other) radius is for standard gauge, 29 ft. 9 in., say 30 ft., it follows that the outer wheels of the cars must slip 0·065 in. per corrugation, which means that the average of the car frames and axles allows the strain to accumulate until the part of the outer wheel in contact with the tread of the rail is 0·065 in. behind its normal position, when it suddenly forces relief by causing the outer wheel to skid forward. (I am assuming in this instance that the pitch has already got marked out, as I hold that what will increase corrugations is also responsible for their formation.)

If we now imagine a series of level concentric circles of rails from 50 ft. radius upwards, and a car, the framework and axle of which when empty admits of this 0·065 in. strain before forcing relief by skid, this figure may be looked on as a constant for this car whichever circle it is on. At 160 ft. radius my measurement shows that it favours a corrugation of 2¼ in pitch; at 150 ft. radius, nearly 2⅛ in.; at 80 ft. (the outer wheel having the same 30 ft. to gain) the 0·065 in. will accumulate in 1¼ in.; at 50 ft. it would favour ⅝ in. pitch; at 960 ft. radius it would favour 13½ in. pitch. The two shorter pitches mentioned, ⅝ in. and 1¼ in., are merely hypothetical, as the diameter of the car wheels in use is such that they would bridge any corrugations formed, and so prevent their formation, which accounts for their non-appearance below 150 ft. radius, the diameter of the wheel, in conjunction with the factor 0·065 in., fixing these minima of radius and pitch. This bridging only applies to the tread of the rail and not to the gauge edge, which accounts for the behaviour of the manganese rails under "Road Inspector's" observation. As for the 13½ in. pitch mentioned above, it would remain hypothetical but that some other factor, which I shall mention later, comes in to shorten the pitch before any corrugation can form at that radius.

I account for the erratic nature of the appearance or non-appearance of corrugations under apparently similar conditions by the various makes and classes of car running on one system having strengths of undercarriage and axles which vary this factor 0·065; say some of the cars have stronger frames and axles and reduce this factor by, say, 25 per cent., and other weaker ones which increase it by a similar amount, and the hypothetical pitch favoured by the various cars on 160 ft. radius are for the strongest 1¾ in., medium 2¼ in., and weakest 2¾ in. If these various pitches were plotted out on a yard of rail it would seem almost impossible for them to get into step, which they must do by striking an average before corrugation can be formed, and once this average is marked out the different cars can adapt themselves to it (within limits); thus it would appear that a system running all the same kind of car favours corrugation and vice versa.

If in the above instance of circles of rails my suggested remedy in the shape of stronger under carriage and axles be applied sufficiently to reduce the factor 0·065 to, say, one half, which whilst doubling the number of corrugations per complete circle, would shorten the pitch (hypothetic and actual) by one-half, with the result that the minimum possible pitch before (viz., 2⅛ on the 150) would be at once moved outwards to the 300 ft. radius circle; thus at one stroke corrugations would be banished on 300 ft. and below, as they are now below 150 ft. But the benefit would not end there, as it will be noticed that from 300 ft. outwards the various corrugations must form on half the amount of slip they had before, or not form at all; the latter, I suggest, is the most probable result. I believe that if car frames and axles were strengthened sufficiently to reduce the factor 0·065 by one-half, corrugations would no longer be formed.

By the process of repeatedly halving the factor 0·065 the minimum corrugating radius will recede outward to 600 ft. to 1,200 ft., &c., so that by the time the factor had disappeared, which it would with absolute rigidity of frame and axle, the minimum corrugating circle would have receded practically to a straight line.

I believe, in this problem, prevention is much easier than cure, and I think there are miles of rail in use which do not corrugate, but if the correct pitch were marked out by a smooth file, it would immediately cause the various cars to get into step and form corrugations. The commencing is a kind of stumbling block which prevents much corrugation.

The above circles were, for simplicity, assumed to be on a level plane, but the conditions are vastly different if we assume the plane to be inclined, which we will now do, and also imagine the circles marked 1 to 12 like the face of a watch, and the inclination from 6 to 12, about the same as the steep-gradients cars have to ascend. I think it may be taken for granted that any slip caused either by accleration or ascending an incline shortens pitch, either hypothetical or actual. I say slip is positive when a car is ascending a steep incline, and negative as when brakes are applied. The car when at 1 and 12 is on the level, and when at 9 (the steepest part of the incline) both wheels have a large amount of positive slip, as may be easily seen by any observer, so that in the case of the inner wheel from 6 to 9 there is a gradual increase from no slip to a large amount of positive slip, and in the case of the outer wheel there is at 6 the negative slip (at the rate of 30 ft. to the circle) due to the curve, but which, by the time it gets to 9, has changed over and become a large amount of positive slip. It therefore follows that there is an intermediate stage, where the outer wheel has no slip and therefore produces no corrugation. I should think this period is of short duration, and should locate it at about 7; this period may not be noticeable in practice owing to the variation of the factor 0·065 in different cars; with some cars it may begin one minute before 7 and finish at 7, whilst others may begin at 7 and finish one minute past. In any case, after this point is passed the slip of the outer wheel is of a positive nature, and brings about this important difference that before reaching it the outer wheel had to be

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pushed forward by the car-frame, and after passing it it begins to assist in pushing the car. Soon after this stage is passed the slip of both wheels becomes so excessive and so shortens the pitch that no corrugations can be formed, and by the time it reaches 9 the hypothetic pitch may be in the neighbourhood of $\frac{1}{16}$ in., and it gives out the grinding screech noticeable on steep curves. Thus it will be seen that between 7 and 8 the pitch of 13½ in. mentioned above would be so shortened by gradient slip as to be able to take the actual form of corrugation. When the outer wheel is subject to positive slip, I think the end drive and springy torque of the axle is mainly responsible for corrugation.

When ascending a steep curve the strain put on a car frame is enormous, and I think that although the cross bracings now in use may be sufficiently strong for the purpose they were intended, they are not strong enough to meet the strain under consideration when ascending a curved incline. Not only have the inner wheels to propel the whole weight of the car themselves, but have, by way of the car-frame (at arm's length, as it were), to push along the outer wheels, which are partially skidding, with half the weight of the car and load on them.

The factor 0·065 in. seems a small and intangible amount especially to have to reduce, and I do not suggest that this embraces the whole amount of distortion in the car frame and axle, but simply the periodic vibration when producing corrugations, but the question is, small though it is, can it be reduced by stronger frames and axles? A calculation shows that with a service of 300 cars per day this slip of 0·065 in. per corrugation amounts to 1,186 ft. per year.

"Road Inspector" says "something has to go"; he will see by this letter that I am not attempting to suppress curve slip entirely by main force, but merely to regulate it in such a way that it will continue to have the continuous slip it has on uncorrugated lines.—I am, &c.,

J. H. BRIGGS.

Leeds, June 4.

THE RADIO-TELEGRAPHIC CONVENTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: By those of us interested in radio-telegraphy in the United States, the proceedings before the Parliamentary Radio-Telegraph Committee, now appearing in your columns, are read with interest certainly, sometimes with astonishment, often with amusement.

Frankly it appears strange that a solemn parliamentary debate is possible on a proposition based on the rights of seafaring men to communicate with the first available wireless station regardless of what name-plate may be attached to the apparatus therein. The question savours of the Ecclesiastical rather than the Academical, and one needs to look twice at the calendar to be certain that the year is A.D. 1907.

There is little fear of the ultimate outcome of these thinly-veiled attempts of one corporation to bolster its divine right to monopoly by an unfair and inhuman policy of aloofness, after its frantic efforts to accomplish this result by its patents has signally failed.

After the great mass of evidence and opinions offered to the Parliamentary Committee, it is refreshing to read so concise and logical a presentation of the technical aspects of the situation as appears in part of Prof. Fleming's statement. He well points out the folly of too intimate and paternal a regulation of the *technical* operation of radio-apparatus by non-technical law makers, especially in an art so "half-baked" as this.

To the writer there is nothing more evident than the absolute necessity of early legislation defining the maximum limit of damping which can be permitted in any radio-telegraph station. This factor, damping, is of far more vital import than any regulation of wave-lengths. The damped half-tuned wave is an etheric pirate, and should be imperatively prohibited the world over. The time is not far distant when the operator who sends out a strongly-damped vibration of even the smallest energy will be subject to heavy fine.

Radio chaos will certainly be the result until such a stringent regulation is enforced. The day of the barbarous spark discharge is numbered, and the sooner it is classed with the filings coherer the better for all concerned.

Not until then can any legislation or intelligent and skilled syntonisation prevent woeful interferences, however unintentional. Limit all wireless communication to the sustained oscillation methods, and there will be ample gamuts of wave-length to "go around." The bugbear of interference and nine-tenths of the palaver of Parliamentary Committees and International Conventions will be quite inexcusable.

The ubiquitous amateur with his high-school Ruhmkorf coil, the operator of the "brute force and ignorance" wireless school, must, like Alice's guinea-pig, *be suppressed*.

This surely necessitates certain "bureaucratic regulations" which Prof. Fleming deplores, and there is no one who really desires to further the safety and comfort of the sea-faring man but will prefer this method to the autocratic and stiff-necked selfishness which seeks to isolate Great Britain from the sisterhood of nations, simply to maintain in monopoly an archaic system whose patents have themselves proven too weak to keep back the march of progress.—I am, &c.,

New York, May 24. LEE DE FOREST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to your report of the proceedings of the Select Committee on the Radio-Telegraph Convention at their sitting on May 28th, and published in your issue of May 31st, in which Mr. Charles Bright is reported as having made the following statement (top of p. 278, second column):—

"With regard to the voluntary statement made by Mr. Henniker Heaton that he had always refused directorships in telegraph companies, the fact that he had served on the board of the original Marconi Company had probably slipped his memory. This fact would have some interest in view of his evidence before the Committee."

I shall be much obliged if you will give publicity to the fact that the above statement is not correct. Mr. Henniker Heaton was nominated to a seat on the board of the original Marconi Company, but declined to serve. He was abroad when the nomination was made, and on hearing of it positively declined the seat which had been offered him.—I am, &c., MARCONI'S WIRELESS TELEGRAPH CO. (LTD).

H. Cuthbert Hall, Managing Director.

London, June 5.

THE SPEED OF FLICKER PHOTOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with very great interest Mr. Dow's article in to-day's issue of your paper on the speed of flicker photometers. Mr. Dow deserves great credit for having carried out these experiments, which I know from personal experience are not to be lightly undertaken. Mr. Dow's figures will be particularly useful to me, as his tests were carried out on a photometer of the general form which I have devised.

I note that Mr. Dow finds that this form of flicker photometer is somewhat less sensitive than the Lummer when used on lights of the same colour. I find that the sensitiveness of my photometers varies very much with the exact form in which they are made up, the preparation of the disc being the most important factor.

I shall be shortly having placed upon the market a form of my photometer which I think will be found even more sensitive than the Lummer. The photometer will also be completely reversible and perfectly free from angularity errors, and as also the disc will be non-fragile and easily cleaned, the photometer will be practically fool-proof.—I am, &c.,

Westminster, May 31. LANCELOT W. WILD.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

Yesterday (Thursday) there was a private sitting of the Select Committee of the House of Commons appointed to consider the question of the ratification of the Convention agreed upon at the Wireless Telegraph Conference at Berlin last year. The meeting was for the consideration of the draft of the Committee's report submitted by the chairman (Sir John Dickson-Poynder). No further public announcement will be made with regard to this matter until after the report has been presented to the House of Commons.

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L.C.C. Electric Supply Bill.—The Hybrid Committee which will deal with this Bill has now been constituted. The House has selected the following: Sir A. Spicer and Messrs. Howell Davies, Joseph Nolan, W. W. Rutherford and D. A. Thomas. To these the following members have been added by the Committee of Selection: Sir Philip Muntz, Major Renton and Messrs. John Ward and A. E. Dunn.

Patents and Designs Bill.—This Bill, as amended, has been reported to the House.

LEGAL INTELLIGENCE.

Electrical Power Storage Co. (Ltd.) v. Patent Exploitation (Ltd.)

The House of Lords gave judgment on May 29 in this appeal of plaintiffs from an order of the Court of Appeal reversing a judgment of Mr. Justice Joyce. The facts of the case were given in *The Electrician* for March 27, 1906, and the judgment of the Court of Appeal appeared in *The Electrician* for July 13, 1906.

The LORD CHANCELLOR, in moving that the appeal be allowed, said it was only after much consideration that he had arrived at the same conclusion as had Mr. Justice Joyce. The only point was whether, under the terms of an agreement contained in letters, the appellants could claim a share of damages recovered from Siemens Bros. & Co. by respondents in an action for infringement of letters patent. Respondents owned and controlled a certain patent, and appellants held from them an exclusive licence for working the patent in the United Kingdom. The question was, to whom did the damages in this matter belong? The appellants claim one half, after all costs were provided for. It was common ground that appellants contributed £250 towards the costs, and that the respondents had to find all costs beyond that, and were alone liable to pay costs to Messrs. Siemens Bros. in the event of failure. Also the respondents were under terms to prosecute the action up to judgment in the Court of first instance. But they were free to act as they pleased in regard to appealing or resisting an appeal. So far all was clear. The difficulty arose in regard to the disposition of the balance of damages after all costs had been met. The two letters of May 6 and May 7, 1901 (containing the agreement between the parties) were not precisely worded, but in his lordship's opinion the words "the agreement does not refer in any way to the Court of Appeal or to the Supreme Court in case the action is brought up to these Courts," when taken in their context, preferably meant no more than that respondents were not bound to prosecute an appeal in those higher Courts, or to resist such an appeal. But they might be read to mean that for all purposes of the agreement those higher Courts were to be treated as if they did not exist. It might fairly be presumed that the parties mean to enter into a commercial agreement, and not merely to make a wager. He thought that the agreement really came to this—appellants gave £250 and stipulated that the case should be prosecuted at least up to the decision of one judge. Respondents were to find all the remaining costs and in return had the sole voice in deciding whether there should be an appeal or not, or whether, if the adverrary appealed, the appeal should or should not be resisted. Whatever damages might be recovered were to be equally divided after paying all costs. He believed that was what the parties to this agreement intended, and he thought that they had expressed that intention.

Lord ASHBOURNE read a long judgment in which he said he regretted that he could not concur with the view expressed by the Lord Chancellor. It seemed to him that the view of the bargain taken by the Court of Appeal was correct and that the appeal should be dismissed.

Lord JAMES OF HEREFORD agreed with Lord Ashbourne.

Lord ROBERTSON and Lord COLLINS concurred in the opinion expressed by the Lord Chancellor.

By a majority of 3 to 2, therefore, the appeal was allowed, with costs.

Assessment of Electricity Undertakings.

In the Outer House of the Court of Session, Edinburgh (before Lord Dundas) on Tuesday, Edinburgh Town Council sought to interdict Edinburgh Parish Council and their collector from recovering poor and school rates upon the valuation of the city's electric lighting undertaking. Deductions amounting to 62 per cent. are claimed from the valuation (£61,923) by the Town Council under Sec. 37 of the Poor Law Act 1845, for repairs and other expenditure upon the undertaking. The Parish Council propose an allowance of 24 per cent. The main question is whether in calculating the deductions to be allowed the Town Council are entitled in striking the "probable average cost" of such repairs and expenses, to take into account the probable cost of these in future years, or whether they are limited to the annual average of the sums actually expended.

Reduction of Capital.—On Tuesday Mr. Justice Kekewich heard a petition by Willans & Robinson (Ltd.) for sanction to reduce the capital by £335,000, which was unrepresented by available assets. The reduction was sanctioned.

United States Exports.—The value of electrical instruments exported from the port of New York in 1906 is given at £1,216,000, compared with £845,000 in 1905, and for electrical machinery £948,000, compared with £707,000.

HAMMERSMITH L.G.B. INQUIRY.

A long and instructive Local Government Board inquiry is at present beingheld into certain matters connected with the erection, equipment, and furnishing of the Hammersmith Infirmary and Workhouse at Wormwood Scrubs, London, W., and the name of Mr. James Enright, B.Sc., M.I.E.E. (of J. & J. S. Enright, consulting engineers), has been mentioned in connection with the electric lighting and power arrangements of the building.

In the course of the inquiry attention was chiefly directed to the excess of the actual over the estimated expenditure in connection with these services, to the alleged excessive number of lights installed, to the heavy expenditure in connection with the machinery and apparatus used in transforming electrical energy, to the system of double wiring adopted, to the manner in which certain parts of the work had been carried out, to certain discrepancies betwen the quantity of material, &c., supplied, and to alleged lack of supervision exercised.

In regard to the several matters with which Mr. Enright was concerned, that gentleman prepared a statement (in reply to a report by Mr. H. R. Hooper, an inspector of the L.G. Board), which statement was presented at the adjourned inquiry on May 29.

Mr. Hooper's Report to the L.G. Board.

In March last Mr. H. R. Hooper conducted an investigation in respect of the electric lighting at the workhouse and infirmary, and made a report to Mr. J. S. Davy, C.B., chief general inspector to the L.G. Board. In this report Mr. Hooper states that he examined the system of electric lighting installed in the building, and points out that the original estimate provided £2,500 for the wiring only of the building under agreement with the consulting engineers (Messrs. J. & J. S. Enright), to whom a commission of 4½ per cent. was to be paid for their consulting and supervision work, with some other allowances provided for. For the two separate sections of the electrical work: (i.) cable, switchboards, wiring, lamps, &c., for a complete system of lighting; (ii.) cable, switchboards, motor-generators, battery, &c., for power supply, the L.G.B. was asked to sanction tenders amounting to £8,761. 12s. 6d. This the Board declined to do, and referred the matter back to the Guardians, who had, it was stated, prepared a more moderate scheme, amounting to £5,641, which was agreed to by the L.G.B. on June 16, 1905. It appears from a report that at August, 1906, there had been an increase on this estimate of £1,362. 12s. 4d., and this has since (Mr. Hooper believes) been further increased. The L.G. Board, in view of this excess expenditure, decided to obtain two independent opinions, and these were received (*a*) from Mr. M. S. Chambers (Messrs. Preece & Cardew) and (*b*) from Mr. A. Gough (Messrs. John Barker & Co.). The points considered were:—

1. Is the system installed a reasonably economical one?
2. Is the price charged for the work as a whole an excessive one?
3. Have the details of the work been satisfactorily carried out?
4. Has the work been properly supervised, and should the excess now applied for be sanctioned without further explanation?
5. Are any alterations desirable, and is it necessary to incur further expenditure.

On item 1, Mr. Hooper points out that the engineer (Mr. Enright) has installed a double system of wiring—*i.e.*, a "day" and "night" installation throughout the whole of the buildings, embodying cables leading from the central switchboard to every distribution board, and from every such board duplicate wiring through every passage and block in the workhouse and infirmary, providing always an alternative system of wiring in the event of breakdown. Mr. Hooper reports on this item that the work was wholly unnecessary and a needless expense.

On item 2, the report states that, taking the whole of the account rendered, viz., £7,240, the items for special fittings (£683), moving the plant (£317), sundry extras (£434), power supply (£1,061, the tendered price not being included in the architect's estimate of £2,345), he regards this balance excess as representing the approximate cost of duplicating the system. He considers the extras charged by the contractors unreasonably high, but that the amount tendered (£4,580) was probably too low for the amount of work required to be done.

On item 3, the report states that the number of lamps supplied is excessive, both inside and outside the buildings, and many other items in the specification are considered by Mr. Hooper to be either in excess of the needs of the work or wholly unnecessary.

On item 4, the report is to the effect that the general wiring throughout the buildings is neat and well arranged, but that the cables in the subways present many indications of want of proper supervision. Mr. Gough, in his report, states that there appear to be overcharges in the amount of cable used to the extent of £72. 7s.

In regard to item 5, certain alterations, some of an important character, are considered desirable, involving some expenditure.

Mr. Enright's Statement.

In the statement presented by Mr. James Enright, as above mentioned, in answer to the report by Mr. Hooper, he points to the nature of his original instructions, and refers to the correspondence which passed between himself and the Guardians in regard to the work which they (the Guardians) required to be done. Mr. Enright particularly points out that in certain matters regarding which he was in correspondence with the Guardians his views were overruled, and, his advice on these points being rejected, his firm decided to act strictly on the Guardians' instructions. In order that the heavy cost of some of the work required by the Guardians to be done against the advice of the engineers should be made clear, the engineers divided the specification into two sections with two forms of tender, and in considering the tenders

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submitted special attention was, they allege, called to the unnecessary expense involved in the adoption of transformer plant. To some extent the engineers' objection in this matter was successful, and £1,000 was saved on this tender.

Mr. Enright proceeds to describe the progress of the negotiations, and his statement is designed to establish the contention that it was rather to the instructions of the Guardians than upon his advice that much of the work was carried through. On the whole, he considers the work was done cheaply and well, though the schedules were not in order and the schedule prices were high. With regard to the alleged excessive number of lights, Mr. Enright states that the Guardians settled the number and position of these lights, and he is under the impression that the L.G. Board approved the number. He regards the number of outside lights as not excessive in the circumstances. The statement made during the inquiry that five incandescent lamps had been provided per inmate, Mr. Enright says is misleading, and he urges that statistics of the kind are useless from the fact that a large staff has to be considered and provided for. Referring particularly to the item of £317 mentioned in Mr. Hooper's report as the cost of moving the transforming plant, Mr. Enright points out that several times verbally, and once by letter, he asked that the room to which the plant was ultimately removed might be utilised, but permission was refused.

Mr. Enright mentions a number of items in the ultimate account upon which his firm were not consulted, and for which he contends the Guardians must take the sole responsibility. He points out that the accepted tender for wiring was £4,580, and this amount was sanctioned by the L.G. Board. The extras which his firm are responsible for amount to £248. 16s. 4½d., including £206. 6s. 11½d. for cutting away and making good. The cost of the work ordered by the Guardians, either without or against Mr. Enright's advice, is put at £2,102. 15s. 9d. Mr. Enright points out that he has been blamed for installing steam and electricity in the laundries and for other items, but as these are all matters with which the architect alone had to do they are not items for which he should be censured.

Finally, Mr. Enright controverts Mr. Hooper's statement and findings in many respects, and contends that they are based upon the architect's, and not upon the consulting engineers', figures and statements. If the extra works, for which the Guardians are, Mr. Enright affirms, wholly responsible, are deducted from the total cost, the excess expenditure is small. He considers that the expenditure on the two-circuit system of wiring is, considering the nature of the entire installation, fully warranted. If the system is properly managed it is a source of economy. It has been proved of practical use at Islington Infirmary, at Brook Hospital, at Hendon Asylum, at Burghill, at Claybury Asylum, at Tooting Bec and at many other similar institutions. The cost of wiring Hammersmith compares, he contended, favourably with similar establishments, the actual cost of the wiring, including fittings and main cables, for the engineers' scheme being £4,828. 16s. 4½d., or £2. 3s. 4d. per point. Prices for such work, Mr. Enright contends, frequently vary from £2. 15s. to £3 per point.

Magnetite Arc Lamps.—An account of the results obtained by the use of magnetite arc lamps at Harrisburg, Pa., is given in the *Canadian Electrical News*. The lamp, which has been recently introduced, is suitable only for outdoor use, and possesses for this purpose a number of advantages. A comparatively high efficiency is obtained, together with an improved distribution of the light, the colour of the latter being very white. The lamps are designed for operation on direct-current series circuits at 4 amperes and 75 to 80 volts. The lower electrode has a life of 140 to 160 hours, and the upper an estimated life of about 4,000 hours. As the position of the arc does not change as the lamp burns, the lamp has been designed with a small horizontal reflector of white enamelled iron placed inside the globe and close to the arc. From careful records kept by the Harrisburg Light, Heat & Power Co., the cost of maintaining the electrodes is 6s. 6d. per lamp per year. The repairs and renewals were abnormally high, for the reason that the company changed the entire outfit so as to use a new type of electrode, the old electrode having a rocker arrangement. This change brought the yearly cost of repairs and renewals up to about 8s. per lamp. With the equipment in the Harrisburg station it is found that, unless the full pressure of the machine is suddenly switched on so as to throw a sort of shock on to the line, all the lamps will not start. This is due to minute particles of magnetite getting between the electrodes and acting as insulators. By causing the lamp to flicker a number of times the arc is finally struck. It is necessary to use care in centring the electrode in the chimney, as at first much unsatisfactory operation was traced to this cause. The lamps are rather heavy, weighing about 50 lb. each, and are hung rather low. The reading distance, as compared with open or enclosed arc lamps, is increased one-third. The cost of maintenance is not so great, as with 761 lamps connected in circuit, only one man is required to trim all the lamps.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An experienced glass blower for chemical and physical apparatus is required. Preference to one with experience in working quartz with an oxy-hydrogen blowpipe. See an advertisement.

An advertisement in another column announces a vacancy for a pupil, without premium, in a company's d.c. station in the south-west of London.

A draughtsman is required with general experience of electric construction details and capable of calculating windings of continuous-current apparatus. Wages, 42s. per week. See an advertisement.

A transformer draughtsman is required for single and three-phase power transformers by Ferranti Limited, Hollinwood, Lancs. See an advertisement.

Messrs. Smith Bros., manufacturers of electrical goods, Gummersbach, Germany, require an English correspondent. See an advertisement.

Teachers of electric lighting and power distribution, physics, practical mathematics, machine drawing, &c., are wanted at Oldham Municipal Technical Schools. Application forms from the secretary.

A teacher of physics, magnetism and electricity and mathematics is wanted for Wakefield Technical School. Particulars from the secretary. Applications by June 15.

Acton Council require a charge engineer. Applications to Mr. J. Martin Blair, 130, Churchfield-road, Acton, by noon June 12.

Durban Corporation require a switchboard attendant. £240 per annum. Applications to Webster, Steel & Co., 5, East India-avenue, London, E.C., by June 11.

The directors of the Great Eastern Railway Co. have appointed Mr. H. W. Firth electrical engineer to the company. Up to the present Mr. Firth has been responsible (under the engineer to the company) for the electric lighting and power works, including the designing and carrying out of the Stratford power house (described in the present issue of *The Electrician*). Mr. Firth will also take over the telegraph department of the company.

Mr. David Smith, the assistant engineer at Tunbridge Wells, has been appointed resident engineer at the electricity works at £225 per annum, to be increased to £250 at the end of a year. This appointment is consequent upon the re-arrangement of the duties of the consulting engineer (Mr. Horace L T. Boot).

Mr. R. J. Strike, formerly mains engineer and technical assistant to Mr. Wm. Corin, prior to the resignation by the latter of the position of city electrical engineer at Launceston (Tasmania), has been appointed acting electrical engineer at £300 per annum, and Mr. Geo. McElwee has been appointed as sub-station and test-room electrician at £150. Mr. Corin continues as consulting electrical engineer to the municipality.

Accrington.—Mr. R. P. Wilson has been appointed Board of Trade arbitrator to ascertain the price to be paid by the Council for the undertaking of the existing tramway company.

Argentina.—The Telephone Service of the Union Telefonica Co. between Rosario and Buenos Ayres will shortly be inaugurated.

The Municipality of Fray Bentos are about to discuss a scheme of electricity supply.

The work of constructing the Lujan tramways has been commenced by the Compañia Transatlantica de Electricidad.

Aston.—On Wednesday the Council decided to apply for sanction to loans of £14,519 for giving a supply of electricity in the Erdington district and £3,000 for cable extensions and house services.

The balance sheet of the electricity department for the year ended March was presented and showed gross profit £6,612, against £4,692 in the previous year. After paying interest and sinking fund there was a net profit of £668, against a loss of £762.

The chairman of the Electricity committee (Mr. Godrich) said the business was progressing in a very satisfactory manner, and, in view of the progress made, he thought they would be able to show by next March a profit of from £2,000 to £3,000.

The various recommendations of the committee were adopted and the salary of the electrical engineer (Mr. Foster) was increased from £300 to £400 per annum.

Australasia.—The "Australian Mining Standard" says that Perth (W. A.) Corporation, which recently obtained power to purchase the undertaking of the local gas company, have failed to come to terms with the company, and have resolved, subject to the approval of the ratepayers, to establish independent municipal electricity works. The Corporation also resolved to advertise for a

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consulting engineer to prepare plans and specifications, and subsequently to act as manager at a salary of £800 per annum.

Mr. W. Thwaites, engineer-in-chief of the Melbourne and Metropolitan Board of Works, has placed before the Board a draft scheme, which he recommends the Board should obtain powers to execute.

The scheme includes the erection of hydro-electric works at Dight's Falls, the construction of electric tramways in the metropolitan municipalities, and the supply of electric energy for light and power to consumers in the Yarra Valley and to the metropolitan municipalities (or their ratepayers) in co-operation with Melbourne City Council. Mr. Thwaites is of opinion that electricity could by this means be supplied to large consumers at 1d. per unit and that, instead of the Melbourne tramways being worked, as at present, from 11 stations, it would be more economical to work them from his proposed station alone, high-tension current being transmitted to the metropolitan district at a pressure of 6,600 volts. The scheme also includes provisions for incidental works and powers, such as the deepening and widening of the river, road construction, the supply of water for domestic and irrigation purposes, &c.

The Victorian Minister of Public Works has deferred consideration of the application for a four months extension of the time for carrying into effect the order giving the Victoria Electric Heat and Power Distributing Corpn. power to provide electricity supply in Footscray, South Melbourne, St. Kilda, Williamstown, Port Melbourne, &c. The order provides that the Corporation shall satisfy the Governor-in-Council of its ability to carry out its objects, and to find £400,000 by June 30, 1904. Various extensions of time have been granted, the last one expiring on Jan. 13, 1907. The applicants are in negotiation with English capitalists for raising the money.

The scheme for the Malvern-Prahran (Victoria) electric tramway has been advanced somewhat by the consent of the Government to the construction of the line and the pledge of the Councils to pay the Victorian Railway Department £13,000 towards the cost of the re-grading of the Caulfield railway at Armadale Gates. There are still points in dispute as to the constitution of the board of control, &c.

Australasian Tax on Catalogues, &c.—It is announced that after July 1 manufacturers will be able to obtain from the Commonwealth offices, 72, Victoria-street, London, S.W., ½d., 1d. and 3d. duty-paid adhesive stamps.

As already stated, printed matter is charged with a duty at the rate of 3d. per pound, but the duty is waived when the collective weight of the packages sent by one sender to any one of the Australian Commonwealth States by any one mail does not exceed 4lb.

Barking.—In future power users are to have the option of taking electricity at a fixed sum of £5. 5s. per annum per kilowatt of the maximum power required, plus ¾d. per unit for all units supplied.

Bermondsey (London).—The Electric Lighting committee have decided not to entertain the renewed offer of the County of London Electric Supply Co. to supply current for public lighting at 1¼d. per unit for a limited number of lamps, or at 1d. per unit if the Council adopt a comprehensive scheme.

China.—It is reported that an electric tramway undertaking is to be constructed at Naiking if sufficient capital can be obtained from native sources. This is necessary owing to the desire of the natives to exclude foreign capital from participating in Chinese industrial enterprises.

At Hankow the British, Russian, and French concessions are now all supplied with electric light, and a native company has obtained a concession and arranged a contract for an independent installation for the Chinese town section. The undertaking, which supplies the British, Russian, and French concessions, is the property of the Hankow Electric Lighting & Power Co.

Dundee.—The Council have decided to pay Mr. John F. C. Snell 50 guineas for a supplementary report upon the proposal to erect a new generating station.

Eastbourne.—An inquiry was held here on Tuesday into the application of the Council to borrow £9,934 for extensions of the electricity supply undertaking.

The town clerk (Mr. H. W. Fovarque) said that the capital expended was £156,875. 17s. 1d., of which £32,628 had been paid off. The borough electrical engineer (Mr. J. K. Brydges) said that last year they sold 1,146,000 units of current, and the net profit was £1,567. 16s. 3d. Since taking over the undertaking the price had been reduced from 7½d. to 5½d. per unit.

Electricity in Mining.—The Maritime and Penrhiw pits of the Great Western Colliery at Pontypridd are being completely equipped with electrical plant for driving all the haulages, pumps and auxiliary machinery. At Maritime an electric winding plant is being put down capable of raising over 1,000 tons per shift, which it is hoped will be in working order by August. This will (it is claimed) be the first complete electrical installation, including electric winding, in this country. The Mold collieries in North Wales are putting down a complete electrical plant, consisting of power station, electric haulage and powerful electrical pumps capable of pumping 4,000 gallons per minute. In both cases the collieries are acting on the advice of Mr. Gerald Hooghwinkel, of Westminster.

Erith.—The consulting engineers (Messrs. Hawtayne & Zeden) are to report upon the proposal to extend the tramways to Upper Belvedere at an estimated cost of £17,000.

Fulham (London).—The Electricity and Lighting committee have issued a report on the subject of improving the lighting of those streets at present lighted by flat-flame gas burners.

The report states that the borough electrical engineer (Mr. A. J. Fuller) had strongly advised the committee to adopt Nernst lamps in those streets where electric-light cables are laid, and the Gas Light and Coke Co. had submitted proposals for converting the existing lamps to incandescent gas. The committee recommend the adoption of Mr. Fuller's proposals and have selected a pattern of lantern specially designed by Mr. Fuller. The annual cost of Nernst lamps is estimated at £3. 7s. 3d., compared with £3. 4s. 7d. for incandescent gas. The Gas Co. has taken photometric tests of the various types of lamps, and from the result of these tests the committee found that while the incandescent gas mantle gave, if anything, more light immediately round the post, it had not the same distributive or penetrative power as the Nernst lamp, which showed up to great advantage. The details of the tests are as follow :—

Distance.	Angle.	Reading.	Illuminating power.
Flat-flame Burners.			
11 ft. 7 in.	30	14·9	116 c.p.
18 ft. 3 in.	20	24·1	93 ,,
Electric Arc.			
35 ft. 5 in.	30	14·35	1,170 ,,
Nernst Lamps.			
19 ft. 10½ in.	20	23·95	112 ,,
10 ft. 7 in.	35	17·05	83 ,,
20 ft. 3 in.	20	18·2	200 ,,
11 ft. 4 in.	35	16·1	106 ,,
Incandescent Gas.			
16 ft. 3 in.	20	21·8	90 ,,
9 ft. 8 in.	35	15·75	81 ,,
15 ft. 3 in.	20	24·6	62 ,,
9 ft. 2 in.	35	18·9	50·5 ,,

The type of lantern designed by Mr. Fuller is estimated to cost 37s. 6d. per lamp.

At the meeting of the Council on Wednesday the chairman of the Electricity committee (Councillor Cook) said :

Although Nernst lamps would cost a little more than gas, they would be able to get customers for electric current on the line of route.. During the peak hours the cost was only 1d. per unit, and for the remaining hours it was ½d. per unit, which would reduce the cost to 12s. 6d. per lamp, so it would really be cheaper than gas. They could not afford to convert all lamps. There were 450 streets (63 miles), and only 130 (or 36 miles) had cables laid in them. The cost of laying cables in the other streets would be about £10,000, and, spread over 1,000 lamps, would be about £10 a lamp. To do that would be a loss, because wherever it was thought possible to get customers they had laid mains. He thought the committee were wise in not recommending that the whole of the borough be lighted with electric lamps. The present cost of lighting the borough was £3,612, and with the Nernst lamps it would be £3,799 an increase of £187. The present aggregate candle-power was 15,000, and with the new lamps it would be something like 83,000 c.p.

An amendment to refer back was defeated, and the committee's recommendations were adopted.

Glasgow.—A long and interesting report has been prepared by the general manager of the tramways (Mr. J. Dalrymple) on the question of tramway fares, and especially in regard to the proposal to double the length of the ½d. stages.

Mr. Dalrymple states that, on first thought, the proposal would seem an eminently reasonable one, as it was equitable that a ½d. passenger should be carried one-half the distance of a 1d. passenger. If the Corporation could carry a 1d. passenger 2½ miles, they could surely carry a ½d. passenger over 1 mile. The average number of passengers carried per car-mile was last year 11·02. It might seem a little strange that, although the cars were seated to carry 62 and 66 passengers, they should only carry, on the average, 11 passengers for every car-mile, and it also seemed somewhat strange that to carry 11 passengers per car-mile meant a considerable amount of overcrowding at the busier times of the day. Taking the average carrying capacity of a car at 11 passengers, they drew last year from these in fares 10·34d., which meant that each passenger on the average paid rather under 1d (0·94d.). Of those 11 passengers 3·23 paid ½d., 6·62 paid 1d., and 1·16 paid 1½d. and over. The average expenditure per passenger was ·886d., leaving a surplus per passenger of 0·05d. If 1d. per passenger per mile were converted into ½d. passenger there would be an average loss on every passenger carried of 0·02d. One-half of the 1d. passengers only ride a little over a mile. Mr. Dalrymple calculates that the ½d. passenger would have contributed nothing towards the actual cost of running the car; the whole of the running costs and profit would have been derived from the passengers paying 1d. and upwards. The proposed change would mean a falling off in traffic revenue of £130,254. 15s. 11d. It might be said that the increased number of passengers which would be induced to travel would make up any reduction in the revenue. The increased passengers could only be ½d. passengers, and to make up the loss in revenue would mean an increase of over 62,000,000 riders. The cars were now up to their full carrying capacity, so that, in order to accommodate these 62,000,000 passengers they would require to run additional cars, which would mean additional expenditure. He estimated that, to carry the increased number of passengers which would be required to make up the revenue

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to its present amount would take at least 150 cars, and to put those on the street to earn their present revenue would result in financial disaster.

Mr. Dalrymple also reports against the proposal to issue 36 ½d. tickets for 1s., and draws attention to the fact that the result of each year's working since 1893, when the net surplus was £100,276. 18s., while last year it was only £56,418. 4s. 11d., thus showing that with an increasing revenue the net surplus was diminishing. In 1905-6 there was an increase in the gross revenue over that for 1902-3 of £169,111. 13s. 5d. There was also an increase in working expenses of £153,472. 18s. 7d., leaving an increase in net revenue of £15,638. 14s. 10d. Taxes, accident insurance and maintenance of track were responsible for £81,920. 19s. 6d. of the increased working expenses, the balance being simply the ordinary increase caused through the greater amount of business done. Other items also showed an increase. In considering requests for cheaper fares and other advantages, the committee should remember that the fares had already been reduced practically to bedrock.

The recommendation of the Tramways committee is to the effect that they do not see their way to recommend any reduction of fares.

Gloucester.—Owing to the financial position of the municipal tramway undertaking, a special committee of the whole Council has been appointed to consider whether the tramways should be continued as a municipal undertaking. One member said if the present loss continued they would in 40 years have paid £179,200 out of the rates. He estimated the gross annual loss, including depreciation, &c., at over £11,000.

India.—"Indian Engineering" states that the Lahore electric lighting scheme has been submitted to the Punjab Government for final sanction; that the Simla water power-electricity scheme is in abeyance and that a licence has been granted to Killick, Nixon & Co. and John Fleming & Co. for electricity supply in the Hooghly (Bengal) district.

Plant is to be purchased for the electric driving of the Perambur works of the Madras Railway.

An engineer is to be appointed to take charge of electrical machinery at the Calcutta Mint.

Italy.—The total revenue of the telephone service of the State in 1906 was £61,577, telegraphs £23,864. A surplus of £2,540,855 is shown as the result of the financial operations of the Government for 1905-6, and it is proposed to expend a large sum in the improvement of the telegraphic and telephonic services of the State during the financial years 1906-7-8.

An interesting return has been made by Mr. Consul Towsey relating to the formation of joint stock companies in the Lombardy district of Italy in 1906. Electrical enterprise represents companies with a total capital of 12,000,000 lire, compared with 10,050,000 lire in 1905.

Referring to Messrs. Pirelli's extensive electric cable factory at Milan, the report states that this undertaking gives employment to 2,500 persons.

Japan.—An interesting report has been prepared by Mr. Oswald White, of the British consular service in Japan, on the subject of Japanese paper mills. There has recently been established at Oji an extensive paper mill, with authorised capital of £613,000. This mill is worked by electricity. A power station is being erected on the banks of the Chitose river, which forms the outlet of Lake Ishikiri, some distance from the factory, which is established at Tomakomai, adjoining the railway. At the Oji mill a turbine is installed. In connection with paper-mill driving various projects are under discussion to utilise the water powers of the rivers Hayakawa and Shivakawa.

Light Railways.—Only 11 applications were lodged during May with the Light Railway Commissioners for light railway orders, and four of these are for extensions of time or amendment of existing powers. Of the remainder, one (Llandudno and District Electric Tramway Construction Co. for authority to construct a mile of new line) is electrical, and the promoters of the Burton and Immingham scheme schedule electricity or steam as the motive power. The total mileage of line in the new schemes is 54½ and the estimated cost is £268,436.

L.C.C. Electricity Supply Bill.—In a circular issued to the other Metropolitan borough councils Shoreditch Council express the view that by co-operation between London County Council and the borough councils having electricity undertakings, some scheme could be agreed upon for obtaining Parliamentary powers for mutual exchange of supplies between the different councils and the L.C.C., which would demonstrate the cheapest source of supply for future use and would effect a substantial saving as well as benefit all the authorities concerned. Shoreditch Council have, therefore, resolved that the L.C.C. be asked to convene a conference of Metropolitan borough councils possessing electricity undertakings to consider the general question of electric supply for London. Other borough councils are asked to co-operate.

Maidstone.—The Council last week decided that the charge of 1d. per unit to power consumers during restricted hours shall only apply to consumers using more than 195 units per quarter per H.P. demanded.

Manchester.—The salaries of the following officials of the tramways department have been increased: Mr. J. T. Oakes, traffic superintendent, from £400 to £425; Mr. H. Mattinson, permanent way engineer, from £276 to £300; and Mr. W. Gray, chief clerk, from £163. 16s. to £180. The advances were agreed to without discussion.

Manchester-Wrexham Tramroad.—An interesting scheme for the construction of an electric tramroad between Manchester and Wrexham is being prepared.

The promoters propose to provide an express service from Manchester to North Wales, by which the through journey could (if necessary) be accomplished in about 1¼ hours. The length of the proposed new electric line would be about 44 miles, and it would be constructed to standard gauge. The Manchester terminal station would be located at Old Trafford, and the route would be via Ashton-on-Mersey and Dunham, and direct across country via Acton Bridge, Delamere, Tattenhall and Holt to Wrexham, where it is proposed to effect junctions with both the Great Western and the Cambrian Railways for the transit of goods traffic. The permanent-way construction and electrical equipment would be similar to that of the Blackpool and Fleetwood tramroad.

Merthyr Tydfil.—The Council have referred back a recommendation to accept the offer of the Merthyr Electric Traction & Lighting Co. to provide 18 4-light and 84 2 light Osram lamps at an annual cost (including renewals and maintenance) of £363. At present there are 51 gas and electric lamps, costing £364. 10s.

Moscow.—The conversion of the tramway system of this city to electric traction on the overhead system is steadily progressing, and, according to a report by Mr. Consul Grove, a British firm is taking a very large share in completing this work, which will probably not be finished for another two or three years.

Municipal Authorities and Workmen's Compensation.—The committees of Birmingham City Council are considering a proposal of a sub-committee of the General Purposes committee that the Corporation should establish a self-insurance scheme to deal with claims under the Workmen's Compensation Act. The Public Works and Health committees are not disposed to adopt it. The Tramways committee have a claims department of their own, and they came to the conclusion that a separate insurance department was unnecessary. The Baths and Parks committee have arranged to act jointly with the other committees. The subject will be dealt with by the General Purposes committee at their next meeting.

Municipal Telephony.—The gross profit of the Portsmouth municipal telephone department for the past year was £3,856, against £3,865 in the previous year. Interest on deposit note and a balance of £67 from 1906 raises the total to £3,942, or £85 less than last year. After deducting £2,105 for repayment of principal and £1,347 for interest, the net profit is £490, against £1,849 in 1906.

Obituary.—The death occurred on May 29 of Mr. E. R. Barrett, chairman of Baily, Grundy & Barrett (Ltd.), Cambridge.

Mr. Wm. Horsfall, engineer, of Leeds, died on Sunday last. Deceased, who was in his 81st year, patented many inventions relating to furnaces, refuse destructors, &c.

Portsmouth.—The Tramways committee have decided to go carefully into the question of depreciation, and a report as to the wear and tear of the plant and the probable cost of replacing the lines in the future is to be prepared by the electrical engineer (Mr. V. G. Lironi), the manager (Mr. W. R. Spaven), and the accountant.

Presentation.—The staff of the Colchester electricity works on Saturday presented a travelling bag to Mr. F. H. Humphrey, assistant engineer, who is leaving to take charge of the electrical installation at the "White City," Manchester.

St. Helens.—The salary of the borough electrical engineer (Mr. E. M. Hollingsworth) has been increased to £425 per annum.

Single-phase Electric Railway Traction.—The recent development of single-phase traction is carried still further by the contract of the Chicago, Lake Shore & South Bend Railway Co., who are equipping 70 miles of railway on this system. The whole of this contract (amounting to £500,000) has been placed with the Westinghouse Electric Mfg. Co., Pittsburg, Pa. The power house will contain three 3,000 H.P. Westinghouse steam turbines, three generators of corresponding capacity, together with the necessary switchboard apparatus. There will be 31 large cars, each equipped with four 100 H.P. single-phase motors, and these cars will be equipped with the Westinghouse multiple-unit system of train control.

Spain.—A new company provided with the sinews of war from Belgium has been established at Corunna to construct and operate a system of electric tramways throughout the districts surrounding Corunna and Vigo, as well as in the towns themselves. It is stated that the whole of the capital of the company has been subscribed.

La Electra Popular, the local electricity supply company of Vigo, are putting down new plant to increase the capacity of their works, it being intended to convert the present mule-drawn system of the town tramways of Corunna to electricity and to extend the line to El Burgo. When this work is completed the Vigo service will be converted, and the company intends to extend its operations to the

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surrounding districts, providing a competitive system of electric tramways in this vicinity.

Stepney (London).—For preparing plans, estimates and specifications for the proposed Blyth's wharf electricity works, the Council are recommended to pay the borough electrical engineer (Mr. W. C. P. Tapper) an inclusive fee of £105. Mr. A. J. Squire, chief clerk is to act for 3 months as secretry to Mr. Tapper at an increased salary.

The electric lighting committee recommend that Mr. Tapper's salary (£575 per year) be increased to £650 as from April 17 in any case, and that his salary should be £750 as from the date on which the tenders for the Blyth's wharf station are accepted.

Switzerland.—The "Feuille Fédérale Suisse" of May 29 contains a copy of a concession granted to M. X. Imfeld, of Zurich, engineer to the Alioth Electricity Co., of Münchenstein, and to M. Zehnder, of Montreux, director of the Montreux-Oberland Railway, for the construction and working of a narrow gauge electric railway from Brigue to Gletsch.

Tunbridge Wells.—At the meeting of the Town Council on Wednesday the proposals of the Electricity committee in regard to the re-arrangement of the staff of the electrical engineer's department were agreed to, and certain members of the staff were granted increases of salary, including the assistant engineer (Mr. David Smith) and the chief clerk (Mr. W. H. Hayden).

It was also decided to approve the extensions of the generating plant, &c., recommended by the electrical engineer (Mr. H. L. T. Boot), and to apply for sanction to a loan of £9,600. The extensions are a 500 k.w. steam turbo alternator, condensing plant, &c., £4,850; boiler, superheater, &c., £1,203; public lamps, £900; contingencies (10 per cent.), £707. 6s. 9d.; and £1,939. 13s. 3d. has been expended on capital account in anticipation of sanction.

Turkey.—An Imperial firman has been granted to a Belgian company to construct and operate an electric tramway about 15 km. in length through Beirut.

Uruguay.—The "Review of the River Plate" says the section of the Transatlantic Tramway Co. of Monte Video from the Centre to Paso del Molino will shortly be opened, but the company's complete system will not be open before August or September, and also that the Sociedad Comercial de Monte Video will shortly inaugurate the line from Buceo to Union (Monte Video).

Walthamstow.—The financial position of the tramways department and the question of fares, &c., have been recently under discussion by the Council.

A suggestion was made that in order to meet the deficit on the working of the tramways, fares should be raised, but, after discussion, it was decided that no change should be made at least for 12 months. During the first 12 months' working (prior to the present manager, Mr. Wm. Murray, taking charge) the tramways incurred a loss of £5,400; but during the following year (the 12 months to March 31, 1907), the deficit was only £1,800. As there has been a marked and continuous increase in traffic receipts, it is anticipated that this increase will enable the department to show a profit on the present year's working.

Wednesbury.—On Monday the Council adopted a recommendation to apply for sanction to a further loan of £8,000 for proposed extensions of the electricity undertaking.

Wood Green.—The National Telephone Co. will establish a local exchange for this district at Palmer's Green.

Worcester.—Application has been made by the Council for sanction to a loan of £10,000 for additional generating plant, mains, services, meters, &c.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Aston.—The accounts of the Electricity department were presented to the Council on Wednesday.

The gross profit for the year ended March 31 was £6,612, against £4,692 in 1906. After paying expenses, including interest and sinking fund, there was a profit of £668 compared with a deficit of £762 on the previous year. During the year the new connections to the mains were equivalent to 12,532 8 c.p. The Electricity committee report "a large and rapidly increasing demand for electricity in the borough."

Barrow-in-Furness.—The annual report of the borough electrical engineer (Mr. H. R. Burnett) has been issued, and states that during the year ended March 31 important extensions have been made at the electricity works.

These extensions include a 500 kw. engine and generator, supplied by Vickers, Sons & Maxim (Willans engine), a 25 kw. balancer booster (by the Phœnix Dynamo Co.), switchboard panels (by Bertram Thomas), steam, feed and exhaust pipes (by Edward Le Bas & Co.), a Hodgkinson mechanical stoker, a new cooling tower, &c. There are 608 consumers, with an equivalent of 64,213 8 c.p. lamps connected, increases of 59 consumers and 7,720 8 c.p. during the year. There are 124 motors (of 804 E.H.P.) connected, increases of 15 motors and 222 E.H.P. The maximum load was 870 kw. (against 817 in 1905-6), and the load factor was 12·45 against 12·82 per cent. There was only an increase of 30,822 in the units sold, owing to economies effected by the tramways department, and to the fact that the increase in the connections to the mains was largely of motors which were only running during the last few months of the year. The adoption of "Tantalum" and other economical lamps and the competition of improved forms of gas lighting, &c., have also tended to restrict temporarily the output. An agreeable feature was the increase of the motor load due to the reduction made in the price of current for power. 1,299,340 units were generated and 948,747 were sold (415,406 for private lighting, 138,173 for power and heating, 99,043 for public lighting, and 296,125 for traction). The total receipts were £11,798, the total costs £5,360 (1·356d. per unit, against 1·354d.), and the average price obtained was 2·912d. per unit against 3·074d. After paying interest (£3,147. 11s. 6d.) and sinking fund (£3,257. 1s. 7d.) there was a net profit of £33. 0s. 11d.

Birmingham.—The annual report of the electricity department (which was abstracted in our last issue) was presented and adopted by the Council on Tuesday.

The chairman of the Electric Supply committee (Mr. ELLAWAY), in moving its adoption, said the result of the year's working was very satisfactory; they had anticipated a deficit, but had made a small profit. The total output for lighting and traction was nearly 11,000,000 units, or double that of the previous year. The reductions they had brought about had made a difference of nearly £5,000. The increase in lamp and motor connections was double that of last year, and that again was double the increase of the previous year. The motor hire system had been well received. At the end of the financial year they had 113 motors on hire. The mains superintendent and his assistants had a very busy time last year, for 187,440 yds. of mains were laid. The gross profit was £54,411, and the net profit £7,713, which it was proposed to carry to reserve.

In moving the adoption of the report of the Tramways committee, Ald. BEALE said it was proposed to dispose of the net profit (£26,660. 1s. 5d.) by placing £14,660. 1s. 5d. to reserve and carrying £12,000 to the borough fund. They were just beginning what he hoped would be a long and prosperous career. The depreciation question was one which must be considered, as in several cases (such as tramway track and rolling stock) renewals must be anticipated before the original loan was repaid. The rolling stock would last about 15 years, but it would not last the sinking fund period. A time would come, too, when the track would have to be relaid, and with respect to assets of that nature the committee proposed to put aside an annual sum sufficient to provide for renewals independently of the operation of the sinking fund.

Burnley.—There was a profit of £8,766 on the past year's working of the tramways department, and this has been placed to reserve.

Out of the profit on the electricity department (£5,384) £3,015 has been applied to reduction of rates.

Blackpool.—The accounts of the electricity department for the year ended March show capital expenditure £189,773, an increase of £1,618.

The total outstanding capital now stands at £179,738. The year's income was £35,291 (compared with £32,768 in 1905-6), including £18,303 for current for private lighting, £9,434 from Corporation tramways, £1,124 from Blackpool, St. Annes & Lytham Tramways Co., and £5,997 from public lighting (including £246 from Tramway Co.) Generation expenses were £9,274 (of which fuel cost £4,153), distribution £1,630, public lighting (wages, carbons, repairs, &c.) £1,162, rents, rates and taxes £1,216, management £1,440, and general expenses (including £300 allowed for bad and doubtful debts and credits) £667, leaving gross profit £19,902 (against £17,800). Loan charges were £11,673 (against £11,680) and net profit £8,229 (£6,120). £4,229 (£2,740) has been placed to reserve and £4,000 (£3,000) devoted to relief of rates. 3,404,000 (3,154,000) units were generated, 1,384,021 supplied for traction, 282,251 to public lamps and 1,232,932 to private consumers. There are 277 arc and 706 incandescent and Nernst lamps for street lighting. There are 1,108 private consumers (compared with 1,056). The total maximum demand was 2,453 kw. (lighting 1,653 kw. and traction 800 kw.).

Bradford.—The annual report of the manager of the municipal tramways department (Mr. C. J. Spencer) was presented to and approved by the Tramways committee on Monday.

The car mileage run was 5,167,261, an increase of 133,000 miles (or about 2 per cent.) over 1905-6. The total revenue was £237,511, an increase of £8,533. To earn £237,511 in a city with a population of 324,000, with fares approximately two miles for 1d., Mr. Spencer thinks is the best proof of the popularity and usefulness of the service. The number of passengers carried was 46,727,488, as compared with 45,331,288, an increase of 1,396,200, or 2·9 per cent. The total expenditure (excluding interest, sinking fund, &c.) was £164,987, leaving a net surplus of £72,524, against £70,279. With an increased expenditure of £6,287, therefore, £8,533 more revenue had been earned. Alterations

"The Electrician" in Canada.—The circulation of *The Electrician* in Canada has for many years past included a considerable number of the leading electrical engineers in the country, and most if not all, of the principal manufacturing and supply houses. The recent changes in the postal arrangements, under which *The Electrician* can be posted to Canada for 1d. per copy, will enable us to cover a wider field in that country, and we have made arrangements by which all persons and firms engaged professionally and industrially in electrical engineering in Canada will receive copies of *The Electrician*.

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in policy had increased the price paid for electricity by ⅛d. per unit, representing an increase of £5,534, and free holidays had been granted to the men at a cost of £1,000. Traffic expenses came out at the low figure of 2·891d. per car mile, against 3·002d. last year, equal to a decrease of £2,390, notwithstanding the extra money paid to drivers and conductors for holidays. The general expenses came out at 0·925J. per car mile, against 1·005d. The decrease was largely due to the reduced amount paid in claims for accidents, £1,228 less than last year. There has been an increase in rates and taxes, which now reached £10,230. The cost of repairs and maintenance was 1·457d. per car mile, against 1·44d. Buildings, fixtures, overhead equipment, &c., showed substantial decreases. The cost of power was 2·12d. per car mile, against 1·912d., equal to an addition of £4,478, entirely accounted for by the increase in price per unit paid for energy. During the latter part of the year the current consumption had been steadily dropping. The parcels department had earned £5,004, against £4,035. There had been 528,637 parcels carried, against 478,214. The expenditure had increased from £3,508 to £4,032, and the profits from £526 to £972. The motor garage department had not been so successful as he (Mr. Spencer) would have liked. It was generally agreed that the use of motor cars for committees and officials had proved of great value in time-saving. The gross profit on the undertaking of £72,524 had been allocated under the following heads :

Interest on capital	£25,020
Income tax	2,543
Rent of leased lines	4,173
Repayment of mortgage loans	1,063
Sinking fund	28,420

The net surplus was £14,536 (against £11,637), of which £10,000 had been taken in relief of rates, and the balance placed to reserve and renewals account. By repaying the debt on the instalment and not the annuity principle, interest charges must of necessity get less year by year. On the question of depreciation Mr. Spencer urges that the contribution of £30,186 (or 3½ per cent. of the capital) to sinking fund account is by no means small. £145,886 had been repaid already, equal to 16 per cent. of the original debt, and a substantial relief from interest from that amount had already made itself felt. There was also £54,160 ready for the payment of loans as they became due, in addition to the reserve fund of £38,024.

Crewe.—It was reported to the City Council on Wednesday that, after paying all expenses, including interest and sinking fund, there was a profit of £680 on the past year's working of the electricity undertaking.

Finchley.—For the year ended March there was a deficit of £170 on the electricity undertaking, 892,000 units were generated, of which 238,000 were for public lighting. The cost of generation was 1·4d per unit. Gross profit increased during the year from £2 854 5s. 3d. to £4,700 3s. 10d. The outstanding capital was £72,062, and the fact that the L.G. Board had altered the period of repayment of loans from 25 to 16 years increased the annual repayments by £866.

In the discussion on the accounts it was mentioned that as a result of the Council embarking upon the scheme the charge for gas had been reduced from 4s. 5d. to 3s. 8d. per 1,000.

Glasgow.—During the year ended May 31 the traffic receipts were £887,380. 14s. 1d., an increase of £73,612. 3s. The car-mileage run was 20,350,367, an increase of 1,463,457 ; 224,063,098 passengers were carried, an increase of 16,004,750. The average track-mileage open during the year was 168½.

Hull.—The report and accounts of the fourteenth year's working of the electricity department, presented to the Council last week, show good progress. At the beginning of October last the charges for lighting and power were reduced, and, notwithstanding this reduction and the competition of gas, the department has been able to show a fair profit on the year's working, and, in addition, the Electricity committee have continued the prudent policy of allocating a considerable amount towards depreciation and contingency funds.

The actual capital expended is £354,977. 6s. 1d., an increase of £30,747. 2s. 8d. The income was £45,433. 1s. 6d., including £30,791. 17s. 4d. from sale of current by meter, £12,455. 18s. 1d. from power consumers and £623. 15s. from public lighting. The expenditure was £22,541. 3s. 3d., leaving £22,891. 18s. 3d. to meet interest (£11,098. 0s. 6d.) and sinking fund (£8,654. 11s. 2d.) and depreciation of meters (£1,326). The balance (£1,813. 6s. 7d.) has been carried to appropriation account. 4,413,758 units were sold. The works costs came to 0·99d. per unit (against 1·02d.), and the total works costs to 1 21d. (against 1·24d.), the total costs being 2·36d. per unit, the same as in 1905-6.

In presenting the annual report, the chairman (Mr. HANGER) said he was able to report a net profit of £1,813, after paying all working expenses, interest on capital, repayments of loans and 10 per cent. for depreciation on meters. The number of lamps, motors and other apparatus connected to the mains was equivalent to 323,309 8 c.p., an increase of 44,708 during the year. The consumption was equal to 13·65 units per lamp connected, a figure which was considerably lower than the average of the large towns in the north of England. The number of power consumers connected was 381 (representing a total of 4,856 H.P.), and of that number 35 consumers (with 115 H.P.) had their motors on hire. There was a steady increase and a growing desire on the part of small users of power to avail themselves of the many advantages which electricity presented for industries carried on in a small way. For the first time during the life of the undertaking they had been able to reduce their works costs to under 1d. per unit, in spite of the fact that the price of coal was higher than during the preceding year. The cost under most heads, however, showed a reduction, and he thought that the future of the undertaking was well assured, and that the total costs would steadily decrease. During the past year they had set to work a great deal of new plant, which was working very satisfactorily, and he hoped they would be able to reduce their repair charges as well as effect considerable economy in coal consumption.

Kendal.—There was a deficit of £715 on the past year's working of the electricity department.

Leigh (Lancs).—The capital expended on the electricity undertaking is £43,624.

There was a deficit on the past year's working of £407, compared with a profit of £219. 3s. 9d. in 1906. The deficit is due to increased capital charges, rates, &c. There are 315 consumers, with the equivalent of 16,818 8 c.p. lamps connected, against 279 and 15,503. There are also 146 motors of 931½ H.P. connected. During the year 702,119 units of electric current were sold.

Nottingham.—The annual reports of the electricity and tramways departments will be presented to the City Council on Monday.

The city electrical engineer (Mr. H. TALBOT) states that the total capacity of the three generating stations is 15,685 H.P.—viz., Talbot-street 8,925 H.P., St. Ann's 6,040 H.P. and Eastcroft 720 H.P. The distributing mains now total 54·26 miles. The number of applications for supply of electricity was 3,257, compared with 3,040 last year. The number of equivalent 8 c.p. lamps connected had increased from 297,553 to 321,240, and there had been an increase of 477,534 in the number of units sold, the number of units sold being 9,530,095 at 2·07d. per unit. Of the units sold for private lighting, 48·16 per cent. were at the reduced rate of 1½d. per unit.

Expenditure amounted to £39,045. 5s. 3d. and the income to £84,127. 6s. 3d., leaving £45,082. 1s., of which £10,000 has been voted in aid of the general district rate for 1907-8, £13,730. 6s. 7d. for interest, £14,886. 19s. 3d. transferred to sinking fund and repayment of loans, leaving £6,464. 15s. 2d. to be transferred to reserve. The total cost was 1·70d. per unit, against 1·77d. in 1906.

The total income of the tramways department was £139,992. 14s. 3d. and the expenditure (including interest and sinking fund) £115,348.12s.9d., leaving £24,644. 1s. 6J., of which £17,000 has been contributed to rate account, £900 written off cost of motor omnibuses and the remainder (£6,744. 1s. 6d.) carried to reserve. The average fare per passenger was 1·06d., the same as in the previous year. The total working expenses were £82,966. 10s. (7·28d. per mile), an increase of £5,435. 11s. 2d. (or 0·17d. per mile). The consumption of electrical energy for traction, car and depot lighting, works, machinery and permanent-way repairs was 4,316,656 units, increase 219,604 units. No accident of a fatal or serious nature occurred during the year. The sums paid in compensation amounted to £366. 2s. 3d.

St. Pancras (London).—The total units supplied by the electricity department during the past three months was 2,220,247, against 2,184,772 in the corresponding period of last year, and the number of consumers was 2,921, against 2,763. The value of the current sold to private consumers was £18,225, against £18,113, but the number of units sold decreased from 1,628,803 to 1,597,750, owing to a fall in the demand for power, only 293,248 units being sold under this head, against 418,251.

Salford.—The Tramways committee have agreed to make a grant of £18,000 out of the profits of their undertaking in relief of rates, or £5,000 more than in 1906.

The Budget for 1907-8 was considered and approved by the Council on Tuesday, and the estimates were passed by 42 votes to 7.

Sheffield.—For the year ended March 25 the net profit on the electric light department was £2,555, compared with a deficit of £1,374. 16s. 4d. in 1906.

The electrical engineer and manager (Mr. S. E. Fedden) reports that the increase in the consumption of electrical energy for power is greater in proportion than the increase in the number of consumers due to the gradual conversion of large works to electric driving which is continually in progress. The use of electric power is becoming better understood and its economy appreciated. Many new connections were traceable to the recommendation of users, and their continuous canvassing, supplemented by the excellent advertising effect of the recent electrical exhibition, was producing very satisfactory results among the local industries. During the year the additions to capital amounted to £21,206, and the total capital expended is £860,241. 15s. 4d. The total income was £69,469 and the working expenses £19,585. 17s. 1d., leaving £49,883. 9s. 6d. to meet interest (£28,092) and sinking fund (£19,236), giving a net profit of £2,555. 12s. 3d. The sinking fund now amounts to £94,691 and the aggregate surplus to date is £16,532. 13s. 1d.

Stafford.—The total revenue of the electricity department for the past year was £3,971 and the expenditure £1,526, gross profit being £2,445. Interest absorbed £863, sinking fund £1,115 and income tax £61.

Sunderland.—The annual report of the electricity department states that during the year ended March 7,577,517 units of electrical energy were sold. The total works costs were £32,847. 11s. 8d., an increase of £3,833 over the estimates, owing to additional cost of coal and other working expenses. The revenue was estimated at £49,912, but the actual amount was £52,843. The gross profit was £20,195. 8s. 4d., or 6½ per cent. upon the capital expenditure.

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Wigan.—A long and acrimonious discussion on the finances of the electricity and tramways departments took place at the meeting of the Council on Wednesday.

An amendment by Mr. Wolstenholme to refer back the minutes of the Electric Lighting and Tramways committee, with instructions to call in expert advice, was accepted. A motion to reduce the salary of the electrical engineer and tramways manager (Mr. J. Slevin) was ruled out of order. Some members defended Mr. Slevin as the financial position was not due to lack of engineering skill on his part or to mismanagement, but rather to the action of the committee and Council in authorising capital expenditure without sufficient consideration. Notices of motion to reduce the salary of the tramways accountant and to ask Mr. Slevin to tender his resignation were withdrawn.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

London County Council invite tenders for the manufacture of two 5,000 kw. three-phase turbo-alternators, with surface condensers, &c., to be delivered and erected at the tramways generating station, East Greenwich. Tenders, on official forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., to be sent in by 11 a.m. July 2. See also an advertisement.

London County Council also want tenders by 11 a.m. June 11 for supply of 400,000 stoneware cable ducts. Forms of tender, &c., from the Clerk, Spring-gardens, S.W.

Portsmouth Town Council invite tenders for the supply, delivery and erection of one 1,000 kw. turbo-alternator, with condensing plant and accessories. Specifications, &c. (after 10th inst.), at the Town Hall, Portsmouth. A copy of the specification may also be inspected (but not obtained) at the office of the consulting engineers (Messrs. Kincaid, Waller, Manville & Dawson), 29, Great George-street, Westminster, S.W. Tenders to the town clerk (Mr. Alexander Hellard), Town Hall, Portsmouth, by noon, 24th inst. See also an advertisement.

Tenders are invited for the supply of 438,000 flame and 24,000 ordinary carbons for the city of *Melbourne* (Australia). Specifications, &c., from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co. Proprietary, Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon of Thursday, June 20. See also an advertisement.

St. Pancras (London) Borough Council invite tenders for the supply of an overhead traveller for the extension at the King's-road power house. Tenders to town clerk (Mr. C. H. F. Barrett), Town Hall, Pancras-road, London, N.W., by noon June 12.

St. Pancras (London) Council also want tenders by noon June 12, for girder work, &c., of extensions to King's-road power station. Specification from the Electricity department offices, 57, Pratt-street, N.W.

Dublin Lighting committee want tenders by noon June 18 for supply and erection of sub-station switchboards, transformers and accessories. Tenders to chairman of committee, 3, Cork-hill, Dublin, by noon June 18.

Belfast Tramways and Electricity committee invite tenders for coal storage bunkers and electric travelling crane. Tenders to Sir Samuel Black, City Hall, Belfast, by noon June 15.

Sheffield Electric Light committee require tenders by June 24 for 12 months' supply of cables. Specification from the electrical engineer.

Hackney (London) Council want tenders, delivered personally at 7 p.m. June 27, for wiring the Central Library, Mare-street. Specification from the Town Clerk.

The Powell Duffryn Steam Coal Co., *Aberaman*, want tenders by June 17 for electrical fittings, ironmongery, &c. Forms from Stores Manager.

Erith Council want tenders by noon June 19 for 12 months' supply of coal to the electricity works.

Bootle Corporation want tenders by noon June 15 for six or 12 months' supply of coal to the electricity works.

Burton Council want tenders by first post June 10 for 12 months' supply of hard steam cobbles for the electricity works.

Colchester Corporation want tenders by 4 p.m. June 19 for 12 months' supply of steam coal for the electricity works.

The Commonwealth Deputy Postmaster-General, *Adelaide*, will receive tenders up to noon July 31 for the supply of a large quantity of telephone material, apparatus and instruments. Further particulars can be obtained at the Commonwealth offices, 72, Victoria street, London, S.W.

The *South Indian Railway Co.* (55, Gracechurch-street, London, E.C.) want tenders by noon, June 11, for supply of electrical stores, hardware, &c.

Tenders are invited for the lighting by gas, oil, electricity or other illuminant of the streets, thoroughfares, &c., of the city of *Calcutta*. The city comprises approximately an area of 20 square miles, containing about 170 miles of main thoroughfares and 130 miles of smaller streets, besides several squares, markets, latrines, slaughter houses, &c., which are now lighted by gas and oil lamps. The new contract is timed to commence on May 1, 1911, and the successful tenderer will be required to have all arrangements completed and ready to begin and continue the lighting with effect from that date. Tenders should be for 10, 15 or 20 years. Tenders will be received by the Vice-Chairman of the Corporation up to 3 p.m. Jan 2, 1908.

Tenders are invited for (1) 25,000 kg. 4·5 mm. galvanised iron wire, strength 40 kg. per sq. mm., coil diameter 600 mm.; and (2) 25,000 kg. 3 mm. galvanised steel wire, strength 120 kg. per sq. mm., coil diameter 400 mm., to be delivered October-December, 1907. Specifications (in Danish) and tender forms may be obtained from the Technical Department of the *Danish Telegraph Direction*, Frederiksholms Kanal 28, Copenhagen, Denmark. Tenders not later than noon July 1.

TENDERS RECEIVED AND ACCEPTED.

St. Pancras (London) Council received the following tenders for arc lamp carbons for the ensuing year:—

H. Tuchman (*accepted*) **£771. 15s.**; Geipel & Lange, £757. 16s. 1d.; Johnson & Phillips, £868. 10s.; G. A. Pestalozzi & Co., £875. 9s. 10d.; Sloan Electrical Co., £886. 8s. 7d.; Sirius-Werter, £916. 9s. 9d.; Crompton & Co., £975. 19s. 6d.; Electrical Co., £1,016. 11s. 5d.; G. Braulik, £1,026; General Electric Co. ("Apostle"), £1,038. 16s. 6d. and ("Nubia") £1,378. 6s. 3d.; International Electric Co., £1,038. 17s.; H. G. Mayer & Co., £1,041. 1s. 9d.; Brush Co., £1,098. 15s.; Siemens Bros. & Co., £1,180. 5s. 6d.; Sun Electrical Co., £1,231. 4s.; Compagnie Française des Carbons pour l'Electricité, £1,506. 13s. 10d.

Derby Council have accepted the tender of the British Thomson-Houston Co. for three double-deck cars at £592 each; that of E. Green & Son for renewing four stacks of pipes in economiser at £50; that of the Electric Construction Co. for tramway panel for switchboard at £55. 10s; and that of Meldrum Bros. for forced draught to six destructor cells at £168. 7s.

Bermondsey Council have accepted the tender of Crompton & Co. for a 20 H.P. motor for the destructor fan at £77. 5s. 8d. (less £18 expenditure already incurred for 13 weeks' hire). There were eight tenders, varying from £70 to £80. 19s., less 2½ per cent.

Bolton Council have accepted the tender of the British Westinghouse Co. for 2,000 kw. rotary converters; that of Herbert Morris & Bastert for a travelling crane, and that of W. Gornall for the erection of a sub-station.

Kingston Guardians have accepted the tender of the Bell Telephone & Electric Co. for erection of telephone installation at £28. 10s., and maintenance of same (after first year) at £14. 10s. per year.

Bermondsey (London) Council have accepted the tender of Johnson & Phillips (at £96) for 500 yds. of paper-insulated lead-covered triple-concentric l.t. cable. There were seven tenders, varying from £96 to £110.

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Derby Corporation have accepted the tender of Johnson & Phillips for the supply of bitumen insulated cable, and that of G. F. Tomlinson for the construction of the Nottingham-road tramways at £19,574. 17s. 10d.

Islington (London) Lighting committee have accepted the tender of E. P. Allam & Co. for an electrically-driven fan for use with the cooling towers at £281. 10s. The annual contract for meters has been given to the Electrical Co.

Barking Council have placed orders with the British Westinghouse Co. (at £541. 10s.) for machinery for the Creeksmouth extension, with the British Thomson-Houston Co. (at £185) for switchboard, and with the Western Electric Co. (at £630) for cables.

Marylebone (London) Electricity committee have provisionally accepted the tender of W. H. Allen, Son & Co. for a centrifugal pump for the electricity works at £765. The Worthington Pump Co. tendered at £773.

Kelvin & James White have an order for a switchboard panel, &c., for the Bengal Nagpur Railway, and W. T. Glover & Co. have recently supplied electric cables, &c., to the same company to the value of £313.

Marylebone Council have accepted the tender of the St. Helen's Cable and Rubber Co. for cable at £460, and that of W. H. Willcox & Co. for grease cups at 15s. per doz. (No. 2) and 20s. per doz. (No. 4).

The Thames Conservancy have placed an order with the Vulcan Electric Co. for an electric power installation at the Port of London Wharf.

Accrington Council have accepted the tender of W. T. Glover & Co. for cable; that of Callender's Co. for three feeder boxes; and that of Simpson Bros. for wiring the new library.

Luton Council have accepted the tender of W. H. Allen, Son, & Co., for a steam dynamo at £2,600; and that of Hayward, Tyler, & Co., for a pump and motor, at £185.

Broadstairs and St. Peters Council have accepted the tender of York, Stapeley & Co. for the supply of 10 arc lamps at £2. 4s. 8d. each.

Aston Council have accepted the tender of Callender's Co. for the supply and laying of high and low tension cables for the Erdington lighting scheme at £11,974. 6s.

Hull Electric Lighting committee have received 10 tenders for the supply of h.t. and l.t. mains, pilot and telephone wires, casing, boxes, &c., and that of Siemens Bros. & Co. has been accepted.

Maidstone Council have accepted the tender of Dick, Kerr & Co. for a steam dynamo at £2,850, and that of the Underfeed Stoker Co. for a mechanical stoker at £700. 17s. 6d.

Weston-super-Mare Council have accepted the tender of P. H. B Neal for electrically-driven pumping plant at the sewage works.

Fulham (London) Council have accepted the tender of Pestalozzi & Co. for the annual supply of carbons.

Accrington Education committee have accepted the tender of Simpson Bros. for wiring the Carnegie library.

Cooling Towers.—Messrs. Balcke & Co. have recently received a number of orders for water-cooling towers, including the following:—Metropolitan Railway Co. (for Neasden power station), two duplex chimney cooling towers for 410,000 gallons per hour; Sunderland Corporation (through Willans & Robinson), two chimney cooling towers for 150,000 gallons per hour, and new interior for cooling tower for 125,000 gallons; Central London Railway Co. (Shepherd's Bush power station), one brick chimney cooling tower for 200,000 gallons.

BUSINESS NOTICES.

Mr. F. T. Hanks, 1, Higham-place, Newcastle-on-Tyne (telephone 3069 Central), has been appointed by Messrs. Evershed & Vignoles, their agent for Newcastle and district. Messrs. Evershed & Vignoles request that all inquiries and orders from the Newcastle district for their manufactures, which include meggers and bridge meggers, moving coil and other switchboard instruments, Murday recording ammeters and voltmeters, &c., should be sent to Mr. Hanks.

Messrs. Newton's Limited have appointed Mr. J. Lawson, 35, Mount Stuart-square, Cardiff, as their agent in South Wales. Telegrams, "Potential Cardiff"; telephone, 01,017 Nat. Mr. Lawson will keep a stock of motors for immediate delivery, and, as he has been representing the company in an unofficial manner for some time, he is thoroughly acquainted with their machines.

Mr. John May, M.Inst.C.E., M.I.E.E., and Mr. G. W. Spencer Hawes, M.I.E.E., announce that, their connection with the firm of Messrs. Robert Hammond & Son having been terminated by mutual consent, they are now practising under the style of May & Hawes, at Caxton House, Westminster, S.W. Messrs. May & Hawes, whose experience in the design, construction and administration of electrical undertakings extends over 17 years, are prepared to deal in a consultative capacity with all classes of electrical engineering work, to advise on rating questions and administrative matters and the technical aspects of electric supply, tramway and railway schemes, &c.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of James Clifford Brown (until recently trading at 6 and 8, Lime-street-square, London, E.C., as Rowland Carr & Co.) the public examination of the debtor will take place on June 26 at Bankruptcy-buildings, London, W.C.

The Phodyne Electrical Co. (Ltd.), 66, Victoria-street, London, S.W., is being wound up voluntarily. Mr. A. W. Langley (secretary) is liquidator.

The Morris-Hawkins Electrical Co. (Ltd.), 265, Strand, London, W.C., is being wound up voluntarily. Mr. E. I. Husey, 56, Coleman-street, London, E.C., is liquidator.

Electrical Improvements (Ltd.), is being wound up voluntarily, Mr. Ira Robinson, 44, Parliament-street, Nottingham, is liquidator.

Deeds of Assignment.—At the meeting of the creditors of George H. Hale and Frederick H. Hale (trading as Hale Bros., wholesale electricians, 156, Upper Thames-street, and 89c, King William-street, London, E.C.), held on June 5, a statement of the debtors' affairs showed indebtedness to trade creditors £1,569. 8s. 4d., cash creditors £1,783. 10s. and preferential creditors £118. 15s. The assets, after satisfying the preferential claims, are set out at £1,248. 3s. 11d., making a total deficiency of £2,104. 14s. 5d. It was decided to wind up the estate forthwith under a deed of assignment, Messrs. F. H. Rogers (Amalgamated Dry Batteries, Ltd.), J. Amey and A. C. Hands acting as a committee of inspection. Mr. J. R. Woodley, 30, Wood-street, E.C., acts as trustee in this matter.

A deed of assignment has been executed by W. H. Day (trading as Day & Hayes), electrical engineer, 78, High-street, Hounslow. Claims to Mr. G. E. Corfield, Balfour House, Finsbury-pavement, London, E.C., by June 11.

Sale by Auction.—Messrs. Horne & Co., 8, Delahay-street, Storey's-gate, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on June 19, at 11 a.m. obsolete and unserviceable stores, including quantities of steel, copper, gunmetal, lead, tin, zinc, phosphor bronze, platinum, &c.; also lathes and tools, jacks, electric cable, Daniell cells, lamps, lanterns, indiarubber, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on the Monday and Tuesday previous to and on morning of sale. Catalogues at the War Office, Whitehall, the Ordnance Office, Tower, and the Ordnance Office, Woolwich, S.E. See also an advertisement.

Plant for Sale.—One Belliss engine mounted on common bedplate with a compound-wound 550 volt Siemens dynamo of 230 kw. capacity and two Brush standard four-wheel trucks with B.T.-H. standard electrical equipment are advertised for sale. Particulars from Mr. H. B. Twyford, purchasing agent, Underground Electric Railways Co., Hamilton House, Victoria Embankment, London, E.C.

Business for Sale.—An old established gas, water, steam and conduit tube and fittings manufacturer's business (situated in the Midlands) is advertised for sale as a going concern, owing to dissolution of partnership. Particulars from Messrs. John Lewis & Co., C.A., 30, Waterloo-street, Birmingham, or Messrs. Kettle, Landor & Cope, solicitors, Wolverhampton.

Union Electric Co.'s New Offices.—On Thursday last the Union Electric Co. invited a few friends to visit their new offices at 50, Grainger-street, Newcastle-on-Tyne, and at the same time to inspect several novelties which they regard as specially suited to the electrical requirements of that district.

Amongst the apparatus exhibited were several high-tension and mining pattern switches with interlocking and other safety devices, but the switch which created most interest was a 10,000 volt 130 amp. triple-pole oil-break switch arranged with overload releases in the high-tension circuit, the releases being connected with fan-blade retarders with variable time element, so arranged that with heavy short-circuits the time before the release acts is considerably shortened, as compared with the time required with an ordinary overload within the capacity of the generating, transforming or other plant. The switch referred to had also a minimum current or no-voltage release, interlocking trip gear for use in connection with induction motors having starting resistances in their rotor circuits and signalling contacts to show the position of the multiple contact, multiple break, switch blades. A spindle worked by an insulated handle enables the value of the releasing current to be adjusted whilst the switch is in circuit. The Union Co. claim this assembly of safeguards on a high-tension switch, providing for all contingencies of actual practice, to be a notable advance on existing practice.

Another novelty shown for the first time was an improvement on the Kohinoor Arc Lamp, adapting it to give indirect shadowless illumination for the lighting of offices, small factories and inside shop premises. The lamps, finished in polished gunmetal, gave an agreeable, steady illumination, with a noticeable absence of the violet rays usually prevalent in the ordinary makes of enclosed arc lamps. This new lamp may open a fresh field for arc lighting inside shop and business premises.

At the conclusion of the inspection the party adjourned to dinner, at which Mr. Justus Eck, general manager of the company, assisted by Mr. James Gilman, the northern districts manager, entertained the visitors. Complimentary speeches followed, wishing the Union Co. and its staff every success in their ventures; and an excellent musical entertainment brought to a close a successful and agreeable function.

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CATALOGUES, &c.

Cell-Testing Voltmeters.—The life of secondary batteries depends entirely on the amount of care and attention given to them. The judicious use of so simple an instrument as a cell-testing voltmeter will add many hours to the working of storage batteries, whether in central stations, private installations, or electric vehicles. The Hart Accumulator Co., in a recently issued list, describes a portable cell-testing voltmeter which they are putting on the market at a moderate price. The scale is divided into tenths of a volt, and reads to 3 volts either way with centre zero. The instrument will read in any position and is carried by a leather strap handle. Suitable contact spears are furnished at a slight extra cost.

Cheap Steam.—A carefully prepared booklet, which emphasises the value of the Bennis system of stoking and compressed-air furnaces, has been issued by Ed. Bennis & Co. (Ltd.), of Little Hulton, Bolton, London and Glasgow. The booklet contains numerous tables, curves and illustrations giving useful data of Bennis specialities.

Suction Gas Engine.—The Campbell Gas Engine Co. are issuing a pamphlet made up of interesting letters bearing upon the trials of suction gas plants at the Royal Agricultural Society's show at Derby in 1906.

Carborundum.—Carborundum and "Electrite" wheels are the subject of an interesting brochure to hand from the Vincit Co., 117B, Queen Victoria-street, London, E.C. This booklet should be in the hands of all users of abrasives.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from May 29 to June 4, with the ports of destination:—

Africa—Alexandria, £696 (including £269 telegraph material); Beira £27; Delagoa Bay, £58; and 42 tons iron telegraph poles; Durban, £2,031 (including £1,392 telegraph material); Kilindini, £40; Port Elizabeth, £14. *Argentina*—Buenos Ayres, £3,281 (including £2,991 telegraph material); Rosario, £1,267 (telegraph cable). *Australasia*—Adelaide, £1,494; Christchurch, £56; Fremantle, £59; Launceston, £137; Lyttelton, £45; Perth, £86; Sydney, £704 (including £31 telegraph material); Wellington, £953. *Belgium*—Antwerp, £253; Brussels, £100 (including £65 telegraph material); Ostend, £73. *Brazil*—Pernambuco, £71 (including £12 telegraph material); Rio Janeiro, £3,807 (including £3,763 telegraph material); Santos, £335 (including £297 telegraph material). *Burma*—Rangoon, £347. *Ceylon*—Colombo, £25. *Channel Islands*, £46. *Chili*—Antofagasta, £301 (including £63 telegraph material). *China*—Shanghai, £1,096 (including £161 telegraph material). *Denmark*—Copenhagen, £160. *France*—Boulogne, £10; Marseilles, £288; Paris, £30. *Germany*—Bremen, £193. *Holland*—Amsterdam, £544; Rotterdam, £512. *Hong Kong*, £75. *India*—Bombay, £4,791 (including £309 telegraph material); Calcutta, £7,561; Madras, £1,164. *Italy*—Genoa, £200. *Japan*—Yokohama, £29 telegraph material). *Malta*, £350. *Persia*—Balek Pappen, £131. *Russia*—St. Petersburg, £128 (including £109 telegraph material). *Siam*—Bangkok, £823. *Spain*—Alicante, £50. *Straits Settlements*—Penang, £1,010 (including £996 telegraph material); Singapore, £522 (including £235 telegraph material). *Sweden*—Gothenburg, £80 (telegraph material); Malmo, £83 (telegraph material). *Turkey*—Constantinople, £10 (telegraph material). *Uruguay*—Monte Video, £435. *U.S.A.* (via Canada), £803. *Zanzibar*, £33 (telegraph material). Total, £30,312, against £28,251 for 8 days last year (May 30 to June 6).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

March 25, 1907.

7,069 BERTANI. Safety mechanism for coupled street tramways. (Date applied for, 24/3/06.)*†
7,078 THOMPSON. Apparatus for telegraphic purposes.
7,079 NOTARIANNI. Electric danger signal alarms for use on railways.
7,086 STEFFENS. Gas turbine.*
7,090 & 7,091 WILSON. Water and steam turbines.*
7,098 WATERS. Lever-type brush-holder for electrical machines.
7,141 ALBRECHT. Dynamo-electric differential driving gear. (Date applied for, 12/5/06.)*†
7,145 STRONG. Chairs for tramway and like rails.*
7,154 LISTER & LEATH. Obtaining currents from continuous-current dynamos of less voltage than the normal voltage.
7,177 MERMOD FRERES. Arc lamps. (Date applied for, 5/4/06.)*†
7,180 B.T.-H. Co. (G.E. Co., U.S.) Electric resistances.
7,181 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems and apparatus.
7,182 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.

March 26, 1907.

7,200 PEACOCK. Operating railway and tramway points.
7,216 TURNER. Arc lamp.
7,219 ERNST. Turbines.
7,233 ROBERTSON. Turbines.*
7,234 GÁTI. Method for measuring alternating currents.*
7,245 KNAPTON & BAGNALL. Arc lamps.
7,249 KNOWLES. (Lincoln Electric Co., U.S.) Battery dry cells.*
7,274 BOWELL. Signalling system for fire alarms.
7,275 JACKSON. Electric train control systems.
7,279 ANGOLD & MAXIM ELECTRICAL CO. Arc lamps.
7,281 BOEHM. Electric fire alarm with an insulation of paraffin.

March 27, 1907.

7,309 SCHAFFLER & LITTMANN. Armatures of magneto electric and like machines.*
7,315 HARRIS. Life-guard apparatus.
7,320 SALPETERSÄURE-INDUSTRIE-GESELLSCHAFT, G.m.b.H. Connecting high-tension spark gaps. (Date applied for, 6/7/06.)*†
7,336 UNIONE ELETTROTECNICA ITALIANA CO. Pole pieces of electrical machines. (Date applied for, 28/3/06.)*†
7,358 FISCHER. Electric automatic igniter.*
7,365 GADDA & CONTI. Turbines. (Date applied for, 23/3/05.)*†
7,407 ALLGEMEINE ELEKTRICITÄTS-GES. Manufacture of tungsten filaments by reduction of tungstic acid. (Date applied for, 30/3/06.)*†
7,408 B.T.-H. Co. (G.E. Co., U.S.) Electric locomotives.

March 28, 1907.

7,248A/06 FRANKLYN & SEYFERT. Electrical commutation devices. (Date applied for, 26/3/06.)*
7,410 HAIGH. Marine electric steering gear.
7,412 THORPE. Tilting shade for electric fittings.
7,432 COOPER. Electric contact makers.
7,438 STEIN. Reversible steam turbine.
7,443 SIEMENS BROS. & Co. & GRIMSTON. Telegraphs.*
7,449 THORPE. Electricity meters.*
7,515 GRÖNDAL KJELLIN Co. & HÄRDÉN. Electric furnaces.
7,519 TINGLEY. Dynamo-electric machines. (Date applied for, 4/4/06.)*†
7,552 CASLAKE. Pendant for electric lighting and other purposes.*
7,555, 7,556 & 7,557 HANDCOCK, DYKES & SMITH. Electric wiring.

March 30, 1907.

7,563 FRIEDHEIM. Electro deposition of metal on hollow articles. (Date applied for, 30/3/06).*†
7,585 RICHARDSON. Support and arrangement of filaments.
7,626 ADAMS, SCHANSCHIEFF & STEPHENS. Combustion engines and recharging accumulators thereby.
7,635 BEALL. Destination, route, station and stopping-place indicators.
7,637 & 7,642 LAKE. (Parker Clark Electric Co., U.S.) Filaments for incandescent lamps.*
7,643 SAYERS. Turbines.
7,644 GRAHAM. Telephonic apparatus for installations.
7,651 LAKE. (Clark, U.S.) Insulators.*

April 2, 1907.

7,657 WARING & WARING. Connecting and disconnecting sockets of incandescent lamps.
7,663 TAYLOR. Vibrators for siphon recorders.
7,664 TONKS. Supports for electric lamps.
7,687 WEBB. Radio-telegraphy and radio-telephony.
7,695 SIEMENS BROS. (Siemens Schuckertwerke G.m.b.H, Germany.) Dynamo-electric machines and motors.*
7,711 D'HOMERGUE. Electrical shunts.*
7,737 WAYGOOD & Co. Electric lifts or hoists.
7,742 COWPER-COLES. Electric furnaces.
7,757 BILLITZER. Apparatus for electrolysis of alkali chlorides.*

April 3, 1907.

7,758 MCMORRAN. Device on sheave end of trolley poles of electric tramcars and the like.
7,768 STATTER. Circuit-breaker mechanisms.
7,785 KITSEE. Duplexing telegraph lines.*
7,791 GRÖNWALL, LINDBLAD & STALHANE. Electric transformer furnaces.*
7,800 GOODMAN & ACKLAND. Conduits for electrical cables and wires.*
7,815 THOMPSON. (Ges. für drahtlose Telegraphie m.b.H., Germany.) Method for producing undamped oscillations.*
7,819 BOWELL. Pendulum-controlled electric circuit closing devices.
7,825 FURCH. Wall or ceiling roses or unions for gas and electric conduits. (Date applied for, 24/11/06.)*†
7,833 LJUNGSTRÖM. Means for balancing axial pressure on the vane plates of radial-flow turbines. (Date applied for, 4/4/06.)*†
7,844 THOMPSON. Faradic medical (tubular) battery.*

April 4, 1907.

7,853 SALTER. Distribution of electricity.
7,861 WENNSTROM. Jewelled bearings for electrical and other instruments.*
7,864 DIGBY & BIGGS. Electro-thermal calorimeter.
7,865 MINSHALL. Controlling automatic push-button electric lifts, hoists, and the like.
7,883 NAUJOKS, NAUJOKS, GOEPPERT. Electrically-controlled elevators.*
7,924 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.
7,926 HATFIELD & LEWIS. Electric lamps.

April 5, 1907.

7,931 DAWE. Electric winding appliances.
7,933 ARCHIBALD. Electric transmission of power.
7,941 BEVIS & ANGOLD. Arc lamps.
7,955 LÉGÉ. Turbines, steam or otherwise.
7,962 JAMES. Reversible turbines.

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7,964 SMITH & LINZELL. Electromagnetic devices.
7,982 BLACKMORE. Electromagnetic separators.
7,994 BIRNBAUM & WHITE. Single line intercommunication telephone systems.
8,019 HILL. Systems of electric motor control and apparatus therefor. (Date applied for, 7/4/06.)*†
8,025 LJUNGSTRÖM. Baffling devices for gas turbines. (Date applied for, 6/4/06.)*†

April 6, 1907.

8,036 CRAIG. Electrodes for the evolution of ozone from oxygen or atmospheric air.
8,055 WRIGHT. Attaching electric alarms to clocks.
8,079 LEONARD. Controlling electric motors.*
8,096 B.T.-H. Co. (G.E. Co., U.S.) Transformers for electric lamps and other apparatus.†
8,097 ATELIERS THOMSON-HOUSTON (ANCIENS ETABLISSEMENTS POSTEL-VINAY). Alternating-current commutating electric machines. (Date applied for, 4/7/06.)*†

April 8, 1907.

8,138 BERRY, SKINNER & MARKHAM. Protected fusible cutouts.
8,151 RAWLINGS & SMITH. Fixing lamp shades or reflectors for the electric light.
8,152 SLATER. Method of and apparatus for electrical heating, cooling and ventilating.
8,153 B.T.-H. Co. (G.E. Co., U.S.) Motor control systems.
8,173 MILTON. Inductor alternators. (Date applied for, 12/2/07.)*†
8,176 KINGSBURY. (Western Elec. Co., U.S.) Automatic telephone exchanges.
8,183 MERSHON. Alternating-current machines.*
8,186 TATARNICOFF. Surface condensers.*

April 9, 1907.

8,231 KELLEY. Electro-thermostatic switches. (Date applied for, 19/4/06.)*
8,240 DAMSEAUX. Incandescent lamps.
8,249 BOULT. Electrical signalling device.
8,255 FERRANTI. Electric furnaces.
8,267 HAMILTON & FERRANTI LIMITED. Double tariff electricity meter.*
8,277 LEHMANN & PLAUSON. Generation of electric energy.
8,284 THIELLET & DENARD. Accumulators. (Date applied for, 12/4/06.)*†
8,285 B.T.-H. Co. & DAWSON. Insulating supports for end connections of windings of dynamo-electric machines.
8,286 B.T.-H. Co. & DAWSON. Rotating members of dynamo-electric machines.
8,287 B.T.-H. Co. (G.E. Co., U.S.) Lightning arresters.

April 10, 1907.

8,314 ACLAND & BRECKNELL, MUNRO & ROGERS. Electric lamps.
8,359 BOULT. (Hoskins, U.S.) Electric resistance element.*
8,364 GES. FÜR DRAHTLOSE TELEGRAPHIE. Receiver for wireless telegraphy. (Date applied for, 10/4/06.)*†
8,365 JOHNSON & PHILLIPS & TUBBS. Arc lamps.
8,373 BURGARD & BOLLIN. Electric curling irons.*
8,376 VANDERVELL. Electric switches.

April 11, 1907.

8,387 B.T.-H. Co. (G.E. Co., U.S.) Electrical apparatus for manufacturing nitrogen compounds.
8,388 B.T.-H. Co. (G.E. Co., U.S.) Systems of lighting by arc lamps.
8,399 BRANDER. Electric clock system, working in connection with a telephone exchange.

SPECIFICATIONS PUBLISHED.

1905 SPECIFICATION.

26,688 BROWN. Converting varying alternating current into similarly varying direct current.

1906 SPECIFICATIONS.

176 JOHNSON-LUNDELL ELECTRIC TRACTION CO. & LANG. Regulation or control of electric motors.
226 BROWN. Obtaining and working electric currents of high periodicity.
297, 297A & 297B SAYERS. Turbines. (Date applied for, 4/1/06.)
5,258 DE FOREST. Wireless telegraphy.
7,603 ROLLIN. Turbines for combustible gases at very high temperatures.
7,668 OLIVE & SWARBRICK. Liquid electric motor starters and controllers.
7,821 FYNN. Alternate-current motors, generators and transformers.
7,829 THOMPSON. (Westdeutsche Thomasphosphat-Werke Ges.) Producing compounds of oxygen and nitrogen by electric discharges.
7,831 B.T.-H Co. (G.E. Co., U.S.) Signalling systems.
7,961 SIEBERT. Dynamo-electric machines.
8,340 SIEMENS BROS. & Co. & LAUCKERT. Telegraphs for transmitting orders.
8,345 DE MARCAY. Accumulators. (Date applied for, 1/24/1906.)
8,616 LEIBIUS. (Leibius.) Electric distance switch.
8,654 NICHOLSON. Electric ignition of internal-combustion engines.
8,932 B.T.-H. Co. & DAWSON. Dynamo-electric machines.
8,933 & 8,934 B.T.-H. Co. & DAWSON. Supporting collecting rings for dynamo-electric machines.
9,191 MACKIE. Automatically operating electric switches.
9,227 ECKSTEIN & HEAP. Electric fuse boxes.
9,509 ELEKTRIZITÄTS-AKT.-GES. VORM. W. LAHMEYER & Co. Electrically operated valves. (Date applied for, 3/5/05.)
9,786 MCKENZIE & HOLLAND & EDMONDS. Electrical detection between railway or tramway signals, points, facing point locks, or fouling bars.
10,603 LAKE. (Stromberg-Carlson Telephone Mfg. Co.) Telephone transmitters.
10,249 KITSEE. Telegraphy.
10,613 JENSEN, NOBBALLE & LAWSON. Starting and reversing the direction of motion of electro motors actuating elevators and hoists.
10,993 ELEKTRIZITATS A.-G. VORM. W. LAHMEYER & Co. Dynamo-electric machines. (Date applied for, 11/5/05.)*
11,067 SLEEP & EVERSON. Brake gear for use on railway cars, tramcars, trucks and motor.
11,335 ECKSTEIN & HEAP. Switches.
11,409 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of incandescence bodies for electric lamps from tungsten compounds.
11,950 HESS. Insulating material.
12,491 LAMME. Windings for dynamo-electric machines. (Date applied for, 2/6/05.)
12,732 B.T.-H. Co. (G.E Co., U.S.) Machines for manufacture of incandescent lamps.
13,222 B.T.-H. Co. (G.E. Co., U.S.) Switches for controlling electric circuits.
13,311 HEYS (Turner). Telephone dictating machine or apparatus.
13,314 FRAMPTON. Hand brakes for railway, tramway and like vehicles.
13,602 WHITE. Electric switches.
13,651 HAMILTON. Electrical contact makers and breakers for use with internal combustion engines.
13,731 TERRY. Electric accumulator plates.
13,985 CHAMBERLAIN & HOOKHAM & HOLDEN. Electricity meters.
14,041 WUNDERLICH & HUGHES. Suspension of electric lamps and other articles.
14,249 B.T.-H. Co. (G.E. Co., U.S.) Shaft bearings.
14,361 B.T.-H.Co. (G.E. Co., U.S.) Machines for making incandescent lamps.
14,458 TAYLOR & CRESSEY. Electric slide bars and bolts for railway carriage doors.
14,792 PEDERSEN. Receivers for wireless telegraphy. (Date applied for, 4/7/05.)
14,851 KJÖBENHAVNS TELEFON-AKTIESELSKAB. Automatic distribution of operating service in telephone exchanges. (Date applied for, 30/6/05.)
15,062 EKERT & HOOVEN. Composition for packing, lining and insulating purposes.
15,142 MASCHINENFABRIK OERLIKON. Multiple stage turbines. (Date applied for, 8/9/05.)
15,237 LAKE. (Rhode Island Electromobile Co.) Separators for secondary battery plates.
15,909 MARCONI'S WIRELESS TELEGRAPH CO. & PLETTS. Variable electric condensers.
16,313 CRAMP & DIAMANT. Turbines.
16,358 B.T.-H. Co. (G.E. Co., U.S.) Air-brake systems.
16,359 ALLGEMEINE ELEKTRICITÄTS-GES. Electromagnetic switches operated by alternating current. (Date applied for, 19/7/05.)
16,863 MACRAE, JOHNSTON & STEPHENSON. Life-guards for tramcars and other vehicles.
17,018 ARON. Prepayment electricity meters.
17,378 TWEEDALE & TWEEDALES & SMALLEY. Electric stop motions of drawing, slubbing, roving and like frames.
17,615 RÖCHLING & RODENHAUSER. Obtaining thin liquid dross in electric furnaces for metallurgical purposes.
17,886 CARL BORG FABRIK FÜR ELEKT. INSTALLATIONSMATERIAL GES. Adjusting height of electric lamps.
17,898 VAUX & MCCULLOUGH. Sanding tramway and railway rails.
18,179 GROB. Electric installations working with turbo-dynamos and accumulators. (Date applied for, 19/9/05.)†
18,643 MICHAUD & DELASSON. Producing indestructible filaments for lighting and heating. (Date applied for, 30/9/05.)
19,239 ALLGEMEINE ELEKTRICITÄTS GES. Cooling dynamo-electric machines. (Date applied for, 30/8/05.)
19,486 BELLIS & MORCAM & MACGREGOR. Electromagnetic devices for doing work on any restrained body.
20,450 ELSHOFF. Commutator bars and method of fastening the armature coil connectors to such bars. (Date applied for, 14/9/05.)
20,546 HOLZWARTH & JUNGHANS. Gas turbines.
21,346 SOC. ANON D'ELECTRICITÉ ET D'AUTOMOBILES MORS. Universal joints. (Date applied for, 12/6/06.)
21,416 KJELLIN. Electric furnaces. (Date applied for, 5/3/06.)
21,945 GIRAUD. Short-circuiting overhead electric conductors. (Date applied for, 6/10/05.)
22,101 KENNAY. Trolley wheels.
22,785 WADDELL. Turbine engine.
23,521 SIEMENS-SCHUCKERTWERKE GES. Centrifugal pumps and fans. (Date applied for, 30/10/05.)
23,851 RUZICKA. Arc lamps with convergent carbons.
23,951 REIST. Dynamo-electric machines. (Date applied for, 27/10/05.)
24,445 KINTNER & ROSENBLATT. Fuses for electrical circuits. (Date applied for, 4/11/05.)
24,632 STRATTON & CLAREMONT. Covering for lead-cased cables.
25,206 STORER. Windings for dynamo-electric machines. (Date applied for, 13/11/05.)
25,489 PARREUR-LLOYD & GARDNER. Electrolytically extracting metals from ores.
26,198 MARSH. Clinchers for trolley wire ears.
26,256 WOLTERS. Telegraphic transmitters.
26,760 MOSBACH. Attachment to telephone receivers for protecting the ear.
28,049 KALLMANN. Standardisation of electrical measuring instruments. (Date applied for, 17/5/06.)
28,342 THIROT & MAGE. Electrolytic production of pure tin.
28,562 FRIED. KRUPP A.-G. Automatic starter for continuous current motors.

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28,775 DEUTSCHE GASGLÜLICHT A.-G. (AUERGES). Producing metallic incandescence bodies for glow lamps.
29,202 FUSS. Operation of vapour electric lamps. (Date applied for, 11/1/06.)
29,416 GEB. SIEMENS & Co. Electrodes for arc lamps. (Date applied for, 17/5/06.)
29,434 VERITY LIMITED & SMITH. Chains for suspending electrical fittings.

1907 SPECIFICATIONS.

494 VARNEY. Current collecting devices for electric vehicles. (Date applied for, 16/1/06.)
1,293 SIEMENS BROS. & Co. (Siemens & Halske A.-G.) Electric signalling installations.
4,227 JOHANNESEN. Electrical transformers. (Date applied for, 3/3/06.)
5,332 DUNWOODY. Wireless telegraph or signalling systems.
5,957 RODMAN. Reducing depreciation in lead storage batteries.
6,502 THIROT & MAGE. Regeneration of electrolyte employed in extraction of copper from old bronze and bronze waste.
6,929 SIEMENS & HALSKE A.-G. Telegraphy.
7,251 COMPAGNIE DE SIGNAUX ELECTRIQUES POUR CHEMIN DE FER. Block signalling.

COMPANIES' MEETINGS AND REPORTS.

BRITISH ALUMINIUM CO. (LTD.)—Mr. J. D. A. Bonner stated at the meeting on Tuesday that the profit for last year (£155,023) was so much larger than that of any previous year that they were confident it would be regarded as very satisfactory. During the current year they had been enjoying just as great prosperity. No dividend had been paid upon their large holding in the Loch Leven Water and Electric Power Co. They hoped that during next year they might begin to benefit from the large expenditure they were incurring at Leven, though as much progress had not been made as they had expected. The contractors, Sir John Jackson (Ltd.), have so far been unable to obtain all the labour they could employ, and for several months to come they could give continuous employment to 1,500 more men than they have at present at work at Leven. The works would be sufficiently advanced by the early part of next summer to enable them to obtain a considerable amount of power, provided the generating plant is ready. They had reason to hope that that plant would be ready and the aluminium factory also. Such a great power scheme must necessarily occupy a considerable time before the works reached the producing stage. They had in consequence, with a view to increasing their production more rapidly, acquired a partially developed power in Norway, and had taken steps to develop some power at Leven which could be utilised without interfering with the progress of the main scheme. Those minor works had been designed by Mr. Murray Morrison, who had done such good work for them at Foyers and who had been appointed technical adviser to the company, jointly with Lord Kelvin. In Norway they expected to start manufacturing aluminium next month and at Leven in September. They anticipated no difficulty in obtaining highly remunerative prices for the combined output of those and their Foyers works for some time to come. In view of the possibilities of the future they had acquired the concessions for a water power of considerable magnitude at Orsières, in Switzerland.

DIESEL ENGINE CO. (LTD.)—The report for 1906 states that the profit was £11,212. The directors recommend a dividend of 5 per cent. on the ordinary shares, and state that, notwithstanding the large increase in gross profits, there has been an actual decrease in management expenses. The value of orders booked during the year was treble that of the previous year.

DOULTON & CO. (LTD.)—The directors announce that, after writing £7,133 off for depreciation, £500 off goodwill and paying the preference dividend, the accounts for 1906 show a surplus of £12,726, which it is proposed to carry forward.

ELMORE'S GERMAN AND AUSTRO-HUNGARIAN METAL CO. (LTD.)—The income from all sources for 1906 was £8,778. 8s. 9d., against £8,416. 12s. 6d. in 1905. After paying all charges, £267. 14s. 10d. is carried forward, against £176. 9s. 3d. The year proved disappointing so far as the Metall Co. was concerned, and had it not been for improvements in manufacture which considerably reduced the cost, the trading profit would have been less than in 1905. The abnormally high price of copper necessitated more working capital, while the high bank rate rendered the borrowing of money very costly, with the result that they had to pay £700 more for interest than in 1905. The continued demand for labour in Germany resulted in a general increase in wages.

RIO DE JANEIRO TRAMWAY, LIGHT & POWER CO.—The first annual report states that the directors decided to develop the Rio das Lages water power first and to hold the Rio Parahyba in reserve. The clearing of the banks of the Rio das Lages has disclosed that the reservoir formed by the dam which the company is building at Rio das Lages will have a much larger capacity than was anticipated, and consequently a much greater power than the estimated 40,000 H.P. can be developed, and by a recent concession the company has acquired the right to tap the neighbouring watershed of the Rio Pirahy, which will ensure sufficient water to develop a total of 120,000 H.P. at Rio das Lages in the driest season. The directors deemed it advantageous to immediately construct at Rio das Lages a preliminary hydro-electric plant, and power was available within the city of Rio de Janeiro during March, 1907. The temporary plant has a capacity of 3,400 H.P., and will be utilised for furnishing all the lighting and power required for the construction work at Rio das Lages, as well as for supplying light and power in Rio de Janeiro over the permanent transmission lines. Meanwhile the main installation at Rio das Lages is being rapidly constructed. The tramways controlled by the company operate about three-fourths of the total lines of Rio. With the completion of the hydro-electric installation at Rio das Lages and the delivery of further power from that source, for which they already have a large number of customers waiting, the earnings of the company are expected to be largely increased.

WESTON-SUPER-MARE & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—The capital expended during 1906 was £1,295. 16s. 3d., after deducting cost of plant sold (£2,676), and the total capital expenditure is £110,318. 18s. 2d. There was a profit of £2,888. 3s. 8d. from electricity supply and £4,002. 14s. 10d. from traction. After deducting expenses (£1,264. 2s. 10d.) and adding £2,122. 5s. 10d. from 1905, the available balance is £7,824. 1s. 8d. Debenture interest absorbed £1,575, cumulative preference dividend £2,100 and a dividend of 4½ per cent. on the ordinary shares £1,575, leaving £2,074. 1s. 8d. to be carried forward. Connections to the supply mains during the year show an increase of 11 per cent. over preceding year. The tramway traffic receipts showed a substantial increase (£7,502. 15s., against £6,839. 16s. 10d.).

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

CUTLER, WARDLE & CO. (LTD.) (93,564).—Reg. June 1, capital £5,000 in £1 shares (2,000 preference), to acquire the business carried on by W. Wardle at Manchester, and to carry on the business of electrical, heating, ventilating and mechanical engineers, &c. First directors, W. Wardle (chairman) and G. Gardner. Reg. office, 35 and 37, Dickinson-street, Manchester.

UNIVERSAL ELECTRIC SUPPLY CO. (LTD.) (93,507).—Reg. May 27, capital £1,000 in £1 shares, to carry on the business of electrical and mechanical engineers, suppliers of motive power, manufacturers of and dealers in electrical apparatus, &c., and to adopt agreements with A. Poad and G. F. Hewlett. First directors, A. Poad (chairman), G. F. Hewlett and A. E. Hewlett. Reg. office, 55, Queen-square, Bristol.

STATUTORY RETURNS.

CITY OF OXFORD ELECTRIC TRAMWAYS (LTD.)—In return to March 4 capital is £150,000 in £1 shares, of which seven have been taken up. Nothing has been called up. Mortgages and charges, nil.

DIRECT SPANISH TELEGRAPH CO. (LTD.)—The capital in return to April 4 is £95,000 in £5 shares (6,000 preference and 13,000 ordinary), of which 12,931 ordinary and 6,000 preference have been taken up. £5 per share has been called up and £94,655 has been received. Mortgages and charges, £30,000 4½ per cent. first mortgage debentures and £16,000 4½ per cent. second mortgage debentures.

ELECTRICAL INSTALLATIONS (LTD.)—Return to April 29 gives capital as £5,000 in £1 shares, of which 2,307 have been taken up. £1 per share has been called up on 107 and £107 has been received. 2,200 shares are considered as fully paid. Mortgages and charges, £1,500 5 per cent. debentures.

MORTGAGES AND CHARGES.

MAWDSLEYS LIMITED.—£5,000 4½ per cent. debentures, created and dated May 27, 1907, charged on company's property, present and future, including uncalled capital, have been registered. No trustees.

"X" ELECTRIC ACCUMULATOR CO. (LTD.)—A debenture dated May 16, 1907, to secure £2,500, charged on company's undertaking and property, present and future, has been registered. Holder, J. A. Blackley.

CITY NOTES.

MEMORANDA (June 6).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 30$\frac{13}{16}$d.—30$\frac{7}{8}$d. per oz. Consols 83$\frac{5}{8}$—83$\frac{3}{4}$ for money, 83$\frac{13}{16}$—83$\frac{15}{16}$ for account; 2½ per cent. annuities 82—82¼. Consols Pay Day, July 3; Stocks and Shares Continuation Days, June 11 and 25, Ticket Days, June 12 and 26; Pay Days, June 13 and 27; Mining Share Carry-over Days, June 10 and 24.

CHADBURN'S (SHIP) TELEGRAPH CO. (LTD.)—The directors recommend a dividend of 10 per cent. for the past year.

MACKAY COMPANIES.—Regular quarterly dividends of 1 per cent. on the preferred shares and 1 per cent. on the common shares in the Mackay Companies will be paid on July 1. The transfer books will be closed from June 17 to 29, inclusive.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed June 20 a special settling day in 10,000 additional $100 shares of the capital stock of the *Sao Paulo Tramway, Light & Power Co.* (*Ltd.*) and have ordered the same, as well as $500,000 additional 5 per cent. $500 first mortgage debentures of the same company, to be quoted in the Official List. The committee have been asked to appoint a special settling day in 200,000 new £5 (£1. 10s. paid) shares of the *National Telephone Co.* (*Ltd.*) and to grant a quotation to £195,000 £100 5 per cent. mortgage debentures of the *Electric Traction Co. of Hong Kong* (*Ltd.*).

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	May 31	1,805	+ 254	§52	71,779	+ 2,124
Airdrie	,, 24	231	+ 12	20	4,489	+ 18
Anglo-Argentine	June 3	16,552	+ 2,352	22	363,805	+ 33,270
Ashton-under-Lyne Corp	,, 1	365	+ 37	10	3,940	+ 647
Ayr Corporation	,, 1	297	- 3	3	703	- 3
Baker St. & Waterloo Ry.	,, 1	2,415	+ 984	12	28,330	+ 10,927
Barnsley	May 24	211	+ 58	20	3,280	+ 4
Barrow	,, 24	326	+ 98	20	4,600	+ 110
Bath Electric Trams, Ltd.	,, 29	959	+ 194	22	15,920	+ 542
Birkenhead Corporation	June 2	1,005	- 84	...	...	...
Birmingham Corporation	,, 1	5,754	...	9	53,088	...
Birmingham & Mid.	May 17	790	...	19	14,634	...
Blackburn Corporation	,, 29	1,051	+ 76	§9	10,675	+ 1,239
Blackpool Corporation	,, 30	1,733	+ 1,062	8	7,700	+ 1,485
Blackpool and Fleetwood	June 2	738	+ 356	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 2	2,308	+ 213	9	20,264	+ 1,342
Bournemouth Corporation	May 29	1,565	+ 113	¶8	14,417	+ 861
Bradford Corporation	June 1	4,250	- 57	9	41,419	+ 1,909
Brighton Corporation	,, 2	815	- 187	9	7,986	- 194
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	May 31	5,018	+ 95	16	78,051	- 1,302
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	June 1	1,216	+ 30	9	9,689	+ 251
Burton Corporation	,, 2	279	- 29	9	2,535	- 128
Calcutta Tramways Co.	,, 1	R14,456	+ R1,045	21	R1,088,703	+ R15,843
Camborne-Redruth	...	...	...	...	...	...
Cardiff Corporation	,, 1	2,068	+ 77	9	18,537	+ 872
Cavehill	May 24	106	+ 31	20	1,473	+ 77
Central London Railway	June 1	5,780	- 462	22	134,545	- 14,178
Chatham & Dist. Lt. Rys.	May 30	689	+ 30	¶21	14,371	+ 1,262
City & South London Rly.	June 2	3,000	+ 394	22	65,054	+ 2,410
City of Birmingham	May 24	3,248	...	20	55,373	...
Colchester Corporation	,, 29	200	...	...	...	...
Cork Electric Trams Co.	,, 30	522	+ 57	22	9,297	- 140
Croydon Corporation	,, 31	1,410	- 54	‡9	12,540	- 342
Devonport & Dist. Trams	,, 24	523	- 76	20	8,947	+ 203
Dover Corporation	June 1	207	- 32	9	1,965	- 98
Dublin & Lucan Railway	May 31	116	+ 14	22	2,239	+ 68
Dublin United	,, 31	5,926	+ 1,049	†22	108,765	+ 7,338
Dudley Stourbridge	,, 24	1,438	+ 665	20	16,783	+ 576
Dundee Corporation	,, 29	1,134	+ 52	2	2,233	+ 151
East Ham Council	June 1	875	- 23	9	8,175	+ 85
Exeter Corporation	May 31	311	+ 48	‡9	2,794	+ 394
Falkirk and District	,, 29	285	...	9	2,591	...
Gateshead & Dist. Trams	,, 24	1,078	+ 171	20	19,956	+ 891
Glasgow Corporation	June 1	18,127	+ 62	1	18,127	+ 62
Glossop	,, 1	146	+ 20	22	2,973	+ 114
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	May 24	326	+ 100	20	4,611	+ 230
Great Northern & City Rly.	June 1	1,721	- 12	22	40,066	+ 92
Gt. Northern, Piccadilly, &c.	,, 1	4,200	...	22	85,219	...
Greenock & Port Glasgow	May 24	742	- 47	20	12,725	+ 178
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 24	362	+ 95	20	5,261	- 151
Hastings Elec. Trams Co.	,, 30	1,033	+ 448	22	18,652	...
Hong Kong	June 1	$7,370	+ $1,102	9	$168,810	...
Huddersfield	,, 1	1,440	- 55	9	14,223	+ 1,091
Hull Corporation	,, 1	2,340	+ 60	9	21,140	+ 1,441
Ilford District Council	,, 1	457	- 24	9	4,316	+ 2
Ilkeston District Council	May 29	124	+ 4	9	1,275	+ 197
Ipswich Corporation	June 1	374	- 46	9	3,441	- 34
Isle of Thanet Co.	,, 1	470	- 7	35	11,105	+ 607
Jarrow	May 24	166	...	20	2,343	...
Keighley Corporation	,, 30	147	+ 4	48	7,254	+ 597
Kidderminster & District	,, 24	228	+ 134	20	2,091	+ 63
Kilmarnock Corporation	June 1	149	- 13	¶2	423	+ 24
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	May 30	1,204	+ 323	22	23,546	+ 5,056
Lancashire United	,, 29	1,886	+ 1,015	§22	25,725	+ 7,729
Leamington	,, 24	259	+ 112	20	2,935	- 15
Leeds Corporation	,, 25	7,242	+ 1,320	8	51,796	+ 4,599
Leicester Corporation	June 1	2,118	- 140	22	48,074	+ 859
Leith Corporation	,, 1	507	- 22	‡3	1,314	- 43
Lincoln Corporation	,, 1	100	- 8	9	1,019	- 20
Liverpool Overhead Rly.	,, 2	1,480	+ 47	22	314	+ 733
Liverpool Corporation	May 25	11,562	+ 940	21	220,513	+ 4,545
*London County Council	,, 23	33,716	+ 9,234	8	212,337	+ 34,935
London United	,, 31	6,649	+ 236	‡22	126,399	+ 7,398
Lowestoft	June 1	163	+ 8	35	5,424	+ 784
Maidstone Corporation	,, 1	80	- 29	9	947	- 2
Manchester Corporation	,, 1	14,549	+ 1,024	9	130,049	+ 15,547
Mersey Railway	,, 1	1,785	+ 111	22	40,326	+ 2,096
Merthyr	May 24	290	+ 99	20	4,176	+ 323
Metropolitan Dist. Railway	June 2	8,184	- 362	22	172,791	- 3,887
Metropolitan Elec. Trams	May 24	5,612	+ 2,392	20	81,300	+ 20,067
Middleton	,, 24	432	+ 127	20	6,637	+ 251
Nelson Corporation	June 1	139	- 20	10	1,144	+ 104
Newcastle-on-Tyne Corp.	,, 1	3,906	- 116	9	36,263	+ 1,046
Newport (Mon.)	,, 1	659	+ 43	9	5,997	+ 553
Northampton Corporation	May 31	415	- 18	‡9	3,826	+ 139
Oldham, Ashton & Hyde	,, 24	686	+ 156	20	11,922	+ 837
Oldham Corporation	June 2	1,905	+ 28	10	19,342	+ 1,866
Perth (N.B.) Corporation	May 29	146	- 7	2	312	...
Perth (W.A.) Elec. Trams	,, 31	1,347	- 91	22	32,229	- 810
Peterborough	,, 24	161	+ 48	20	2,320	+ 89
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	June 1	1,847	+ 39	9	16,937	+ 670
Potteries	May 24	2,194	+ 425	20	37,442	+ 974
Preston Corporation	,, 22	1,022	+ 374	9	6,806	+ 588
	,, 29	698	+ 13			
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 30	527	+ 60	‡9	5,103	+ 976
Rothesay	,, 24	226	+ 39	20	1,906	+ 27
Salford Corporation	June 3	4,304	- 481	9	42,795	+ 2,422
Sheerness	May 22	65	+ 13	20	1,010	- 3
Sheffield Corporation	June 2	5,248	- 131	10	51,504	+ 3,102
Singapore Trams	,, 1	$9,819	+ $2,058	9	$88,866	+ $15,843

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	May 29	362	+ 34	9	2,923	+ 75
South Metropolitan	,, 24	948	...	20	14,524	...
Southport Tramways	,, 24	497	+ 247	20	5,112	- 3
South Staffs	,, 24	1,334	+ 504	20	18,064	+ 1,815
Stalyb'dge, Hyde, &c., Jt. Bd	June 1	756	+ 63	9	7,195	+ 626
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 2	1,312	- 158	9	12,248	+ 277
Sunderland and District	May 29	400	+ 33	22	9,227	+ 1,437
Swansea Trams	,, 24	1,117	+ 332	20	16,603	+ 769
Swindon Corporation	,, 29	165	- 34	...	...	...
Taunton	,, 24	54	+ 12	20	822	- 44
Tynemouth and District	,, 24	333	+ 145	20	3,611	- 220
Tyneside Trams Co.	,, 29	390	- 13	22	8,973	+ 845
Victoria, Elec. Supply Co. of	April 28	942	+ 108	5	5,192	+ 544
Warrington Corporation	May 30	379	+ 14	9	3,411	+ 170
Wallasey District Council	June 1	828	+ 50	9	7,266	+ 506
Walsall Corporation	,, 1	471	- 35	22	10,511	- 278
West Ham Corporation	May 30	2,274	+ 87	9	21,520	+ 1,553
Weston-super-Mare	,, 22	307	+ 229	20	1,223	+ 171
Wolverhampton Co.	,, 24	816	+ 439	20	8,906	+ 665
Wolverhampton Corpn.	,, 29	792	...	19	17,195	...
*Worcester	,, 24	388	+ 136	20	5,169	+ 52
Wrexham	,, 24	124	+ 35	20	1,976	+ 13
Yorkshire W.R. Trams	June 2	1,032	+ 180	22	24,279	...
Yorkshire Woollen District	May 24	1,164	+ 356	20	19,016	+ 1,55

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Divi-dend	Name.	Price Wed., June 5.	Rate % Yield-ed. £ s. d.	Divi-dend Due.	Business Week to June 5. High-est.	Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
£	4/0	Anglo-Argentine Ord. Shares	7⅞–8¼	4 17 0	Ap, Oct	8⅛	7⅞
£	2/9	Do. 5½ per Cent. Cum Pref.	5⅝–6	4 12 0	..	5⅞	5⅝
St.	6⅞	Do. Permanent 6% Deb. Stock	135–136	4 8 8	..	135½	135
St.	5⅞	Auckland Elec. Trams. 5% Deb. (red.)	101 –107	4 13 6	..	..	..
£	2/0	Brisbane Electric Trams. Invest. Ord.	2⅞–3⅛	8 4 0	..	3	..
£	2/6	† Do. 5 per Cent. Cum. Pref.	4¼–5	5 0 0	..	..	..
St	4½%	Do. 4½ per Cent. Db. Prov. Certs.	93 –102	4 8 0	..	..	..
St.	7⅞	British Columbia El. Ry. Df. Ord.	1 3 –127	4 14 3	..	..	..
St.	6⅞	† Do. Pref. Ord. Stock	103½–108½	4 12 0	..	..	..
St.	5⅞	Do. 5% Cum. Perp. Pref. Stock	102 –1 6	4 14 3	..	101⅜	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	99 –102⅞	4 8 0	..	101⅜	..
100	4½%	Do. Vancouver Power Debs.	102½–1 4½	4 6 0	..	103	..
£	3/0	Buenos Ayres & Belgrano Ord.	3½ – 4	8 15 0	..	3⅞	3⅝
£	3/0	Do. 6 per Cent. "A" Cum. Pref	4⅛–5⅜	5 11 6	..	5	4⅛
£	3/0	Do. "B"	4⅜–5⅛	5 14 0	..	..	..
St.	5⅞	Do. 5 per Cent. Debs.	105 –115	4 7 0	..	110	..
St.	5⅞	Do. 5 per Cent. 2nd Debs. (red.)	101 –104	4 16 0	..	..	..
St.	5⅞	Buenos Ayres Elec. Trams. (1901) Ltd.	98 –101	4 19 0	..	..	..
1	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	100 –104	5 5 9	..	..	..
100	6⅞	Do. 6 per Cent. 1st Deb. Bonds.	106 –105	5 14 0	..	..	..
£	4/6	Calcutta Tramways (1 to 137,610)	7½–8	5 0 0	..	7⅞	7⅝
100	2/6	Do. 5 per Cent. Cum. Pref.	4¾–5⅛	4 7 0	..	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	103 –108	4 3 3	..	..	..
St.	..	Cape Electric Tram Shares	¾ ⅛	..	..	..	..
..	5⅞	Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 –100	5 0 0	..	..	..
1	5⅞	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 - 90⅞	5 11 0	..	..	..
100	5⅞	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 –95	5 5 0	..	..	..
		Do. 6 per Cent. "B" Ditto	81 - 85	7 1 0	..	84	..
£	1/0	Lisbon Elec. Trams. Ord.	1⅞–1⅞	3 9 6	..	..	..
100	0.7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅛	5 1 0	..	..	..
St.	6⅞	Do. 5 per Cent. Reg. Mort. Debs	98 – 1 1	4 19 0	..	..	..
St.	5⅞	Madras Elec. Trams. 5% Deb. Stk.	93 –101	4 19 0	Ja, Jul	98½	98
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 –104	4 6 6	..	..	..
St	6%	Perth E. Trams. 1st Mt. Db. Stock	102 – 106	4 14 3	..	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	123 – 128	3 2 6	..	..	..
..	5⅞	Do. 5 per Cent. 1st Mt. $500 Db	43–45⅞	5 4 0	..	46½	93¼
		ELECTRICITY SUPPLY.					
£	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½–5½	5 11 0	..	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅜–8⅜	5 15 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 – 98	4 11 9	..	..	..
£	5/3	Calcutta Elec. Supply Ord.	7½ – 8½	5 2 0	..	..	..
5	2/3	Do. £4 paid	6 –7	..	..	..	..
50	5⅞	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 –51	4 13 0	..	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼–2¾	..	..	..	..
St.	5⅞	Do. 5 per Cent. Deb Stock	88 –92	5 8 6	..	..	..
St.	5⅞	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	96 – 98	5 2 0	..	..	..
St.	6⅞	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 –1 9	5 10 0	..	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	⅝–⅞	..	..	..	..
St.	5⅞	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	91½–97½	5 2 6	..	95	91½
1	1/6	Rand Electric	1⅛–1⅛	..	..	..	..
1	0/6	River Plate Electricity Co. Ord.	⅞–1	..	..	..	..
1	1/2½	Do. 6 per Cent. non-Cum. Pref.	⅞–1⅛	6 8 0	..	..	..
St.	5⅞	Do. 5 per Cent. Deb. Stock	97 –100	5 0 0	..	98½	97
5	3/0	Rosario Elec. Co. 6% Pref. (120,000)	5 –5½	5 9 6	..	..	..
..	5⅞	Shawmigan Water & Power 5 per Cent. Bds., Scrip	100 –102⅞	4 13 0	..	101	100½

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHRS	LAST DIVIDEND	NAME.	Price Wed., June 5.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 5. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	1⅜–1⅝	6 0 0	..	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅜–10⅛	4 9 0	..	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1⅛ 10⅜	5 11 8	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	101 –10⅛	4 6 6	..	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜–5⅛	5 5 0	..	..	..
St.	4½%	Do. Do. 1st Debs.	97 –99	4 11 0	..	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	8 – 9	5 11 0	..	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅛– ⅛	4 6 0	Mar, Sept	..	..
St.	4%	†Central Elec. Sup. Co 4% Guar. Db. Stock	93 – 101	3 19 0	..	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	2½–4	6 5 0	Feb, Aug	..	..
5	2/3	Do 4½ per Cent. Pref.	4 –4½	5 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 – 99	4 1 0	..	£8⅝	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅝–4⅛	5 9 0	..	..	..
5	2/3	Chelsea Electric Supply Ord.	3½–4⅛	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	103 – 106	4 5 5	June, Dec	104⅜	..
10	7/0	City of London Electric Lighting Ord...	9⅜– 10⅛	5 17 6	Feb, Aug	9⅝	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅛–12⅛	4 16 0	Jan, July	11⅝	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 –124	4 0 9	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	..	9⅞	98⅜
5	5%	County of Durham Elec. P. D. Ord.	4⅛–4⅜	3 0 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜–5	4 10 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅛ –8⅛	5 17 6	..	7⅞	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅜–11⅛	5 4 0	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)...	1 6 –1/9	4 2 6	..	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	94 –97	4 12 9	..	95	94
5	3/6	Folkestone Electricity Supply Co. Ord	4⅝–5⅛	5 2 0	..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅛	4 11 0	..	..	..
St.	4½%	Do. 4½ 1st Pref. Stock (red).....	93 –101	4 9 0	..	..	..
5	5/0	Hove Electric Lighting Ord.	7 – 7⅛	6 0 0	..	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8⅛–9⅛	5 5 0	..	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜– 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 – 100	4 0 0	..	..	..
St.	4%	Kensingtn. & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 1 2	3 13 0	..	101½	..
3	2 4½	London Electric Supply Ord.	1⅞ –2⅛	5 13 0	..	..	..
5	3 0	Do. 6 per Cent. Pref.	4⅜–4⅝	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	95 – 98	4 2 0	Mr,Jn,S,D	97	..
5	4/0	Metropolitan Electric Sup. Ord.	6 – 6⅛	6 3 0	April, Oct	6	5⅞
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 –5⅛	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	106 –109	4 2 9	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	90 – 93	3 15 3	..	..	..
100	4½%	Midland Elec. Corp. for P. D. 1st Mort. Db.	88 –89⅛	4 13 9	..	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅞–9⅛	5 0 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	£9 –101	4 10 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7½–7⅝	5 8 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛–4⅜	4 10 1	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 –100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 –1⅛	2 16 6	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	100 –101	4 10 0	Jan, July	..	..
10	9/0	Notting Hill Electric Ord.....	12 – 13	5 15 0	March ..	..	..
5	4/6	Oxford Electric Ord.	6 –6⅜	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 – 99	4 1 6	..	..	..
5	5/0	St. James' & Pall Mall Elec. Ord	7⅞–8⅛	6 1 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅜–7⅛	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	88 –93	3 15 3	..	100	..
5	..	Smithfield Markets Electric Sup. Ord...	1⅛–2⅛	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 – 77	5 4 0	..	..	..
5	3/0	South London Electric Supply Ord.	2⅛– 2⅝	6 8 0	..	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝–¾	3 6 9	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.	1⅛–1⅜	4 15 0	..	1⅛	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	101 –103	4 7 6	..	..	..
5	2/6	Urban Electric Supply Ord.	1⅛–2⅛	10 0 0	..	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	2⅜– 3⅛	7 3 0	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	..	..	..
5	6 6	Westminster Elec. Sup. Ord.	9⅛ 9⅜	6 3 0	Mar, Sept	9⅜	..
5	2 3	Do. 4½ per Cent. Cum. Pref.	5⅛–5⅜	3 13 3	..	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 – 95	4 4 0	..	92½	90⅛
1	1/0	Bath Elec. Trams Pref. Ord.	⅜– ⅝	5 14 0	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¾– 1	5 0 0	..	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	..	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 – 99	4 11 0	..	..	..
10	9½	Bristol Tramways & Carriage Ord.	14½–14⅝	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 –9⅛	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 – 102	3 18 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	8 – 8¼	..	..	8⅜	8
10	6/0	Do. 6 per Cent. Cum. Pref.....	7 – 7⅛	8 0 0	Feb, Aug	7⅜	7⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 101	4 16 0	..	102	100
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	79 – 82	5 9 6	..	..	..
St.	4%	Central London Ordinary Stock	70 – 72	5 11 0	June, Dec	71	..
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	..	93½	..
St.	4%	Do. Deferred Stock	53 – 56	7 2 8	..	..	..
100	4%	Do. 4 per Cent. Debs.	103 – 106	3 15 6	..	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db Stk.	83 – 86	4 13 0	..	83	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref	4½–5	5 0 0	..	..	..
100	4%	Do. 4 per Cent. 1st Mort Debs.....	98 – 101	3 19 0	..	..	..
St.	2%	City & South London Rly. Con. Ord. ...	40 –42	4 15 0	Feb, Aug	42	40⅜
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ..	117 –121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 – 118	4 4 9	..	..	..
St.	5%	Do. (1901)	115 – 119	4 4 9	..	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 –105	3 16 0	May, Nov	104	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½ – 14½	4 2 9	..	..	..
10	6/0	Do. 6 per Cent. Pref.	13 – 14	4 5 9	..	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2⅛–2⅜	..	..	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	85 – 88	4 11 0	..	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ D. St	93 – 101	4 9 0	..	..	..
10	9%	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11½	5 6 6	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	99 – 101	4 9 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref	1 – 1⅛	..	..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 – 73	5 9 6	..	..	..
St.	47/6	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 –99	..	..	..	..
10	..	Liverpool Overhead Railway Ord.	1⅜ –1⅝	..	Feb, Aug	..	..
10	6%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 – 90	4 9 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ..	7⅜–7⅝	5 14 3	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 88	4 11 0	..	88	..
St.	..	Mersey Con. Ord. Stock	2 –4	–	..	..	..
St.	..	Do. 3 per Cent. Perp Pref.	3 –6	–	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅛–⅜	–	..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜–⅝	5 3 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0	..	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜–1⅜	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	3½–6⅛	6 8 0	..	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 –7⅛	6 18 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock	90⅜–99⅜	4 11 6	..	..	..
1	3/5/6d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝–1⅛	5 16 6	..	..	..
St.	36/3½	Do. 4 per Cent Deb. Stock	82 –86	4 13 0	..	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	86 –90	5 11 0	..	..	..
..	5%	†Underground Elec. Rys. Co. of London ...	70 –73	6 17 0	..	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1⅛–1⅜	–	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛–3¾	–	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 – 94	4 15 9	..	–	..

SHRS	LAST DIVIDEND	NAME.	Price Wed., June 5.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 5. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅛–¼	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜–½	8 0 0	..	..	..
1	9/4½	Babcock & Wilcox Ord.....	3⅜–4	5 0 0	..	8⅛	8⅛
1	0/7⅛	Do. Pref.....	1⅛–1⅜	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅛–7	7 3 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅞– 6⅛	4 16 0	Jan, July	..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 –1 5	4 5 9	..	..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3	..	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	..	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£4 – £8	5 18 0	..	..	..
2	..	Brush Electrical Engineering	½ – ¾	–	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	1 –1½	8 0 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	80 – 82	4 13 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 –78	5 14 6	Jan, July	..	..
5	5 0	Callender's Cable Con. Ord.....	10 – 11	6 15 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ – 5⅞	4 7 0	Jan, July	..	..
St.	4½	Do. 4½ per Cent. 1st Mort Debs (red.)	106⅛–106⅝	4 3 0	Nov, May	..	..
1	0/9½	Castner-Kellner Alkali Co.	1⅛–1⅜	5 14 0	..	1⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	..	..	..
1	0 9½	Chadburn's (Ship) Telegraph Ord.	1⅜ – 1⅝	7 5 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜–1⅝	5 4 0	..	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 51,000).....	1⅜ – 2	3 15 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96⅞–99⅞	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅞–1⅛	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1⅞–1½	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 – 105	4 5 6	..	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1 –1⅛	2 0 0	Feb, Aug	1⅛	..
5	4/2	Do. (£5 paid)	2⅛–2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	85 – 87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 –9⅜	5 8 6	..	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅛–1⅛	10 0 0	H'lf-yearly	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅛–2⅛	..	..	2	1⅛
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	78 –83	5 8 0	..	80	..
2	..	Electric Construction Co.....	½–⅞	..	July	..	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1⅛– 2	7 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. obs.	79 – 83	4 16 3	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8⅛– 9⅛	5 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 95	4 4 0	..	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅛ – 12⅜	5 17 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5⅛– 5⅜	3 18 3	Feb, Aug	..	..
St.	4½% †	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 –107	4 4 0	..	..	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15 –16	6 5 0	Feb, Aug	15⅞	15⅞
100	4%	Do. 4 per Cent. Debs. (red.).....	£8 –100	4 0 0	..	..	..
1	1/4½	Richardsons, Westgarth & Co., Ltd. Ord.	¾–1⅛	7 6 0	..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅛– 1	6 0 0	..	1	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 –100	4 10 0	..	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	30⅛–31⅛	5 14 3	Mar, July	31½	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	101 –104	3 16 6	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛–2⅞	6 1 0	..	2⅛	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛–1⅜	4 1 0	..	1⅜	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 –117	4 5 6	..	1/6	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 –104	3 17 0	..	..	..
100	4½% †	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 –105	4 5 6	..	1.7	104
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9⅛–10	5 0 0	..	..	..
5	..	Willans & Robinson Ord.	1⅛–1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅞–4⅛	..	Apr, Oct	3⅞	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	78 –82	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	–	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 –91	5 10 0	..	88⅛	88
St.	15/0	Anglo-American	6⅛–6⅜	6 0 6	F,My,Ag,N	6⅛	..
St.	30/0	Do. Preferred	107 –108	5 10 0	F,My,Ag,N	10⅞	10⅞
St.	12½	Do. Deferred	19⅜–19⅝	4 8 0	F,My,Ag,N	20⅛	19
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 –94	4 5 0	Jn,Ap,Jy,O	..	..
10	5 0	Cuba Submarine Ord.....	7⅜–8⅛	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅛–16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜–3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅝ – 9⅛	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝–103⅝	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	16⅜–15⅞	5 17 6	Ja,Ap,Jy,O	15⅞	15⅛
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	101	..
St	£5/0	Eastern Ordinary	139 –141	4 19 3	Ja,Ap,Jy,O	141	139
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 –91	3 17 0	Ja,Ap,Jy,O	90⅛	8
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104⅛–106⅜	3 15 0	May, Nov	105⅞	..
10	6/6	†Eastern Extension	13⅛ – 14	5 0 0	Ja,Ap,Jy,O	13⅝	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock	104⅜–106⅛	3 15 0	Feb, Aug	1.4	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	£8⅜–100⅜	4 0 0	May, Nov	..	..
10	8/0	G.N. (of Copenhagen), with Coupon 70...	84 –86	6 19 0	Jan, July	8⅝	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 –102	4 8 0	June, Dec	..	..
25	£2/6	Indo-European.....	56 – 58	5 12 0	May, Nov	..	..
100	4%	Mackay Companies Common	71 –73	5 8 6	Jan, July	..	..
100	4%	Do. Preference	69 –71	5 12 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅝–¾	..	..	..	..
100	4%	Pacific & Europe'n Tel. 4 Guar. Dbs. (red.)	£14–100⅛	3 19 6	June, Dec	..	..
10	4/0	†West African Telegraph Shares	10 –10⅛	8 16 0	..	..	..
2½	1/3	West Coast of America	1⅛– 1⅜	3 12 9	..	..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅛–⅜	..	May, Nov	..	..
10	8/0	† Do. 6 per Cent. 1st Pref. xd & arrears	7⅛–7⅞	7 12 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref	6⅛–7⅛	..	May, Nov	7⅛	..
100	5%	* Do. 5 per Cent. Debs.	100 –103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	14 –14⅜	4 18 6	Mr,Jn,O,D	14⅛	14
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 –105	3 16 0	..	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 –94	4 5 0	..	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 – 101	4 19 0	..	..	..
5	3 0	Chili Telephone	6⅞–7⅛	5 11 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	⅞–1⅛	4 14 0	..	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞–1	5 0 0	..	..	..
St.	6%	National Co. Pref. Stock	108 –110	5 9 0	..	1 9½	108½
St.	5⅝%	Do. Def. Stock.....	105 –107	5 2 6	..	1 6⅛	106⅜
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11⅛–13⅛	4 9 0	Feb, Aug	11⅜	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	11⅜	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛–6⅜	4 10 0	Feb, Aug	6⅛	5⅛
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	93⅜–97⅜	3 11 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 0	..	..	..
1	0/9½	Oriental	1⅛–1⅜	4 17 6	April, Oct	1⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 16 0	..	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 – 98	4 2 0	..	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	£9 –102	4 7 0	..	..	..
5	8/0	United River Plate.....	6⅞–7⅛	5 9 6	July	16⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 11 0	June, Dec	5⅛	5⅛
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	108½–111½	4 9 9	June, Dec	109	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	4 – 5	6 0 0	..	..	..
10	2 0	Globe Telegraph & Trust.....	10⅛– 11⅛	4 19 6	Ja,Ap,Jy,O	11⅜	10⅝
10	3/0	Do. 6 per Cent. Pref.....	13⅜–14⅝	4 5 0	Ja,Ap,Jy,O	14⅝	..
10	6/6	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these

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NOTES.

Manganin Resistances.

FOR some time past it has been observed that resistance coils made of manganin have been liable to certain slight variations of an unaccountable kind. These variations have been greater in this country than in Germany, and it has been supposed that they were due to our methods of manufacture not being so good as those in Germany. This idea, however, has been discounted by the fact that coils made in Germany and used in America have been subject to variations quite as large. In a Paper, which we publish in this issue, Messrs. ROSA and BABCOCK give some account of observations carried out at the Bureau of Standards at Washington, from which it appears that the resistance of a coil varies with the time of year, being greater for a given temperature in summer than in winter. This variation has now been traced to the effect of humidity, and it appears that as the humidity increases, the shellac with which such coils are generally impregnated takes up moisture and expands, the expansion being sufficient to cause a slight elongation of the wire, thus causing an increase of resistance which is quite appreciable in coils of 10, 100 or 1,000 ohms, though negligible in coils of low resistance. Apparently, if the coils are insulated in such a way that variation of humidity cannot affect them, for example if they are sealed in glass, the resistance is quite constant. It is gratifying to find that these variations are not due to any defect in the manganin itself, which still appears to be quite satisfactory as a resistance material.

The Moore Light.

CONSIDERABLE interest has been aroused in the daily press by the installation in the courtyard of the Savoy Hotel of what is known as the Moore light. One of the objections which has been raised against the use of metallic filament lamps is the small surface of the source of light; but, as will be seen from Mr. MCFARLAN MOORE'S Paper, read before the American Institute of Electrical Engineers, of which we give an abstract in this issue, no such objection can be brought against the long length of tube used in the Moore system. The chief point of interest, however, is the simple valve by means of which a trace of air is admitted to the tube about once a minute. By changing the gas that is admitted, the colour of the light is altered, air giving a pink and nitrogen a yellow illumination. It is this valve which has caused the non-technical press to describe the arrangement as "an electric light that breathes." The lamp itself is not new, as it has been known in America for many years; but we believe that this is the first occasion on which it has been brought into use in this country.

IT is a little difficult to judge merely from a Paper of the kind read by Mr. MOORE to what extent the Moore light in its most recent form will really be of commercial value. It has certain drawbacks; for example, if the light of the room depends upon a single tube, and this becomes defective, no more light is obtainable until the tube can be replaced, which is not the sort of operation that can be carried out by the usual domestic servant. It would, therefore, seem that in a system of this kind most people would feel it necessary to have tubes installed in duplicate. Another objection is that a high pressure is required, and, therefore, each tube must terminate in a box containing a suitable transformer. This, of course, must add materially to the cost, about which very little

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is said in the Paper. As to advantages, these are undoubted in some respects. The colour is good and the light is more diffused. From the optical point of view, indeed, the system appears to be very desirable, because the intrinsic brilliancy is quite low, being less than 1 hefner c.p. per square inch of tube surface, whereas in incandescent lamps this value is stated to be 250, and for Nernst lamps 600. Consequently the Moore tube would not be fatiguing to the eye, even if directly in view.

THE whole question of utility, however, must depend upon cost and efficiency. With regard to the latter, Mr. MOORE gives figures showing that the illumination produced is superior, from the efficiency point of view, to that given by enclosed arc lamps. Comparative illumination tests of this kind, however, are subject to certain errors and must be accepted with caution. In measuring the light emitted per unit length of tube, Mr. MOORE finds that the efficiency in a tube 40 ft. long is 2·5 watts per hefner candle-power, which is increased for a tube 220 ft. in length to 1·4 watts. It, therefore, seems a little doubtful as to what the efficiency really is, and, further, the power factor is somewhat low, though it is stated that in the latest form this rises to 0·84. Undoubtedly Mr. MOORE seems to be working in the right direction in adopting a gaseous medium, and later developments will be watched with interest; but we doubt if the Moore light will at present find more than a limited application.

Aluminium as a Substitute for Copper.

ELECTRICAL engineers have always been anxious to obtain a substitute for copper which would be cheaper for a given resistance and length of line, and on that account attention has been frequently directed to aluminium, but so far without very greatly increasing its use, for as a rule the gain in cost by the use of aluminium has not been sufficient to counteract certain disadvantages. Judging, however, from the report of the directors of the British Aluminium Co., presented last week at the annual general meeting, there seems to be some reason to believe that the price of aluminium will be somewhat lower in another year or two, not through the method of production being cheapened, but owing to the fact that not only is the British Aluminium Co. about to increase its output largely from new works at Leven, but other companies also seem to be about to follow the same policy. There can, therefore, be only one natural result—namely, that the price of aluminium will fall until the manufacturers find it necessary to restrict their output owing to cost of production. Coupled with the high price of copper, which seems likely to be maintained, this lower price of aluminium should cause engineers to consider its claims more seriously. Unfortunately, underground conductors are peculiarly ill-adapted to the use of aluminium in place of copper, and so far overhead transmission in this country has not made any great advance. Nevertheless, the latter is certainly increasing, and it may be found more and more worth while to use aluminium for such a purpose where the increased diameter of the wires due to the use of the aluminium is not such a serious disadvantage. In other countries high-tension transmission is more likely to reach that point where the increased diameter may be regarded as one of the advantages.

The Power Scheme of the L.C.C.

THE London County Council evidently appear to recognise the difficulty of getting their Electricity Supply Bill through Parliament this session, for on Tuesday the Council adopted certain recommendations of their Parliamentary Committee for withdrawing and amending those clauses of the Bill which were not deemed essential to the main object of providing a cheap supply of electricity. The most important clauses to be dropped are those relating to the compulsory acquisition of the undertakings of the Borough Councils and the transfer of the powers of purchase of company undertakings, so that the Bill will differ very considerably from that put forward by the Council last year, especially as the capital expenditure is limited to £100,000 instead of the £4,500,000 originally proposed. This modification will ensure the leasing of the Council's powers to a company. It was also agreed to make provision in the Bill that, if the Council lease their powers, the undertaking shall be purchasable at the end of a period not exceeding 50 years. It was suggested by some members that the lease should expire in 1931, when the existing companies' concessions expire, but such an arrangement would obviously only lead to high prices being charged for energy, and so defeat the object which the Council has in view. As the Hybrid Committee are now sitting and taking evidence, we shall doubtless soon be in a position to judge whether the new proposals are likely to assist the Bill in its passage through Parliament this session.

British Association.—The Council of the British Association for the Advancement of Science has nominated Mr. Francis Darwin, F.R.S., as president for next year's meeting, which is to be held at Dublin.

Electricity in Farming.—We referred last week in our notes to the report that the Durham Electric Power Supply Co. were offering to supply electricity to farmers at 0·55d. per unit. We regret to learn from the Company that this report is without foundation.

Submarine Telegraph Extensions.—After lengthy negotiations, the King of Spain has granted landing rights to German negotiators for a cable to Teneriffe. This cable will start from Emden, touch Teneriffe, probably branch to the German West African possessions, and may ultimately, if landing rights are obtained, be taken to Pernambuco, Brazil.

The Tramways and Light Railways Association.—The "Official Circular" for June gives further correspondence in regard to the proposed clause to be inserted into tramway bills by the Postmaster-General, allusions to other matters concerning the Association and light railways, &c., and a translation of that portion of Herr Busse's report to the Milan International Tramway Congress of 1906, which deals with rail corrugations.

Wireless Telegraphy Notes.—In view of the probable ratification of the Berlin Radio-Telegraphic Convention the Directors of Posts and Telegraphs of Uruguay and Argentina have agreed to the establishment of radio-telegraphic communication between Buenos Ayres and Montevideo. It is proposed to erect wireless telegraph apparatus at the Cerro, Uruguay, capable of transmitting messages over a 300 mile radius, and a similar station in Buenos Ayres.

Cable Interruptions.	Date of Interruption.
Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907

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National Telephone Company.—We regret to learn that Mr. W. E. L. Gaine, general manager of the National Telephone Co., has caught a chill and is down with a serious attack of pleurisy. The fourteenth annual staff dinner, which was to have taken place last evening, with Mr. Gaine in the chair, has, therefore, been postponed.

Electrical Progress in Spain.—The report of the U.S. Consul-General at Barcelona shows that there are at present 1,140 generating stations in Spain having a total annual output of 99,513,170 kw.-hours. Madrid has the largest station (15,998 kw.), while Barcelona is second (8,082 kw.). The total number of incandescent lamps in Spain for street lighting is 119,105, with a total candle-power of 1,427,408. There are also 1,691 arc lamps in use, with a total candle-power of 1,214,476. In private use there are 1,593,402 incandescent lamps of 13,333,783 total candle-power and 8,051 arcs with a total candle-power of 5,303,777. There are also 3,293 electric motors with a total capacity of 25,382 H.P.

Shocks from a Fire Engine.—An unusual experience, probably due to static electricity, is reported from Chattanooga, Tenn., in the *Western Electrician*. It is said by the firemen of that city that the new La France fire engine, which was installed in December last, has taken to generating electricity when, after operating, the steam is allowed to "blow off." One of the firemen says that he has received several electric shocks when the boiler was "blown off," and the agent for the fire-engine company has been notified to make an examination and explain the mystery. The engine is mounted on rubber tyres. The fire insurance interests as well as the fire department of Chattanooga are much interested in this elementary electrical phenomena.

L'Association pour l'Avancement des Sciences.—The thirty-sixth annual meeting of l'Association pour l'Avancement des Sciences will be held at Rheims from August 1st to 6th, under the presidency of Dr. Henrot. A programme of meetings has been arranged, several excursions to places of interest in the neighbourhood will be made, and a reception will be held by the municipality and the local Council. The president of the fifth section (*Physique*) is M. Blondin, and among the subjects down for discussion are "The Properties of the Electric Arc and their Application to the Production of (1) Luminous Rays, (2) Electric Waves for Use in Wireless Telegraphy and Telephony, (3) Nitric Acid and Nitrates." "The Effects of Hertzian Waves on the Magnetism of Iron, with reference to their Application to Coherers," and "The Transformation of Heat Energy into Light and its Application to Lighting by Electricity and Incandescent Gas," will also be discussed.

Royal Observatory, Greenwich.—Last Saturday the annual official visit was paid by the President of the Royal Society and the Board of Visitors to the Royal Observatory. The Astronomer Royal in his annual report, which is always presented on these occasions, referred to the controversy over the electricity generating station of the London County Council at Greenwich. He stated that the tremours which were caused by the generating station could be masked by the use of a thin film of mercury; but it was uncertain whether they caused the telescopes to oscillate to such an extent as to interfere with delicate work, such as the observation of close double stars. Further experience would have to decide this. The danger due to the discharge of the heated gases from the chimneys was more serious, as the effects possibly would not become apparent for some years, when results might be found to be untrustworthy from this cause. The recommendations of the committee of inquiry were the minimum, and were absolutely necessary; a further reduction in the height of the chimneys might be found necessary to safeguard the work now being carried on.

Engineering Standards Committee.—We have received from the Engineering Standards Committee copies of their standard specifications for Ingot Steel Forgings for Marine Purposes and for Steel Bars (for use in automatic machines). The former of these contains clauses dealing with the process of manufacture, freedom from defect and annealing of the ingots, together with details of the tests to be carried out on them before acceptance. An appendix to the specification gives some useful information regarding the dimensions of the test pieces with sketches of the same. Clauses in the latter deal with the manufacture, standard section, testing and chemical analysis of steel bars (for use in automatic machines). Two attached tables give details regarding round and square, and hexagon bars respectively. The former of these gives the margin in manufacture of hot rolled and bright rolled, and drawn round and square bars. The latter gives the minimum width allowable when the hot rolled bars are left black and when allowance has to be made for grinding. In their preface to this specification the sub-Committee state that owing to the widely differing results obtained when bars of small diameter are subjected to mechanical tests, they have decided that none of these tests are to be included for steel bars less than $\frac{1}{2}$ in. in diameter.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 14th (to-day).

PHYSICAL SOCIETY.

8 p.m. Meeting in the Pender Electrical Laboratory, University College, Gower-street, W.C. Papers on "Observations on the Electric Arc," by Mr. W. L. Upson; on "The Poulsen Arc as a Means of Producing Electrical Oscillations" (with experiments), by Dr. J. A. Fleming, F.R.S.; and an "Exhibition of a Direct-reading Conductivity Bridge for Rods," by Mr. R. Appleyard.

TUESDAY, June 18th.

INSTITUTION OF ELECTRICAL ENGINEERS.

9 p.m. Conversazione at the Natural History Museum, Cromwell Road, South Kensington, S.W.

WEDNESDAY, June 19th.

Institution of Civil Engineers.—Engineering Conference.*

10 a.m. Meeting in the Theatre, Institution of Civil Engineers, Great George-street, Westminster. Presidential Address by Sir A. B. W. Kennedy, F.R.S.

10:30 a.m. Meeting of Section VII. (Applications of Electricity) in the Council Room. Papers on "Electrical Transmission-Gears on Motor-Vehicles," by Mr. A. A. Campbell-Swinton; on "The Application of Electricity to the Working of Railway Points and Signals," by Mr. L. M. G. Ferreira; and on "Upkeep Charges on large Electric Generating Sets," by Messrs. H. R. J. Burstall and J. S. Highfield.

Meeting of Section VI. (Waterworks, Sewerage and Gasworks) in the Upper Library. Papers on "Comparative Cost of Pumping by Steam, Internal Combustion Engines and Electricity, based upon Actual Working," by Messrs. C. Hawksley and H. Davey; and on "Water Softening," by Mr. W. Matthews.

2:15 p.m. Visit to Messrs. Crompton & Co.'s Works, Chelmsford.

2:45 2:55 and 3:5 p.m. Visit to the Charing Cross, Euston & Hampstead Railway.

THURSDAY, June 20th.

Institution of Civil Engineers.—Engineering Conference.*

10 a.m. Meeting of Section II. (Harbours, Docks and Canals) in the Main Library. Paper on "Dock Equipment; including the Relative Advantages of Electric and Hydraulic Appliances," by Mr. W. W. Squire.

Meeting of Section I. (Railways) in the Theatre. Papers on "The Action between Wheel and Rail," by Mr. H. R. A. Mallock; on "A System of Audible Signalling," by Mr. W. Dawson; and on "Light Railway Policy," by Mr. W. Barrington.

Meeting of Section VI. (Waterworks, Sewerage and Gas Works) in the Upper Library. Paper on "The Distribution of Gas at Increased Pressure," by Mr. C. C. Carpenter.

2:30 p.m. Visit to the National Physical Laboratory, Teddington.

3 p.m. Visit to the Chelsea Generating Station of the Underground Electric Railways Co., Lot's-road, Chelsea.

Visit to Central Telephone Exchange, General Post Office, Carter-lane, E.C.

INSTITUTION OF CIVIL ENGINEERS.

9 p.m. Conversazione at the Royal Albert Hall, Kensington, W.

FRIDAY, June 21st

Institution of Civil Engineers.—Engineering Conference.*

10 a.m. Meeting of Sections IV. and VII. (Mining and Metallurgy and Applications of Electricity) in the Theatre. Papers on "Electro-metallurgy," by Mr. B. Blount, and on "Modern Applications of Electricity to Mines," by Mr. C. P. Sparks.

Meeting of Section V. (Shipbuilding) in the Reading Room. Paper on "The Welding of Structural Materials in Place," by Mr. H. A. Ruck-Keene.

1:45 p.m. Visit to the Greenwich Generating Station of the L.C.C. Tramways and Messrs. Siemens Bros'. Works, Charlton.

Visit to the Greenwich Generating Station of the L.C.C. Tramways and Deptford Generating Station of the London Electric Supply Corporation.

Visit to Messrs. Vickers, Sons & Maxim's works at Erith.

* The above announcements of the Papers to be read and the visits to be made at the forthcoming Engineering Conference do not include all the Papers and visits, but only those of special interest to electrical engineers.

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ELECTRIC TRACTION ON RAILWAYS.*

II.—SOME FINANCIAL CONSIDERATIONS IN CONNECTION WITH ELECTRIC RAILWAYS.

BY PHILIP DAWSON.

(*Continued from page 46.*)

Summary.—After referring to the character of an electric railway load on the generating station, the Author discusses two main causes which conduce to electrification of existing railways, viz. (1) reduction in working expenses and (2) the desire for the better utilisation of existing facilities. A steam locomotive in suburban work consumes fuel for about 76 per cent. of its life, but does useful work only during about 28 per cent. Detailed figures are given for running costs of steam locomotives. Another basis of comparison is by weight and carrying capacity, which often apparently tells in favour of steam owing to the internal arrangement of coaches adopted for electrical working. Running costs are given for a number of railways, including the Mersey Railway, which is a good example for comparative purposes. Finally, the general results obtainable are discussed and illustrated by examples taken from the London, Brighton & South Coast Railway.

As already mentioned in a previous article,† it must be clearly understood that the term railway applies in the generally accepted meaning of the word in this country.

The subject of the electrification of railways covers a very wide field, and the financial aspect, which is the most important one, varies according to the particular form of service required, the location of the line and the conditions of the district in which it is to be operated.

Generally speaking, it can be broadly stated that, as far as this country, at least, is concerned, the chief field of electric traction lies in the operation of those lines where stops are frequent and trains follow each other in rapid succession; in other words, in the suburban systems round our large cities and in the connections which bind together many of our large manufacturing centres of the North, lying as they often do in close proximity to each other.

There is little reason at present to anticipate that the near future will see the general introduction of electric traction for every purpose and for all distances on our railways.

In every case, but particularly where electricity has to be generated from coal, the cheap supply of electricity depends principally upon the load on the power station being as constant as possible.

Fig. 1 shows the energy taken by a train over a given run. From this it will at once be seen that unless a large number of trains can be superposed there is little chance of the load being equalised and what is known as the load factor being brought up. The result of this averaging up of a large number of trains is shown in Fig. 2, from which it will be seen that the average load works out at 8,200 kw., corresponding to a load factor of 41 per cent.

It will be at once seen that, in order that a large service should be of any use, all the power must be supplied from one generating station, and this condition at once limits the area in which electrification with a given train service can be carried out satisfactorily.

There are, as has already been explained, two causes which conduce to electrification of existing lines: one, a desire to reduce working expenses, and the other (the principal cause) the desire for the better utilisation of existing facilities and cultivating suburban travel to increase the revenue without undue capital expenditure.

As regards the first cause, it is, of course, evident that a steam locomotive is working at its very worst efficiency in hauling suburban trains, for the reason that although for the whole portion of the time that it is away from the locomotive shed it is burning coal, it is only actually exerting a tractive effort and doing useful work for a very small portion of that time. Naturally, the result is unsatisfactory, both as regards operating expenses, consumption of fuel, water, &c., and maintenance expenses, all of which, being on a small train mileage, assist to run up its cost.

The conditions of working of a goods engine (except where used for shunting, which will be considered later) and an express train engine are exactly the reverse, and under the latter conditions the steam locomotive, notwithstanding its heavy cost of repairs and maintenance, has proved itself to be an efficient and economical machine.

Repairs have already been mentioned, and these, owing to frequent starting and stopping, are heavier in the case of a suburban engine than with expresses.

The total life of a suburban service locomotive cannot be taken at much over 25 years, and of this time only 28 per cent. is actually spent in exerting a draw bar pull on a train and doing actual useful work. Bringing the whole thing down into one day, we should have the following results:—

Locomotive under steam but doing no work.....	12 hours
,, ,, pulling train	6¾ ,,
In repair shop, cleaning and getting under steam or blowing off	5¼ ,,

In other words, although a steam locomotive or suburban train is only doing actual useful work during about 28 per cent. of its life, it is actually consuming fuel and wearing itself out during, approximately, 76 per cent. of its life, the remaining 24 per cent. being spent in the repair shops and in being got ready for work and generally overhauling and maintaining.

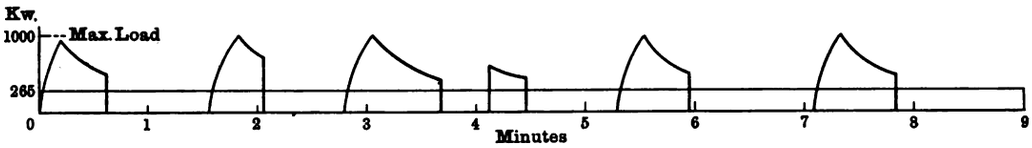

FIG. 1.—8 W.E. 51 MOTORS. TRAIN WEIGHT 132 TONS. RUN FROM BATTERSEA PARK TO PECKHAM RYE. Load Factor = 25·5 per cent.

But, besides this, there is the point that, owing to the lower average speed of steam as compared with electric traction, where runs with frequent stops are the rule, an electric train is capable of being run about 50 per cent. more train-miles than a steam train on the same service, and therefore (for the same service) fewer electric trains are needed.

All the published figures which are commonly available in connection with steam roads refer to the average cost of locomotive power per train-mile, based on the average service, which includes express and through as well as goods trains, and the costs, as far as fuel and maintenance

Table I.—*Average Cost for Five Years, from 1901 to 1905 inclusive, per Train-mile, in Pence. From Board of Trade Returns.*

RAILWAYS.	Loco. power (in pence).	Percentage of loco. cost to total cost.	Total (in pence).
Great Central	11·06	29·8	38·40
Great Eastern	10·24	26·3	39·18
Great Northern	11·17	29·6	37·66
Great Western	11·31	30·8	36·82
Lancashire & Yorkshire	12·09	26·6	45·41
London & North-Western.....	11·97	26·1	45·76
London & South-Western	10·78	29·9	37·24
L.B. & S.C.	12·87	29·8	43·19
North-Eastern	14·16	30·0	47·1
South-Eastern & Chatham ...	12·43	27·1	45·98

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† *The Electrician*, April 19th, 1907.

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are concerned, are necessarily lower than would be the case if the suburban service could be entirely separated from the main-line passenger and goods services; and in considering the following figures this fact must be carefully borne in mind.

Table I., compiled from the Board of Trade returns, gives the locomotive cost and the total cost per train-mile over a period of five years, from 1901 to 1905 inclusive.

From these figures it will be seen that the locomotive costs are nearly one-third of the total costs of operating a railway, and may be taken on the average as 12d. per train-mile. Or, if we take the average for the year 1905 of all British railways, we get the figures given in Table II.

Table II.—*British Railways Average Cost of all Railways per Board of Trade Returns in 1905.*

	Per train-mile.
Locomotive power	11·09d.
Rolling stock	3·45d.
Maintenance of way	6·33d.
Traffic	12·32d.
General	1·62d.
Rates and taxes	2·95d.
Government duty	0·22d.
Compensation	0·42d.
Legal, Parliamentary and miscellaneous	1·41d.
Total	39·81d.

Percentage of locomotive costs to total costs, 28 per cent. Or, on the basis of the five years 1901 to 1905 inclusive, as below :—

Average Costs per Train-mile for Five Years, 1901 to 1905. England and Wales.

Maintenance of way and work	6·31d.
Locomotive	11·69d.
Repairs of carriages and trucks	3·44d.
Total cost per train-mile	40·77d.

Taking into consideration the fact that local stopping trains, as already explained, must of necessity consume considerably more fuel than express trains, and basing our estimate on cost of fuel in case of such railways as the South-Eastern and L.B. & S.C. Railway and the South-Western, we find that the costs average, say, 12d. for locomotive power per train-mile, which, according to general experience, should be divided up somewhat as follows :—

Estimated Locomotive Cost on Typical English Railway with London Termini and Heavy Suburban Traffic.

	Cost in pence per train-mile.	
Fuel, 45 per cent. of 12d.	5·40d.	
Allow for extra consumption due to suburban work, say, 30 per cent.	1·62d.	
		7·02d.
Wages, 27 per cent. of 12d.		3·24d.
Water, oil, waste, stores and office expenses, 7½ per cent. of 12d.		0·90d.
Repairs and maintenance, 27 per cent. of 12d.	3·24d.	
Increase of repairs due to local traffic conditions, 5 per cent. of 12d.	0·60d.	
		3·84d.
Total locomotive costs of suburban service per train-mile	15·00d.	
Cost of train lighting, including interest on capital	0·83d.	
		15·83d.

There are few cases where a suburban locomotive runs more on the average than about 20,000 useful locomotive or train-miles per annum, from which, on the figures given above, we deduce that the cost of maintenance and renewals per annum works out at, approximately, £300 per locomotive owned per annum, or about 12 per cent. per annum on the cost of locomotives such as are under discussion, a very high figure when compared to the cost of maintenance of electric motor cars and locomotives, as will be shown later. But, after all, the cost per train-mile is not a proper basis of comparison, and one would, perhaps, be better advised to use the ton-mile of useful load, *i.e.*, passengers carried—or, perhaps, base the comparison on seating capacity. As a matter of fact, any comparisons on the basis of cost are useless when one considers the enormous advantage conferred by electric traction on the management of a road; and it is from this point of view that it should be considered. To get the same train-mileage with steam trains would require a capital expenditure, in order to increase the number of roads and terminal facilities, which it is difficult, if not impossible, to estimate, but, as far as London is concerned, would probably very considerably exceed all the expenditure involved by electrification. All these facts must not be overlooked when considering the capital costs of electrification as well as the operating costs.

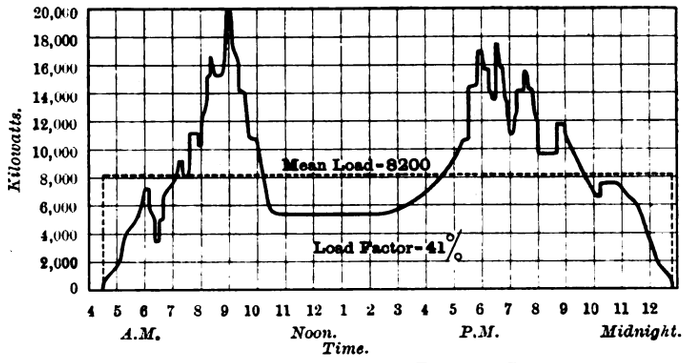

FIG. 2.—DAILY LOAD CURVE ON A TRACTION SYSTEM.

A standard suburban train, such as is to be found around London, including the steam locomotive, and assuming comfortable and easy-running carriages to be provided, does not weigh much under 210 tons without passengers, and would probably not offer seating accommodation much exceeding 520 passengers. The steam locomotive included in the above weight would probably not fall far short of 60 tons.

The old steam trains on the Metropolitan District Railway weighed, it is true, inclusive of the locomotive, 161 tons, and had seating accommodation for 450 passengers, but it took them (under the most favourable conditions) about 40 seconds to get up a speed of 25 miles an hour, whereas the electric trains on the Liverpool Overhead Railway attain 25 miles an hour in 24 seconds.

Table III.—*Capacity and Acceleration of Some English Electric Railways.*

RAILWAY.	Average rate of acceleration.	Weight of train without passengers.	Seating capacity. Passengers.	Number of cars per train.	Weight per seat inclusive of passenger. Lbs.
Liverpool Overhead	3·0 ft. per sec. per sec.	46 Tons.	154	2	677
North-Eastern	2·0 ft. per sec. per sec.	80	186	3	964
Lancashire & Yorkshire	1·5 ft. per sec. per sec.	144	270	4	1,005
Central London	1·2 ft. per sec. per sec.	114	324	7	865
Great Northern & City	1·5 ft. per sec. per sec.	200	394	7	1,147
Metropolitan	1·25 ft. per sec. per sec.	140	304	6	1,032

Steam trains given previously, would compare as follows :—

Typical London suburban train	0·5 ft. per sec. per sec.	210 Tons.	520	7	940
Metropolitan District steam train	0·5 ft. per sec. per sec.	161	450	...	780

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The difference in the weight and carrying capacity of an electric train, as compared to the weights just given for steam traction, depends on the method in which the electric service is run and the capacity of electric train unit chosen, as well as upon the average acceleration and average speed and type of passenger coach adopted, and also depends on whether electric locomotives or multiple unit motor-car trains are employed.

The differences as far as this country is concerned are indicated in Table III.

The greater apparent weight of electric trains per seat is accounted for by the better, and therefore often heavier, passenger coach, as well as by the fact that as regards many of the lines the seating capacity of the coach is small when compared to the cubical contents, owing to the arrangement of the seating and the adoption of that pernicious American idea of strap-hanging. This is clearly shown by the following figures:—

Table IV.—*Weight and Seating Capacity of some Carriages on Electric Railways.*

Railway.	Weight of trail car, Tons.	Seating capacity.	Ratio of weight in tons to seating cap. Per cent.
Central London	15·5	48	32·2
Liverpool Overhead	12·3	60	20·2
North-Eastern	21·0	70	30·0
Lancashire & Yorkshire	26·0	66	39·4
Great Northern & City	20·0	58	34·5
Metropolitan	17·0	52	32·7
Typical London surburban steam train	20·5	90	22·7

The above figures clearly demonstrate the truth of the above statement, and show that it is the arrangement adopted, and not electricity, to which is due the apparently greater weight per seat for electricity as compared to steam. If it were necessary, this would furthermore be demonstrated by the fact that whereas a steam locomotive, as shown, weighs about 60 tons, the electrical equipment of a much greater potential capacity would certainly not weigh more than 40 tons, and would be capable of giving three to four times as great an acceleration as can possibly be obtained by steam.

Enough has been said to show that even if electricity, when properly applied and with a reasonable train service, were to cost as much to operate as regards locomotive power as steam, this would in no way affect the great and inestimable benefits to be derived, as far as local service is concerned, by the substitution of electric for steam haulage.

This being the case, it may not be without interest to look a little closer into the cost of operating electrically, and to see how this compares with the figures which have been given for steam.

Before going into this question in greater detail, it is first necessary to settle some basis of comparison, so as to know what figures to compare. For this purpose the items entering into each case should be compared. They are as follows:—

Steam locos.	*Electric traction.*
Fuel.	Electricity delivered to elec. train.
Wages.	Wages.
Water.	Does not exist.
Oil, waste and stores.	Oil, waste and stores.
Salaries and office expenses.	Salaries and office expenses.
Repairs and renewals.	Repairs and renewals.

With the exception of the first item on each list these figures are directly comparable. As regards steam haulage, the first item of fuel comprises all maintenance and repairs of coal sheds, and all labour of stoking and loading and unloading coal, &c., and, therefore, in order to compare it directly to the corresponding item with electric haulage—*i.e.*, supply of current at trains—one will have to allow something for the capital charges on, as well as maintenance of, the current conductors, such as overhead conductors and trolley wire or third rail, as the case may be, and for similar items in distributing cables and switch cabins; no such allowance, however, is necessary as far as the main feeders are concerned, as it is supposed that electric energy is either purchased wholesale and delivered to the railway at various points along its line in such a form that it can at once be used, or, if the railway generates its own electricity, then the cost of electricity, besides including the mean cost of generation, will also include capital and maintenance charges, and allow for losses in transmission.

On the basis of British requirements—*i.e.*, underground feeders, and solid and reliable construction—the capital cost per mile of double track, including feeders for transmitting and for distributing current, as well as the return circuit, boosters, necessary alterations to telegraph and telephone wires, will, of course, come rather high, since the best form of construction is essential for satisfactory operation. However, even on this basis, the capital charges and maintenance per train-mile should not exceed 0·9d., and it is this figure we will take for calculations.

As regards the cost at which electricity can be generated and delivered at different points along the line, there is no doubt that, with the very good load factor which railway electrification, properly worked, would give, the maximum cost, delivered at, say, 10,000 to 20,000 volts alternating at points along the line, should not exceed 0·40d. per unit, and, including transformation and distributing losses, the maximum cost at the motors on the train need not exceed 0·50d. per unit delivered. This figure includes maintainence and capital charges on distributing system and contact line.

The following figures will give some idea of the actual cost of operating electric trains, although these can only be taken as a guide in calculations, being based on train-mileage, the trains in the different cases not being similar either in weight or motor equipment.

Table V.—*Costs per Train-mile. Locomotive Costs.*

—	Orleans Railway.	Western of France.	German experience.	U.S.A. experience.	City & South London.	British experience.
	d.	d.	d.	d.	d.	d.
Depot charges...	0·2558	...	...	...	...	...
Train staff	4·8128	1·6220	2·752	2·50	...	1·65
Oil, water, grease, &c. ...	0·1502	0·2940	0·096	...	0·098	1·40
Maintenance & repairs	1·1587	2·503	0·826	2·00	0·367	
Sundry.....	0·0776	..	...	...	...	...

Table VI.—*Some American Figures. Interurban Road.*

Name of road.	Motor trucks and motor coaches per car-mile.	Electrical equipment per motor car-mile.
Albany and Hudson	1·0d.	0 5d.
Schenectady	0·6d.	0·5d.
Northern Ohio Traction	0·35d.	0·25d.
International Traction, Buffalo	0·23d.	0·19d.
Cleveland, Painsville & Eastern.	1·28	
Rockford, Belort and Jacksonville	0·21d.	0·16d.
Niagara, Buffalo and Lockport.	...	0·395d.
Lackawanna & Wyoming Valley	...	0·42d.
Wilkesbarre and Hazleton	...	0·195d.
Interborough Rapid Transit, N.Y.	...	0·19d.

	British Experience.	Cost per car-mile.
Maintenance of four motor equipment motor car	Bodies and trucks	0·40d.
	Electrical equipment	0·25d.

The American and estimated British figures refer to costs per motor car-mile, and can also only be used as a guide, owing to the difference in the motor equipments, weight of cars and variance in speed attained. It is practically impossible to compare directly the cost of electricity and

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Table VII.—*Mersey Railway. Costs per Train-mile in Pence.*

Locomotive costs.	June 30, 1901.	Dec. 31, 1901.	June 30, 1902.	Dec. 31, 1902.	June 30, 1903.*	Half-year Dec. 31, 1903.	June 30, 1904.	Dec. 31, 1904.	June 30, 1905.	Dec. 31, 1905.	June 30, 1906.	Dec. 31, 1906.
Salaries and general ...	0·070	0·072	0·114	0·045	0·032	0·059	0·249	0·254	0·258	0·245	0·242	0·218
Wages	3·575	3·590	3·538	3·602	2·815	2·030	2·170	2·010	2·042	1·990	1·893	1·765
Coal and coke	6·200	4·785	5·095	4·515	3·425	2·287	2·000	1·795	1·962	1·975	1·907	2·045
Water	0·655	0·665	0·631	0·653	0·516	0·070	0·088	0·093	0·100	0·063	0·067	0·068
Oil, grease and stores...	0·417	0·486	0·539	0·431	2·583	0·572	0·552	0·298	0·402	0·368	0·437	0·320
Repairs and renewals { Wages ...	1·928	1·897	1·933	1·610	1·309	0·783	0·414	0·593	0·651	0·598	0·612	0·665
Repairs and renewals { Material.	1·545	1·420	1·245	1·148	0·593	0·683	1·111	0·945	1·155	0·777	0·898	0·781
Net loco. cost	14·390	12·915	13·095	12·004	11·263	6·434	6·584	5·988	6·570	6·011	5·856	...
Cleaning and lighting trains	1·668	1·662	1·362	0·946	1·223	0·702	0·504	0·472	0·588	0·572	0·588	...
Repairs and renewals of carriages	1·702	1·735	1·612	1·437	1·103	0·833	1·188	0·747	1·072	1·083	1·417	1·330
Gross receipts.....	59·6	52·6	49·45	45·65	28·7	22·28	23·88	24·15	25·40	25·40	27·42	...

* Electric traction started May 4, 1903.

Table VIII.—*Mersey Railway. Financial Data.*

—	Total expenditure.	Gross receipts.	Train-miles run.	Passengers carried.	Maintenance of permanent way.	Maintenance of carriages and waggons.	Cleaning and lighting trains.
June 30, 1901	£33,500	£38,327	154,272	3,728,292	£3,516	£1,078	£1,094
December 31, 1901 ...	31,162	34,395	157,088	3,379,976	2,539	1,087	1,134
June 30, 1902	29,456	31,782	154,070	3,104,294	3,169	874	1,034
December 31, 1902 ...	28,082	29,470	155,039	2,844,708	4,557	611	928
June 30, 1903*	32,062	32,278	218,308	3,201,644	4,651	1,113	1,030
December 31, 1903 ...	32,441	37,358	401,046	4,153,777	2,054	1,394	1,176
June 30, 1904	33,591	40,918	411,683	4,499,147	1,712	2,037	863
December 31, 1904 ...	32,883	41,789	415,625	4,657,876	1,590	1,292	990
June 30, 1905	34,728	43,537	412,215	4,862,378	1,586	1,840	1,007
December 31, 1905 ...	34,308	44,060	417,683	4,937,840	2,207	1,880	991
June 30, 1906	35,046	47,129	412,683	5,352,867	1,669	2,484	1,010
December 31, 1906 ...	35,884	47,359	416,555	5,271,524	2,300	2,209	1,038

* Electric traction introduced May 4, 1903.

steam per train-mile and obtain anything like satisfactory results, for the reason that the introduction of electrical haulage on a suburban line will at once alter the size and type of train adopted, and in all probability lead to smaller train units being used and run at more frequent intervals than was the case with steam.

Furthermore, whereas for suburban service there is very little difference, as far as steam locomotive costs are concerned, in hauling a train having a capacity of, say, 250 passengers, as compared with the cost of hauling a train seating, say, 700 passengers, with electricity on the multiple unit system, a unit train, say, of three cars, once adopted, would, according to requirements, be made up in multiples of three, and the cost per train-mile for locomotive power would be practically strictly proportional to the number of units of which a train is composed.

Still, it may be interesting to compare some published results on the train-mile basis for steam and electricity on the same road.

Tables VII. and VIII. are of particular interest, as the Mersey Railway is the only one of what may be called main line system, which has been completely electrified and working for a sufficient number of years to warrant fairly accurate conclusions being drawn from the results obtained. It is also a good example to quote, since electricity superseded steam on a given day when the whole system was converted from steam to electric haulage. There is little use in considering the increase of traffic resulting from electrification, because the lines when operated by steam gave a fairly rapid and frequent service, the line is a short-distance traffic line, and there existed no particular reason why electricity should very largely increase the traffic.

But the financial results, as regards cost of operating and the cost of locomotive power per train-mile operated by steam and electricity, as well as the cost of maintenance of permanent way, fully bear out the expectation of those engineers who have made electric haulage on railways a serious study. The figures show that with the increased speed which electrification renders possible, with slightly smaller and, therefore, more convenient train units, the train-mileage can be enormously increased without increasing the total operating costs, and that, notwithstanding the very much larger train-mileage, the repairs of permanent way do not, as might be expected, increase, but are rather lower in their total annual cost than when steam was the propelling power. Thus, from these tables we extract the following highly interesting comparison (Table IX.) of steam and electric operation on the Mersey Railway for the years 1901 and 1905 respectively :—

Table IX.

—	1901, with Steam.	1905, with Electricity.
Locomotive cost per train mile in pence ...	13·653d.	6·29d.
Train lighting and cleaning per train mile in pence	1·665d.	0·580d.
Repairs and renewals of carriages and waggons per train mile in pence	1·719d.	1·075d.
Train miles run.....	311,360	829,898
Total expenditure	£64,662	£69,036
Maintenance of permanent way.....	£6,055	£3,793

The total gross receipts for the half-year ending June 30, 1901, were £38,327, whilst those for the half-year ending June 30, 1906, were £47,129, or an increase of 23 per cent.

In the following table (Table X.) a comparison on another basis has been made between costs of operating by steam and electricity on the Mersey railway, one being based on the average of two years, and the other based on working entirely by electricity for one year from June, 1905, to June, 1906. In this table the items which can be compared in steam and electricity have been put opposite to each other, and it will be seen that as regards cost per train-mile there is a considerable decrease in the cost of

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Table X.—*Mersey Railway.—Comparisons of Steam and Electricity.*

Steam items.	Electricity items.	Av. steam costs per annum based on two years' working		Elec. within year June, 1905, to June, 1906.	
		Total costs.	Per train-mile.	Total costs.	Per train-mile.
Wages of loco. men	Train men	£4,620	3·58d.	£6,712	1·94d.
Coal and coke, lighting of trains, water	Electric current	9,587	7·43d.	8,932	2·58d.
Loco. salaries and general car salaries	Car salaries	189	0·146d.	971	0·28d.
Loco. repair materials, oil, grease and waste, car repair material	Car repair material	3,380	2·62d.	4,547	1·31d.
Traffic salaries and wages	...	8,171	6·32d.	10,446	3·05d.
Maintenance of permanent way, wages and materials		6,841	5·3d.	3,876	1·12d.
Signals		607	0·47d.	1,126	0·33d.
Train-mileage		310,235		830,316	

Table XI.—*Mersey Railway.*

Items.	Steam, year 1901.		Elec., year 1906.	
	Total expenses in pounds.	Cost per train-mile in pence.	Total expenses in pounds.	Cost per train-mile in pence.
(*a*) Locomotive expenses	£17,660	13·65d.	£20,459	5·95d.
(*b*) Maintenance of permanent way	6,055	4·70d.	2,970	0·86d.
(*c*) Repairs of carriages	2,160	1·66d.	4,743	1·37d.
(*d*) Traffic expenses	17,611	13·50d.	21,864	6·35d.
Total for above items	43,486	33·51d.	49,636	14·53d.
Total train-mileage	311,000		829,000	
Total expenditure	£64,662		£70,930	
Total train-mileage	311,360		829,188	

Increase in *cost* = less than *10 per cent.* for increase in *train-mileage* of *167 per cent.*

operating by electricity as compared with the cost of operating by steam.

Another comparison of tables of the Mersey decrease are for the year 1901, operated by steam, and for the year 1906, operated by electricity, which entirely confirm the figures given in the previous table, and from this we see that in 1901 the total expenditure, including everything, was £64,662, the train-mileage being 311,360 train-miles; in 1906 the total expenditure, including everything, was £70,930 and the train-mileage 829,188 train-miles (Table XI.). It will thus be seen that an increase in train-mileage of 167 per cent. increased the total expenditure by only 10 per cent.

(To be continued.)

THE CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY.

(Concluded from page 261.)

The current for operating the Charing Cross, Euston and Hampstead tube is supplied from the Lot's-road generating station of the Underground Railways Co. at Chelsea.

A description of this generating station appeared in *The Electrician*, Vol. LIV., p. 4, and it will be remembered that the current generated is three-phase at a pressure of 11,000 volts. From the generating station three-core high-tension feeders run to the various sub-stations. These are situated at Golder's Green, Belsize Park, Kentish Town, Euston, and Charing Cross. This last-mentioned sub-station also supplies current to the District Railway, and the Waterloo and Baker Street tube, and contains four 1,500 kw. rotary converters.

Rotary converters are also used in the sub-stations mentioned on the Hampstead tube. Thus, at Euston there are two 800 kw. rotaries; at Kentish Town two 800 kw.; at Belsize Park two 1,200 kw.; and at Golder's Green two 800 kw.

In each sub-station the high-tension current is transformed down to 375 volts, at which pressure the three-phase windings of the rotaries are supplied, continuous current at 600 volts being obtained for supply to the third and fourth rails.

Each rotary converter is started up by means of an independent motor coupled on to the same shaft. Equaliser switches are also required, as the rotary converters are compound wound.

We described in *The Electrician*, December 30, 1904, a typical sub-station in connection with the Metropolitan Railway, and somewhat similar sub-stations have been put down in connection with the Hampstead tube.

We give in Fig. 8 a diagram of the connections, and this diagram is applicable to any of the sub-stations on the tube railways. The sub-station at Golder's Green, which is seen on the right-hand side of Fig. 2, is of somewhat more importance than the others on that line, as it controls the supply of current to the car sheds, &c.

As we mentioned above, this sub-station contains two 800 kw. British Westinghouse rotary converters running at 400 revs. per min. Three-phase current at 375 volts is supplied to these from six transformers, in which the extra-high-tension supply from Chelsea is transformed down, the direct current full load of each rotary being 1,333·3 amperes at 600 volts. These transformers are fixed above the switchboards, which are on the ground level, and access to the transformers is by means of a staircase to the floor above; they are each of 300 kw. capacity, and are cooled by an air blast which is supplied by two British Westinghouse three-phase 10 H.P. motors driving fans.

The instructions for starting up the rotary converters are as follows:—

(1) Inspect the rotary and switchboard. (2) Open transformer blast dampers for the bank or banks required. (Dampers are to be closed except on transformers actually in use.) (3) Close rotary oil switch. (4) Inspect blowers. (5) Start blowers by throwing alternating-current switch down and then up. (6) Close the synchroniser switch on the section to which the rotary being started up is connected. (To do this it may be necessary to change the setting of the selector switches as well. In this case care must be taken to open one blade on each phase before closing the other on the same phase.) (7) Insert plugs for synchroniser and lamps. (8) Insert direct-current voltmeter plug and adjust the field to give about 550 volts direct current. (9) Start the rotary by turning starting switch first to the right and then to the left. (10) The rotary is started up. (11) Use the field rheostat to adjust the speed for synchronising. (12) Close two of the L.T.A.C. switches together, and then, as soon as possible, close the third. (13) Switch off starting motor. (14) Remove synchroniser and lamp plugs and open synchroniser switch. (15) Close equaliser switch. (To ensure the equaliser switch not being overlooked, it will always be closed before the other direct-current switches, whether the machine is run alone or in parallel with others.) (16) Close positive direct-current switch. (17) Close circuit breaker. (18) Adjust direct-current volts to the same as those on the direct-current 'bus bars. (19) Close negative direct-current switch. (20) If it is desired to bring up the field very quickly, or if there is any doubt of the machine coming up the right way, the series field may be excited off a machine already on load by closing the equaliser and positive switches of the machine to be started up. This

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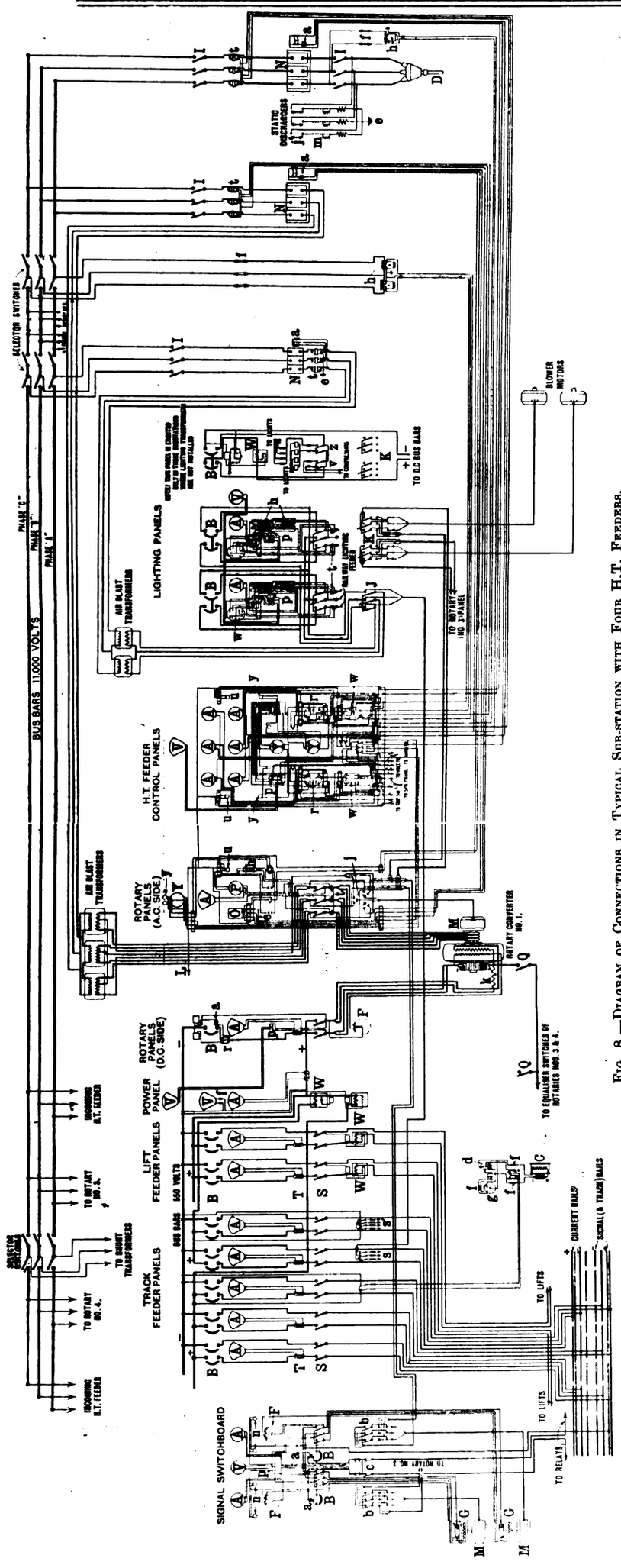

FIG. 8.—DIAGRAM OF CONNECTIONS IN TYPICAL SUB-STATION WITH FOUR H.T. FEEDERS.

The above arrangement does not apply to any particular sub-station. All apparatus is shown viewed from the rear.

A Ammeters.
B Automatic circuit-breakers.
C Air compressor motor.
D Three-core H.T. incoming feeder.
F Field rheostats.
G 70 volt generators.
I Isolating switches.
J Main lighting switch.
K Blower switches.
L Common wire to pilot lamps.
M Induction motors.
N Oil switch.
O Overload time-limit relay.
P Power factor meter.
Q Equaliser switches.
S Switches.
T Shunts.
V Voltmeters.
W Wattmeters.
Y Synchroscope.
a Trip coils.
b T.P. switch.
c Negative main switches.
d Magnetic blow-out.
e Earth.
f Fuses.
g Regulating gauge.
h Potential transformer.
j Starting switch.
j Isolating plugs.
k German silver shunt.
m Spark gap.
n Lamps.
p Potential plug receptacle.
r Reverse current relays.
s To sub-station lights.
s To switchboard lights.
t Current transformers.
u Pilot lamp (red).
v Air compressor switch.
w Integrating wattmeter.
y Synchronising lamps.
z Sub-station lighting switch.

can, of course, only be done when there is a load on the machine already running.

In addition to the six transformers for the rotary converters, two 150 kw. transformers are installed for the purpose of supplying current for the tunnel lighting at 220 volts.

Four motor-generators are installed for supplying the current required in connection with the signalling. These motor-generators run with continuous current at 600 volts, and the dynamos generate continuous current at 70 volts. A separate switchboard is installed for controlling the signalling circuits. Two direct-current 10 H.P. motors are used for driving the air compressors, which we mention below in connection with the system of operating the signals.

The machine seen in the front in Fig. 9 is another motor-generator, used for charging the accumulators fitted on a special car, which is employed for running on the track at times when current is off the conductor rails.

The motor of this motor-generator is supplied with three-phase current at 220 volts from a circuit supplied by the two lighting transformers mentioned. The dynamo side is of 50 kw. capacity and can supply 180 amperes at from 160 to 200 volts.

In Fig. 9 the levers operating the high-tension switches are seen in front of the switchboard. These high-tension switches, which are operated by hand, are fixed against the wall behind the switchboard and are of the well-known oil break extra-high-tension type.

The simplicity of the front of the switchboard panels is noticeable in Fig. 9, but, what is of more importance, the arrangement of the cables behind the panels has been carried out with the idea of providing against any possibility of breakdown.

The main cables come through the floor in earthenware pipes, and are perfectly fireproof. As will be seen in Fig. 10, they are securely held in position, being kept clear of one another and from the smaller cables, which it will be noticed are neatly cleated against the board. Where a large number of small cables are run behind one panel, this method, besides providing the greatest security, also allows of any particular cable being easily traced out.

The method of supporting the 'bus bars is also worthy of notice. These are of flat copper, and are held in position by means of a number of small porcelain blocks which lie in the usual cast-iron bracket fitted on to the steel framework of the switchboard. As will be seen from Fig. 11, which shows the arrangement adopted, the porcelain blocks are held, and may be tightened up, by means of a set screw. A short length of 'bus bar, which will be noticed at the left-hand end of Fig. 10, gives an idea of the arrangement adopted.

The system of signalling adopted on the Hampstead tube is exactly similar to that used on the District Railway and other tubes of the Underground Railways Company. It is the well-known Westinghouse electro-pneumatic system, which has already been described in *The Electrician*.

D

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The line is divided up into sections, each about 700 ft. long, and, as trains are allowed in adjacent sections, a 1½ minutes service could be adopted if it were at any time required.

Air at 70 lb. pressure, supplied from the compressors installed in the sub-stations, is used for operating the signals, which are worked both automatically and semi-automatically.

Signal cabins are provided only at Charing Cross, Mornington-Crescent, Camden Town, Hampstead, Golder's Green and Highgate. The apparatus in those at Mornington-crescent and Hampstead is so arranged that when the cross-overs are not required to be operated the levers controlling the main line signals can be pulled over, and their signals then work automatically. Thus, no signalman will be required in these two cabins under normal conditions.

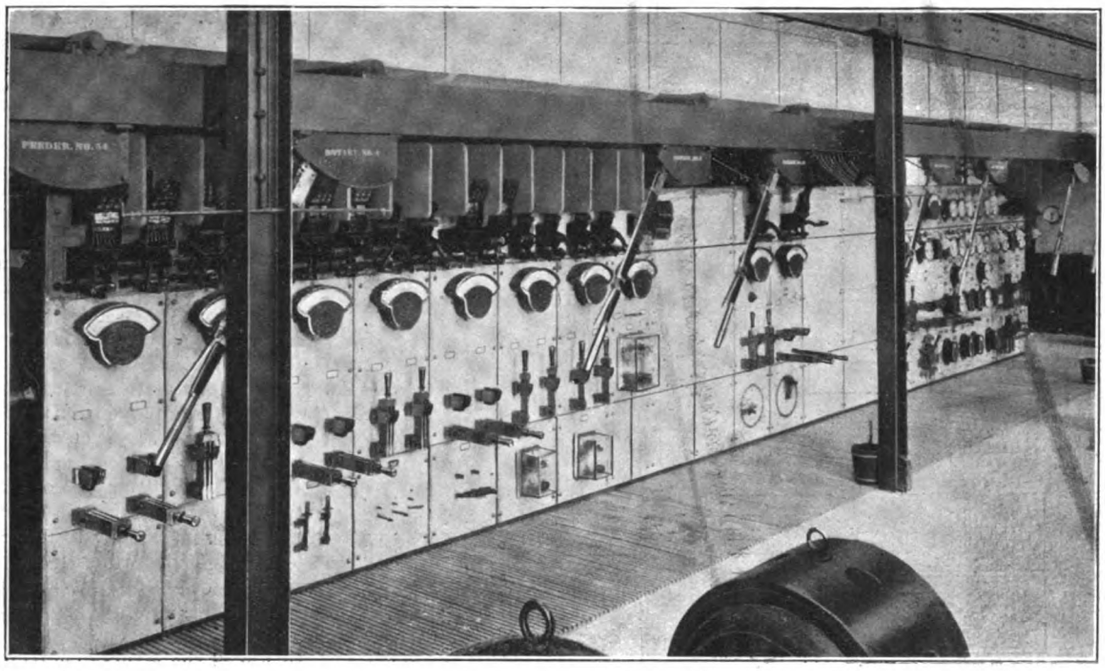

FIG. 9.—SWITCHBOARD IN GOLDER'S GREEN SUB-STATION.

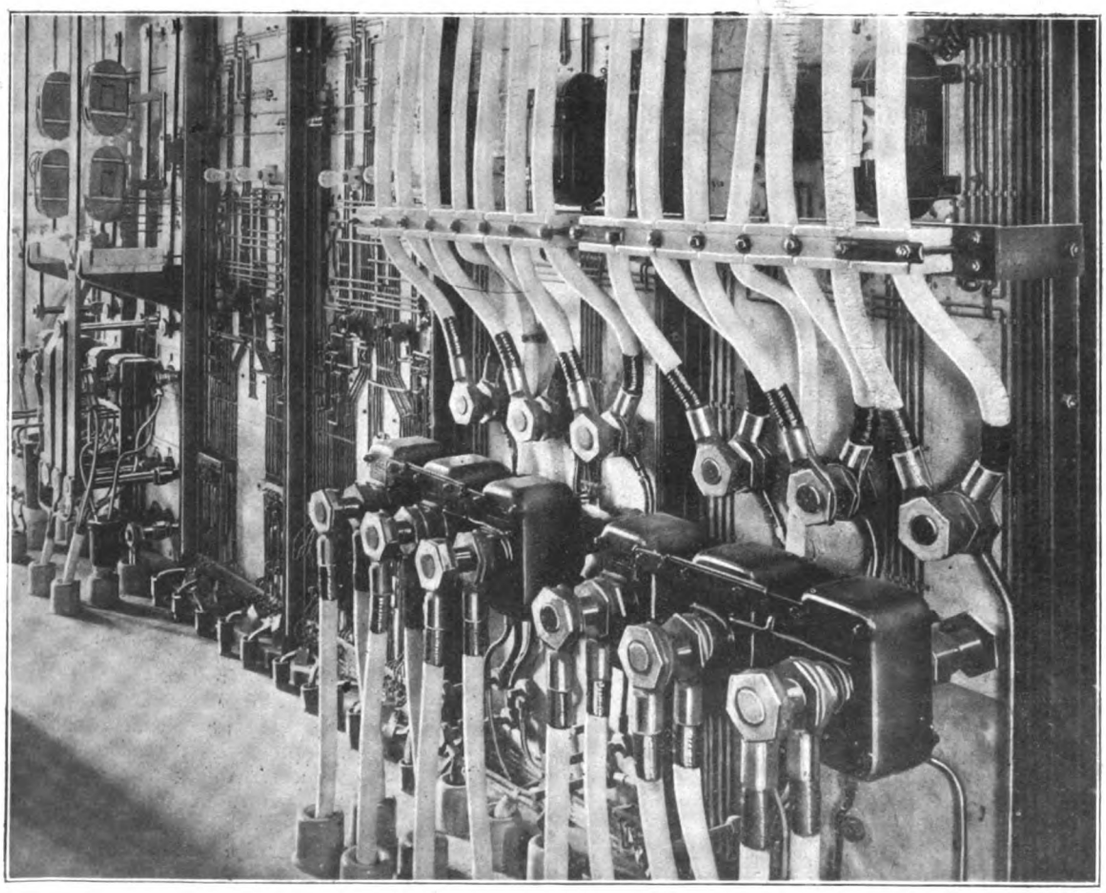

FIG. 10.—VIEW BEHIND THE SWITCHBOARD AT GOLDER'S GREEN SUB-STATION.

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Illuminated diagrams are fixed in the signal cabins at Charing Cross, Camden Town, Golder's Green and Highgate, so that the sections occupied by trains are clearly indicated. In the other cabins banner indicators are fixed behind the diagrams showing the different sections into which the line is divided.

Signal cabins are only required at junctions and "cross-overs," and over the greater part of the line the signals will be operated automatically by the trains themselves.

The installation comprises:—60 working levers; 131 track circuits; 80 automatic signals; 53 semi-automatic signals; 3 semi-automatic repeaters; 17 automatic repeaters.

For the present it is only intended to run every third train through to Golder's Green; of the intermediate trains one will run to Highgate and the other to Hampstead. In this way Golder's Green will have approximately a 12 minutes service and the same service also as Highgate, whilst between Camden Town and Charing Cross there will be about a four minutes service.

The passenger lifts have been made by the Otis Elevator Co., and are like those used on the other tube railways. We gave a detailed and illustrated description of the method of control used with these lifts in our issue of December 14, 1906.

We are informed that the line will be opened for traffic on Saturday, June 22nd. It has been decided that on that day passengers may travel over any part of the line free of charge, the gates being opened at 1.30 p.m. and closed at 9 p.m. This method of opening the line has been decided on by the

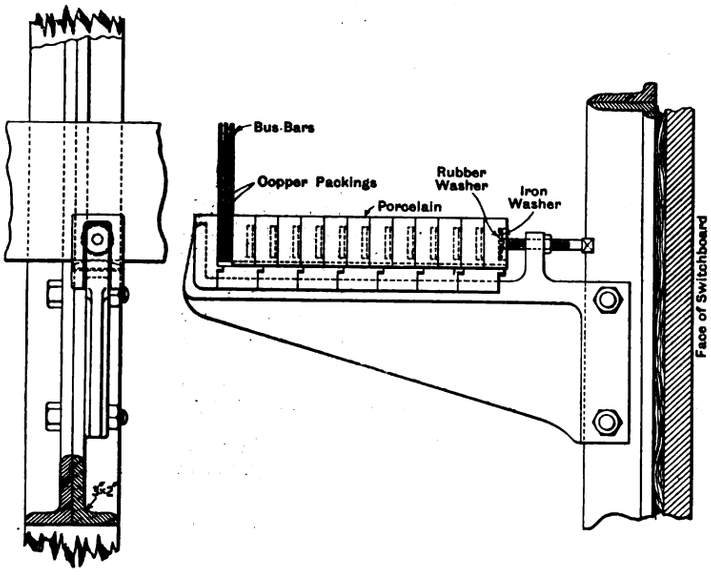

FIG. 11.—METHOD OF SUPPORTING 'BUS BARS.
Scale 1 : 8.

directors in order to give the public an opportunity of appreciating the advantages of tube travelling, and so that the districts served by the new tube may become better known.

The resident engineer at Golder's Green is Mr. P. W. Beattie.

We are indebted to Mr. J. R. Chapman, engineer-in-chief and general manager of the Underground Electric Railways Co. of London, for the drawings and information which he has kindly supplied, and also to Mr. Cox and Mr. R. Whiteley for their assistance in the preparation of this article.

Single-phase Railways.—According to a table given recently in the *Elektrotechnische Zeitschrift*, there are at present in Europe 13 railways worked by single-phase current, and 16 are worked on the same system in America. The longest line is that from Spokane to Inland (108 miles). The highest voltage at the trolley wire is 11,000 in America and 6,000 in Europe. This latter is on an experimental line from Tomteboda to Värten in Sweden, which is about 8 miles long. Tests have been made with voltages of 6,000, 18,000 and 20,000.

THE VARIATION OF MANGANIN RESISTANCES WITH ATMOSPHERIC HUMIDITY.*

BY E. B. ROSA AND H. D. BABCOCK.

Summary.—It has been noticed that manganin resistances change their value regularly with the time of year. The authors show that this change, which is quite appreciable, is due to variations of humidity, and that the shellac used in insulating the wire takes up more or less moisture, according to the humidity, and therefore to the time of year, thus causing mechanical stretching of the wire and change in resistance.

It has long been known that manganin resistances prepared in the manner developed by the Physikalisch-Technische Reichsanstalt do not remain entirely constant in value, but that appreciable differences occur among a group of apparently exactly similar coils. These variations are much less with coils of 0·1 and 1 ohm than with coils of larger values. With coils of 10, 100, 1,000 ohms and higher values, when used for precision work, the variations are so considerable that it has been necessary to determine their values by stepping up frequently from the 1 ohm standards. These variations have been found to be greater in England than in Germany, and the difference has been attributed to some difference in the methods of preparation followed in England and in Germany.† At the Bureau of Standards the variations in the values of manganin resistances have been a source of great annoyance, and they have been found to be as great in the resistances made by the best German makers as in those made in America. These variations occur in the most carefully prepared standards of the Reichsanstalt form as well as in the resistances of Wheatstone bridges, potentiometers, resistance boxes, &c. The explanation that has been suggested is that the variations are greater in the coils of higher values because they are wound with finer wire, which is drawn cold and is less perfectly annealed than the heavier wire.

SEASONAL CHANGES OF RESISTANCE.

In the course of an extended investigation‡ at the Bureau of Standards on the ratio of the electromagnetic to the electrostatic unit of electricity, it was found that all the resistances employed had a higher value at the same temperature in summer than in winter, the change being a gradual drift upward from early spring to midsummer, followed by a steady drift back to the same minimum in the winter. The amplitude of the change was of course small, varying from 15 to 25 parts in 100,000, but was far too large to be neglected in precision work. Most of these resistances were kept submerged in oil all the time, but some were in air. In all cases the temperatures were taken and the resistance measurements made with great care.

The possibility of these changes being due to atmospheric humidity suggested itself, but it was not at first evident how an increase of resistance could be produced by an increase of humidity. The effect of leakage arising from moisture deposited on the coils or upon the tops of resistance boxes is, of course, to decrease the resistance, and this effect would increase with the humidity. In order to ascertain the cause of the marked change in the opposite direction, to determine its magnitude and to find how to prevent it, we took up last November a systematic study of the question.

It was very soon found that changes such as occurred during an interval of six months in the atmosphere of the laboratory could be induced in a few days by placing the resistances in a closed case in which an atmosphere of high humidity was maintained, although it usually required several weeks for the resistance of a coil to reach a maximum, or to return to its former value when restored to the original conditions of humidity.

Two apparatus cases were employed, the atmosphere within one being kept at a nearly constant relative humidity of about 25 per cent., the other being kept at higher humidities, ranging from 40 to 100 per cent., although seldom higher than 80, and most often about 60 per cent. Each case was provided with thermometers and recording hygrometers. The higher resistances were measured generally to one or two parts in a million, and corrections made for small fluctuations in temperature. All measurements were finally referred to the standard of the Bureau, determined by the mean value of certain 1-ohm coils. The changes in the resistances of the latter are known to be very slight.

Changes are due to moisture absorbed by shellac. The cause of the increase in resistance of the manganin coils, the wire of which i embedded in a heavy covering of shellac, thoroughly dried out by baking, is that the shellac absorbs moisture from the surrounding atmosphere and expands, stretching the manganin wire and thereby increasing its resistance. The amount of moisture absorbed depends on the relative humidity of the atmosphere, the moisture in the

* Paper read before the American Physical Society, at Washington, April, 1907.

† Report of Dr. R. T. Glazebrook, Director of the National Physical Laboratory, in *Engineering*. (London: March 22 and April 5, 1907.)

‡ By E. B. Rosa and N. E. Dorsey, shortly to be published.

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shellac gradually coming to equilibrium with the moisture outside when any given humidity is maintained constant. When the atmosphere is drier the shellac gives up moisture and shrinks and the wire also contracts and its resistance decreases. The resistance, therefore, is constantly changing with changes in atmospheric humidity and is a constant only when the atmospheric humidity is constant or when the coil is sealed so that moisture cannot get into the shellac. Dipping the coils in melted paraffin will seal them effectually against moisture, so that even the finest wire, such as is used in coils of 1,000 and 10,000 ohms, remains of constant resistance. Sealing such a coil in a test tube will keep its resistance constant, even though it had previously been exposed to a moist atmosphere. Submerging the coils in oil does not protect the shellac from atmospheric humidity, as the oil absorbs moisture and transmits it to the coils. Hence submerged coils increase in resistance when the atmospheric humidity increases, and decrease in resistance when the humidity decreases. The oil retards the change of resistance and decreases the amplitude somewhat, but still permits great changes to occur, especially in the higher resistances.

A change of resistance of 25 parts in 100,000 will be produced by an increase in length of the wire of 12·5 parts in 100,000. If the wire is wound on a spool 4 cm. in diameter (the size used in a Wolff standard of the Reichsanstalt form) the diameter must be decreased by the swelling of the shellac by 0·0005 cm., or 5 microns. This is, of course, an appreciable decrease in diameter, although much more difficult to measure than the change in resistance. Coils sealed by a covering of paraffin will remain constant for months through wide fluctuations of moisture, certainly to within a few parts in a million, which indicates that the diameter has not changed during the time by as much as 0·2μ, if at all. We shall presently give evidence to show that manganin wire of all sizes is remarkably constant in resistance, and that changes that have been attributed to the manganin are due to the shellac in which it is embedded.

In Fig. 1 are given curves showing the seasonal changes of certain resistances during the past two years. These resistances were exposed only to the atmosphere of the laboratory, and in summer the humidity was kept lower than normal during six or eight hours of nearly every working day by means of brine coils in the room. The object of thus reducing the humidity was to secure more perfect insulation than could be obtained otherwise. The changes in resistances were therefore appreciably less than would have occurred normally. All resistance measurements were made in an atmosphere dry enough to give thoroughly satisfactory insulation.

Fig. 2 shows the changes in certain manganin resistances when subjected to variations in atmospheric humidity, the values of the humidity, the dates and the variations in resistance being shown in the curve. The 1,000 ohm coil represented by curve 13 was first placed for a few days in a saturated atmosphere. The change in resistance was very rapid, but was suddenly stopped by reducing the humidity to 30 per cent. A sudden drop in resistance followed, the rate of decrease being reduced by raising the humidity for a few days to 40 per cent. The rate of decrease was again augmented by

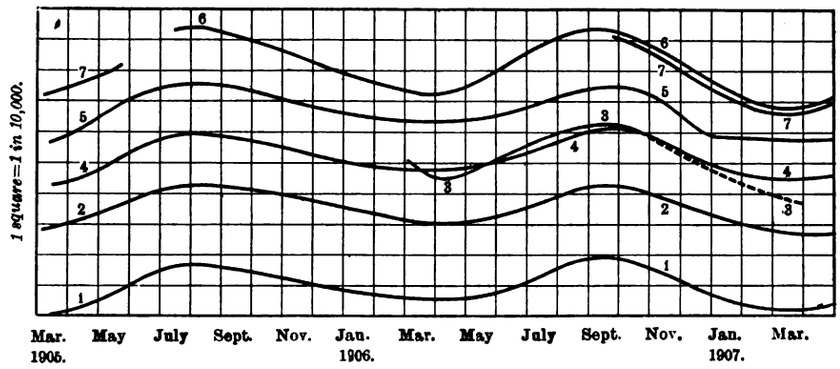

FIG. 1.—CURVES SHOWING SEASONAL CHANGES OF MANGANIN RESISTANCE DUE TO VARYING ATMOSPHERIC HUMIDITY.

Observations extended through two years and two months. Resistances always in laboratory atmosphere. All resistances were of usual construction, and were made by Otto Wolff. One vertical space is 1 part in 10,000 in resistance.

Curve 1 is 1,000 ohm coil submerged in oil from resistance box No. 2,470.
" 2 " 1,000 " " " " " " 2,471.
" 3 " 1,000 " " in air " " " 3,087.
" 4 " Σ1,000 " " in oil " " " 2,470.
" 5 " Σ1,000 " " " " " " 2,471.
Curve 6 is mean of 9 coils each of 10,000 ohms in oil from resistance box No. 2,620.
" 7 " " " " " " in air " " 2,621.

Σ1,000 indicates 1,000 ohms made up of coils 500+200+200+100. There is no record of the values of the resistance for curve 7 between May, 1905, and September, 1906.

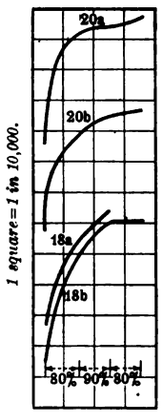

FIG. 3.—CURVES SHOWING CHANGES IN RESISTANCE OF MANGANIN COILS OF 10 AND 100 OHMS.

Curves 18A and 18B are two coils of 100 ohms each in air, Wolff box No. 3,080.

Curves 20A and 20B are two coils of 10 ohms each in air, Wolff box No. 3,080.

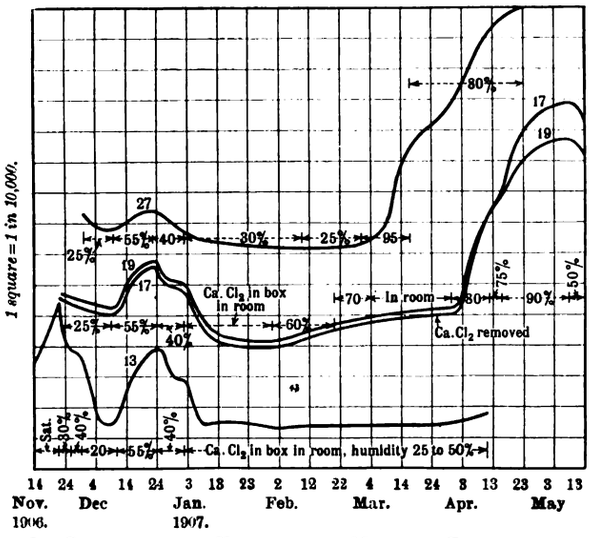
1 square = 1 in 10,000.
Ca. Cl2 in box in room
Ca. Cl2 removed
Ca. Cl2 in box in room, humidity 25 to 50%
14 24 4 14 24 3 13 23 2 12 22 4 14 24 3 13 23 3 13
Nov. Dec Jan. Feb. Mar. Apr. May
1906. 1907.

FIG. 2.—CURVES SHOWING VARIATIONS IN MANGANIN RESISTANCES DUE TO CHANGES IN ATMOSPHERIC HUMIDITY.

Resistances kept in enclosed space where humidity was under control. Observations extended through six months. The relative humidities are indicated on the curves. One vertical space is 1 part in 10,000 in resistance.

Curve 13 is 1,000 ohm coil in air from Wolff box No. 3,087.
(Same coil as No. 3 of Fig. 1.)
" 17 " 1,000 ohm coil in air from Wolff box No. 3,080.
" 19 " Σ1,000 " " " " 3,080.
" 27 " 1,000 " " made by the Leeds & Northrup Co.

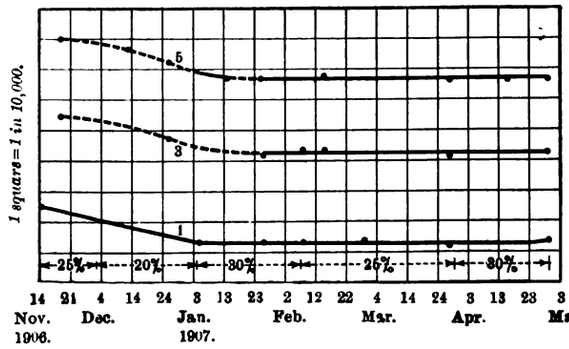

FIG. 4.—CURVES SHOWING THE SLIGHT VARIATIONS OF RESISTANCE OF MANGANIN COILS SUBMERGED IN OIL WHEN KEPT AT VERY NEARLY CONSTANT HUMIDITY.

All these coils were from Wolff box No. 2,471. No. 1 of this series is the same coil as No. 5 of Fig. 1.

Curve 1 is Σ1,000 ohms. } All in oil at a nearly constant humidity of 25 per cent., varying
" 5 " 10,000 " } between 20 to 30 per cent.
" 3 " Σ10,000 "

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reducing the humidity to 20 per cent. After the resistance had decreased to a point below its initial value the humidity was increased to 55 per cent., when the resistance rose as shown, and then fell when the humidity was reduced to 40 per cent. The change in resistance between the maximum value of November 22nd and the minimum value of December 7th was 40 parts in 100,000. On January 2nd a quantity of calcium chloride was placed in the bottom of the resistance box, which was closed up as nearly air-tight as practicable without sealing. The resistance fell rapidly for a few days (about 15 parts in 100,000), and then remained nearly constant for three months, but was not entirely independent of changes in room humidity. The higher average humidity of April caused the resistance to rise appreciably.

Curves 17 and 19 show how closely the 1,000 coil and the Σ1,000 (made up of coils of 500+200+100+100+Σ100) vary together as the humidity is varied. In this case also $Ca\,Cl_2$ was added to the box on January 2nd, resulting in a decrease in resistance. When the box was placed in an atmosphere of 60 and 70 per cent humidity the resistance rose appreciably in spite of the $Ca\,Cl_2$. After the calcium chloride was removed the box was put in the damp case and the resistances rose rapidly.

Curve 27 represents a shellaced manganin coil made by the Leeds & Northrup Co., showing large changes in resistance as the humidity is varied.

Fig. 3 shows that the changes in coils of heavier wire, as used in resistances of 10 and 100 ohms, are very considerable, amounting to 35 to 50 parts in 100,000, due to 80 per cent. humidity.

Fig. 4 shows three resistances from Wolff box No. 2,471 (all in oil), which have been kept for several months at as nearly constant humidity as possible and which have remained remarkably constant in value. Curve 1 represents the same set of coils (Σ1,000)

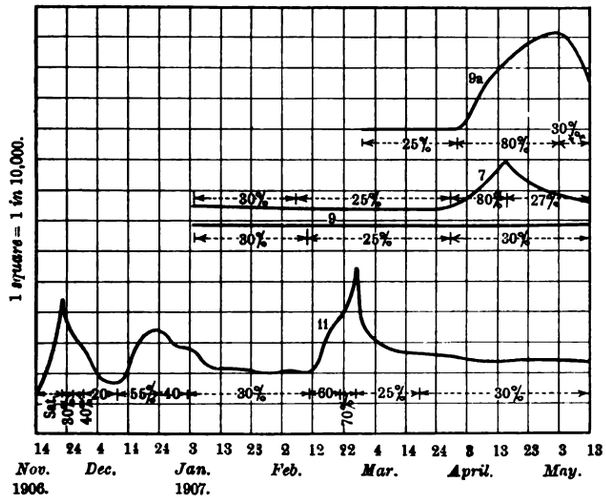

Fig. 5.—Curves showing the Difference in Behaviour between Wolff Standard Coils (Reichsanstalt form) when kept at Constant Humidity and when in an Atmosphere of Varying Humidity.

Curve 7 is standard coil of 1,000 ohms, submerged in oil, No. 3,039.
" 9 " " " 10,000 " " " air, 1,392.
These two coils were maintained at nearly constant humidity until March 26th, when 7 was placed in an atmosphere of 80 per cent. humidity until April 16th, when it was restored to the drier chamber.
Curve 9A is standard coil of 10,000 ohms. in air, No. 3,040.
" 11 " " " 1,000 " " " 3,057.
These two standard coils were at varying humidities as shown on the curves.

as curve 5 of Fig. 1. During November and December it gradually decreased in value, coming to an equilibrium value for approximately 25 per cent. humidity about January 1. Between January 1 and April 28 this coil changed only a few parts in 1,000,000, having come down to a minimum value in March. The average humidity in the case was a little higher during March and April, and this accounts for the slight increase in resistance. Curve 5 represents a single spool coil of 10,000 ohms, and curve 8 represents the Σ10,000 coils of the same box. These three curves are practically horizontal, all showing a minimum in March a few parts in a million less than the values in January and April, the drop in January and February being doubtless due, as stated above, to the continued drying out of the oil, and the rise in April to a slightly higher humidity in the case, due to higher humidity in the room, the case not being entirely tight.

Fig. 5 shows four curves, all representing standard coils of the Reichsanstalt form by Otto Wolff. Curve 7 is a 1,000 ohm standard (No. 3,039) kept totally submerged in oil in a space at nearly constant humidity of 25 to 30 per cent. from January 4th to March 28th, the resistance decreasing slowly during that period, as the oil dried out gradually. From March 28th to April 16th the coil still submerged in the same oil was in a case at approximately 80 per cent. humidity and the resistance rose about 17 parts in 100,000. The humidity was then reduced to about 25 per cent. and the resistance fell off 11 parts in 100,000 in the same time that it rose 17 parts. This shows how great a change can take place in a coil kept submerged in pure petroleum oil, when the humidity of the atmosphere changes. Curve 9 is a standard 10,000 ohm coil (No. 1,392) kept in air at a nearly constant humidity of 25 to 30 per cent. from January 4th to May 3rd. Its changes are very slight, showing a small decrease at first and a small increase later, corresponding to the coils in oil. Curve 9A represents another 10,000 ohm standard (No. 3,040) in air, at different humidities, and curve 11 represents a 1,000 ohm standard (No. 3,057) in air at different humidities. The fluctuations in the resistance of the latter amount to about 35 parts in 100,000 between the minimum of January and the maximum of February. As the humidity in the laboratory atmosphere in Washington often goes above 70 per cent. in summer (unless the air is artificially dried) it will be seen that this coil would be very unreliable as a standard.

Fig. 6 represents five coils of 1,000 ohms each of 0·1mm. manganin wire, wound on wooden spools (mahogany). These curves are drawn to a different vertical scale from that used before, one space representing a change 10 times as great as before. Curve 43 represents a coil which was given several coats of shellac and baked in the usual manner, the spool being thoroughly shellaced as well as the wire. Curve 55 represents a coil in which the spool was thoroughly shellaced, but the wire was not shellaced or baked after winding. Curve 57 represents a coil wound on a similar wood spool that had been thoroughly paraffined, but the wire neither paraffined nor heated after winding. Curve 77 represents a coil on a shellaced wood spool (the wire being shellaced and

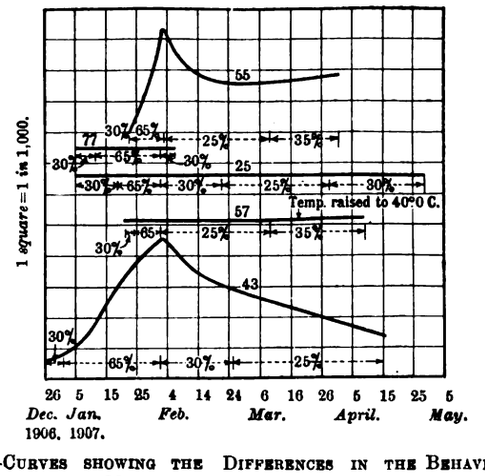

Fig. 6.—Curves showing the Differences in the Behaviour of Resistances of Manganin Coils, all of which were Wound on Wooden Spools, and kept in an Atmosphere of Different Humidities, but with Different Methods of Preparation or of Mounting.

Curve 55, 1,000 ohms, wood spool thoroughly shellaced and baked, no shellac on outside of wire, no baking of wire.
Curve 57, 1,000 ohms, same kind of wire wound on similar wood spool, latter boiled in paraffin, no paraffin on wire, no heating of wire.
Curve 77, 1,000 ohms, on wood spool, wire and spool shellaced and baked, and then coated with paraffin.
Curve 25, 1,000 ohms, on wood spool, wire shellaced and baked, and coil then sealed in a test tube by means of a cork and hot paraffin.
Curve 43, 1,000 ohms, on shellaced wood spool (several coats), wire shellaced and baked after winding. Unifilar winding.

baked as usual) and then dipped in melted paraffin. Curve 25 represents a coil on a wood spool, shellaced and baked after winding, and sealed in a test tube (with some calcium chloride inside the tube). The last three coils, in one of which no shellac was used and in the other two the shellac was protected from the moisture of the air, have remained remarkably constant, no change more than 1 in 100,000 having occurred in several months. The first two coils, on the contrary, changed as much as 340 and 400 parts respectively in 100,000.

Shellaced coils may absorb sufficient moisture in a saturated atmosphere to reduce the resistance by leakage, the coils in that case showing polarisation. A shellaced coil plunged in water absorbs moisture very rapidly; in one case the resistance of a coil of 1,000 ohms decreased about 50 ohms in a short time, showing polarisation strongly. On the other hand, some paraffined coils submerged in water for an hour did not change more than one part in 100,000, if at all. These coils were from a box by an English maker and had been in use for over four years. This shows that the paraffin coating had not become cracked or defective in use. The shellaced coils of a Wheatstone bridge, potentiometer or other

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resistance apparatus may be dipped in melted paraffin and so be protected from moisture. A high grade of paraffin should be used —that is, paraffin of high melting point, free from dirt and acid. The paraffin coating, of course, slightly increases the lag of temperature of the coils when the temperature of the room is changing, but the increased error due to this would probably not be $\frac{1}{100}$th part of the error that may be due to absorption of moisture.

Since a small and inexpensive coil sealed in a tube or covered by paraffin has a very constant resistance, one may possess a number of such working standards of resistance with very slight expense or trouble, and may have them compared at a standardising laboratory more frequently than the bulkier and more expensive standards that have heretofore been thought necessary. We are developing some new forms of sealed standards which will be small enough to be sent through the mails.

LIGHT FROM GASEOUS CONDUCTORS WITHIN GLASS TUBES—THE MOORE LIGHT.*

BY D. McFARLAN MOORE.

To duplicate daylight closely, three premises were determined upon: (1) Large light source, the practical solution being a long glass tube emitting light. (2) Use electricity flowing through a gaseous conductor, not a solid conductor. (3) Perfect imitation of colour values.

The life of the first lamps or tubes constructed was extremely short, since, as then expressed, "the vacuum deteriorated." Up to date, four methods have been used for the replenishing of the gas and thereby overcoming this vital difficulty of the gaseous conductor becoming non-conducting, due to the peculiar chemical reaction that must occur when electricity passes from a solid conductor to a gaseous conductor. These methods are as follows: (1) By obtaining a cycle of events through catalytic action. The intensity of light possible was found to be very low. (2) Obtaining a cycle by evaporation and condensation. Probably mercury is the only element that can ever be used in this way in glass tubes. (3) By re-supplying the necessary gases automatically by the action of heat on suitable substances. (4) By automatically feeding gas to the tube when needed, which is the method used at the present time.

The absolute temperature of the individual particles of matter within the tube after collision is greater than that of any other temperature on earth. But the quantity of heat of each of these ultra-incandescent though infinitesimal bodies is so small that there results that which at first would seem paradoxical—namely, the "coldest" source of light. In this expression we crudely refer to the external temperature of the entire tube.

The present system, which has become known as the "Moore light," has passed the experimental stage. It is a result of 12 years of experimenting, but its advance from year to year has always been steady.

The illumination of the assemby room in which this Paper is being read is at the present moment by a Moore vacuum tube, and it is noted that the light emanates with absolute uniformity from the entire area of a single, continuous glass tube 1·75 in. in diameter in the form of a large rectangle 62 ft. by 25 ft., which is supported on the cove designed to conceal the incandescent lamps. The glass tube is 13 in. from the ceiling and 16 ft. from the floor. It is supported by plain brass rings 1⅞ in. in diameter, attached to small porcelain insulators inserted in the ends of brass fixture tubing, which, of course, contains no wires.

The two ends of this continuous tube at the centre of the rear side of the rectangle approach within such a short distance of each other that the gap is scarcely discernible from the floor. They then extend horizontally through the wall and into a rigid steel terminal box, which contains all the necessary electrical apparatus. It is fed by 60 cycle alternating current at 220 volts. Besides the two carbon electrodes of the tube, the terminal box contains a step-up transformer and a small specially-designed valve with its solenoid, which represents an entirely new departure in vacuum tube lighting and also one that is vital to its success. The electrical circuits from this apparatus are extremely simple and are shown in Fig. 1. There is no distributed or high-potential wiring. The high-potential terminals of the transformer within the terminal box are only 2 in. or 3 in. in length, and are attached directly to the electrodes within the box. All the high-potential wires, therefore, always remain within the box, which has a wire seal placed upon it. A hand can be placed on each of the glass tubes near where they emerge from the two holes in the side of the box, but the glass tubes insulate the gaseous conductor within them so well that no shock can be felt.

Since the feeder-valve operated by the solenoid just mentioned is an essential feature of this system, a description of its operation will be interesting. Any vacuum tube when commercially luminous will, in a few minutes, seriously alter the degree of its vacuum unless special provision be made to replenish its gaseous conductor. Due to the flow of current, a portion of the residual gas within the tube is absorbed—that is, changed to a solid form, and thereby the degree of vacuum in the tube becomes higher.

This higher degree of vacuum so increases the resistance of the tube that at first the light simply becomes unsteady, but rapidly changes to a condition of violent spasmodic flickering, which soon entirely ceases and the tube gives no light whatever. The light has actually died for want of air. This simple fact was not recognised for many years by prominent investigators in this line of phenomena. The problem, therefore, was to devise thoroughly practical means for replenishing the gaseous conductor of a vacuum tube. This is the function of the feeder-valve, which permits air or other gas to enter the tube only when it is needed and in such a manner that it is entirely automatic. A piece of ⅞ in. glass tubing is supported vertically (*see* Fig. 2), its bottom end is contracted into a ⅜ in. glass tube which extends to the main lighting tube. At the point of contraction at the bottom of the ⅞ in. tube there is sealed by means of cement a ¼ in. carbon plug, the porosity of which is not great enough to allow mercury to percolate through it, but which will permit gases easily to pass, due to the high vacuum of the lighting tube connected to the lower end of the plug and approximately atmospheric pressure above it. This carbon plug is normally completely

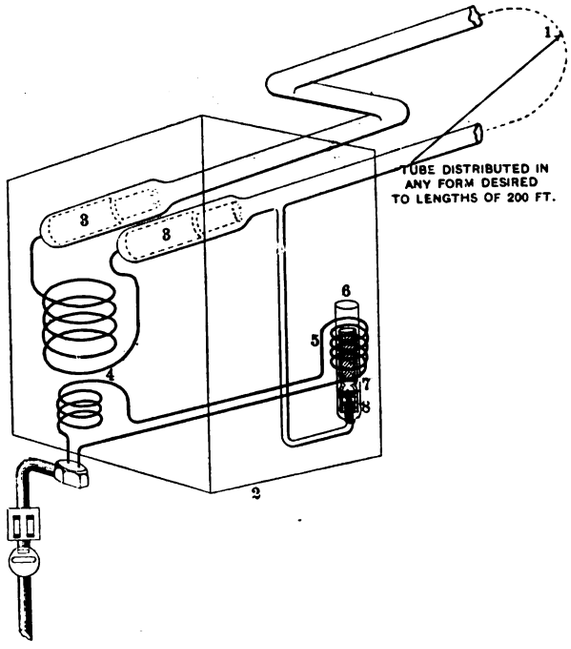

FIG. 1.—DIAGRAM SHOWING ESSENTIAL FEATURES OF THE MOORE LIGHT.

covered with what would correspond to about a thimbleful of mercury, which simply seals the pores of the carbon plug and therefore has nothing whatever to do with the conducting properties of the gas in the main tube which produces the light. Partly immersed in the mercury and concentric with the carbon plug is another smaller and movable glass tube, the upper end of which is filled with soft iron wire, which acts as the core of a small solenoid connected in series with the transformer. The action of the solenoid is to lift the concentric glass tube partly out of the mercury, the surface of which falls and thereby causes the minute tip of the conical shaped carbon plug to be slightly exposed for a second or two, and an extremely small quantity of air or other gas filters through it and then finds its way into the vacuum tube proper. In normal operation most of the tubes expose this carbon tip for about one second every minute. Therefore this system, broadly speaking, consists in continuously burning air electrically.

Fig. 3 will explain the theory of this action still more clearly. This curve shows the relation between conductivity and degree of vacuum. Of course, there must be a critical degree of vacuum at which the conductivity is a maximum; this point corresponds to X. By means of the adjusting screw at the top of the solenoid the degree of vacuum is kept normally at a lower vacuum corresponding with Y, therefore as the electricity uses up the gaseous conductor, the vacuum, of course, becomes higher, the conductivity better, and a greater current flows through the solenoid, causing it to lift the displacer and expose the carbon tip above the surface of the mercury. As others have expressed it, this apparatus actually breathes. Immediately upon the air being admitted the vacuum falls, its resistance increases, and the current through it decreases, as does

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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also the current from the mains; therefore the feeder magnet weakens and the displacer falls, thereby shutting off the air or gas inlet. This cycle is repeated about once a minute throughout the life of the tube, which is indefinitely long. Of course when the tube is not in service there is no leakage of air or other gas through the mercury covering the plug.

The following comparative illumination tests were made between the Moore tube located in the lobby of a large theatre and the incandescent lamps formerly used to light the same area:—

	Moore tube.	Incandescent system.
Mean illumination (average hefner-feet of 16 stations)	3·12	1·09
Average variation from mean	27 %	16 %
Average volts	222 a.c.	115 d.c.
Amperes	21	51·75
Watts total	3,075	5,470
Power-factor	66	—
Area square feet	2,110	2,110
Watts per square foot	1·46	2·82
Illuminating efficiency $\frac{\text{mean hefner-foot} \times \text{area}}{\text{watts}}$	2·15	0·39

Therefore the tube system has 5·1 times the illuminating efficiency of the incandescent lamp system under the same local conditions.

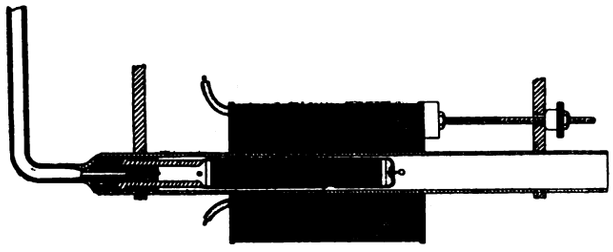

FIG. 2.—FEEDER VALVE.

A new and excellent type of portable illuminometer recently developed by Mr. Marshall was used to make these illumination measurements. At all stations it was placed 32 in. from the floor, although the floor of the lobby slopes towards the entrance end. The tube was not provided with a reflector of any kind, and therefore the ceiling was much brighter than when the incandescent lamps were used, most of which were located directly on the ceiling. The walls and ceiling were covered with a buff-coloured paint. The tube operated directly from the street mains, 220 volts, 60 cycles, single-phase.

If this tube had been longer its efficiency would have been still better, and by equipping it with a simple white reflecting enamel on the exterior of its upper half it would have had the benefit of a

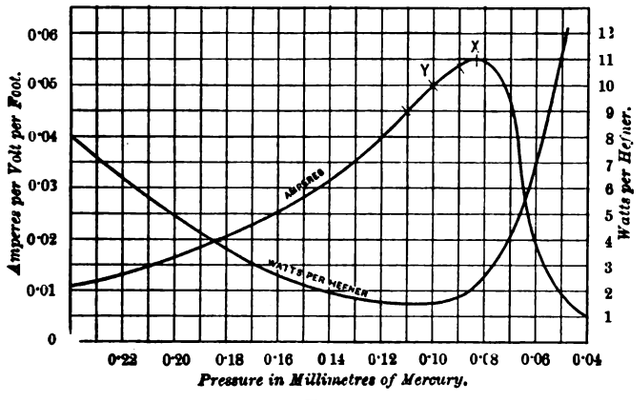

FIG. 3.

reflecting surface like most other forms of light in normal operation. Measurements of tubes so equipped show an efficiency corresponding to less than 1 watt per hefner, and therefore approaching the theoretical limit for a light of such a commercially good spectrum.

Experiments made by lighting the basement floor of a departmental store when the tube was fed with pure nitrogen and therefore giving a yellow light showed that the tube system with yellow light had 2·9 times the illuminating efficiency of the enclosed arc-lamp system under the same local conditions, the illuminating efficiencies being 2·79 and 0·967 respectively. If the losses of the terminal box are deducted, the actual efficiency of this tube, simply as a light source—which is the manner in which practically all other light sources are usually rated—reaches the remarkably high figure of 1·3 watts per hefner. When a Moore tube is diffusing its yellow light, one seems at least to be able to see far better than when it is producing the same hefner power of white light.

Although the above tests indicate that this system is now the most efficient light source known, nevertheless not only theory but experiments already made show that greater advances in efficiency are yet to be made. The best gaseous conductors particularly adapted for selective radiation must be determined upon. For example, nitrogen has about twenty times the efficiency of hydrogen. A gaseous conductor must also be selected that not only has proper colour values but must maintain high efficiency over wide ranges of intensity; for example, mercury vapour (to say nothing of its colour) is very inefficient in the long-tube system. It is only efficient at intensities which should be considered too high, and which is also the reason why the mercury tube is so sensitive to temperature changes.

Moore tubes are now used in lengths varying from 40 ft. to 220 ft.

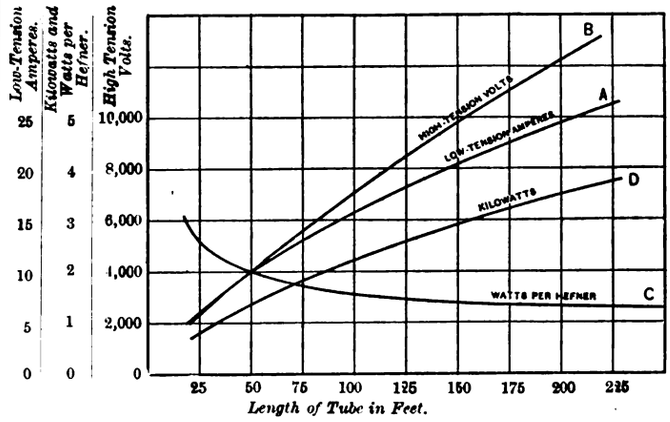

FIG. 4.

The following curves show the watts per hefner for 40 ft. to be 2·5, and for 220 ft. to be 1·4, on the basis of a yellow light. Therefore when tubes are operating at 12 hefners per foot, which is the average intensity now used, tubes from

40 ft. to 70 ft.	use a	2-kw. transformer.
80 ft. to 125 ft.	,,	2·75-kw. ,,
130 ft. to 180 ft.	,,	3·5-kw. ,,
190 ft. to 220 ft.	,,	4·5-kw. ,,

In order to insure steady light the power factors of the circuits supplying these transformers average at present 65 per cent. This is obtained either by using a shell type transformer of special design with a leakage reactance of about 65 per cent., depending on the size of the transformer required, or there can be used a standard type of core transformer, operated in a series with a special type of adjustable inductance consisting of two composing coils on the centre leg of an iron core of the shell type formation.

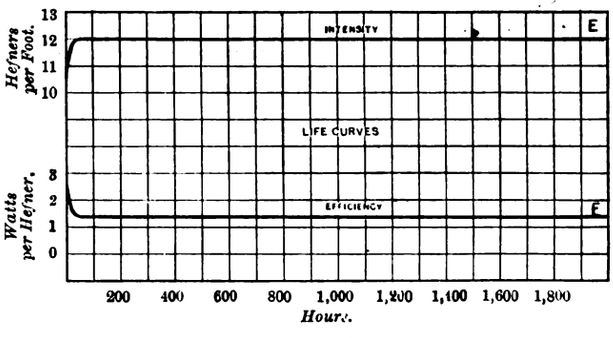

FIG. 5.

Although the average power-factor is now about 65 per cent., there is no theoretical reason why all these tubes should not operate at a considerably higher power-factor. In fact, a very recent improvement in the valve which has entirely eliminated capillary attraction has made it practical to adjust tubes to a power-factor as high as 84 per cent. Since all of the electrical factors of the entire system are based on the conductivity of the gas column, it is possible to vary the power-factor over a wide range simply by changing the degree of vacuum by regulating the amount of gas fed to the tube.

The accompanying curves (Figs. 4, 5 and 6) show the relations existing between the salient factors that have to do with the tube performances. Curve H shows that the light intensity is directly proportional to the voltage, not as the square or the cube of the volt-

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age as is the case with incandescent lamps. This is an advantage of great practical importance. It is also found that the efficiency does not vary over a wide range of supply voltage.

The degree of vacuum required in these tubes is about 0·10 of a millimetre, which, comparatively speaking, can be called a high vacuum. This vacuum is maintained within 0·01 of a millimetre or 0·00001 per cent. of an atmosphere either above or below the normal degree of vacuum. The solution of this very difficult problem of maintaining a degree of vacuum so nearly constant was found by taking advantage of the fact that but slight changes in the vacuum cause enormous changes in the electrical resistance of the gaseous conductor. For example, a tube 220 ft. long at its lowest vacuum (0·11 mm.) takes 24 amperes, but at the end of every minute this has crept up to 25 amperes, when a new supply of gas causes the amperes slowly to drop again to 24. Of course it is impossible to detect this slight oscillation either in the steadiness or intensity of the light in the tube. Making use of electricity to govern the vacuum is equivalent to using a multiplier of about 400,000.

These long tubes are built in place by hermetically sealing together 8 ft. 6 in. lengths of 1·75 in. glass tubing, with walls $\frac{1}{16}$ in. thick, by means of a new blast illuminating gas—fire or double-flamed torch. This work can be done rapidly and cheaply, since in a 100 ft. tube about a dozen joints are needed and only about two minutes are required for each one. This has necessitated the development of a new trade:—namely, "glass plumbing."

The two ends of the tube within the terminal box each contain a graphite cup electrode 8 in. long. Immediately in front of one of these electrodes a branched small-bore tube extends to the bottom of the feed valve, and the other branch is available to be connected temporarily by a rubber hose to a new small portable oil

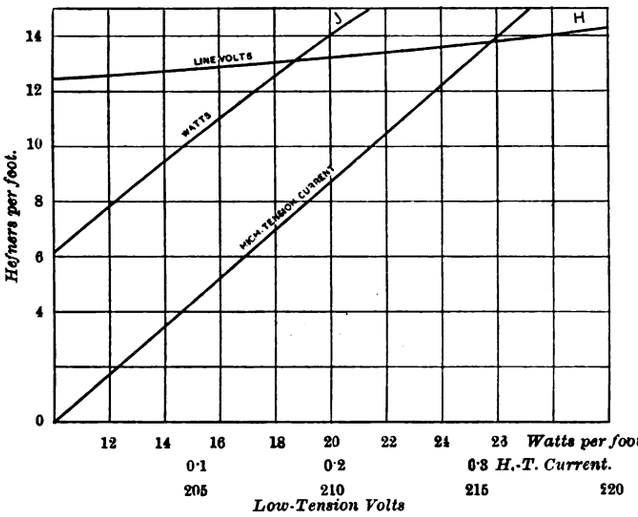

FIG. 6.

vacuum pump. The electricity is switched on in the tube shortly after the pump is started and the amount of light resulting indicates in a measure the degree of vacuum in the tube; but in investigating a field of this nature a simple, rapid and accurate vacuum-gauge was found to be necessary.

As soon as the vacuum of the tube is sufficiently high, the feed-coil is adjusted to feed at proper intervals the right quantity of air or other gas. When the light automatically and continuously feeds itself from the atmosphere, the supply of which is, of course, inexhaustible, its life can be said to be indefinitely long. When it is desired to feed the tube on nitrogen only, the air is simply made first to pass through a small iron cylinder containing enough phosphorus to last several years. Should a longer life than this without any attention be desired, several cylinders can be used in series, and these can be renewed an indefinite number of times at a negligible cost.

Various portable or unit forms of this light have been designed, some resembling somewhat an arc lamp.

The automatic feeding-valve is, of course, applicable not only to alternating-current vacuum tubes, but also to direct-current vacuum tubes. It can be made invaluable for all kinds of vacuum-tube apparatus, such as X-ray tubes, vacuum oscillographs, wireless telegraphy or telephony, transmitters and receivers, vacuum or vapour rectifiers, or lamps.

A careful analysis of this system of illumination in general discloses the large number of advantageous features it possesses. It is the first artificial light that can rightly be called imitation daylight.

Since it is possible and practicable to use these tubes graduated from an intensity of light per foot that is almost negligible up to 30 or more hefners per foot, it is impossible to state arbitrarily just what is the intrinsic brilliancy of a Moore tube. The average long tube now in use operates at 12 hefners per foot. The following table compares the tube with some other illuminants on the basis of hefners per square inch:—

Moore light	at 6 hefners per foot	0·33
	at 12 ,, ,,	0·66
	at 36 ,, ,,	2·0
Cooper-Hewitt mercury tube		19·0
Incandescent filaments		250·0
Nernst glower		600·0
Arc crater		10,000·0

Some authorities have stated that an intensity greater than about 5 hefners per square inch is beyond the theoretically correct limits, therefore this light is the only one that has a low enough brilliancy not to fatigue the eye. This has also been demonstrated by practice.

The Moore light is generated in such a manner that it needs no unsightly and expensive auxiliary apparatus either to distribute it by reflection or to diffuse and soften it. There is a marked difference between the illumination produced by a Moore tube and intense-point sources. After being accustomed to the tube light, workmen, whether machinists or employés in packing and shipping departments, very much appreciate the fact that they "can't get into their own shadows." For reading addresses or markings on loading or shipping platforms it can scarcely be surpassed.

This tube lighting accurately resembles cove or concealed lighting, yet there is no necessity for concealing the tube; should it be desired to conceal the source of light the cove itself is not needed, because all that is necessary is to place an opaque reflector on the lower side of the tube so that all of its light would be thrown toward the ceiling and illuminate the room therefore entirely by reflected light. The most common kind of natural light is almost shadowless and always pleasing, as is also the lighting of many large areas by means of skylights, and so are artificial imitations of diffused daylight if made intense enough. A lack of uniformity in intensity does not rest the eye.

The Moore light will operate successfully on all frequencies, but at frequencies as low as 25 cycles the images will probably become too pronounced unless two or three-phase currents are available, in which case, by the use of multiple tubes, the images of moving objects are entirely removed. Careful tests on various frequencies up to about 10,000 cycles have shown that the number of alternations of the current used to excite these long tubes has nothing to do with their efficiency.

The only commercial and proper method of comparing all sources of light is on the basis of their ability to produce useful illumination, and not by any other basis. I have advocated for some years past the comparing of all lights by measurements of illumination and not by candle-powers, and now see indications of this procedure becoming standard. The term hefner-foot will soon replace the unsatisfactory candle-power, and contracts for lighting any area will be based on specifications calling for a definite intensity in hefner feet on each square foot or square yard of the area to be lighted. This is far more practical than agreeing to furnish a lamp which is supposed to require no more than a certain number of watts per candle-power, at the beginning of its life. All light users want to deal with terms that have to do with useful light, and this is one reason why the term "watts per candle-power" has always been so extremely unsatisfactory. There should be used a single commercial quantity or figure that would correctly express the "illuminating efficiency" of each and any system of lighting used to illuminate a given area. Such a figure or value is readily obtained by dividing the average of the hefner feet measured at a suitable number of stations by the watts per square foot. This method will finally be widely adopted, not only by illuminating engineers, but also by the intelligent public—now that simple and perfectly self-contained illuminometers are available. The term hefner foot is preferred because the hefner is the only practical primary standard.

The lapse of time since the first automatically fed tubes were installed being so short, it is not now possible to state definitely what their final life will be, beyond the general statement that some of these tubes have already been in operation over 4,000 hours without change, and that there are good reasons for believing that they should continue to run at least as long again, which is a much longer life than any other form of illuminant yet invented. Since air or other gas is regularly admitted to the tube and changed to some solid form, due to certain electrochemical reactions, it is certain that the time of operation without any attention whatever cannot be prolonged indefinitely. Before adopting the chemical method of obtaining a nitrogen supply for the long tubes, it was stored under about 3 lb. pressure in a small tin cylinder placed in the terminal box, which supplied an average tube before needing to be recharged for considerably over a year. Therefore the quantity of gas (nitrogen, for example) necessary to support a light of 12 hefners per foot is so small that a tube of average length should

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remain in perfect condition for a number of years before it would be expedient to remove the small quantity of dark-coloured powder which may have accumulated only within or near the graphite electrodes.

When a tube has been properly exhausted, the discolouration in front of the electrodes should not at any time extend more than 2 in. or 3 in. When a tube is striated it indicates that other gases are present that are foreign to the one decided upon to be used.

The cost of a long-tube installation, due to its being construction work, varies with its location, its length, its shape, the intensity of the light required, the kind and number of fixtures desired, and other local conditions; but is already less than the cost of a first-class incandescent lighting system with its necessary wiring, fixtures and shades. Eventually it will be far cheaper. It should be borne in mind that the first cost of this tube corresponds with the entire cost of an incandescent lighting system—its iron piping, wires, cut-outs, fixtures, shades and lamps—and also that the first cost should be considered only in connection with the fact that in many instances this tube will pay for itself several times over during its first year of use from the amount saved on what the current bills would have been if incandescent lamps had been used to produce the same amount of useful light.

Owing to the high efficiency of the tube and the large area from which any heat accompanying the light can radiate, the temperature of the tube is remarkably low, being in the neighbourhood of 100° F.; therefore it cannot injure either perishable goods or the health of those working under it.

This light is the first and only illuminant the colour of which can be changed at will over a wide range. This is accomplished by changing the character of the gas within the tube. If a tube is permitted to feed itself on plain air an efficient pink light results, but if the air is first caused to pass through a cylinder of phosphorus to absorb its oxygen a golden-yellow light is produced that is the most efficient light source known. When these tubes are supplied with CO_2 they appear pure white. Most inexperienced persons, especially when contrasting the tube light with reddish lights, criticise the colour as being too blue without realising that daylight is a decidedly bluish white. The laws of nature make the operating expenses of the pure white-light tube almost double that of the yellow-light tubes, because the eye is affected to a maximum degree by yellow rays. But the white tubes which simply contain CO_2 have been used for over a year by stores in their ribbon departments for matching colours, day and night, because their spectrum remains absolutely constant. There are many other industries also where colour values are of vital importance. Also, since the colour factor is now under perfect control, those light rays can be scientifically selected which are essential for the forcing of all kinds of plant life, flowers, fruits and vegetables. The colour of the light can be varied by feeding the tube with any gas, or by using multiple valves, &c., various gases can be mixed within the lighting tube itself.

It is hoped that the facts in this Paper show that electric illumination resulting from incandescent gases or vapours has vastly less limitations than when solids are used, because the molecules or atoms are free to vibrate, while those of solids are not.

THE PRESENT STATE OF DIRECT CURRENT DESIGN AS INFLUENCED BY INTERPOLES.

The following is an abstract of the discussion which took place on the Paper read by Messrs. F. H. Page and F. J. Hiss before the Institution of Electrical Engineers. We gave an abstract of this Paper in our last issue.

Mr. F. E. USSING said that the authors had used Dr. Breslauer's formula for reactance voltage and rightly pointed out that the term in that formula, which took into account the reduction in magnetic reluctance due to the auxiliary pole being placed exactly over the coils undergoing commutation, was not necessary for machines with solid pole pieces. He, the speaker, would go further and say that it was not necessary at all. The Paper again brought to the front the important question whether d.c. machine designs should be completely rearranged on the interpole basis or not? The authors seemed to advocate standardising machines of outputs above 40 to 50 kw. on the interpole basis, but considered the standardising of machines below this output as likely to be uneconomical. He was of almost the opposite opinion and believed it was most rational in all cases to consider the interpole machines as a special line of machines. It would perhaps be possible in some degree to standardise the smaller machines on an interpole basis, in so far as one would be able to use most of the mechanical parts of the normal machines also for the interpole machines, and one could in many cases with advantage provide the 500-volt machines with interpoles; but for machines above 50 kw. he believed that standardising on an interpole basis was quite out of the question, due to the greatly varying working conditions for machines of greater outputs; even with normal machines they could hardly standardise above 200 kw., and he did not see that the authors of the Paper had given any proof to the contrary. For instance, they stated that the heating limit was the same for machines with and without interpoles. He had always found that the interpoles impaired the ventilation very considerably. Furthermore, they stated themselves that a reduction in commutator copper for the interpole machine was to a certain extent more apparent than real. This, he thought, could also be said of the gain in efficiency claimed by the authors for interpole machines. He generally found that the efficiency was about the same for interpole as for normal machines. He believed that interpoles had their own useful field, but found that many firms had gone in for the interpole machines on a far too general scale. He was of opinion that all the known and possible improvements in direct-current dynamo design should be fully utilised before turning to the use of interpoles. Series parallel windings with equalisers under the Arnold patent might in many cases prove useful. Several Continental firms were using these windings extensively and with good results, and he found the authors' statement regarding this winding rather ambiguous. He would like to draw attention to a new improvement in direct-current windings—namely, the use of equalisers between the various separate parallel windings of a multiple circuit doubly re-entrant duplex or multiplex winding. This patent was the invention of Franklin Punga. The arrangement was illustrated in the diagram (Fig. 6). The normal multiple-circuit doubly re-entrant duplex or multiplex windings without equalisers could only be used to their full advantage when the voltage between the segments belonging to the different parallel windings was equally distributed; that was to say, the potential between segments 1 and 2 should be exactly half of the potential between segments 1 and 3; but, without special means of bringing about this condition, it was rather dangerous to use those windings, as it might happen that the potential was very unevenly distributed between the segments, which would give rise to very great equalising losses over the brushes. The winding shown in the diagram was a multiple-circuit doubly re-entrant duplex winding. The normal equaliser connections for one winding were shown at the bottom, and the lines at the top indicated the normal equaliser connections for the other winding. The corresponding equaliser rings of the two parallel windings were connected through the equalisers indicated on

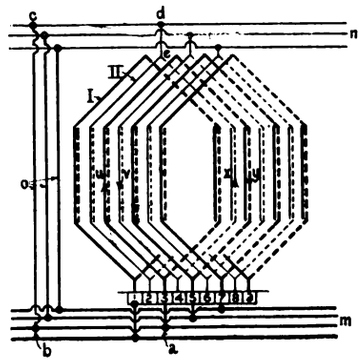

FIG. 6.—MULTIPLE CIRCUIT DOUBLY RE-ENTRANT DUPLEX WINDING WITH SPECIAL COMMUTATING CONNECTIONS.

the left of the diagram, and by means of these connections an equal division of potential between adjacent segments was ensured. It would be seen that the point *c*, which should be of the same potential as segment 3, was connected through two equaliser rings and the connection *o*. The complete equalising connection was denoted by the letters *a*, *b*, *o*, *c*, *d*, *e*. The potential of point *e* lay midway between the potential of segments 2 and 4. The potential of segment 3 would, therefore, also be midway between 2 and 4. His firm were also finding that winding useful for interpole machines, especially turbo machines for low voltage. He believed that windings and improvements like those he had mentioned would considerably extend the field for normal continuous-current machines, and at the same time should tend better to define the wide but nevertheless limited field of interpole machines.

Mr. A. G. ELLIS said that the authors had given a good account of the several factors which were brought into prominence by the application of interpoles, but he did not think their conclusions could be regarded as perfectly general. The employment of interpoles had in itself been made far too general a matter. Interpoles had a definite and legitimate field of application, but their application to cases where a good design could be obtained on ordinary lines was not justifiable. The authors stated in the Paper that "the development of the interpole has led to a better mechanical design which ensures a more efficient ventilation at a lower works cost due to the greater saving in material." It would seem to be implied from this that the saving in material was a consequence of the more efficient ventilation, and that interpole machines had as an inherent property better ventilation. It should be remembered that the better mechanical designs and ventilating schemes were equally applicable to machines without interpoles; in fact, a modern non-interpole machine had decidedly better heat dissipating facilities on account of the fact that the air circulation was not impeded by the interpoles. Then as to the statement "lower total works cost due to the greater saving in material"; it should be noted that the interpole machine was essentially a copper machine, and the present high price of copper would have a marked influence on the total works cost. Further, although an interpole design might in certain instances show a slight total economy in material, there were the extra labour charges associated with the interpoles which tended to offset any such saving. In the surfaces marked in Fig. 3 of

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the Paper a difference should be made for large and small machines; as in the latter, where the stampings were mounted directly on the shaft, the internal cylindrical surface of the armature, even if it had ventilating tunnels, contributed only in a very small degree to the heat dissipation. He had found that for high speed alternators a useful surface on which to reckon the watts per square decimetre was the total external surface of the core—*i.e.*, the internal and external cylindrical surfaces and the two end surfaces of the core. As to commutation limits, the authors called attention to the distorting effects of the armature in variable speed machines when running at top speed with the weakest field, and the obtaining of the low reactance voltage by use of large commutators with many segments, and the use of strong fields. These points could not be too strongly emphasised, as there might exist the impression that, with the interpoles to take care of the commutation, few segments and high reactance voltages might be employed without trouble. Such procedure was in no way justified by interpole designs. A matter which became very prominent in wide range variable speed motors was that of flashing over the commutator at top speed. A motor with a speed range of 4 : 1 or 5 : 1 might have at certain points on the commutator a voltage per segment several times the average voltage per segment, and there existed between certain points a potential much greater than the actual terminal voltage. Oelschlaeger had recorded some tests in the *Elektrotechnische Zeitschrift*, March 7th. He found by test that a 500 volt 21 H.P. 200-875 revs. per min. motor had a voltage of over 800 volts existing at the commutator at the highest speed. The reason for this was the uneven distribution of potential caused by the much distorted field. The conditions were clearly shown by the adjoining diagram which he exhibited, which showed the results on a 50 H.P. 500 volt 200-1000 revs. per min. motor, which Mr. Hobart

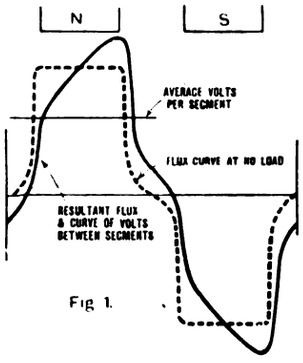

Fig. 1.

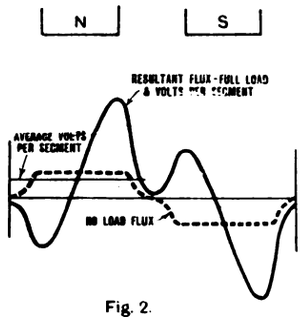

Fig. 2.

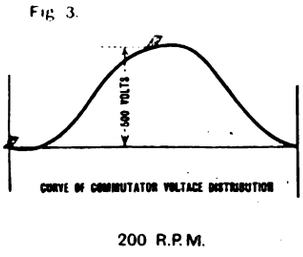

Fig. 3.
200 R.P.M.

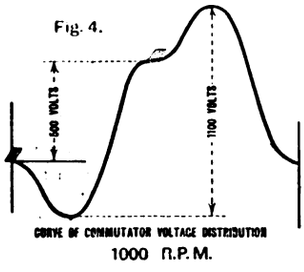

Fig. 4.
1000 R.P.M.

had carried out and kindly placed at his (Mr. Ellis') disposal. Figs. 1 and 2 showed the resultant flux distribution at 200 and 1000 revs. per min. respectively with the armature loaded. The dotted curve indicated the field flux at no load. Figs. 3 and 4 showed the potential distribution around the commutator at those two speeds. At 1,000 revs. per min. there existed, between certain points of the windings and on the commutator, a voltage of about 1,000 volts, although the voltage between brushes was only 500. The flux curves in Figs. 1 and 2 also represented the curves for the volts per segment. The volts per segment reached a value of five times the average volts per segment. The interpoles themselves did not assist in overcoming the distortion even if they extended the whole length of the armature, and such proportions were undesirable and uneconomical. It appeared that a distributed compensating winding was better in such cases, as the distortion would be much reduced and the flux curve assumed almost the shape of the dotted curve in Fig. 2 due to the main field. The Paper mentioned that the interpole core should be made circular in section. This was quite correct. It was remarkable that the four typical examples given by the authors each had a rectangular pole extending the whole length of the armature. The shape of the interpole affected the shape of the main pole, and he did not quite follow the argument for a square main pole. He believed that the best use might be made of the space by employing circular main poles and circular interpoles set at the ends of the armature. Of course, this was not possible if the interpoles were very wide, but he did not think wide interpoles were required in other than rare cases. Mr. Hobart had recently investigated designs of various rating over a wide range of speed, and found that it was not more economical, nor advantageous, to use interpoles for speeds below the following: 250 kw., 250 volts, 500 revs. per min.; 500 kw., 500 volts, 500 revs. per min.; 1,000 kw., 1,000 volts, 250 revs. per min.

Mr. S. E. GLENDENNING said two very interesting formulæ were given in the Paper, but these would, however, never come into general use. The more complicated a formula was the more it would be distrusted. He thought the introduction of new formulæ undesirable. He was glad the authors did not advocate the practice of interpoles for small machines, and even in large machines he was of opinion that the advantage was nothing like so great as it was assumed to be. He did not, however, wish to discourage the use of interpoles, as they were extremely useful in certain circumstances.

Mr. R. POHL (communicated) said he had strongly advocated the use of interpoles, not only for variable speed motors, but also for most machines above 40 H.P.; he was pleased to see that the authors in their Paper arrived at very similar conclusions, and that they corroborated his views as to the question of wide versus narrow interpolar arc, the advantages derived from axially shortening the poles, the number of main and auxiliary poles employed, &c. There were one or two points, however, with regard to which he would like to express a somewhat different opinion. When the reactance voltage was small or compensated, the ratio of the ampere-turns for the gap and tooth to the armature ampere-turns under pole arc was not negligible, but generally should not fall below unity, because otherwise the field under the weakened pole tip would become reversed and cause greatly increased iron losses. It was this consideration and not always the mechanical limit which settled the length of the air-gap in interpole machines. Fig. 5 in the Paper, showing the length of the air-gap as a function of the armature diameter, though fairly well in accordance with modern practice for four, six and eight-pole machines respectively, should therefore be considered with reserve, as the length of the gap was very nearly inversely proportional to the number of poles, *ceteris paribus*. In regard to the permissible voltage per segment, the authors had not stated whether their figures 20 to 25 volts referred to the average or the maximum value. In any case it appeared to be low, as in his experience even for turbo-generators a maximum voltage of 40 volts per segment was permissible, whilst in ordinary machines even 50 to 60 volts could be dealt with, provided that in the general design of the armature and commutator due care was exercised. As to the number of interpoles, the authors said that this might be smaller than the number of main poles provided that the armature had a series winding. Theoretically, he considered for all kinds of windings the number of interpoles could be equal to one-half that of the main poles. In practice, however, the authors had found that the sphere for machines with a reduced number of interpoles was very limited and their operation less reliable. From experiments carried out two years ago in the test room of the Phœnix Dynamo Mfg. Co., he could confirm that statement. The interpolar arc was, in his opinion, primarily fixed by the width of the actual commutation zone—as part of the neutral zone—which should be covered with ample margin. The number of slot pitches in the arc was a consideration of secondary importance, although in smaller machines it should not altogether be lost sight of. In conclusion, he would emphasise the author's valuable hint that the most economical machine was not necessarily the one with the highest output coefficient.

Mr. W. E. ROBSON (communicated) said that as the result of some years' experiments in the construction, manufacture and application of interpole machines, he thought it possible that their greatest future would be as variable speed motors. Prior to their advent a direct variable speed electrical drive for certain classes of machinery was hardly possible, for the cost of a variable speed shunt motor even for a 3 to 1 range was so much above the price of a standard shunt motor as to make it much cheaper to employ gearing. Further, in spite of the claims made for the variable speed motor it was not generally a sparklessly running machine at the high speeds. Using interpole motors it was possible to get a 6 to 1 speed range by shunt field regulation, which would operate completely without sparking and stand heavy momentary overloads at the top speed. Taking, however, the case of constant speed dynamos, the question as to whether the interpole type would displace the present general form would be decided mostly on the question of works cost. Competition was now excessively keen and many firms were glad to accept orders at prices which precluded the possibility of supplying anything but the cheapest article that would meet the specification. The fact that constant speed dynamos with interpoles were frequently supplied showed that in those cases the manufacturer was convinced that it was cheaper to adopt the interpole type than to face the cost of constructing a normal machine of good commutating qualities. Prior to the use of interpoles, the output of even 500 volt dynamos in many cases was limited by sparking and no great attempt had been made therefore to improve the ventilation. But now in those cases, if interpoles were used, the heating might become the limit, and to enable a small size of frame and armature to be used, greater attention had to be given to the ventilation, with the result that in many cases a direct saving occurred, or more generally a lower price could be quoted and the order secured. He could not see that the claim for standardised interpole dynamos was justified. The saving in cost due to lessened copper on the main poles due to smaller air-gaps would be much more than offset in most cases by the extra labour and material costs of the interpoles and their windings. The cooling surfaces taken into account by the authors in determining their constants for temperature rises were of interest, but the method used in the case of field coils was open to criticism. In most machines there was a clear layer of stagnant air between the inner surface and the pole owing to the magnet frame. The layer of presspahn, red rope paper, &c., on the inner side of coils was also prejudicial to effective conduction or radiation. The relative efficiency of interpole and ordinary type machines was likely to remain more or less obscure, as there was a dearth of data of machines for identical conditions. It would appear that the efficiency of the interpole machine was likely to be higher than that of the ordinary dynamo at light loads, but for full loads the position would be reversed owing to increased losses caused by the field, &c., while the additional loss in the commutating pole coils came in also.

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PHYSICAL SOCIETY.

At the meeting held on May 24th, Prof. J. Perry, F.R.S., President, in the chair, a paper on

"The Measurement of Mutual Inductance by the aid of Vibration Galvanometer"

was read by Mr. A. CAMPBELL. The measurement of mutual inductance is of importance, not only in electrical science, but also in electrotechnics; for example, it forms the basis of the magnetic testing of iron by the ballistic method. Carey Foster's method of comparing a mutual inductance with a capacity is one of the most convenient methods, and the formula is very simple, being $M = KRr$, where K is the capacity (in farads) and R and r are resistances. The great advantage gained by the use of a vibration galvanometer in methods for measuring capacity or inductance—*e.g.*, Wien's methods and Anderson's (as used by Rosa and Grover)—led the author to apply it to the Carey Foster and the Hughes-Rayleigh methods. He found, however, that with alternating currents it was necessary to modify the Carey Foster method by adding a series resistance in the condenser branch; this left the formula $M = KRr$ unaltered and gave an additional formula involving the ratio of a mutual and a self-inductance. It turned out that this modification had been suggested by Rowland. The modified method is extremely convenient, the two adjustments required for a balance being independent and the result not involving a knowledge of the frequency; the use of the vibration galvanometer is a great improvement, making the method independent of the wave form of the current used. The author next discussed vibration galvanometers. They belong to the class of tuned (or resonance) instruments, the use of which in such measurements is due to Max Wien, whose work on the subject, beginning with his tuned optical telephone in 1891, is of the utmost value, and includes many methods which are now standard. If the detecting instrument used in a null method (with alternating current) is adjusted so that its natural period is in tune with that of the applied voltage, it will be set into strong resonance and will be enormously increased in sensitivity for this particular frequency, practically ignoring in comparison all the other components of the wave-form. Thus in any method in which the tuned instrument is used, a sine wave-form may be assumed. Rubens brought out his vibration galvanometer in 1896, the moving part being small soft-iron needles (on a torsion wire) polarized by a pair of magnets with polar windings carrying the current to be measured.

The author exhibited a vibration galvanometer of another type, having a moving coil controlled by an adjustable bifilar suspension. By adjusting the tension of this the tuning is very easily effected. For measuring the frequency to which a tuned instrument is responding, it is convenient to use the Hughes-Rayleigh method, in which a known self-inductance is compared with an unknown mutual inductance, the balance being dependent on the frequency. The author showed such an arrangement in which the slide-wire was graduated directly in frequency (~ per sec.). With accurately known frequency on the other hand, the method gives absolute values of L and M.

In conclusion, the author gave results of tests (by several methods) of a standard mutual inductance of 0·05 henry. The Kirchhoff method with direct deflection on a ballistic galvanometer (of measured time of swing) gave a mean of 0·05014 henry, while the Carey Foster method gave 0 05009 henry; the probable error of the latter was much smaller than that of the older method.

Mr. A. RUSSELL thanked the author for his most interesting and instructive demonstration. He considered that the bifilar method of suspending the vibrating coil was a great improvement on the single wire method described by Wien in the *Annalen der Physik* in 1901. In the *Physical Review* of last December Mr. Wells states that an alteration of 0·3 per cent. in the length (about 12 cm.) of the stretched wire of a vibration galvanometer, when tuned, diminished the amplitude of the oscillation to less than one-fifteenth of its former value. The resonance point is very sharply defined. Hence to work such an instrument at its greatest sensibility it must be most accurately tuned and it must be supplied with a current of almost absolutely constant frequency. When used to measure currents, the shape of the wave must be known. Mr. Campbell, however, apparently uses his vibration galvanometer mainly in null methods, and so any kind of interrupted or alternating current can be used, the shape of the wave being almost immaterial. He noticed that Mr. Campbell obtained his balance very rapidly by adjusting both the tension of the suspending spring of his galvanometer and, by means of a simple interrupting device, the frequency of the supplied current during the course of the same experiment. The suggested method of measuring frequency was extremely ingenious. He asked whether Mr. Campbell had found it necessary to take into account the "effective internal resistance" of the condensers he used in his tests.

Dr. ECCLES asked the author for information as to the differences in performance between vibration galvanometers like the one shown, which employed rotational vibrations, and string galvanometers such as that of Einthoven, where the vibrations are transverse. The latter is a tuned instrument, and, it has been stated, has been used in the measurement of inductance, with what method and degree of success Mr. Campbell might know.

Mr. ROLLO APPLEYARD said the author's methods should be applicable to the case of an inductance shunted by a capacity. In that event it would be useful for measurements of the inductance of telephone cables. If it could be adapted to that purpose it would be of great service in affording a rapid means of determining the "attenuation constant," when frequency was of importance.

Dr. R. S. WILLOWS said the suspension used by the author was an improvement on those in general use, which were liable to be broken when changing the frequency.

Mr. CAMPBELL, in reply to Mr. Russell, said that the second formula in the modified Carey Foster method involved the resistance in series with the condenser. With a mica condenser it gave results in such close agreement with the first formula that it precluded the possibility of any apparent resistance in the condenser of the order observed in certain condensers by Rowland and by Mr. Russell. The author was not aware of the use of the Einthoven string galvanometer as a vibration galvanometer, but if the damping could be made small enough there seemed no reason why it should not be so used. In reply to Mr. Appleyard, he thought that one of M. Wien's methods would be applicable.

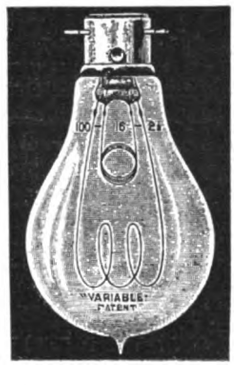
A "Note on the Rate of Decay of the Active Deposit from Radium,"

by Messrs. W. WILSON and W. MAKOWER, was taken as read. In some experiments in which the ionisation produced by the α rays from radium C was balanced against that produced by the more penetrating β and γ rays, it was found that after a short time these two ionisations were no longer exactly equal, however carefully they had been adjusted to equality at first. A similar effect had been noticed by Brousson, and was attributed to the slowly-moving β rays emitted by radium B which is present with the radium C. Since these rays are emitted by radium B, whereas the α and more penetrating β rays are emitted by radium C, it is to be expected that the rate of decay as measured by these two types of radiation will be different. The author's experiments test this point and confirm the view that the observed difference in the rate of decay as measured in the two vessels is due to the slowly-moving β rays emitted by radium B.

Mr. S. G. BROWN exhibited "Apparatus for Relay Working of Long Submarine Telegraph Cables."

THE "VARIABLE" ELECTRIC LAMP.

The advantages of an electric lamp that can be turned high or low, with a corresponding reduction in the current consumed, have always been admitted, and most lamp makers have made attempts in that direction. In the "Variable" lamp these difficulties are



solved in a somewhat novel way, and where it is desired to vary the light this lamp may be found advantageous.

It contains two filaments of high and low candle-power respectively, which can be used separately, or the two in parallel; therefore the lamp will give three distinct candle-powers, and the current used is approximately in proportion to the light given. A 5-16 c.p. lamp will give 5, 16 or 21 c.p. at will, by simple rotation of the lamp. Any combination of candle-powers can be made above 2½ c.p.

The lamp is made to fit any standard lamp-holder. There are three contacts at the top of the lamp, one being common to the two filaments, whilst the other two are connected to each of the two filaments respectively. The lamp can be twisted so that a connection is made to both the filaments at once, or the filaments can be used separately, thus giving a choice of three candle-powers. This will at times be found of great advantage, and will tend to economy in current consumption.

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PATENTS IN 1906.

THE report of the Comptroller-General of Patents for the past year, which has just been issued, and which we give elsewhere at some length, is of particular interest as showing the effect of the Patents Act of 1902. There was a good deal of misgiving when this Act came into force, because it was contended that the method of search to which it gave effect would be of little value owing to the fact that the search applied only to British patents, and also because, as is well known, most patent actions in the Law Courts do not depend simply upon anticipation by previous patents, but upon the state of common knowledge at the time when the patent was filed. It was also felt that the fact of a specification being accepted by the Patent Office after search would be taken as an indication that the patent was certainly valid, thus giving it a spurious value. But these forebodings do not appear to have been fulfilled.

The new Act only came into force in 1905, and therefore the year under review, which is the second to which the Act applies, is the first one to which we can look for

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the true effects of the Act to be traced. There was a sudden change noticeable in 1905, complete specifications in that year numbering 18,806, whereas in 1903 there were 15,831, and in 1904 there were 15,925. A considerable part of this increase was no doubt due to the more expeditious filing of complete specifications necessitated by the shortening of the time allowed for completion from nine to six months; but in 1906 it is noticeable that the number of complete specifications was 18,228, which is still very much higher than the numbers for 1903 and 1904, and not very much lower than that for 1905. As there is no corresponding explanation for the past year, it can only be concluded, in the words of the Comptroller, that inventors generally have appreciated the benefits of the official search.

One effect of the search has been that a great number of specifications have been amended, such amendments being often the result of conference between the Examiner and the applicant. Naturally this course would be preferred as a rule, since non-compliance means that the name and number of those patents which in the opinion of the Examiner are prior patents are stated in the specification before it is issued. It will be recognised how very generally modifications are desirable, when it is mentioned that no less than 8,785 specifications were amended out of a total of 15,369 that were accepted. In 556 cases, however, reference to a prior patent was officially included in the specification.

It is also noticeable that whereas in the 10 years prior to 1905 the average annual number of applications which became void due to corresponding complete specifications not being filed was 196, in 1905 no less than 1,374 became void in this way. This, no doubt, is due also to the official investigations. We think, therefore, that it will generally be agreed that the search necessitated by the Act of 1902 has had a salutary effect. It has in no way diminished the number of desirable patents—indeed, the reverse seems to be the case—but it has probably avoided the completion of a considerable number of useless patents. It has, probably, tended to discourage the taking out of patents for objects other than the protection of a real invention, and it has doubtless been beneficial, as was suggested by Sir Edward Fry's Committee that it would be, to honest and bona fide applicants, and we do not doubt that it has rendered many patents of greater value, owing to their form being more satisfactory as the result of amendment.

With regard to the trend of invention during the past year, the small increase in the number of applicants over that in 1905 appears to be in a large measure due to activity in the automobile industry. For example, there have been a large number of inventions to prevent skidding. Also there seems to be great activity after any serious accident of a mechanical kind. Thus, following the motor-car accident at Handcross Hill, and also the tramcar accident at Highgate, there were many applications for emergency brakes. The tragedies at Merstham and Rugby incited inventors to look for systems for locking the doors of a train in motion, either automatically or by means under the control of the guard or driver. Curiously enough, flying machines have not attracted the attention that might have been expected, but the competition between gas and electricity for lighting still gives rise to a good deal of activity. Inventions in gas lighting relate chiefly to incandescent burners, and those in electric lighting to metallic-filament lamps and the use of metallic substances in the electrodes of arc lamps. Telegraphy, contrary to what might have been expected, does not receive mention in the report in connection with the past year, though in 1905 this was one of the subjects in which the number of complete specifications issued was larger than in any previous year.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Mechanical Theories of Electricity. 1. **Bases d'une Théorie Mécanique de l'Électricité.** By M. Seligmann-Lui. (Paris: H. Dunod & E. Pinat.) 3 fr., 206 pp. crown 8vo. 2. **Erklärung der Gravitation, der Molekularkräfte, der Wärme, des Lichtes, der magnetischen und elektrischen Erscheinungen aus gemeinsamer Ursache auf rein mechanischem, atomistischem Wege.** By Dr. Johann Sahulka. (Vienna: Carl. Fromme.) M. 5.

The natural craving for uniformity and simplicity which is the driving force of all philosophic speculations has sent large numbers of physicists on the quest of an all-embracing theory which shall reduce electromagnetic phenomena to purely mechanical conceptions. Two more such attempts are now before us, and they proceed on almost diametrically opposite lines. M. Seligmann-Lui begins with pure energetics, and after dismissing the one-fluid theory of electricity in a single sentence, on the ground that the mass of such a fluid is undiscoverable by the most delicate balance, he uses a formidable array of mathematics to prove that electricity is "a function of the parameters which define the state of matter." After an equally elaborate investigation of conductivity, he is obliged to confess his inability to explain the structural conditions determining it. When he comes to account for electrolysis, he assumes that "the atoms are not entirely insulating, but still the liquid is a bad conductor." An attempt is made to explain electric and magnetic fields by the deformation of ether particles contained in it, but this type of explanation breaks down when it comes to gravitation, and the author then declares the problem "insoluble or inaccessible." It is difficult to see what he has gained by discarding so much successful work of his predecessors.

Dr. Sahulka's work is bolder and more comprehensive. He altogether discards action at a distance, and acknowledges nothing but collisions between particles of ether or matter as transmitting force and energy. He uses little mathematics and no numerical calculations. Ether consists of very small ponderable masses, which lose no energy in mutual collisions, but do give up energy to atoms of matter when colliding with them. These collisions are made to explain gravitation somewhat on the lines of Boscovich's hypothesis. But they are also made to explain light and radiation generally. The energy taken up by atoms from ether particles is restored to them in the form of "transverse impulses" which make the ether particle describe a zigzag path when colliding with further ether particles. These zigzag "vibrations" constitute light. It is, of course, by no means obvious why chance collisions should produce a zigzag path, but they certainly do so in the author's diagrams.

An electric current is simply a current of ether, which for some occult reason travels more easily through a metal than across an air-gap. The direction of the ether stream, be it noted, is that of the "positive" current. The free exchange between the ether inside and outside the wire brings about a current of ether outside the wire in the same direction, but decreasing in strength with the distance from the wire—a decrease which produces a rotation of the ether particles, and this constitutes magnetism. The author, however, encounters insuperable obstacles in attempting to explain permanent

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magnetism (p. 150), and this is hardly to be wondered at. The author alleges with reason that the accepted electron theory does not account for the electric field. It does not profess to do so, but prefers to accept it as a simple postulate. It certainly explains nearly everything else. There is a certain fascination in the prospect of a complete reduction of electromagnetic phenomena to mechanics, but it should be borne in mind that even the simplest mechanical processes, such as collisions, may in ultimate analysis prove just as unthinkable as action at a distance.

The Manufacture of Light. By S. P. Thompson, D.Sc., F.R.S. (London: Macmillan & Co., 1906.) 1s. net. Pp. vi.—67.

This little book is a reprint of the discourse delivered by the author to working men during the meeting of the British Association at York last year. The whole subject is reviewed in a simple and clear manner, though to some people the title may appear a little misleading, as the book is concerned solely with the conversion of energy into light and not with the obtaining of the energy in suitable form. It is the word "manufacture" which may give that idea. Luminous efficiency is dealt with at some length, as also the value of the radiation spectrum in showing us how very inefficient all our artificial sources of light really are. In that way the problem of the production of light and the difficulties involved in further progress are clearly stated. The latest developments, both electric and gas, are briefly described, and in conclusion a table (deduced from Wedding) is given showing the efficiency and cost of a number of sources of light; in the latter, our gas friends are likely to take exception to the heading of a column "Poison," giving the cubic inches of CO_2 produced per candle-hour. The book will be found useful by those who wish to obtain a general view of the subject with a minimum of trouble.

Practical Methods of Inorganic Chemistry. By F. Mollwo Perkin, Ph.D. (London: Archibald Constable & Co.) 2s. 6d. net. Pp. vii.—152.

It is a common experience that "preparations" are very generally restricted to organic chemistry, and when students pass beyond the student stage research generally tends towards organic bodies, partly because organic chemistry is the fashion, and partly because the methods of attack proceed along recognised lines. To those who realise that a good deal is gained by carrying out inorganic preparations the present volume will be welcome. After a short introductory chapter on chemical methods, seven chapters are devoted to actual preparations, including salts, halogens, metallic oxides, acids, metals and metalloids; these are followed by some useful tables and notes on preparing reagents.

Some Founders of the Chemical Industry. By J. Fenwick Allen. (London: Sherratt and Hughes.) $5 net. Pp. xxiii.—289.

This book is a reprint of biographical articles which appeared in the *Chemical Trade Journal*. The subjects, who were closely connected with the success of the alkali and other trades in their early days, are William Gossage, J. C. Gamble, James Muspratt, Andreas Kurtz, Henry Deacon, James Shanks, Christian Allhusen and Peter Spence. As might be expected, they dealt with purely chemical applications and were before the days of electrochemistry. The author remarks in his preface that "the main purpose in re-publishing these memoirs is not only to put into worthy and permanent form the story of lives that deserved to be remembered, but also to indicate to their successors the path that led to fame and affluence."

L'Année Electrique, Electrothérapique et Radiographique. By Dr. Foreau de Courmelles. (Paris: Ch. Béranger.) 3fr. 50c.

We have received the seventh issue of this work. In spite of its title, it is not altogether devoted to the medical applications of electricity. After an interesting chapter giving a very complete account of the year's new inventions, lighting, heating, traction and wireless telegraphy are briefly discussed; but a large portion of the book is, of course, devoted to electro-and radio-therapeutics. A chapter is given to jurisprudence and its relation to medico-electrical work, in which it is contended that administering of the X rays should be restricted by law to persons who are properly qualified.

RECENT CONTRIBUTIONS TO ELECTRIC WAVE TELEGRAPHY.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

(*Continued from page 312.*)

Turning, then, from transmitters to receivers, we may notice one or two recent types. By far the larger portion of electric wave telegraphy was until a few years ago conducted by means of some form of coherer either requiring tapping or else self-restoring The coherer in certain forms has the advantage that a current of about 0·1 to 1 0 milliampere can be passed through it and hence through a relay, so that messages can be printed down by it when using a Morse inker in dot-and-dash signals. After that came Mr. Marconi's magnetic detector, making use of a telephone to create an audible signal. This is now the instrument employed by him on all long-distance work. In Germany and the United States a type of telegraphic wave detector has come into use commonly called the electrolytic receiver. In one form it was invented in the United States by Fessenden and called by him a liquid barretter. It was independently discovered and described shortly afterwards in Germany by W. Schloemilch, and is generally there called the electrolytic detector (*see* Fig. 12). It consists of an electrolytic cell or vessel containing some electrolyte, usually nitric acid. In it are placed two electrodes, one a metal or carbon plate of large surface and the other an extremely fine platinum wire prepared by the Wollaston process, a very short length of which is immersed in the liquid. A convenient plan is to prepare a Wollaston wire of silver, having a core of platinum, which is drawn down until the latter is only $\frac{1}{1000}$ mm. in diameter. If the electrolyte is strong nitric acid, then when the above wire is immersed to the depth of a millimetre the acid dissolves off the silver

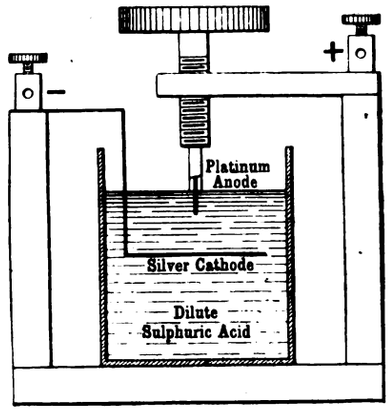

Fig. 12.—Electrolytic Detector.

and leaves the fine platinum wire exposed as an electrode. This cell has its two electrodes connected respectively to a receiving antenna, and an earth plate, and also to a circuit containing a shunted voltaic cell and a telephone (*see* Fig. 13). The voltaic cell sends a current through the electrolyte in such a direction as to make the fine wire the positive electrode or anode. Some dispute has taken place whether the cell will work when the fine wire is the negative electrode Fessenden, who adopts a thermal theory of the cell, claims with Rothmund and Lessing that it is equally sensitive whether the small electrode is positive or negative.

According to one theory, the action of the cell as a wave detector depends on the power of the oscillations to remove the so-called polarisation of the electrodes or adhering films of ions. According to another theory it is due to the heating action of the oscillations on the small electrode and liquid in its neighbourhood. In any case the action is just as if the resistance of the electrolytic cell were suddenly changed, either increased or decreased. It has also been found by Rothmund and Lessing that the cell may be made to supply its own electromotive force. If we form a simple polarisable voltaic cell with fine zinc and platinum wires, immersed in dilute acid, and connect a telephone or high resistance galvanometer to these elements, then when electric oscillations pass through the cell the current sent by it through the telephone or galvanometer is momentarily increased. That the action is not altogether due to the removal of polarisation films is shown by the fact that the fine platinum wire in the Schloemilch form of detector wears away or is dissolved in the nitric acid when oscillations are passed for some time through the cell, and there is some evidence that gold and platinum can be made to dissolve even in dilute acids by the action of electric oscillations.

* A Friday Evening Discourse delivered at the Royal Institution of Great Britain, Friday, May 24, 1907.

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In 1904 I was so fortunate as to discover another and quite different principle on which a sensitive electric wave detector can be based. If a carbon filament glow lamp has a metal plate carried on a third terminal sealed into the bulb it is well known that a current of negative electricity flows from the plate to the positive terminal of the lamp when the filament is rendered incandescent by a continuous current. This is the so-called Edison effect. It is also now known that incandescent bodies discharge negative corpuscles or electrons from their surface, and incandescent carbon when in a vacuum exhibits this power in a marked degree. Negative electricity escapes freely from it, but not positive. In 1904 I was endeavouring to find some way of rectifying electrical oscillations—that is, of separating out the two sets of alternate currents and making them separately detectable by an ordinary galvanometer. It occurred to me to make use of a carbon filament lamp having a metal cylinder insulated in the bulb surrounding the filament, the cylinder being connected to a platinum wire sealed through the bulb (*see* Fig. 14). This lamp was then used as follows. A circuit was connected between the terminal of the metal plate and the negative terminal of the filament, the latter being made brightly incandescent by a small battery. In this circuit a galvanometer and one circuit of a small transformer or induction coil was inserted. On connecting the other circuit of the transformer between an antenna and the earth I found that oscillations set up in the antenna caused a deflection in the ordinary mirror galvanometer (*see* Fig. 15). The action is as follows. The antenna oscillations induce others in the circuit of the transformer which is in connection with the lamp. A movement of electricity in this circuit, which consists in the flow of negative electricity from the filament to the plate through the vacuum, can take place, since this negative electricity is, so to speak, carried across the vacuous space by the electrons emitted from the hot carbon. On the other hand, negative electricity cannot flow in the opposite direction. Hence the glow lamp separates out the two oppositely directed movements of electricity and allows only one to pass. I therefore called the

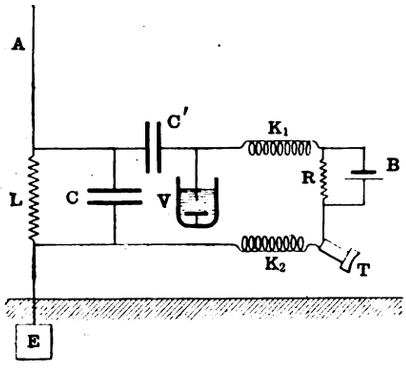

FIG. 13.—ELECTROLYTIC DETECTOR WITH SHUNTED CELL AND TELEPHONE.

appliance an oscillation valve. This instrument was shown by me to the Royal Society early in February, 1905, and was employed by Mr. Marconi soon after as a long-distance wireless telegraph receiver in conjunction with other improvements. M. Tissot, of the Naval College, Brest, in France, has made use of this glow lamp detector, and with a sensitive galvanometer has received signals at a distance of 50 km.* Employing a special form of transformer and a telephone in place of a galvanometer, Mr. Marconi has used it for some time past over distances of 200 miles or more and finds it a very sensitive form of receiver. Since this particular form of electric wave detector was brought to notice by me Dr. Wehnelt has found that a metallic wire coated with oxides of calcium, barium or other earthy metals may be substituted for the carbon filament in the vacuous bulb.

The oscillation valve is capable of giving very remarkable effects when used as a receiver with a transmitter producing undamped waves. The reason for this is obvious. The valve passes all the unidirectional currents in the attached secondary circuit. If, then, these are intermittent damped trains, say, having a frequency of 1,000,000 and 50 trains of 20 oscillations per second, the total time during which electric current is passing is only one-thousandth of the whole time. Accordingly, if we, so to speak, fill up the gaps between the trains of oscillations with other oscillations and generate a continuous train, we greatly increase the quantity of electricity passing and re-passing any point in the secondary circuit, and the indications on a galvanometer in circuit with the valve are enormously increased. A true comparison between the two cases of damped and undamped waves involves many factors, and is not fair unless we compare together transmitters taking the same mean power. Generally speaking, however, we may say that not only this glow-lamp detector, but all forms of thermal detector give greatly increased effects when employing undamped oscillations.

I find, for instance, that if undamped oscillations are created in a closed-wire circuit which forms part of a circuit-containing capacity and inductance shunted across a Poulsen arc, I can induce powerful secondary oscillations in a similar closed and syntonic secondary circuit at a considerable distance, and detect these by the use of my oscillation valve and a galvanometer placed as a shunt across the condenser in the receiving circuit.

In fact, the use of undamped oscillations in a closed primary circuit and this oscillation valve used with a telephone in a closed secondary circuit brings to the front again the possibility of making use of so-called wireless telegraphy by electromagnetic induction over very large distances. The old form of electromagnetic induction telegraphy, as practised by Trowbridge, Preece, Lodge and others, made use of relatively low-frequency alternating currents in a closed primary circuit, and employed a telephone in a distant closed secondary circuit to detect the magnetic field so produced, signals being made by interrupting the primary current. I have, however, found a means of improving this form of wireless telegraphy. In a closed primary circuit I establish continuous undamped oscillations having a frequency, say, of 100,000 or 200,000 by the arc method. At a distance I place a syntonic secondary circuit containing my oscillation valve as a detector, a telephone being used with it connected between the middle plate and negative filament terminal. Both the primary circuit and secondary circuit are connected to earth at some point. The signals are made by breaking and making the earth connection of the transmitter in accordance with Morse code. When the earth connection is made

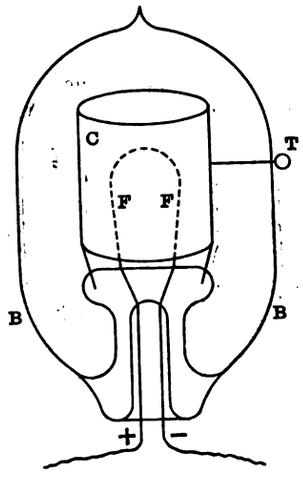

FIG. 14.—FLEMING OSCILLATION VALVE.

at both ends a sound is heard in the telephone, but not when it is broken. This seems to depend upon the fact that the oscillations produced by the arc method are not absolutely continuous, but cut up into groups, as already proved by the experiment with the rapidly-moving Neon tube and helix.

I have found that it is not necessary to employ a high voltage carbon filament, a small lamp with 4 volt filament taking about 1 ampere works quite as well as a wirele-s telegraph receiver as a 12 or 100 volt lamp. The filament has, however, to be at a certain critical temperature to obtain the best result, the vacuum also has to be extremely good. There are, no doubt, many possible variations of the above-mentioned type of oscillation valve wave detector. Every glass vessel containing rarefied gases or mercury vapour having electrodes of different sizes or shapes or temperature has some degree of unilateral conductivity, and can be used in the above manner to separate out the two constituent currents of an electrical oscillation and make them detectable by an ordinary galvanometer or telephone. I have also tried, with some success, a flame in which two platinum wires are immersed, one of which carries a bead of potassium sulphate, as a means of rectifying oscillations of high frequency. It is well known that negative ions are then liberated in the flame and negative electricity can pass more freely from the electrode which carries the bead of salt to the other than in the opposite direction. I have not, however, found anything as simple and useful as the above described low voltage carbon filament glow lamp. Moreover, other inventors have endorsed its utility by granting it the compliment of imitation. In October, 1906, Dr. de Forest described to the American Institute of Electrical Engineers an appliance he called an audion, which is merely a replica of my oscillation valve described to the Royal Society 18 months previously, and to the Physical Society of London six months before, particularly with reference to its use as a wireless telegraph receiver. Apart from the name the only difference introduced by him was to

* See *The Electrician*, Vol. LVIII., p. 730, Feb. 22, 1907. M. C. Tissot "On Ionised Gas Electric Wave Detectors."

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substitute a telephone and battery in series connected between the middle plate and positive terminal of the filament for the galvanometer used by me connected between the middle plate and the negative terminal. As Mr. Marconi had before that time used my oscillation valve with a telephone with it for long distance work, and M. Tissot has found a galvanometer used as I described it effective up to 50 km., the modification made by Dr. de Forest does not make any fundamental difference in the operation of the device as a wave detector.*

Very closely connected with the question of the production of continuous or undamped electric waves is that of the electrical transmission of speech through space without wires, in other words, wireless telephony. Some considerable progress has already been made in this direction. Any complete treatment would require a

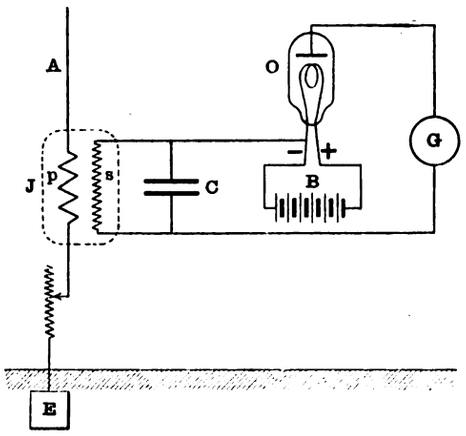

FIG. 15.—FLEMING OSCILLATION VALVE OR GLOW LAMP DETECTOR, USED AS A RECEIVER IN ELECTRIC WAVE TELEGRAPHY.

lecture in itself. If, however, we pass by the investigations of Bell with the photophone, Simon, Ruhmer, and others with apparatus employing the resistance variation of selenium by projected beams of powerful light, and also those of Preece, Gavey and others with electromagnetic induction, we may say that at the present time the chief interest attaches to methods of wireless telephony which involve the use of undamped electric waves. The problem may then be stated to be as follows: Articulate speech made against a diaphragm at a transmitting station has to affect similarly the diaphragm of a telephone at a receiving station not connected with it by wire.

Time only permits me to give you a brief sketch of some interesting experiments which have been carried out lately by the German Wireless Telegraph Co. between Berlin and their large station at

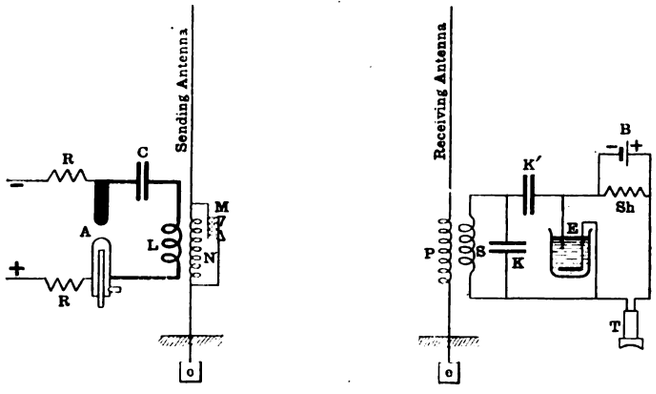

FIG. 16.—WIRELESS TELEPHONY BY ELECTRIC WAVES.

Nauen, 20 miles distant. At the transmitting station they employ 12 electric arcs in series, each of which is composed of a carbon negative and a water-cooled copper positive electrode. These arcs take 4 amperes at 440 volts. In parallel with this series of arcs is joined a condenser and inductance, to which is inductively but loosely coupled an antenna, from which undamped electric waves, 800 metres in wave-length, are radiated, having a frequency therefore of 400,000. The oscillations set up in this antenna can be more or less enfeebled by shunting them to earth through a microphone transmitter M, the resistance of which is varied by the act of speaking against it (*see* Fig. 16). Hence, although the wave-length of the emitted electric waves is not altered, their intensity is modulated in accordance with the wave form of the sounds impressed on the transmitter diaphragm. At the receiving station there is a receiving antenna tuned to the wave-length used, having a quantitative electrolytic detector in connection with a telephone coupled inductively to the antenna circuit. Hence, the vibrations of the transmitter diaphragm vary the intensity of the radiated electric waves but not their wave-length. These waves travel through space, fall on the receiving antenna and affect the resistance of the electrolytic detector in proportion to their intensity. Hence, the receiving telephone repeats the sounds or articulations made against the transmitting microphone and reproduces speech. The German experimentalists say that a satisfactory wireless transmission of speech can be made in this manner 20 kilometres, or 12 miles, over water with antennæ 25 metres, or about 80 ft., high.

Ruhmer has recently described in the *Elektrotechnische Zeitschrift* some similar experiments made with a 220 volt Poulsen arc. In this case the necessary modulation was impressed upon the radiated electric waves by inserting the primary circuit of an induction coil in the continuous-current arc circuit and closing its secondary through a microphone transmitter and working battery. The receiving arrangement involved an electrolytic receiver as just described. Prof. Fessenden has recently described very similar experiments in electric wave wireless telephony.* We can, therefore, say that something more than a beginning has been made in the art of the wireless transmission of human speech to a distance. The energy expenditure is at present considerable, and much will have to be done before telephony without wires can be looked upon as coming within the range of commercial work. Nevertheless, having regard to the enormous improvements in wireless telegraphy in the last seven years, it is quite within the bounds of possibility we may soon be able to speak across the English Channel without a wire, and not scientifically impossible for the sounds of the human voice to be some day transmitted from the shores of England or the United States to an Atlantic liner in mid-ocean.

(*To be concluded.*)

* In a private letter M. C. Tissot has already acknowledged gracefully my priority of invention in this matter, although he himself was independently working in the same direction. I had already shown in the Royal Society Paper in February, 1905, that the conductivity of the vacuous space increased to a maximum value corresponding to a certain P.D. between the filament and plate.

PATENTS IN 1906.

The 24th report of the Comptroller-General of Patents has just been issued, and from this we give the following extracts:

The receipts from patents fees were £255,646, as compared with £238,047 in 1905, an increase of £17,599; from designs fees £4,344, as compared with £4,783, a decrease of £439; and from trade marks fees £15,559, as compared with £13,234, an increase of £2,325. The increase in trade marks fees is due to the revised scale of fees which came into operation at the beginning of the year. The receipts from the sale of Patent Office publications were £10,593, as compared with £9,676, an increase of £917. The total receipts were £286,142, as compared with £265,740, an increase of £20,402.

The total expenditure on behalf of the office amounted to £175,272, as compared with £159,296, an increase of £15,976. The payments for salaries, &c., exceeded those of the previous year by nearly £6,000, and the amount spent upon the Patent Office extension was nearly £12,000 more than in 1905, while there was a saving of over £1,000 on the cost of stationery, books, &c.

The number of letters and correspondence forms despatched from the office in 1906 was 283,000, and the number of parcels of publications 93,000, as compared with 232,000 and 99,000 respectively in 1905.

The number of persons employed in the office is now 572, as compared with 520 in 1905, and the staff of assistant examiners has increased from 129 to 153.

The number of readers who made use of the library in 1906 was 143,750, as compared with 142,447 in 1905, an increase of 1,303, or 0·9 per cent., and the largest number recorded in any one year. The number of volumes added to the library was 5,334, of which 1,267 were volumes of patent specifications or journals (English and foreign), and 503 were trade catalogues. The remaining 3,564 volumes were text books or periodical publications relating to scientific and technical subjects, and of these 2,539 were obtained by purchase and 1,025 by donation. The number of works in the library at the end of the year was 33,115, and the approximate number of volumes (exclusive of duplicates) was 107,000.

PATENTS.

The work of carrying on the official investigation required by sec. 1 of the Patents Act, 1902, has proceeded satisfactorily during the year.

This investigation, so far from having a deterrent effect on inventors, as was anticipated by some who were opposed to it, has been accompanied by an immediate and substantial increase in the number of complete specifications filed at the Patent Office. As will be seen from the tabular statement, the number of these specifications which was 15,831 in 1903 and 15,925 in 1904, rose suddenly after the investigation began on January 1, 1905, to 18,806 in that year, and 18,228 in 1906. A considerable part of the increase in 1905 was attributable to the more expe-

* See *The Electrician*, Vol. LVIII., p. 710, 1907.

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Year.	Patents.			
	Applications.	Specifications.		Sealed.
		Provisional.	Complete.	
1903	28,854	22,210	15,831	15,718
1904	29,702	22,461	15,925	15,089
1905	27,577	19,862	18,806	14,786
1906	30,002	21,012	18,228	14,707

ditious filing of these specifications necessitated by the shortening of the time allowed for this purpose from nine to six months. But no such explanation will account for the increase in 1906. It is difficult to account for it on any other assumption than that inventors generally have appreciated the benefits which the official search has conferred on them.

As the complete specifications of all cases numbered as of 1905 have now been accepted, or the applications have become void through the non-acceptance of the complete specifications during the statutory period, it is possible to present final statistics in regard to the 27,577 applications of that year. In respect of these applications 16,746 complete specifications were filed, and the investigation required by the Act of 1902 showed that of the 15,369 cases finally accepted, 1,308 (8·5 per cent.) were reported by the examiners as having been anticipated wholly, 8,238 (53·6 per cent.) were reported as having been anticipated in part, whilst in 5,823 cases (37·9 per cent.) no anticipations were reported by the examiners.

Of the 9,546 cases in which anticipations had been reported, 7,725 (81 per cent.) were amended so as to meet the anticipations to which attention had been directed, such amendments being often the result of conference between the examiner and the applicant or his agent. Where the necessary amendment could not be agreed upon between the examiner and the agent, or where no action was taken by the agent prior to the lapse of time prescribed by rule, it became necessary to appoint a hearing under the Act. In 1,060 cases the specification was amended as the result of the issue of decisions, and in 556 instances the prescribed reference by name and number to a prior patent or patents was inserted. It will thus be seen that of 15,369 cases accepted, no less than 8,785 specifications were amended as the result of the official investigation. In all these cases the effect of the amendment was to cause the specification to define more clearly and closely the nature of the invention and the scope of the patent to be granted, having regard to the condition of the art as disclosed by the prior specification or specifications found by the examiner during his investigation.

It is noticeable that in the 10 years prior to 1905 the average annual number of applications which became void owing to the fact that the corresponding complete specifications were not accepted within the statutory period was 196, but of the 1905 cases no less than 1,374 became void owing to this reason. Presumably, the voiding of this additional number of cases was mainly due to the official investigation prescribed by the Act of 1902, and it seems to be eminently satisfactory and a great advantage to prospective patentees and to the public generally that the procedure has resulted in the non-granting of such a large number of patents which would prima facie have been invalid.

The applications received in 1906 numbered 30,002, as compared with 27,577 in 1905, an increase of 2,425, or 8·8 per cent. Of these applications 21,012 were accompanied by a provisional specification and 8,990 by a complete specification. The applications which are accompanied by complete specifications have been steadily increasing in number since 1885, and at a much more rapid rate than those accompanied by provisional specifications. It is interesting to observe that the proportion of applications accompanied by provisional specifications to those accompanied by complete specifications was in 1885, 87 : 13 ; in 1890, 84 : 16 ; in 1895, 83 : 17 ; in 1900, 76 : 24 ; in 1905, 72 : 28 ; and in 1906, 70 : 30. The number of complete specifications filed after provisional specifications was 9,238. The total number of specifications received was 39,240, as compared with 38,668, an increase of 572, or 1·5 per cent. The applications received from women inventors numbered 600, as compared with 586 in 1905.

Out of a total number of 14,707 patentees to whom patents were granted in 1906, 2,595 were resident in the United States of America, 2,091 in Germany, 769 in France, 257 in Austria-Hungary, 190 in Switzerland, 145 in Canada, 137 in Belgium, 111 in Italy and 105 in Sweden.

A statement of the number and results of the hearings before the Comptroller in connection with oppositions to the grant of patents, oppositions to proposed amendments of specifications and the exercise of the discretionary power conferred upon him by sec. 94 of the Act of 1883, so far as patents are concerned, and the appeals to the law officer from the decisions of the Comptroller, shows that during the 10 years ended in 1906 the number of hearings upon oppositions to the grant of patents has been 1,423, and that the number of appeals to the law officer against the decisions of the Comptroller and his deputies in these oppositions was 269, of which 41 were withdrawn or abandoned and 7 are still outstanding. In one case the application for the patent was abandoned. The number of appeals in opposition to the grant of patents which have been heard by the law officer during the last 10 years in question has, therefore, been 220.

In 23 of these appeals the decision of the Comptroller or his deputy was reversed, in 73 varied, and in 124 supported.

During the same period the number of hearings upon oppositions to amendments in specifications has been 68, and the number of appeals 26, of which two have been withdrawn and two are outstanding. In the remaining 22 appeals which have been heard by the law officer the decision of the Comptroller or his deputy has been supported in 15 instances, varied in five and reversed in two.

There have been 800 hearings during the decade under sec. 94 of the Act, and 23 appeals, of which three have been withdrawn and one is still outstanding. In 15 of the remaining 19 cases the decision of the Comptroller or his deputy was supported, in two it was reversed and in one it was held that the decision was not subject to appeal. The remaining case was referred back to the Comptroller.

The number of hearings in connection with oppositions to the grants of patents fixed during the two years that have passed since sec. 1 sub-sec. 6 of the Act of 1902 came into operation has been 5,192 ; but of these 2,081 were rendered unnecessary by reason of the abandonment of the application or amendment of the specification by the applicant. In all of the remaining 3,111 cases formal decisions were given by the Comptroller or his deputies, with the result that in five cases only an appeal against the decision was made to the law officer. One of these appeals has been withdrawn. Of the other four, which have been heard by the law officer, the decision has been supported in three instances and reversed in one. These figures indicate clearly that the official requirements made in consequence of the official investigation as to prior patenting under the Act of 1902 have not on the whole been regarded by the applicants for patents as unreasonable. They also demonstrate the correctness of the view taken by Sir Edward Fry's committee, who, when recommending the official search instituted under the Act of 1902, expressed the opinion that if their scheme received the sanction of the legislature, it would be highly beneficial to honest and bonâ fide applicants for patents, whilst it would tend to discourage the taking out of patents for objects other than the protection of a real invention.

The names of 10 patent agents were added to the register during the year, the total number on the register on December 31st being 255.

The total number of complete specifications for 1905, the first year under the Patents Act, 1902, was about 4·5 per cent. less than the number for 1904, but greater than that for any other year, although the total number of applications was less than in 1896, 1897, 1898, 1902 and 1903, as well as in 1904. The number of classes at a maximum decreased from 61 to 24, and three—viz., Ships, &c., Division III. (rigging, sails, spars, and boat raising, lowering and disengaging gear) ; Sugar ; and Umbrellas, &c.—were in the lowest position they have attained since the Act of 1883 came into operation.

The following is a complete list of the classes having a larger number of complete specifications in 1905 than in any previous year : Air and gases, compressing, &c. ; books ; brushing, &c. ; centrifugal drying, &c. ; cutlery ; electric telegraphs, &c. ; fencing, &c. ; gas manufacture ; hand tools, &c. ; hydraulic machinery, &c. ; indiarubber, &c. ; mechanism, &c. ; metals and alloys ; nails, &c. ; ornamenting ; philosophical instruments ; pipes, &c. ; railway signals, &c. ; rotary engines, &c. ; small-arms ; toilet, &c. ; valves, &c. ; washing, &c. ; writing instruments, &c.

The decrease in the total number of applications in 1905, the first year of the operation of the Patents Act, 1902, has been followed by a small increase in 1906. This increase is in a large measure due to activity in the motor-car industry. The development of the motor-omnibus has given rise to a considerable number of inventions for devices to be fitted on the tyres or carried by the wheels for the purpose of preventing side-slipping or "skidding." The liability to puncture of the ordinary pneumatic tyre continues to cause inventors to turn their attention to other means for securing a resilient action, such as the provision of pneumatic cushions or arrangements of metal springs in the body of the wheel. Other details of motor-cars, such as clutches and change-speed gearing, petrol engines and wind-screens, as well as allied subjects, such as the handling and storage of petrol and the prevention of dust, have also been prominent during the year. Following the accident at Handcross Hill there were many applications for emergency brakes for motor-cars, as was also the case in connection with tramcars after the accident at Highgate. Fatal accidents on railways at Merstham, Rugby and elsewhere appear to have incited inventors towards devising systems for locking the doors of a train in motion, either automatically or by means under the control of the guard or driver. The number of flying machines has not been as large as might have been expected, considering the initial successes which have recently attended efforts made to solve the problem of flight, but prizes offered towards the end of the year to the successful inventor appear to have stimulated invention in this subject. The competition between gas and electricity for lighting purposes still continues. The chief developments in gas lighting relate to inverted incandescent burners and the adaptation of ordinary upright fittings for use therewith. In electric lighting the growth is due mainly to the introduction of metallic filaments in incandescent lamps, and the use of metallic substances in electrodes of arc lamps. A considerable increase in connection with dyes comprising new sulphur analogues of the indigo series marks an interesting and important advance due to scientific research. Other subjects worthy of note are reinforced concrete constructions for buildings and spark arresters for locomotives.

A number of appendixes attached to the report set out in tabular form the details that have been given above and the figures are compared with former years. In connection with one of these tables it is interesting to note that out of the total number of patents issued in the United Kingdom in 1905, 42·3 per cent. were issued to foreigners. The percentages in other countries were 10·9 in the United States, 34·5 in Germany, 67·6 in Austria-Hungary, 64·9 in Switzerland, and 74·4 in Russia.

Electrical work receives a fair amount of attention from inventors ; the average number of patents for the years from

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1855-1905 is for dynamo-electric generators 91, for electric measuring instruments 37, for regulating arrangements 149, for lamps 87, and for telegraphs and electrolysis 87 and 80 respectively. The report concludes with a copy of the rules made by the Board of Trade by virtue of the provision of the Trades Marks Act, 1905, and of the various forms to be used in connection with this Act.

CORRESPONDENCE.

CORRUGATIONS IN TRAMWAY RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to Mr. Briggs' letter of June 4th in reply to mine of May 20th, we are, I think, beginning to get at the bottom of this subject. I will not make a long letter in reply, but what I am going to say is based on absolute facts, without the slightest supposition about it. I asked Mr. Briggs whether he ever saw a "straight" rail, or the inner rail of a curve, corrugated. He seems to evade these two very open questions.

Mr. Briggs is, I feel sure (along with the rest of us), trying his best to solve this somewhat difficult problem, and, as the saying goes "two heads are better than one," a little friendly argument might bring out something new. Mr. Briggs is quite right in saying that the outer wheel on a curve has (with the standard gauge) to travel something like 30 ft. further than the inner one in a circle, or 15 ft. in a semicircle. But does Mr. Briggs really think that by strengthening the axles and frames, so as to reduce to a minimum the "give" or twist, he would help the outer wheel to gain this 15 ft. in a semicircle of, say, 770 ft. in length? I say not. Of course Mr. Briggs may say this is a matter of opinion, but I say it is a stubborn fact. It is something the same as a regiment of soldiers turning the corner of a street—the inner man must stop and mark time while the outer man must quick-march, with this difference, the two outside men are not fast together, as the two wheels are; consequently the inner wheel keeps going ahead, as usual, while the outer one has to gallop, as it were; and this, and this alone, is what causes corrugations.

Mr. Briggs' figures are quite correct and interesting, and he deserves credit for the trouble taken, but, in my humble opinion, they tend to work backward to a small radius rather than to a large radius. My contention is this. It does not matter in the least if a rail is only $\frac{1}{8}$ in. out of line on a "straight" road in 10 ft. or 12 ft., the outer rail of that small curve of large radius will be corrugated. If Mr. Briggs will open out a short length opposite a corrugated rail as above, and slew the rails over so as to reverse the curve, he will find that in a few weeks' time the corrugated rail will have worn smooth and the smooth rail will be corrugated. A singular coincidence, but absolutely true, and it will take a lot of figures to prove the contrary.—I am, &c., ROAD INSPECTOR.

June 11.

ELECTRICAL CONTACT WITHOUT RECOIL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the article by Dr. J. T. Morris in your last issue on p. 292, and his trials of different forms of contact-breaker to avoid recoil and chattering, it is remarkable how slightly known appears to be the simple and effective method introduced by Dr. Alexander Muirhead in connection with his chronograph—namely, a needle point impinging on a block of lead, which for some purposes is smeared over with mercury.—I am, &c., OLIVER LODGE.

Birmingham, June 8.

THE RADIO-TELEGRAPHIC CONVENTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to have Mr. Cuthbert Hall's correction as to Mr. Henniker Heaton having ever served on the board of the Marconi Company, though on p. 452 of "The Electrician" Electrical Trades' Directory for 1901 may be found the name "J. Henniker Heaton, M.P.," amongst the list of directors returned by "Marconi's Wireless Telegraph Co. (Ltd.)."

From Mr. Hall's letter it is evident that the company had reason to feel fairly certain that Mr. Heaton would serve on the board, or presumably they would not have included his name in their "return" to the above official directory merely on the strength of their having "nominated" him.—I am, &c.,

Westminster, June 10. CHARLES BRIGHT.

NOVELTIES BY THE GENERAL ELECTRIC CO.

A useful and unique electrical advertising device for shop windows, &c., which is also suitable for use in hotels, club-rooms, &c., has been put on the market by the General Electric Co. It consists of a board carrying small incandescent lamps, mounted at points of the compass, and a wind vane with contact-making device, which lights up lamps on the board corresponding to the direction of the

WIND DIRECTION INDICATOR.

wind. The arrangement can be worked by a 2 volt accumulator or by primary cells giving 2 volts. A length of 12 yds. of cable is supplied to allow of the indicator being fixed where desired.

Under the title of "Sherardized Geekoduct," the General Electric Co. have introduced a new type of conduit, which is claimed to be absolutely weatherproof and non-rusting. The process is effected by heating iron tubes and fittings with powdered zinc dust in specially constructed furnaces. As a result the zinc forms an alloy with the surface of the metal, producing a protective coating varying in thickness according to the duration of the heating. The appearance of "Sherardized Geekoduct" resembles electro-galvanising, but it is more lustrous and metallic.

One of the advantages claimed for it is that, owing to the formation of an alloy of iron and zinc in between the pure zinc coating and the surface of the iron or steel, the zinc coating can be scraped away without allowing the tube to rust or corrode. Further advantages claimed are: The conduit is cheaper than when treated by the old hot galvanising process; the interior of the tubes is perfectly smooth, owing to the tubes being coated both inside and out; no internal rusting can take place; screw threads remain perfectly uniform and do not require re-cutting after treatment.

Birmingham and District Electric Club.—At the meeting on May 9th a Paper was read by Mr. R. D. Archibald on "Polyphase Induction Motors." The author described the principles and construction of these motors, and the methods of starting and speed regulation. He also exhibited slides to show the application of induction motors to several kinds of work.

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PARLIAMENTARY INTELLIGENCE.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

The Select Committee of the House of Commons appointed to consider this bill met on Wednesday for the first time. Mr. D. A. THOMAS presided, the other members being Sir Albert Spicer, Sir Philip Muntz, Major Renton and Messrs. J. Nolan, W. W. Rutherford, A. E. Dunn and John Ward.

There were 86 petitions against the bill, amongst the petitioners being most of the local authorities in the proposed area of the measure, gas, water, dock and railway companies, Messrs. Crompton & Co., the Electric Supply Corpn., Curtis & Harvey, Kent Electric Power Co. and Kent Electric Power Synd., South Metropolitan Electric Tramways & Lighting Co., British Electric Traction Co., North Metropolitan Electric Power Supply Co., Smithfield Markets Electric Supply Co., Twickenham & Teddington Electric Supply Co., London United Tramways (1901) Electromobile Co., Metropolitan Water Board, Conservators of the River Thames and owners and lessees of property within the proposed area, and the companies supplying electrical energy in the neighbourhood of the Administrative County of London.

Mr. Freeman, K.C., Mr. Coward, K.C., Mr. Clode and Mr. Clease appeared for the London County Council; Mr. Balfour Browne, K.C., Mr. Moon, K.C., and Mr. Tyldesley Jones for the companies supplying electrical energy in the neighbourhood of the Administrative County of London (Mr. Balfour Browne also representing Middlesex County Council); Mr. Vesey Knox, K.C., and Mr. Hutchinson for Hornsey, Finchley, Chiswick and Beckenham Councils; Sir Ralph Littler, K.C., and Mr. Rigg, K.C., for the Corporation of London; Mr. Greig for Willesden District Council; Mr. Reader Harris, K.C., for Ealing Corporation; Mr. R. P. Blennerhassett, K.C., and Mr. Dighton Pollock for Lambeth Council; Mr. E. Morton for West Ham Corporation; Mr. W. L. Williams for Stepney Council; Mr. H. Lloyd and Mr. Devonshire for Curtis's & Harvey; Mr. C. F. Jones for Dartford Gas Co.; Mr. Reginald Neville for Brentford Gas Co.; Mr. Jeeves for Kingston Corporation; Mr. J. D. Fitzgerald, K.C., and Mr. H. B. Cane for Marylebone Council; Mr. Courthope Munroe for Wimbledon Corporation and St. Pancras Council; and Mr. Wedderburn, K.C., and Mr. Monroe for Shoreditch and Woolwich Councils.

Mr. FREEMAN, K.C., in opening for the promoters, said although there were a large number of petitioners against the bill, he was glad to learn that in by far the majority of cases the words had been added "Counsel reserved," which meant that in the earlier stages at any rate the Committee would only be troubled with a limited number of opponents. The bill differed from many bills which came before Committees because it was a matter of almost national importance that the question of the supply of electrical power in the Metropolis should, if possible, be settled upon a satisfactory basis. He proceeded to relate the history of electricity supply in the Metropolis and the legislation on the subject, and explained the procedure followed in applying for and granting of provisional electric lighting orders. There had been a little misconception, he said, as regards the Electric Lighting Acts of 1882 and 1888. They were not confined to lighting, but were also for the supply of electricity for other purposes. In 1889, or shortly after, the whole of London was occupied by holders of provisional orders. There were then, as now, 16 local authorities, and there were 13 companies. The capital expended between the companies and local authorities was in round figures £19,000,000. When the County Council's bill of last year was before a Committee of the House of Commons, Mr. Ferranti suggested that the Council might undertake one part of the business, such as providing the land for stations, and permit other undertakers to actually provide the supply of electricity, and Mr. Merz said the Council could not do many things that a private company could do to obtain customers, and it was seen that there was some common sense in this, and that a company would have readier means of doing this than a large body like the County Council, which had to consider references and reports. The Office of Works then objected to the placing of the generating station in a place like Battersea, and thought the stations should be away from the centres of population on account of the fumes from the chimneys, and the Board of Trade presented a report prepared by Mr. Llewellyn Smith agreeing with this view, and also stating that various Councils in the provinces had obtained authority to supply current outside their areas, and there was sufficient precedent for giving the London County Council similar powers. It would be remembered that the Committee last year reported that the preamble of the Council's bill was not proved and the special report of that Committee was the foundation on which the bill now under consideration was founded. The main object of the bill as originally drawn was to enable the County Council to supply electricity in bulk to various distributors within the Administrative County of London and certain districts in Kent, Essex, Surrey and Middlesex, and to supply direct to railway, tramway and dock companies and to the Council's own buildings. The special report referred to stated that the Committee were of opinion the London County Council should be the authority to control the whole of the supply in London, and that any authorised distributor should have the right to acquire a bulk supply. This report was presented on June 28 last year and was as quickly as possible taken into account by the County Council. The Highways committee recommended on July 17 last year that preliminary steps be taken to draw up a new bill, and this was adopted. A further report in confirmation was adopted on Nov. 6. The Finance committee reported in October that the plant, &c., to supply one-fourth of the estimated demand for current would cost £4,500,000, and that the new bill differed from its predecessor inasmuch as it was an obligatory bill requiring the Council to give supply instead of a permissive bill. At the last meeting of the old Council on Dec. 6 last a report by the Parliamentary committee recommending that the bill should be approved was carried by 70 votes to 32. But the elections on March 2 resulted in a distinct change in the position of the Council, and a majority was returned unfavourable to the direct supply of commodities like electricity by the municipal authority. The report of the Parliamentary committee presented to the Council on May 7 suggested three ways in which the Council might deal with the matter. They pointed out that the difficulties referred to in the Finance committee's report would be largely obviated if the Council only directed and did not actually carry out the work, and recommended that the bill should be proceeded with with that object in view. The bill had been amended in various respects, and as late as Tuesday last there was a final debate in the Council on the subject, and the bill, with the amendments now before the Committee, represented the measure as finally approved by the Council. The amendments included a modification of para. 8, on page 7 of the bill, by which the powers of the Council to supply electrical energy and to transmit, transform and utilise it were deleted The area of supply provided for in the bill consisted of 451 sq. miles, of which 117 miles were within the county and 334 in suburban districts. The proposed area was a little more extensive than in the bill of last year. It left out certain parishes in Kent—Orpington and the three Crays, and a part of the Rural District of Dartford—because these are non-manufacturing districts, in which a supply is not likely to be required for some time. Clause 10 dealt with the conditions affecting supply. This was a clause formulated by a Committee presided over by Sir James Kitson in 1900, and he thought it was finally settled in the South Wales Bill. It was to the effect that the promoters may supply electrical energy to authorised undertakers and also to persons requiring supply for power purposes, but in the case of supply for persons other than authorised undertakers they could only be supplied with the consent of the authorised distributor in the district, and if the consent of the distributor is unreasonably withheld the person wishing to give the power supply could go to the Board of Trade. The object of that clause was to save consumers being prevented from getting supply. With regard to clause 17, it had always been felt that an exception ought to be made in the case of those bodies, such as railways, whose works passed through a considerable number of different districts, so that they should be able to obtain supply for all those districts from one source. If, for instance, the Great Central Railway wanted to run a local line by electricity, they could only work it to the border of the district of the authority supplying the current and then take a different supply. The Council sought in the bill the right to supply those persons because they could not in practice take it from the local authorities. Part 3 (page 16) of the bill dealt with the acquisition of lands. The Council had made this provision because it could not hand over to anybody else compulsory powers of acquiring land. Certain land must be acquired for generating stations, and these they propose should be put up at Barking and Erith, and in the financial part of the bill they reserved the right to expend £100,000 in acquiring that land, which would then be available to hand over, without the exercise of any further powers, to the lessee to erect generating stations upon. With regard to clauses 40 and 42 in the bill, as originally introduced the Council proposed to utilise power from their tramway generating stations in connection with the power supply, but now as they were going to lease the electrical undertaking this part was struck out except that authority was reserved for using any surplus power for general purposes. As originally introduced, the bill sought power for the Council to acquire the undertakings of local authorities at any time after the expiration of four years from the passing of the Act. That was subject to compensation. As the scheme was now to transfer the undertaking, subject to their control, they felt it would not be right to enable their lessee to acquire the undertakings of local authorities against their will, and he thought that would have the effect of reducing the opposition of the local authorities, except in regard to one small matter, to which he would draw attention. With regard to clause 66 (p. 40), that was a clause which would enable the Council to carry out the suggestion of the Parliamentary committee—viz., to retain control, but to lease the powers to someone to carry out. The new clause 43 met the objections raised by certain local authorities that the Council were unduly interfering with their streets. One of the new clauses, in substitution for the original clause giving compulsory powers to the Council to acquire the undertakings of local authorities, made it now solely a matter of agreement, and he did not anticipate any difficulty in satisfying them. Clause 66A was an endeavour, and he hoped a proper endeavour, to meet the instruction that had been given to that Committee by the House. It provided that if within a year from the passing of the Act no transfer or assignment of the Council's powers under the Act had been made, the Council's powers should cease, and if an assignment with regard to a part or parts of the area of supply had been made at the end of that period, the parts for which an assignment had not been made should cease to be part of the authorised area of supply. They had put that in in deference to the Committee's remark that they thought the delay of one year might be advantageous, but, of course, if the Committee thought a longer period was desirable that might be altered to 18 months, or something of that sort.

With regard to the period of 50 years for the re-purchase of the undertakings by the Council, that was subject to the direction of the Committee that they should resume possession after the initial stages. As to the charges for energy being on a sliding scale, it was almost impossible in such a bill as that now before the Committee to put in every detail of the provisions under which they would be prepared to enter into a deed of transfer, but he thought they had indicated the heads of what they would require every deed to contain. There were no bills competing with the Council's bills. There were originally 86 petitions against the bill, but of these only 20 were represented by counsel; 17 were local authorities, one an electric supply company, one a gas company and one was called "miscellaneous." The local authorities

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objected in their petitions to clause 10. They objected to the supply to railways, canals and such like undertakings, which were partly in their area. His answer was that the bill would deprive them of nothing which they hoped to do themselves, because they had no power to supply outside their own area. They objected to the transfer of the purchase rights of their own undertakings, and this had gone out of the bill; also to certain powers in reference to the breaking up of the streets, and a modified clause had been substituted which practically limited the County Council to the general law, and he thought the objections would now be confined to the Kitson clause, the supply to the railways, &c., and possibly the supply to the Council's own buildings. The electric supply company who petitioned against the bill said there was no necessity for the scheme, which was speculative, and that the capital powers were inadequate, but that was a criticism against the original bill and had no bearing upon it in its present form. There was a question raised by a gas company as to supposed damage by electrolysis to their mains, and that was the whole of the opposition. When the petitions had to be deposited, the bill was a bill for enabling the Council to itself carry out the works, and it would, therefore, not be fair to severely criticise the nature of the opposition now; but it also made it rather difficult for him to know how far the opposition would go. The Corporation of the City of London had put in a petition which he thought was of a temporary character.

He proposed to call Mr. Peel, the chairman of the Parliamentary committee of the County Council, and he would also call Mr. Rider, the electrical engineer of the Council's tramway undertaking, who would be prepared to show what works they would require their lessees to carry out, and that, if they carried out those works, the undertaking would be sound electro-technically, and that a reasonable profit could be made; and these witnesses would also show how such a supply could be given in London as would put it on the same level as other great cities. They did hope the question would once for all be solved in a way that would commend itself to Parliament. In support of the bill there were two witnesses-in-chief and two other witnesses who would support them very briefly.

Mr. GREIG (for Willesden Council) said they did not intend to pursue their opposition to the preamble, but would reserve the right to bring opposition forward to clauses as they were reached.

Sir RALPH LITTLER, K.C. (for the City of London), thought it would facilitate the proceedings if they had an opportunity of looking through their petitions in view of the amendments that had been made in the bill, and he suggested that they should adjourn for that purpose.

Mr. MOON, K.C. (for the London electricity supply companies proposed that they should hear the evidence of Mr. Peel.

Mr. COWARD, K.C. (for the promoters), proposed they should go on in the usual course, and proceeded to examine

The Hon. W. R. W. PEEL, who said the bill as deposited contained, in addition to the provisions of the Power Bill, clauses for the compulsory acquisition of electrical undertakings and the transfer to the Council of the purchase rights which the local authorities now had. Shortly after the election in March last the question of the steps to be taken came before the Council. The recent report of the Parliamentary committee proposing amendments was carried without any change and the bill was now as approved by the Council on Tuesday last. The area of supply was now 450 square miles. In the Bill promoted last year it was 387. The Select Committee of the House of Commons that considered the Council's Bill last year was of opinion that the best means of providing electricity in bulk and for motive power purposes was by one large and inclusive scheme, not only for the entire County of London, but extending also to adjoining boroughs and districts. He was of opinion that further facilities for obtaining cheaper electricity in those outlying districts were as much required as in the County of London. They were advised so by their engineers, and also that the needs of those districts might be anticipated to become greater in the immediate future.

Mr. COWARD then read the Kitson clause, under which the Council would be authorised to give a supply to any person for power purposes and permit a portion of such supply to be used for lighting premises, provided that where electrical energy was supplied to any person for power in an area in which an authorised distributor gave a general supply the energy used for such lighting should not in any year, except with the consent of the authorised distributor, exceed 20 per cent. of the total energy supplied, and except as aforesaid the Council could not supply energy for lighting. That did not include the bulk supply.

Have the Kent Electric Power Co. and the Central Electric Supply Co. powers to supply in bulk to companies?—Yes.

And the bulk supplies existing in the proposed area are owned by ordinary authorised distributors who have obtained bulk supply powers?—Yes.

Unless the Council's prices are lower than those of these companies they will having nothing to fear?—Nothing.

And if the Council's prices are lower there is good ground to ask Parliament to give them those clauses?—That is so.

In the session of 1905 the Administrative Power Co. were given those powers over areas in which other companies were empowered to supply in bulk?—Yes.

And if the Council were deprived of supplying districts in London over which power for bulk supply already existed it would so emasculate the bill that it would be worthless?—It would seriously reduce its value.

In sub-clause 2 there is a limitation that the supply of energy for lighting purposes must not exceed 20 per cent. There have been cases where the amount has been much larger?—Yes, 50 per cent.

The clause giving the Council power to supply current for lighting their own buildings is, I think, somewhat strenuously opposed. For what purposes would you require this supply?—For schools and other buildings. In many cases the Council would take supply from the authorised distributor, probably in most cases, but it might be an advantage to reserve the power to use their own supply. The bridges and the Embankment were specifically mentioned in that connection.

With regard to clause 17 enabling the Council to supply to railway companies, tramways, &c. Would this be a serious deprivation to authorised distributors?—No, the authorised distributors can only supply in their own area, but the consumers would want the supply over the whole of their undertaking. We attach some importance to that matter.

With regard to clause 23 giving the Council power to enter into agreements with authorised distributors for the supply of energy to the Council, and for the use of that energy in any part of the area of supply, whether within or without the area of supply of the authorised distributor, is that a clause that may be useful in case of emergency?—Yes.

A new clause has been substituted for clause 43 as to breaking up streets?—Yes; we did not consider it right to give companies such powers which they might use over local authorities.

The present Council is not prepared to establish and work the undertaking?—No.

And therefore you have omitted the £4,500,000 and inserted £100,000. Why?—There may be some technical difficulty in handing over to companies compulsory powers for the acquisition of land which has been acquired by the Council, and in the interests of municipal control we thought it might be valuable to be able to lease the powers and take rents, and there would be no serious risk of ratepayers' money in the purchase of land.

Do you think it desirable to obtain powers for linking up the various distributors as proposed in clauses 64 and 65?—Yes, it might be of value for convenience of distribution and it would facilitate giving a cheap supply.

Are there precedents for the proposal in clause 65 with regard to supplying electric fittings?—Yes, the power companies.

I think the Council have obtained these powers for the benefit of the metropolitan boroughs?—Yes, last year.

With regard to the cessation of the Council's powers unless a transfer or assignment is made in one year; why have you put in one year?—The Council considered it necessary to deal with this matter as quickly as possible.

Why was the provision with regard to the purchase of the undertaking within 50 years put in?—The Council are impressed with the necessity of being able to deal freely with persons or companies. That is only a maximum period. The period under the Act of 1882 was too short and persons could not be found to provide capital for the undertakings. The period was afterwards made 42 years. The 42 year periods were applicable to companies which had bulk supply powers but made their money chiefly out of electric lighting. This is a power supply bill. There are about 26 acts that have been passed and I find no precedent in any one of them as to terms of purchase, so that we are starting on something like a new principle in authorising power companies with terms of purchase. The 50 years allowed for re-purchase of the undertakings gives a margin for negotiation. We can deal with any shorter period if it is thought desirable.

Mr. BALFOUR BROWNE, K.C. (for Middlesex County Council): The bill was orignally promoted with the idea that London County Council was to become the authority for the supply of electricity and actually carry it out. The bill originally stated that it was for the supply for London to be provided by one large and inclusive scheme, and the Council was of opinion that it should be the authority. The Bill, as now amended, is to carry out another suggestion, to substitute for the London County Council some other body?—Yes, as the actual executor but not as the controller.

By clause 66A you enter into arrangements with the executors and control their prices, and then at the end of 50 years, or a shorter period, you are to resume possession?—Yes.

If at the end of, say, 42 years, you are to become the supplying authority, why not now?—I do not think I implied that we should be the supplying authority.

You have put in an obligation that the undertakers are not to have their powers more than 50 years?—After 50 years our ideas may have changed with regard to municipal trading. We should then probably lease the powers again to them or to another concern, in that case no doubt at a considerable rent.

Do you think it right that you should come here for extensive powers and within one year have the power to transfer them to some other body that has not been before Parliament?—I am not a legislator. It seems, however, to be a convenient way of obtaining control.

Is it not usual for Parliament to authorise a certain body to have the powers?—Yes, I think it is.

One of the great ideas underlying this Bill is that electricity can only be supplied cheaply if manufactured on a very large scale?—That is so.

Under clause 66 are you compellable to give the powers to supply to one company, or can you split them up into 50?—I think we could split them up if were likely to do anything so ridiculous.

The object is to get rid of the present undertakers and have one great supply, which would be cheaper?—I do not think we want to get rid of them. They may be the distributors. The question whether they should do away with their plant would be left to their discretion. If they could get the current from us they might do so.

Under sec. 66 you might have a dozen companies supplying London. Where is the economy?—If we did that we should defeat the object of the bill.

How many authorities are there supplying in London?—Eighty.

How are they to be compelled to give over their works?—They cannot be compelled.

Do you know that the companies in London have been prohibited from linking up?—Yes, they cannot do so.

Suppose you get power to buy up one company by agreement in a certain area, and the company is competing in that area with another com-

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pany, do you think that fair with all the rates of London behind you?—We are not proposing rate-aided competition. We propose to transfer the powers.

Suppose you enter into an agreement with a company, you could work the undertaking by supplying money which could be authorised to be borrowed in your annual Money Bill?—We could not introduce an amount into the Money Bill which had not been authorised in the Act. We might do that by a separate bill, but not in the Money Bill.

In a great portion of Middlesex the North Metropolitan Co. is authorised to supply, and also in the western part of Middlesex there is the Metropolitan Electric Supply Co., and they have large powers to supply to distributing authorities?—Yes.

So that the whole of the district in Middlesex which you wish to incorporate is covered by power companies?—A very large portion is.

Do you know of any case where a power company has power to supply where another power company has power to compete?—In 1905 two Committees of Parliament agreed to give such powers.

But in the powers actually granted such competition was prohibited. Why should you be given powers to do what the North Metropolitan and the Metropolitan Companies are doing?—That is a question which, perhaps, the engineers could better answer, but the prices at which we propose to supply are lower. The Electric Lighting Act of 1888 contemplated competition.

The 1888 Act only says the existence of one provisional order shall not prevent the granting of another. Why should you have power to supply in the county of another County Council?—By reason of the hard necessity of business. The production of electricity on a very large scale is necessary for cheap supply.

Mr. MOON, K.C. (for the Electric Supply Companies): You seek powers for the purpose of transferring them until the expiration of the period for which you transfer them. You have no intention to directly utilise those powers?—That is so.

Suppose the Council could not transfer the powers, and then wanted to carry on the works themselves?—That would have to be by a subsequent bill.

Take Chelsea. This area is being supplied by the Chelsea Co., and the London Co. have powers to supply there. Suppose, under clause 49, you purchased the undertaking of the London Co.?—Then we might be able to supply in that area.

Whether the consent of the distributor were unreasonably withheld or not?—Yes.

The transferee having the generating station would be able to compete effectively in that portion directly with the Chelsea Co., whether the latter were properly carrying out their duties or not?—Yes.

Do you think it fair that legislation should be introduced so that another company having the advantages given by this scheme should be able to compete with a company like the Chelsea Co.?—The Chelsea Co. could demand to have this cheap bulk supply given to them, and having that and the mains already there, it would be at an advantage over the bulk supply company, who had to lay their own mains.

The only source from which it could get its supply would be from its rival?—Yes.

Mr. VESEY KNOX, K.C. (for Hornsey, Finchley, Chiswick and Beckenham Councils): Your committee say they think it desirable that a portion of the profits, after payment of a specified dividend, shall be allocated to relief of rates. Whose rates?—The fair thing would be for the profits to be allocated to the ratepayers both inside and outside the London area.

You would not object to a clause being put into your bill which would compel you to do the fair thing?—We do not like being compelled. There would be various matters, like costs of promotion, which would fall chiefly upon the people of London. The Maldens, for instance, might benefit at the expense of the London ratepayers. Then we employ inspectors and other people who deal with the details of electrical supply.

But should not we have to appoint inspectors?—We should look carefully after your interests.

Is there no other reason why if profits are to be divided we should not get our share?—I think we should consider your claim.

If there are profits to be divided, why should not provision be made now and here to divide them throughout the whole district covered by the Act?—I think, personally, it would be fair that there should be some such arrangement.

In the Administrative Bill of 1905, which passed two Committees, the company did not take powers to supply the ordinary consumer without the consent of the distributor?—That is so.

In your bill of last year you did not take power to compete at all?—No.

Your bill now contemplates greater competition than has been proposed before?—Yes.

On the Committee resuming yesterday morning, the cross-examination of Mr. Peel by Mr. Vesey Knox was proceeded with.

Witness said he considered that all protection necessary for the large amount of existing invested capital in electricity supply undertakings was given in the bill, and thought the safeguard of the consent of the Board of Trade took this into consideration. The object of the bill was to consider the development of London as a whole. Manufacturers were moving out from the centre to the districts round London, which he thought was to be encouraged, and the characters of the various districts were thus being very much changed as regarded the supply of electrical energy for power. The Council had not negotiated with anyone for taking a transfer of their powers if the bill were passed, but they had had discussions with various sets of people who betrayed no unwillingness to come in and offer for these powers. Asked why they had included the City of London in the bill, witness said if they made exceptions they would weaken their case. It was true that the Administrative Power Company had excluded the City of London, and he did not dispute that the City was hardly likely to become a manufacturing centre, on account of the high rental of premises. In the case of Croydon, also, it was true that while the Administrative County scheme last year did not include Croydon, there were technical reasons for doing so in the present bill. He agreed that, although at the present time all the electricity supply undertakings in London were purchasable by the borough councils in 1931, these powers might be postponed for 42 years (till 1952) under clause 49 of the bill. He was afraid, however, that under present circumstances there was a possibility in many cases that the rights of the borough councils in 1931 would be of very little value. In residential districts like Ealing, where Mr. Reader Harris said that four-fifths of the land was held under leases forbidding manufactures, he thought the advantage under the bill would be an improvement in the electric lighting, but the Council's engineer would be better qualified to speak on this matter. The charges for electric lighting, both for house lighting and street lighting, which were very high in London, would be brought down by the bill.

COUNSEL for Woolwich Council contended that under the provisions of the bill the transferee would undersell the Council, kill it and then raise the price for supply, but Mr. Peel said the Board of Trade would have to take that into consideration, and the transferee would have to show he was able to supply at the price. There was no danger of the transferee cutting anyone out. The Council could, in fact, call on him to supply to them. He agreed they might, under certain circumstances, become distributing undertakings only, that is, if they took the whole of their power from the transferee in order to obtain it at a cheaper rate.

In regard to the Erith generating station, he was not aware that the site chosen was within 130 yards of the magazine of Messrs. Curtis's & Harvey, on whose premises as much as 600 tons of gunpowder could, under their powers, be stored. If that company had to go in consequence of the erection of the station and had to get considerably larger acreage in order to deal with so much explosive, he thought it would be a matter for compensation. He was unaware whether the proximity of the powder magazine had been taken into consideration in selecting the site. He thought they could agree to a clause ensuring compensation if removal were necessary.

As to the supply of electricity to schools under the control of the County Council, nothing had arisen to alter the provisions made in the 1906 bill.

The object of the bill was to supply power to manufacturers and other large consumers. It was not proposed to ask for powers which would enable the transferees to supply current for heating and cooking, for electric fans or other domestic purposes.

As to the disturbance of streets, in West Ham there might be streets which were not necessarily busy streets or main thoroughfares which it would be inconvenient to disturb for the purpose of laying the power mains, and with regard to which the local authority's consent should be necessary, but he preferred to consult before giving a definite answer on the point.

As to the West Ham electric tramways, he was aware that when the Administrative Bill was brought forward in 1905 a clause was inserted, at the request of London County Council, protecting their tramways against interference, but he would like to consider the question of inserting a similar clause in the present bill protecting the West Ham tramways in a similar manner.

With regard to the supply of current for traction to such concerns as the Great Eastern Railway and the London, Tilbury & Southend Railway, he could not consent to a clause restricting such supply to the haulage of trains and lighting of the carriages, leaving any works belonging to such companies to be supplied by the local authority in whose area they happen to be situate.

As to the transferees under the bill coming into West Ham or other borough and competing for power supply, he thought they should have that power, as, if the local authority could supply at a sufficiently low rate, such competition would be ineffective. If they could not supply at a low rate the transferees would, of course, fill the gap in that regard. The price of 1d. maximum, ¾d. minimum and average ¾d. for current for power, as charged by West Ham, was sufficiently low, he thought, as to eliminate any fear of competition by the transferees for power supply for ordinary purposes, but he doubted whether West Ham could supply extraordinary large consumers at sufficiently low rates.

The transference of the Council's powers in the bill would doubtless be on the basis of a share of the profits, and such income as would be derived from this source would naturally come from the whole area, which was considerably larger than the Administrative County of London. He could not say whether such income would be spent entirely inside the Council's county boundary although derived to some extent from outside districts. He thought the distribution of some proportion of the income to the outlying districts included in the power area worth consideration. By participating in the profits from such a scheme he did not think the County Council were putting themselves in a false position, although local authorities wishing to extend their systems would probably come to the County Council for the money they required for the purpose. They were not, however, compelled to come to them. He could not admit offhand that, assuming the bill went through, local authorities ought to be in the same position as was provided in the Administrative County Bill of 1905. He was aware that in the 1905 bill a clause was inserted which would enable Stepney Council to take supply in bulk at a maximum of £3 per kilowatt per annum and ½d. per unit, whereas in the present bill the charge proposed for such a supply was £5. 12s. 6d. per kilowatt per annum and 1·22d. per unit. He could not see why special facilities and exceptionally low rates should be offered to Stepney.

As to the capital expenditure involved in Islington Council's undertaking, the capital expenditure incurred by the local authorities within the proposed area had been considered as a whole. The transferees would, possibly, be able to supply current in a district

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where the load factor was low as cheaply as in a district where the load factor was high. Naturally, precautions would be taken to prevent the transferees getting into a district with exceptionally low rate, and after swamping all other sources of supply, raising the charges at their discretion. In the case of the transferees buying the local authority out, they would be able to charge for current up to the maximum provided for in the local authority's provisional order, which in the case of Islington would be up to 7d. for lighting.

Mr. Peel's cross-examination was concluded, and the Committee adjourned until to-day (Friday), when Mr. Peel will be re-examined.

LONDON COUNTY COUNCIL (GENERAL POWERS) BILL.

This bill, which provides for the extension by two years of the time for acquiring the Millbank-street works of the Westminster Electric Supply Corpn., has been passed by a House of Commons Committee. It is proposed to reinstate the works of the company in Horsferry-road, near the Lambeth Bridge. An unsuccessful attempt was made to get a clause inserted which would protect the Houses of Parliament and the British Art Gallery and the art treasures therein, as well as the vegetation in the Victoria Tower Gardens from injury by fumes, &c.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Council of University College, Bristol, invite applications for the position of lecturer in electrical technology. Particulars from the registrar, Mr. James Rafter. See an advertisement.

The governing body of the Northampton Polytechnic Institute (Clerkenwell, E.C.) invite applications for the appointment of junior lecture assistant in the electrical engineering department, full time. Particulars and forms of applications (to be returned by 26th inst.) from the principal, Dr. R. W. Mullineux Walmsley. See an advertisement.

The Governor of the East London College, Mile End-road, London, E., will shortly appoint an assistant professor of engineering. Commencing salary £300 per annum. Applications to Director of Studies, Mr. J. L. S. Hatton, M.A.

Mr. L. L. Horrell, engineer-in-charge at Walsall Corporation electricity works, has been appointed electrical engineer to the Edendale Estates Co., Hatherley, South Africa.

Acton.—The Metropolitan Electric Supply Co. has agreed to charge the Council for electricity supplied in bulk on a power factor of 0·75, instead of the present charges on a power factor of 0·9, and a quarter off consumers' maximum demand where motors are installed exceeding 20 H.P. The amount paid to the company for the year ended March 31 was £3,066 for 634,247 units, which, reckoned at the consumers' terminals (after deducting losses on transforming and distribution, &c.), was at the rate of 1·99d. per unit. If the reduction in price now proposed had been in operation the cost would have been 1·83d. per unit. The estimated loss for the coming year of £1,887 would be reduced to £1,545.

Argentina.—The "Review of the River Plate" says the Union Telefonica Co. has inaugurated its system between Buenos Ayres and Rosario.

The Buenos Ayres Sub-committee of Works has decided to set aside the decree which declared as lapsed the concession granted to Urdaniz & Co. for the construction of a system of tramways. The concessionaires have been given two months to deposit the guarantee.

It is announced that work is about to be commenced on the construction of a telegraph line between Bahia Blanca and Tornquist. This will complete the new circuit between Bahia Blanca and Buenos Ayres.

Battersea (London).—The Council are appealing to the London County Council to rearrange the periods for repayment of electric lighting loans, so that these may be the same as those granted to other borough loans, especially in regard to loans for mains and machinery.

Objection is being lodged to the proposed scale of fees for electrical testing, &c., drawn up by the London County Council.

Beckenham.—An inquiry was held here on Tuesday into the application of the Council for sanction to borrow £5,460 for purchasing that portion of the undertaking of the South Metropolitan Electric Light & Power Co. situate in Beckenham.

The clerk of the Council (Mr. F. STEVENS) said they were entitled to purchase under the Crystal Palace and District Provisional Order 1890. The purchase price was to be the capital outlay, plus 33⅓ per cent. After negotiations with the company the purchase price had been agreed at £5,187. 3s. 5d.

There was no opposition.

Burslem.—At the meeting of the Council on Monday the town clerk submitted a copy of the report by Col. Druitt to the Board of Trade on an inspection of the tramways in the district recently made by him.

In the report Col. Druitt stated that he had met representatives of the local authorities regarding the complaints as to the noise and nuisance caused by the electric cars on the various routes. It was explained that complaints had been general for a long time past regarding the noise made by the cars and the nuisance caused by the cars dropping oil. The noise was so bad that people living on the main route could get no rest, as the cars did not cease running till 12.30 or 1 a.m., and began again soon after 3.30 a.m. The authorities asked the Board to compel the company to remedy this if possible. Col. Druitt went over several miles of route in the various towns, and thought the cars made excessive noise. It appeared to be caused by many of the bolts and nuts connecting parts of the car together being loose, to some of the cars not having gear cases, the gearing making an irritating noise when running dry, and to many of the joints of the rails being sunk, so that every wheel jumped from one rail to another at those joints. Flats on the wheels would also cause extra noise if cars were run with such defects. With regard to the dropping of oil he saw little to complain of at the time of his visit. If the gear cases were kept in order there should be no nuisance from this cause, and the noise of the gearing would be diminished. The company were taking steps to remedy the defects in the permanent way and the directors had already sanctioned an expenditure of £10,681 for relaying certain parts of the track as double line. They had under consideration proposals for relaying a double track in Burslem and Stoke at a further cost of £10,336. They also proposed to relay lengths of line in Stoke and Newcastle as double line, at a cost of £9,656, but the local authorities refused permission for doubling, so that the track would have to be repaired as best it could while the traffic was still being maintained.

The Tramways sub-committee reported that they had discussed with Mr. J. V. Kitchener (a director of the Potteries Electric Traction Co.) and Mr. Thom (general manager) the proposal to double one line of rails and other matters, and proposals by the company were accepted.

Camberwell (London).—The Council have received the Board of Trade award on the appeals made by the County of London Electric Supply Co. as undertakers under the Camberwell Electric Lighting Order (1896), against the conditions upon which the Borough Council and the L.C.C. approved certain works proposed to be constructed by the company. The point was that permission was only given with regard to any works, pipes or wires to be used exclusively for the company's purposes under their Camberwell order. The award states that the appeals are allowed and the proposed works approved.

Canterbury.—The salary of the electrical engineer (Mr. C. A. Blascheck) has been increased to £325 per annum.

Sanction to a loan of £4,000 for cable extensions, house services, &c., has been applied for.

Charing Cross, Euston & Hampstead Railway.—This line will be opened on June 22, and it is expected that the President of the Board of Trade (Mr. Lloyd-George, M.P.) will perform the opening ceremony.

Customs Duties.—It has recently been decided that under the Commonwealth of Australia Tariff electrical automatic tea-weighing machines are subject to an import duty of 20 per cent. ad val., as weighing machinery.

East Ham.—The work of connecting up the East and West Ham tramway systems at Plashet-lane is to be proceeded with.

Electric Traction in Victoria—The Premier of Victoria (the Hon. Thos. Bent) made a statement on Thursday of last week to a number of British capitalists in connection with his scheme for the electrification of the suburban lines running from Melbourne. The State (he said) was prepared to expend £3,000,000, but he had found difficulty in coming to a decision as to the system to adopt. Mr. Bent assured his hearers that British capital, whether invested in electrical enterprises or anything else in the State, was absolutely safe, and that they could be satisfied that no socialistic legislation would injure their investments.

Exhibition Lighting.—At the recent Trades Exhibition at Cardiff several industries were fully represented, and we understand that the enterprise was well supported. An interesting feature was the stand taken by the local electricity department, which was fitted up with artistic electric light fittings in the shape of floor and table standards, ship fittings, cooking and heating appliances, and an extensive collection of lamps of various types. An attractive exhibit was one of the "Ediswan Carbone" white flame arcs, giving daylight effects.

A feature of the Bath and West Show which received considerable attention from the crowds was the exhibit of Crossley Brothers, the gas and oil engine builders, who were showing their machinery in motion. Interest to the visitors was enhanced by the fact that, in order to obtain the necessary load for the engine, they had coupled up various fittings lent by the Cardiff depot of the Edison & Swan Co., including an example of the ubiquitous "Ediswan Carbone," the new flame arc, made throughout at the Ediswan works at Ponder's End, Middlesex.

Fleetwood.—Some time ago the Council constructed a road alongside the Blackpool and Fleetwood Tramroad Co.'s lines, beginning at a point where the tramways leave the street. The appor-

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tionment of cost was duly made, and a notice requiring payment of the cost of that portion of the road adjoining their lines was served upon the Tramways Co., as "owners adjoining and abutting." The company raised objection to this on several grounds, and appealed to the L.G. Board. It has now been intimated by the Board that the company cannot be properly charged with the £1,588. 3s. 2d. apportioned as the cost of that half of the road adjoining or abutting on the tramway lines.

France.—Reporting on the trade of the Bordeaux district in 1906, Mr. Consul R. Macdonald writes concerning the tramways and coast railway at La Rochelle and states that it is proposed to adopt the overhead trolley system of electric traction on the departmental tramways on the Vendée. The power station is to be situate immediately at a pit's mouth, the inferior coal from the mine being utilised in a gas-producer plant supplied by a British firm of manufacturers. About 3,500 H.P. will be developed and the surplus power will be utilised in supplying energy for all purposes to the neighbouring town of Niort. The enterprise is in the hands of a local syndicate.

Electric traction will also most probably be adopted for the light railway which is to be constructed along the coast of the Department of Charente Inférieure. The line has already been surveyed and marked out, but actual work has not yet been commenced.

A scheme for the distribution of electric light and power in the town of La Rochelle is, Mr. Macdonald states, likely to mature shortly, and he considers that this will give an opening for small electric motors suitable for use in the workshops of the various industries of the district.

A number of steam trawlers belonging to the port of La Rochelle have been fitted with small electric lighting sets of British manufacture.

Glasgow.—The Uddingston extension of the tramway system was opened on Saturday.

Halifax.—The report of the tramways manager (Mr. F. Spencer) was presented to the Council last week, and stated that the expenditure was considerably increased by compensation incurred by the serious accident on North Bridge on July 1 last. The income was seriously affected by the strike, exceptionally bad weather since October and other causes.

If (continues Mr. Spencer's report) Halifax could purchase current on as advantageous terms as certain towns named by Mr. Spencer, the tramways undertaking would show a handsome profit. The cost of the permanent way and electrical equipment of the line could not be reduced, but was likely to be increased. To reduce tram services would be false economy, as increased traffic could not be induced by reducing facilities. To increase fares on any section would result in a diminished total revenue, while to reduce fares would have the same effect, because of the limited population served. During the year about 500 tons of sand were used at a cost of about £180. A new type of slipper brake has been designed by the rolling stock superintendent to overcome the difficulties found after nearly nine years' experience with slipper brakes on the Halifax system. The accidents of July, 1906, and February last were due to the braking effect of the slipper brake being absent when most necessary, in the first case owing to the motorman not applying the brake sufficiently before descending the gradient; in the second case, by the blocks being worn to such an extent that they were useless when required. If the cars were equipped with the new brake mentioned the serious results of thoughtlessness and lack of judgment would be less liable to occur. All slipper brakes that he (Mr. Spencer) had any knowledge of, which had been designed for the Halifax type of car trucks, had used a steel shaft parallel with the car axle and supported by bearings fixed to the truck sides. With the new brake the shaft across the truck was dispensed with, and the downward pressure was taken by four bearings fixed on the truck side close to the axle box. That did away with the elasticity, and the efficiency was increased 50 per cent. It would also be possible to issue regulations with regard to the use of the brake which were not possible with the present brakes, and thus make the serious results of thoughtlessness less liable to happen, because blocks could be attached which it would be impossible to wear away in a day or a week. Besides obtaining the advantage of increased safety, Mr. Spencer computes that there will be a saving of £200 per annum in labour and material in connection with the brake.

Hammersmith (London).—A canvasser for the electricity department is to be appointed at a salary of £3 per week.

India.—The "Indian Electrical, Mechanical and Textile News" states that the Bara Doab Falls 5,000 H.P. water-power electricity scheme for supplying Lahore with electric light, fans and power is before the Punjab Government for final sanction.

The United Provinces Government have approved the principle of the 30,000 H.P. Jumna River project for supplying power to the mills at Delhi.

"Indian Engineering" states that a special electrical department of the East Indian Railway has been established as a separate department, and the electrical engineer in charge is Mr. H. L. Tyson-Wolff, who has been granted the maximum salary of R.1,000 per month.

Leicester.—The Corporation tramways department have opened 20 receiving offices for collection and delivery of parcels within ½ mile radius of any part of the tramways system. The charges vary from 2d. to 4d. per parcel.

Llansamlet.—The Council are considering an electricity supply scheme submitted by Mr. J. W. Johnston.

London County Council.—At Tuesday's meeting the report of the district auditor on the accounts of the Council for 1905-6 was submitted.

L.C.C. (Electric Supply) Bill.—After considerable discussion the Council adopted the recommendations of the Parliamentary Committee with regard to the Electric Power Bill as follows:—

(*a*) That the clauses in the London County Council (Electric Supply) Bill, 1907, providing for the compulsory acquisition of the electrical undertakings of the metropolitan borough councils by the Council and for the transfer to the Council of the powers of purchase possessed by local authorities throughout the area of supply proposed in the bill in regard to electrical undertakings in their several districts, be deleted.

(*b*) That the provision in the bill for the expenditure of a sum not exceeding £4,500,000 on the proposed undertaking be so amended as to limit any such expenditure to a sum not exceeding £100,000.

(*c*) That the special powers sought in the bill in regard to the breaking up of streets in London be deleted, and that the general law on the subject be incorporated in the bill, so far as it is applicable, together with a clause dealing with routes to be followed in laying electric lines.

(*d*) That the powers sought in the bill to enable the generating stations and other works comprised in the Council's tramway undertaking to be appropriated as part of the proposed undertaking be omitted, but that power be sought to enable the Council to supply surplus electrical energy from its Greenwich generating station for the purpose of the proposed undertaking, and to permit of the use of the Council's tramway ducts for purposes of the undertaking.

(*e*) That provision be made in the bill to the effect, that any assignment or transfer shall be subject to the following conditions, namely:—

(i.) The undertaking to be purchasable by the Council at the end of a period not exceeding 50 years on the terms of the Electric Lighting Act, 1888, or on such other terms as may be specified in the deed of assignment and approved by the Board of Trade.

(ii.) The amount of dividend which may be divided by the transferees to be regulated by the prices charged by them for electrical energy on a basis to be approved by the Board of Trade.

(iii.) The maximum prices to be charged by the transferees not to exceed those prescribed by the bill, and such maximum prices and the relation between price and dividend to be subject to periodical revision.

(iv.) Facilities to be granted to the Council at any time to examine accounts and works of the proposed undertaking, and the assignment to contain such other provisions as may be deemed necessary for securing adequate control by the Council with regard to the powers transferred or assigned.

(*f*) That the bill do provide for the cesser of the Council's powers thereunder unless a transfer or assignment has been made within a period of one year from the passing of the intended Act.

(*g*) That the Parliamentary committee be authorised to insert the necessary clauses in the London County Council (Electric Supply) Bill, 1907, in order to give effect to the foregoing resolutions, and to make any further alterations in the bill that may appear necessary.

In the course of the discussion the Hon. W.R. W. Peel said the Council would welcome the passing of the bill of the electric lighting companies before Parliament.

Rating of Tramways.—It was agreed to discharge the reference to the Highways committee to inquire into the question of the rating of tramways by the Borough Councils, principally on the ground that the question of the action to be taken on the report of the Traffic Commission is likely to engage the attention of the Council in the near future.

Longton.—The Council have increased the salary of the electrical engineer (Mr. C. Cuthbertson) to £160 per annum.

Madeira.—The British Consul at Madeira (Capt. J. Boyle) urges that a telephone system is badly needed in Madeira, as, owing to the rough and mountainous nature of the country, communication is at present carried on at great expenditure of time, money and effort. The population of the island (which is about 18 miles in length and 13 miles wide) is about 150,000, and Funchal, the capital, contains 50,000 inhabitants. There are a large number of hotels, and British, Portuguese and German merchant houses have considerable establishments at Funchal. It is considered probable that, as the island is well wooded, suitable poles could be obtained on the spot. Local capital should be invited, and, of course, the necessary licence for operating the service will have to be obtained from Lisbon.

Manchester.—At the meeting of the Council on Wednesday it was decided to apply for sanction to a further loan of £112,850 for extensions of the electricity undertaking.

The Chairman of the Electricity committee (Mr. HOWARTH) said the experiment of supplying the day load at a lower rate had been amply justified by the result. The committee were in negotiation with other large firms and additional money was required for the necessary plant.

The Council have granted the following increases of salary:—

Mr. A. E. M'Kenzie, resident electrical engineer at Stuart-street station, from £350 to £500 (by £50 a year); Mr. F. E. Hughes, secretary of

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electricity department, from £400 to £425; Mr. L. R. Lee, mains engineer, from £350 to £450 (by £25 a year); Mr. F. H. Whysall, resident engineer at Dickinson-street and Bloom-street stations, from £280 to £325.

Marylebone (London).—The Electric Supply committee report that the commission on capital expenditure hitherto paid to the consulting electrical engineer (Mr. Arthur Wright) is £22,072. "Mr. Wright has submitted further claims totalling £2,057, and the committee recommend payment of £1,200 subject to its being made without prejudice to any matters which might be raised in pending arbitration proceedings, the balance being more or less in dispute."

Middlesex.—On Friday the chairman of the Middlesex Light Railway committee opened the new line of electric tramway from Wood Green to Palmer's Green. The line will ultimately be extended to Enfield.

National Association for the Promotion of Technical and Secondary Education.—Sir H. E. Roscoe and Sir Wm. Mather have issued a circular announcing the winding up of this Association, which was formed 20 years ago with the Duke of Devonshire as president. The reason for the winding up is that the objects of the Association have been accomplished.

Northallerton.—The Council have asked the directors of the Northallerton Electric Light & Power Co. to state the terms upon which they would dispose of their undertaking.

Obituary.—Mr. Joseph Halden, for 30 years head of J. Halden & Co., electrical appliance dealers, Newcastle-on-Tyne, Manchester and London, died on June 6, aged 65.

Oxford.—A long discussion took place last week on a report of the Tramways committee recommending certain modifications of the agreement between the Corporation and the National Electric Construction Co. in regard to the purchase and electrical equipment of the local lines by the latter. The modifications include an extension from 15 months to three years of the time for the flotation of a local company to construct and equip the lines and a reduction of the penalty for default from £100 to £25 a week. The Corporation get a new guarantee that the company will pay the purchase money of the old lines and the costs incurred at the due time.

Patent Amendment.—Mr. Philip M. Justice, 55 and 56, Chancery-lane, W.C., has requested that certain clerical errors in the specification of letters patent No. 6,803 of 1906, granted to him for 'Improvements in Electric Glow Lamps," may be corrected. Particulars of the correction are given in the "Illustrated Official Journal" (Patents) of June 5. Notice of opposition to the Patent Office, 75, Southampton-buildings, London, E.C., within one calendar month of June 5.

Personal.—Mr. C. S. Northcote, of 2, Queen Anne's-gate, Westminster, S.W., who is away on the Continent, asks us to notify that he will be personally available for business again on 24th inst.

Presentations.—The members of Leyton Tramways Athletic and Social Club have presented Mr. F. Schofield, manager of the tramways, with an oak-framed enlarged photo of himself as a token of esteem.

On Friday evening last a smoking concert and social gathering was held at St. Stephen's Restaurant, Bristol, in connection with the departure of Mr. J. H. Bolam, of the Corporation electricity department, who has been appointed borough electrical engineer at Weymouth.

In the unavoidable absence of Mr. H. Faraday Proctor (who is out of England), Mr. HERBERT COUZENS (deputy city electrical engineer) presided over a large attendance. A varied and lengthy musical programme was provided, and during the course of the evening a handsome stop watch (subscribed for by the staff and employés) was presented to Mr. Bolam as a token of the high esteem in which he was held. The enthusiasm which greeted the toast of Mr. Bolam's health was full testimony to his popularity.

Mr. COUZENS, in making the presentation, referred to the respect and esteem in which Mr. Bolam was held, and whilst regretting his departure from Bristol, wish him every success in his new appointment.

In reply Mr. BOLAM hoped he would have at Weymouth as loyal a set of workmen as he had had at Bristol. It was impossible for him to adequately express his thanks, not only for the presentation, but for the goodwill and courtesy that he had received from all during his seven years' connection with the Bristol Corporation electricity department.

The employés of Brook, Hirst & Co., electrical engineers, Chester, have presented a silver rose bowl and a pair of silver candlesticks, and the office staff a pair of silver flower vases, to Mr. P. S. Brook on his marriage.

The officials and employés of the South Lancashire Tramways Co. have presented a silver spirit kettle and smoker's cabinet to Mr. E. H. Edwardes (resident engineer at Atherton) on his marriage.

The employés of the National Telephone Co. at Dundee on Monday presented the district manager (Mr. William Brown) with a solid silver rose bowl on the completion of 25 years' continual service with the company. The telephone manager at Dundee (Mr. Mackenzie) made the presentation.

South Africa.—The "British and South African Export Gazette understands that the Government intend to spend £50,000 on the electric lighting of the Eastern and Midland Railways, that orders are about to be given out for additional generating plant for the Central South African Railways, and that an order is to be placed in England for electrical plant for the Durban Roodepoort Deep Mine, to replace the 500 kw. steam-driven plant recently sold to Johannesburg Corporation.

The "Gazette" also states that failure after failure has been experienced in the use of the *Johannesburg* Corporation's gas producer and electrical plant, which is to be tested some time this month prior to being handed over by the contractors (D. Stewart & Co.), and (continues the "Gazette") in preparation for the anticipated rejection of the plant, the Corporation have placed a contract with Reunert & Lenz for an auxiliary steam-driven d.c. plant of 1,000 kw., switchboards, instruments, &c., at a cost of about £19,000. The total cost of the original lighting and tramway scheme was about £1,250,000.

Mr. J. F. I. Thomas, the manager of the Johannesburg light and power department, stated in a recent report that the seven sets of generators had never been all available at once owing to breakdowns, and each set usually fell 20 per cent. short of its full output. The producer gas was not free from tar; the engines could not last long under the extra stress to which they were subjected through pre-ignition troubles, and breakdowns of pumps, bearings, water service and compressor plant were frequent. The cost of working per unit worked out at 2·55d., instead of 0·86d. as originally estimated.

Cape Town Corporation propose to hire out and maintain electric motors, but local dealers in motors and electrical plant are protesting against the scheme.

Port Elizabeth ratepayers have approved the borrowing of £25,000 further for the completion of the municipal electricity scheme. The original loan was £100,000, and this has been overspent by nearly £11,000. The undertaking is progressing satisfactorily, new connections are being made at the rate of 21 per month, and there are at present 215 consumers taking current for lighting. Power consumers have motors aggregating 160 H.P.

The Lancashire Dynamo & Motor Co. have shipped a 500 kw. steam-driven d.c. generating set (Belliss engine) for Johannesburg Municipality.

The new electrical plant for Durban Harbour comprises Bruce Peebles motor-generators, a Willans turbine set, E.C.C. switchboards and transformers supplied by G. Hanchett, Barrett & Co.

Southampton.—Sanction to a loan of £3,000 for mains and services has been applied for by the Corporation. It is proposed to terminate the agreement with the Southern Electric Free Wiring Co. in six months.

Southwark (London).—An electrically-driven feed pump is to be obtained at a cost of £300 for the electricity station.

The offer of the County of London Electric Supply Co. to supply current for lighting the interior and exterior of the tower now in course of erection at St. George's-circus has been accepted by the Council. The offer was 3d. per unit for interior and exterior lighting with £54 per annum for maintaining four lamps. The London Electric Supply Corpn. quoted 3d. per unit with 15s. per quarter for maintenance of arc lamps. Assuming 4,200 hours of lighting these figures are estimated to represent £122 and £142 per annum respectively.

Sterilisation of Water by Electrolytic Chlorine.—Dr. S. Rideal has been permitted by the Westminster City Council (under protective conditions) to carry out experiments on the sterilisation of water at one of the swimming baths by electrolytic chlorine, with the object of ascertaining whether the water need be changed as frequently when kept purified as at present.

Swinton.—The Council have now completed the laying of distributing mains in the compulsory area, and the sub station from which current will be distributed by the Lancashire Electric Power Co. is nearing completion. It is anticipated that the supply will be available by the end of August, and in the meantime a vigorous canvass of the district is being carried out by the company.

Torquay.—The dispute between the Dolter Electric Traction, Ltd., and the Corporation as to the claim made by the Council for payment of £1,200 (being the minimum annual payment for electric current guaranteed to be taken by the company) has been settled amicably.

Tramway Managers' Conference.—The annual conference of the managers' section of this association was held at Blackpool on Thursday and Friday last, Mr. J. M. McElroy, of Manchester, presiding.

The Mayor of Blackpool welcomed the delegates on Thursday, and in acknowledgment Mr. MCELROY said every municipality in the country that controlled a tramway system was represented in the association, which, through united action, had got matters brought before Parliament and the Board of Trade which could not have been done otherwise.

The delegates then privately heard Papers. The first was by Mr. J. Lancaster (manager at Blackpool) on Accidents, and he submitted the

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question whether it was wiser for corporations to insure against accidents or take the risk themselves. The general opinion seemed to be that local conditions had a great deal to do with settling the policy to be followed.

Other Papers were by Mr. L. Johnstone (Gloucester) on "Transfer Tickets"; Mr. J. Dalrymple (Glasgow) and Mr. H. Mozley (Burnley) on "Single Truck and Bogie Cars"; and by Mr. C. J. Spencer (Bradford).

On Friday Mr. L. SLATTERY (Oldham) read a Paper on Air Brakes, and said Oldham was the only town in the country where the system was adopted on all cars.

Mr. H. MOZLEY dealt with the Corrugation of Rails.

Mr. J. B. HAMILTON (Leeds), dealing with "Pay and other Allowances to Motormen and Conductors," suggested a committee to deal with the question, so that a comparable method of computing the rates of pay for tramway employés might be arrived at and the rate in different towns be compared.

The conference closed with a luncheon at the invitation of the Mayor of Blackpool. At this function the president (Mr. MCELROY) spoke of the great value of those conferences to tramway managers, many of whom had to specialise in certain sections of tramway work, and they were thus able to draw from one another useful information.

Trunk Telephone Communication in the Tyneside District.—In connection with the scheme of trunk telephone construction for the current year a commencement will shortly be made with the construction of a number of trunk lines for the Newcastle-on-Tyne district, including Newcastle-London (four lines), Newcastle-Glasgow, Newcastle-Edinburgh, Newcastle-Liverpool, Newcastle-Manchester, Newcastle-Birmingham, Newcastle-Middlesbrough (two lines), Newcastle-Stockton, Newcastle-Darlington, Newcastle-Durham.

Wallasey.—Extensions of the tramway system are to be carried out at an estimated cost of £48,695.

West Ham.—The electrical engineer (Mr. A. Hugh Seabrook) has reported, with regard to salaries and commission in connection with the sales department, that many inquiries were coming in now for light and power and heating and it required a larger staff to deal with them. He was even receiving complaints that inquiries were not being attended to promptly.

He was anxious to commence pushing fans vigorously, which could be hired out and upon which a good percentage could be obtained on the cost. If this suggestion could be dealt with, a firm of heating appliance makers were offering to supply, on sale or return for one month, 50 irons to be delivered to private consumers for sale or hire. He also desires to push the sale and hire of electric signs, from which a big revenue could be obtained on the charge-per-hour system. During next winter he proposes to push radiators and heating at the present rate of 2d. per unit, and he expresses himself sanguine that even at this figure a large amount of business is to be obtained by employing salesmen of the proper type and experience. He is unable to push as he would like the new arc lamp hiring system. The sales department (continues Mr. Seabrook) is rapidly becoming one of the most important of the sub-departments, and it is of so purely commercial a character that the usual commercial salary and commission basis of payment must be adopted. He suggests payment per kilowatt for consumers obtained and 2½ per cent. to salesmen on sales effected.

The Electricity committee have decided to sanction the electrical engineer's scheme.

Will.—The late Admiral Sir Leopold George Heath, K.C.B., at one time chairman of the Eastern & South African Telegraph Co., left estate of the gross value of £43,664, with net personalty £41,970.

Willesden.—The L.G. Board have confirmed the district auditor's decision that the cost of acquiring alternative sites for a new generating station and a sub-station, in the event of the bulk-supply agreement with the North Metropolitan Electric Power Supply Co. being terminated, should be debited to revenue and not be paid out of the profit of £3,300. 9s. received from the company on the sale of the Taylor-lane station.

The Board are still considering the alternative of granting a loan for the purchase of the sites.

The electrical engineer (Mr. J. G. Bruce) is reporting on the cost of extending the street arc lighting.

Workhouse Lighting.—Epsom Guardians have decided to wire their workhouse.

J. B. Saunders & Co.'s Jubilee Dinner.—An excellent group photograph of the principals and guests present at the jubilee dinner given by Messrs. J. B. Saunders and Co. at the Great Central Hotel on April 24 has been made by Messrs. Harrods (Ltd.), with the unusual result in such cases that every person present on the occasion can be clearly distinguished.

Electro-Harmonic Society.—The annual general meeting will be held at 4:30 p.m. on 19th inst. at 92, Victoria-street, S.W., to receive the statement of accounts for the 21st season, to elect officers for the 22nd season, and to transact the ordinary general business of the society. During the past year 88 new members were elected, 2 members died, 52 resigned, and 7 were struck off the register for non-compliance with rule 11. There are now 578 members. The accounts show a balance of £60. 14s. 10d.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Blackburn.—The accounts of the electricity department show capital expenditure £252,877, an increase of £7,286 during the year ended March last.

Annual revenue was £32,078, and the receipts included £16,182 from private consumers, £2,353 for public lighting, £11,018 for current for tramways and £1,364 from other corporation departments; total £30,917, minus discounts (£1,082). Rental of motors and lamps produced £940, and sale of lamps, fittings, &c., £1,303. Generation, distribution, management and general expenses came to £15,178, leaving a gross profit of £16,900. Interest absorbed £6,712, and instalments paid off loans £3,020; £5,640 has been transferred to sinking fund, and the net profit (£1,528) to reserve fund. 4,181,594 units were generated (compared with 3,917,723 in the previous year), 331,420 (against 282,614) supplied to public lamps, 1,853,270 (1,757,974) to tramways and 1,498,229 (1,290,872) to private consumers. The total maximum supply demanded was 2,390 kw., against 2,270 kw.

The report of the borough electrical engineer (Mr. P. P. Wheelwright) states that the increase of over £2,000 in income is due to the healthy condition of trade in Blackburn. A concession of ·1d. per unit was made to the tramways department in July last, resulting in a decrease of revenue of £560. The number of private consumers increased by 190, and the equivalent of 8,000 8 c.p. lamps was connected during the year, the total connections (exclusive of tramway demand) being equal to 139,500 8 c.p. lamps. 50 motors (266 B.H.P.) were added, an increase of 40 per cent. The horse-power of private motors connected is 865, and the total, with hired motors, over 1,800 H.P.

Brighton.—The accounts of the tramways department for the year ended March 31 show a net profit of £2,410 after paying all expenses, interest and sinking fund, &c.

Crewe.—The income of the electricity department for the year ended March 31 was £6,570. 19s. 11d., including £3,078. 1s. 9d. net from the sale of current by meter, and £3,358. 13s. for public lighting.

Expenses were £3,052. 4s. 6d., leaving £3,518. 15s. 5d. to meet interest (£1,342. 4s. 7d.), repayment of loans (£845. 7s. 5d.) and contribution to sinking fund (£735. 11s. 3d.). The surplus on the year's working was £680. 2s. 3d., and the aggregate surplus to date is £5,040. 14s. 10d. The total capital expended is £50,669. 2s. 5d., an increase of £485. 4s. 3d. on the year. 537,625 units of electric current were generated, 251,837 supplied to the public lamps and 230,121 sold to private consumers. The total maximum supply demanded was 338 kw.

Croydon.—There is a credit balance on the working of the electricity undertaking for the past year of £10,248, of which £5,000 has been placed to reserve and renewal fund, £3,000 applied for improvement of street lighting and distribution, and £2,248 carried forward. The borough electrical engineer (Mr. A. C. Cramb) and his staff are to be congratulated upon the year's record.

The total revenue of the tramway undertaking for the 10 months has been £62,075, and after deducting working costs the balance was £20,695. Deducting interest, depreciation, sinking fund, &c., the net balance was £9,053, and this has been carried to reserve. During the 10 months the trams carried 13,514,918 passengers at an average fare of 1·08d. per passenger.

Dundee.—The accounts of the electricity department for the year ended April 30 show an income from all sources of £31,109, and working expenses £13,943, leaving a gross profit of £17,166. With this large profit on their electrical undertaking the Electricity committee have decided to take the opportunity of decreasing the capital debt and have transferred £6,736 from capital to revenue account, which, with interest and sinking fund (amounting to £9,782), leaves a net profit for the year of £914. The units generated were 4,564,721, an increase of 600,000 over last year, while there is a corresponding increase in units sold, which amounted to 4,008,413.

Erith.—The accounts of the electricity department for the year ended March 31 show a total income of £11,570. 8s., including £8,156. 17s. from sale of current for lighting, power and traction and £2,199. 0s. 10d. from public lighting.

Total expenses were £7,107. 3s. 10d., leaving £4,463. 4s. 2d. to meet interest (£2,134. 17s. 8d.), repayment of principal (£1,600. 18s. 6d.) and other items, the net result being a deficit of £63. 1s. 7d. on the year. The total capital expenditure is £64,340. 11s. 3d., an increase of £5,898. 5s. 8d. during the year. 1,352,213 units were generated, 207,500 were supplied to the public lamps and 895,240 were sold to private consumers. The total maximum supply demanded was 700 kw.

The increase in connections during the year was equivalent to 14,798 8 c.p. lamps for lighting and power, bringing the total connections to 54,933 8 c.p. The works costs for the year were 1·097d. per unit, against 1·190d. in 1906, and the total cost was 1·340d., against 1·468d.

Hastings.—The total income of the electricity department for the year ended March 31 was £19,765. 19s. 6d., including £15,134. 10s. 10d. from sale of current for private lighting and power and £3,960. 11s. 7d. from public lighting.

The total expenditure was £9,159. 16s. 4d. Gross profit was £10,606. 3s. 2d. Interest absorbed £4,903. 13s. 5d. and sinking fund, &c., £5,431. 16s. 4d., leaving a net profit of £198. 15s. 7d., against £117 in 1905-6. 1,087,751 units were generated, and the total maximum supply demanded was 700½ kw. The total capital expended is £150,522. 18s. 3d. The cost of fuel was higher than in the previous

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year, but this has made but little difference in the generation charges. The charges for repairs and maintenance are also higher, these charges being borne out of revenue.

Hull.—The accounts of the tramways department for the year ended March show capital expenditure £417,467, increase £14,744.

The year's revenue was £122,590, of which £121,186 was received as fares. Traffic expenses were £30,569, general expenses £9,644, general repairs and maintenance £21,965, and power expenses £9,378. The gross profit was £51,008. Interest required £12,942, income tax £1,310, annual contribution to district fund £2,528, and the balance carried to appropriation fund was £35,132, of which £9,528 was required for sinking fund instalments, £10,604 was placed to reserve, and £10,000 devoted to relief of borough rate. The balance (£15,000) has been carried forward. Power expenses were 0·76d. per car-mile (compared with 0·77d. in previous year); total working, management and general expenses 5·79d. (5·76d.), and total expenses (including capital charges) 7·75d. (7·68d.). 3,349,964 units were delivered to the line, or 1·13 units per car-mile. The maximum load was 1,325 kw. (1,250 kw.). 29,151,543 passengers were carried and 2,956,406 car-miles were run.

Ipswich.—For the year ended March 31 the total revenue of the electricity department was £11,580. 9s. 4d., including £10,278. 8s. 1d. from sale of current for lighting, power and traction, and £1,148. 13s. 3d. profit on the installation department.

Total expenses came to £7,299. 4s. 5d. The gross profit was £4,281. 4s. 11d., and after deducting interest (£2,368. 8s. 7d. less £17. 11s. 11d. contributed by destructor department), bank interest (£685. 6s. 9d.), &c., balance was £1,244. 8s. 11d. After repaying instalment of loan, &c., the deficit on the year's working was £1,363. 7s. 9d., compared with £249. 13s. 7d. for 1906. The total capital expenditure is £83,347. 11s. 9d., an increase of £1,866. 10s. 11d. 1,310,277 units of electric current were generated, 258,402 units were sold for private lighting, 187,677 for power, and 720,246 for traction. The total maximum demand was 912 kw.

The revenue of the tramways department was £22,042. 13s. 4d. and working expenses £16,137. 7s. 1d. The gross profit was £5,915. 6s. 3d. Interest on loans absorbed £3,689. 8s. 10d., bank interest £286. 18s. 9d. and repayment of loan £1,753. 7s. 2d., so that there was a small net profit on the year. The total capital expended is £114,331. 5s. 6d., an increase of £529. 14s. 10d.

In the report of the chief engineer and manager (Mr. Frank Ayton) it is stated that, owing to the high price of copper, great care has been exercised in the matter of laying extensions of mains. At the end of May, 1906, a reduction in price of electricity was made to private residences, clubs, hotels and other long-hour consumers to 4d. per unit. The reduction brought a number of new consumers, but the new business during the year was a long way short of what was anticipated. Comparatively few tradesmen could be induced to adopt electric lighting, the reason generally given being that with bad trade they could not afford the expense of installing it. The number of consumers increased from 284 to 372, and the equivalent 8 c.p. lamps connected show an increase of 25 per cent.; but the units sold (excluding traction) are only 13 per cent. greater than for 1905-6. The inauguration of the new installation department has had the effect of raising the standard of wiring work done in the town and of reducing prices to a reasonable level. A scheme for the maintenance of lamps was also introduced, and the number of lamps on maintenance at the end of the year was 947. A show room for lamps and fittings has also been opened.

Kirkcaldy.—The annual reports of the electricity and tramways departments were presented to the Council on Monday.

The gross profit on the electricity department was £3,559. 17s. 9d., against £3,627. 17s. 2d. last year, while the charges for interest and sinking fund were £3,603. 14s. 8d., compared with £3,031. 9s. 8d. The deficit on the year's working is, theretore, £39, 8s. 4d.

The gross profit on the tramways was £4,619. 4s. 3d., compared with £2,455. 11s. 8d. Charges for interest and sinking fund amount to £5,203. 11s. 4d., less £400 contributed by rates (£4,803. 11s. 4d.), compared with £3,963. 17s. 2d. The deficit on the year's working is £580. 17s. 6d., compared with £1,924. 12s. 9d.

Lancaster.—The accounts of the electricity department for the year ended March 25 show a total income of £9,228. 12s 10d., including £5,609. 13s. 7d. from sale of current for private lighting.

Expenses were £5,589. 11s. 3d., leaving £3,639. 1s. 7d. to meet interest and sinking fund. The net profit (£369. 14s. 8d.) has been placed to reserve. The total capital expended is £63,266. 10s. 10d., an increase of £975. 16s. 4d. on the year. 882,152 units were generated and 396,516 were sold by meter, 8,131 by contract, 66,000 units were supplied to the public lamps, and 247,400 to the Tramways committee. The equivalent of 41,900 8 c.p. lamps is connected to the mains, and the maximum supply demanded was 728 kw. (528 kw. for lighting and 200 kw. for tramways). The total cost per unit sold was 1·47d.

The total income of the tramways department for the year was £5,479. 9s. 8d., including £5,359. 15s 8d. traffic revenue, leaving an adverse balance of £143. 19s. 2d. Interest on loans came to £1,554. 9s 3d. and repayment of debt to £1,228. 18s 2d. The deficit was £2,836. 19s. 7d., making the aggregate deficit to date to £9,160. 12s. 11d. 1,353,681 passengers were carried and 194,577 car-miles run, the receipts per car-mile being 6·61d., and the working expenses 6·94d. The total expenses (including interest and debt redemption) per car-mile were 10·87d.

Leigh (Lancs.).—The total income of the electricity department for the year ended March was £6,314. 18s. 10d., including £3,067. 9s. 10d. from sale of current for private lighting, and £2,925. 1s. 7d. from power consumers.

The annual expenses were £4,102. 5s. After paying interest, sinking fund, &c., the deficit was £409. 10s. 1d.

The annual report of the borough electrical engineer (Mr. A. T. Smith) states that there has been a considerable increase in the units sold and a corresponding increase in revenue from both lighting and power. There are 315 consumers, representing 16,818 8 c.p. lamps connected. 702,119 units were sold, the maximum load was 404 kw. and the load factor 20·5 per cent. The total generation and distribution charges were 1·24d. per unit sold, against 1·10d. in 1906, and the total cost (including interest and sinking fund) was 2·61d. per unit, against 2·02d. in 1906. The total capital expended is £43,624.

Manchester.—On Wednesday the Electricity committee had before them the report of the department for the year ended March 31. The net surplus was £26,267, compared with £16,219 in 1905-6.

During the year the L. G. Board granted additional borrowing powers to the extent of £165,136, and an application for further powers has been made. The various amounts sanctioned come to £2,545,941. The capital outlay shows a total of £2,338,373. In framing the estimates for the current year provision has been made for a reduction in the present prices charged for current for lighting, and the Council will be recommended to sanction the following:—

(*a*) To consumers on flat rate, a reduction from 4½d. to 3¾d. per unit.

(*b*) To long-hour consumers, a reduction from £7 per kilowatt of maximum demand and 1¾d. per unit to £7 per kilowatt and 1½d. per unit. Both alterations to take effect from 25th Dec. next.

Satisfactory progress has been made with the work required to give effect to the engineer's scheme of closing down the Dickinson-street station and transferring the load to Stuart-street during the six summer months in each year. The scheme is expected to come into operation on the 30th inst. Messrs. Willans & Robinson, who have been entrusted with the contract for the supply and erection of a 6,000 k.w. Willans-Siemens turbo-alternator set to Stuart-street station, are proceeding rapidly with the work in their shops, and it is confidently expected that the set will be delivered, erected and in readiness for the generation of current by the end of December. To cope with the continued increased demand for electricity, more particularly for power, there have been installed at several of the distributing stations during the year an additional 3,500 kw. of transforming machines, including the plant required for the new tramway services to Chorlton-cum-Hardy and Altrincham. The important scheme of laying new high-tension feeders from Stuart-street to Dickinson-street, and the provision of spare ducts, is nearing completion. Extra high-pressure mains have been laid during the year in connection with three-phase supplies to a large number of works, including Shaw, Jardine & Co., Hans Renold, Richard Johnson & Nephew, Kendall & Gent, Mather & Platt, Armstrong, Whitworth & Co., and Johnson, Clapham & Morris.

The total output of electricity from the three generating stations during the past 12 months amounted to 63,056,914 units, compared with 55,025,966 units in 1905-6, an increase of 14·59 per cent. The quantity sold was 51,361,612 units.

The total mileage of main conductors laid at March 31 equals 322 miles 83 yds., 20 miles 1,439 yds. more than in 1906.

The annual report of the general manager (Mr. J. M. McElroy) for the year ended March 31 has been adopted by the Tramways committee.

During the past year additions to and extension of the tramway system of an aggregate of 10 miles (bringing the total length of single track to 161 miles) were opened. On Jan. 22 was commenced the through running arrangements between Manchester and Oldham, a distance of nearly 9 miles. Similar arrangements have been made with Ashton-under-Lyne Corporation. The revenue for the past year was £719,673, against £663,707 in 1905-6. Working expenses were £454,693, against £433,561, and the gross profit was £264,980, against £230,146. After adding bank interest, the available balance was £266,809. Interest absorbed £50,141, redemption of debt £39,594, and rent of tramways £24,039. Out of the balance, £87,827 has been appropriated to reserve, renewals and depreciation, £55,000 to relief of rates, and £4,211 to street improvements, interest, &c. The total borrowing powers of the undertaking are £1,875,014. The amount borrowed is £1,558,668 and the capital expenditure is £1,725,814. The car-miles run were 15,523,459, and 143,264,501 passengers were carried. The number of units of electrical energy used was 25,072,791. The sinking fund now stands at £144,197, the amount applied in reduction of debt is £141,310, and the amount of renewals and depreciation fund is £320,020.

Poplar.—The report of the borough electrical engineer (Mr. J. H. Bowden) for the past year states that 5,321,383 units of electrical energy were generated, and 4,208,302 units were sold, against 3,041,100 in the previous year.

The lamp connections for private lighting represent 64,493 8 c.p., and there are also 332 motors of 4,710 H.P. The aggregate capital expenditure is £258,772, and, deducting amounts written off for redemption of capital, the net outstanding capital is £238,317. The annual revenue was £30,837, against £25,659; the total costs were £15,597, against £12,586; and the cost per unit sold was 0·912d., against 0·993d. After paying interest and sinking fund the net balance is £574, which is carried to reserve. The surplus in 1906 was £600.

Mr. Bowden states that the most important feature of the year was the enormous development of the power load and its bearing upon the

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cost of production. Two years ago, out of a total output of 2,331,827 units (producing an income of £20,717) 835,200 units were for power (the revenue from same being £5,221), while the expenditure representing the the works costs was £9,023. During the past year the total output was 4,208,302 units, producing £30,596, of which 2,423,538 units were for power (the revenue being £11,677), while the works cost was £10,676; thus an increase of 1,876,475 units, producing an increased revenue of £9,879, was obtained at an increased expenditure for works costs of £1,653, or only 0·211d. per unit, notwithstanding an advance of about 15 per cent. on the price of coal. The total capacity of the station is 3,400 kw., and the maximum demand 1,980 kw., leaving 1,420 kw. of reserve plant. The outstanding capital is £238,317. The result of the policy pursued by the borough in catering for the demands of power consumers during the past few years has been the conversion of a deficit of £1,542 in 1904-5 to a surplus of £574 in 1906-7, the acquisition of an additional stand-by of 1,044 kw. generating plant, the average reduction in price for power of 0·344d. per unit, and practical demonstration of the fact that existing undertakers can and are supplying energy at low rates with a sufficient margin of profit, which will be amplified when the plant is loaded up to its fullest extent.

Sunderland.—The annual report of the hon. consulting engineer (Mr. John F. C. Snell) and the borough electrical engineer and manager (Mr. Alfred S. Blackman), which was briefly referred to in our last issue, states that the number of consumers was 1,170, representing the equivalent of 425,683 8 c.p. lamps connected, compared with 1,120 consumers and 367,893 8 c.p. lamps in 1906, and the units of electric current sold were 7,577,517, against 6,159,954.

The maximum load was 4,286 kw., against 3,746 kw., the load factor 20·0 per cent. against 18·8 per cent., and the capital expended per kilowatt installed £51 against £51. 16s. The total capital expenditure was £351,828, against £326,494. Total revenue was £52,832, and total costs £32,119, leaving a gross profit of £20,713, against £21,404 in 1906. Interest on loans absorbed £10,503 and sinking fund £10,900, showing a net deficit of £690, against £1,429 profit for the previous year. The temporary deficit is accounted for by the large reduction in the prices to lighting consumers made in October last (amounting to a loss of income of £1,000), and the reduction to tramways and power users, resulting in a loss of revenue of over £3,000. Special expenditure on repairs to buildings and machinery, and delay in delivery of condensing plant at Hylton-road, also contributed to the deficit. The total costs (including 0·661d. per unit for interest and sinking) were 1·666d. per unit, against 1·784d. Motors of 10,031 H.P. are connected to the mains, compared with 8,480 in 1906.

In presenting the annual report of the tramways for the year ended March, the chairman (Mr. Geo. New) stated at the Council meeting on Wednesday that the total traffic revenue amounted to £67,847, an increase of £4,207.

The net profit had been £14,044, and £7,124 had been devoted to relief of rates.

Mr. NEW complained that the Tramways committee had to pay more than many other corporations for their electrical energy, the Electricity committee charging them 1⅛d. per unit against 1¼d. at Wolverhampton and other places.

Ald. BRUCE, chairman of the Electricity committee, said his committee had again and again reduced the price of electricity supplied to the tramways department. They had to provide special machinery for that particular service, and those machines could not be used for anything else. The report was adopted.

Taunton.—On Monday the Electricity committee reported that for the year ended March there was a net profit on the electricity undertaking of £335. 10s. after paying all charges, including interest and sinking fund, and setting aside £173. 14s. 1d. towards cost of motors purchased for hiring.

The chairman of the committee (Ald. Potter) stated that the report was very satisfactory, but owing to the state of his health he would not ask the council for a renewal of their confidence. Members expressed regret at the impending retirement of Ald. Potter, and acknowledged the good work he had done in connection with the electricity undertaking.

West Bromwich.—The capital expenditure on the electricity undertaking at March 31 was £69,405. 5s. 5d., an increase of £4,933. 12s. 5d. during the year.

The total revenue was £13,033. 5s. 4s., and total works and management costs were £6,369. 14s. 5d., the gross profit being £6,248. 0s. 5d. Interest required £1,494. 18s. 11d., and sinking fund £1,880. 3s. 6d., leaving a balance of £2,872. 18s., or, taking into account the motor hiring and assisted wiring departments, a net profit of £2,623. 17s. 9d., compared with £1,931 last year. 1,799,353 units of electric energy were sold, including 1,080,443 to the tramways department, 277,265 for private lighting, 334,721 for power and 106,924 for public lighting. The total maximum demand was 1,061 kw. Total working costs were 0·85d. per unit and total costs 1·3d. per unit. The connections of all consuming devices (including public lighting) amount to 36,388 8 c.p. lamps. There was an increase of 20 private consumers during the year, representing 5,956 8 c.p. lamps. The combined load factor for lighting and traction was 19·3 against 19·8 per cent., and the lighting and power load factor was 13·5 compared with 13·3 per cent.

The borough electrical engineer (Mr. W. A. Jackson), in his report, states that the hire-purchase department has not been active during the year. The installation work carried out consisted chiefly of wiring for hired motors and arc lamps, and had been paid for in cash by the consumers. During the year 33 additional arc lamps were hired to consumers, making a total of 92 lamps on hire (65 Davy, 15 Jandus and 13 Verity). At the beginning of the year 49 Nernst lamps were on hire, the present number being 40. 17 hired motors were added, making a total of 70, aggregating 304 H.P.

Wolverhampton.—The profit on the working of the tramways for the year ended March 31 was £2,190 (against £1,012 in 1906), reducing the aggregate deficit to £1,291. £5,300 has been contributed to renewals fund, and £11,266 has been paid for interest on and repayment of loans. The passengers carried increased from 8,844,424 to 9,276,023, and the car miles run from 950,338 to 966,133, Passenger receipts increased from £41,252 to £42,994, and receipts per car mile from 10·418d. to 10·680d.

Yarmouth.—The total income of the electricity department for the year ended March was £18,065. 18s. 1d., compared with £17,327. 16s. 7d. in 1905 6.

Total works cost was £10,225. 5s. 4d., leaving £7,840. 12s. 9d., out of which £2,558. 3s. 7d. was paid for interest, £3,341. 0s. 3d. for sinking fund, £223. 12s. 9d. granted as rebates, £181. 3s. paid in income tax and £418. 12s. given in discounts, leaving £1,118. 1s. 2d. With the balance forward the surplus is £4,638. 2s. 4d. £900 has been allocated in relief of rates and £1,000 transferred to reserve.

The electrical engineer (Mr. G. Bryant) and the borough accountant have been instructed to report upon a system of graduated discounts to large consumers, and Mr. Bryant has also been authorised to supply arc lamps on a maintenance scheme, the wiring, &c., to be sublet to local contractors.

At the meeting of the Council on Tuesday it was considered that the report was most satisfactory, and that the result reflected credit upon Mr. Bryant.

The traffic receipts of the tramways department amounted to £21,390, and with other receipts the total income was £21,902. 1s. 2d., compared with £18,328. 19s. 9d. in 1905-6. Working expenses were £14,270. 9s. 2d. To the electricity department £3,941. 16s. 3d. was paid for current, £3,376. 1s. 11d. was paid as interest, and £1,962. 4s. 9d. to sinking fund, leaving a net profit of £2,293. 5s. 4d. The amount brought forward was £252, making £2,545. 5s. 5d. available for appropriation. The Tramways committee resolved that £1,000 be voted to relief of rates and £1,500 to general reserve. The total number of passengers carried was 4,296,953.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

The Education committee of the borough of *Portsmouth* invite tenders for (1) electric machinery and accessories for dynamo rooms and accumulators for the electrical engineers' department, and (2) experimental compound steam engine and condenser, feed measurement tanks, gas engine and suction plant, oil engine, petrol motor and electrically-driven machine tools for the mechanical engineers' department. Specifications from the Principal of the Technical Institute, Arundel-street, Portsmouth. Tenders, addressed to the chairman of the Higher Education Committee, Technical Institute, Portsmouth, by Tuesday, July 2. See also an advertisement.

Portsmouth Town Council invite tenders for the supply, delivery and erection of one 1,000 kw. turbo-alternator, with condensing plant and accessories. Tenders to the town clerk (Mr. Alexander Hellard), Town Hall, Portsmouth, by noon 24th inst.

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Portsmouth Corporation want tenders by 10 a.m. 19th inst. for one or two years' supply of Durham rough small and North Country screened nut coal for the electricity department.

Newport (Mon.) Electricity and Tramways committee invite tenders for low tension switchboard, two motor alternators (d.c. to a.c., single-phase), one battery, extensions to switchboard gallery, cooling tower (steel) and battery reversing booster. Applications for specification to the borough electrical engineer and tramways manager (Mr. H. Collings Bishop, M.I.E.E.). Specification and drawings may be seen at the borough electrical engineer's office, and copies of the switchboard drawings may be had on payment of 7s. 6d. Tenders to the Town Clerk, Town Hall, Newport (Mon.) by first post July 1. See also an advertisement.

Clacton District Council are prepared to receive tenders for supply of two 25 kw. 500 volt dynamos, two existing 100 volt Taunton machines (which can be viewed on application to the resident engineer) to be taken in part payment; also for additions to switchboard. Specifications may be obtained from the consulting engineer (Mr. W. H. Trentham), 39, Victoria-street, Westminster, S.W. Tenders to the clerk (Mr. G. T. Lewis), Town Hall, Clacton-on-Sea, by noon July 3. See an advertisement.

The Electricity committee of *Stepney* (London) Borough Council invite tenders for supply during the year ending June 30, 1908, of (1) ampere-hour meters and demand indicators, and (2) arc lamp carbons. Specifications from the engineer and manager (Mr. Wm. C. P. Tapper, 27, Osborn-street, Whitechapel, E., where tenders must be delivered by July 1. See also an advertisement.

London County Council invite tenders for the manufacture of two 5,000 kw. three-phase turbo-alternators, with surface condensers, &c., to be delivered and erected at the tramways generating station, East Greenwich. Tenders, on official forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., to be sent in by 11 a.m. July 2.

Bradford Corporation want tenders by June 22 for supply of 375 tons of steel girder rails, 25 tons of fishplates, 8 tons of joint pieces, 92 steel poles and trolley wire. Specifications from City Surveyor.

Wednesbury Corporation want tenders by June 20 for supply of two 240-250 B.H.P. producer gas engines, each coupled to three-wire dynamo.

Weymouth Corporation want tenders by noon June 17 for Welsh smokeless, through-and-through large and small steam coal for the electricity department.

Manchester Electricity committee require tenders by noon June 18 for 12 months' supply of d.c. motors and motor starters, ampere-hour and watt hour meters and fuse boxes.

Tenders are wanted by 10 a.m. June 24 for electric lighting on the stage at the Central Club Society's premises, Clerkenwell-road, *London*, E.C. Specification, &c., from the Secretary.

Eastbourne Corporation want tenders by noon June 29 for water-tube boiler and steam, exhaust and circulating water piping for the electricity department.

Swindon Corporation want tenders by noon June 17 for the right of advertising on tramcars and tickets and supply of tickets and ticket punches.

Salford Electricity committee want tenders by 9 a.m. June 24 for 12 months' supply of coal. Forms of tender, &c., from the Borough Electrical Engineer.

Long Eaton Council want tenders by noon June 28 for engine and 500 kw. dynamo and accessories and water-tube boiler.

Warrington Electricity and Tramways committee want tenders by noon June 18 for supply of slack.

Darlington Corporation want tenders for a small extension of steam and exhaust pipes.

The Deputy Postmaster-General, *Sydney*, N.S.W., requires tenders by 2:30 p.m. Aug. 14 for the supply of telegraph, telephone and electric light material. Specifications, &c., from the General Post Offices, Sydney, Melbourne, Brisbane, Adelaide, Hobart and Perth, and from the Commonwealth Offices in London, 72, Victoria-street, S.W.

The Deputy Postmaster-General, *Perth*, Western Australia, will receive tenders until noon Aug. 6 for supply of a desiccating apparatus with motor-driven air pump for telephone cable work. Specifications, &c., from the General Post Offices, Melbourne, Sydney, Adelaide, Brisbane and Perth, and from the Commonwealth Office, 72, Victoria-street, London, S.W.

Tenders are invited for the supply of 438,000 flame and 24,000 ordinary carbons for the city of *Melbourne* (Australia). Specifications, &c., from the agents for the City Council (Messrs. McIlwraith, McEacharn & Co. Proprietary, Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon June 20.

TENDERS RECEIVED AND ACCEPTED.

Hammersmith (London) Council received the following tenders for the supply of cables:—

Western Electric Co. (*accepted*)	£2,254	18	11	British Insulated & Helsby Cables	£2,340	10	0
St. Helens Cable Co.	2,523	0	0	Johnson & Phillips	2,333	4	2
Callender's Co.	2,398	5	0	Rumney & Rumney	2,214	5	6
W. T. Henley's Telegraph Works Co.	2,366	3	4	Lahmeyer Electric Co.	2,122	9	3
Siemens Bros. & Co.	2,361	18	2	Union Cable Co.	1,973	1	7
W. T. Glover & Co.	2,359	0	10	Land and Sea Cable Works	1,949	3	0

In reporting upon the above tenders the Electricity Committee stated that the four lowest tenders were for foreign-made cables, whereas the quotation of the Western Electric Co. was for English-made cables, and as contracts placed by the Council with the Western Electric Co. in the past had been executed with entire satisfaction, the committee had accepted that company's tender.

Mason's Gas Power Co. have recently obtained the following contracts:—

For new works of Schoen Steel Wheel Co. (Leeds), "Duff" producers, "Weardale" furnaces and steel chimneys.

1,500 B.H.P. power gas plant (to order of Mather & Platt) for South Wales, to use cheap bituminous slack.

For works of Cape Copper Co. (South Wales), "Duff" producers, coal bunkers, &c.

Also "Duff" producers, with accessories, for Brown, Bayley's Steel Works (Sheffield), Latch & Batchelor (Birmingham), Consett Iron Co. (Durham), a shipment of "Duff" producers to Japan, and suction-gas plant to the Mansourah Electric Supply Co. (Egypt).

Coventry electricity department has accepted the tender of Ed. Bennis & Co., of Little Hulton, Bolton, and 28, Victoria-street, London, S.W., for mechanical coal and ash-handling plant, with overhead coal and ash bunkers and automatic weighing apparatus, at £3,279. A repeat order has also been placed by the Corporation with this firm for six chain-grate stokers (Bennis-Miller-Bennett patents). The work is to be completed by August.

Hackney (London) Council have accepted the tender of Rose & Co. for Granville and Exhall mixed coal and Staffordshire slack at 10s. per ton, that of Phillips & Co. for West Hallam nutty slack at 12s. 6d., and that of Kaye, Son & Co. for Norton Cannock seconds at 13s. 6d.

Southwark (London) Council received 21 tenders for wiring, &c., the Old Kent-road library, ranging in amount from £191. 5s. to £301, and that of W. G. Cannon & Sons, at £240. 11s., has been provisionally accepted.

Messrs. Bruce Peebles & Co., Edinburgh and London, have received an order from Krugersdorp (South Africa) municipality for six generators, being the electrical power plant for the new municipal lighting scheme.

The tender of A. W. Penrose & Co. (at £461. 15s.) has been accepted by the London County Council for providing an electrically driven goods and service lift for the Day Training College at Holborn.

Colne Council have accepted the tender of Dick, Kerr & Co. for a generating set at £2,350, and that of Galloways Limited for a boiler at £670.

A contract has been placed by the War Office with the Bryant Trading Synd. for ordinary Royal glow and patent Royal glow switch lamps.

Warrington Council have accepted the tender of McDowell Limited for six tramcar covers at £85 each.

Wallasey Council have accepted the tender of Dryland & Preston for extensions of the tramcar sheds at £5,415. 13s.

The Felixstowe Council have accepted the tender of Whipp & Bourne for a switchboard at £579. 4s.

Derby Electricity committee have accepted the tender of Johnson & Phillips for supply of Peterson's vulcanised bitumen cables.

Bristol Docks committee have accepted the tender of Royce Limited for two electric capstans.

West Ham Electricity committee have placed an order with the Fuller Electrical Co. for two rotary converters at £625.

Hammersmith Council have placed a contract for 6,000 tons of through-and-through coal at 18s. per cwt.

West Ham Corporation have accepted the tender of W. Lucy & Co. for the annual supply of house cut out boxes at 2s. 5½d. each.

Machine Stoking.—Is machine stoking economical? A convincing answer to this question is to be found in the list of orders secured during the last six weeks by Ed. Bennis & Co. for their machine stokers and self-cleaning compressed air furnaces. The manufacturers represented in the list include electricity supply works, colliery proprietors, cement manufacturers, flour millers, cotton manufacturers, silk spinners, &c., and more than 60 per cent. are repeat orders:—

Carlton Main Colliery Co. (Frickley Colliery), 12 stokers and c.a.f. to Lancs. boilers, and complete coal and ash-handling plant (repeat); A. Thompson & Sons (Rochdale), two stokers and camel furnaces; W. Ingham & Sons (Padisham), two stokers and c.a.f.; MM. Bouchon

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(Nassandras, France), two stokers and c.a.f. (repeat); Weaver & Co. (Swansea), one double stoker and c.a.f. (repeat); Handforth Bleaching Co., six stokers and c.a.f.; Greaves, Bull & Lakin (Stockton, Rugby), two stokers and c.a.f.; T. Gillibrand & Sons (Darwen), one double stoker and c.a.f. (repeat); Tootal, Broadhurst & Lee (Bolton), one double stoker and c.a.f. (repeat); J. Pullar & Sons (Perth), one double stoker and c.a.f.; S. Courtauld & Co. (Coventry), one stoker and c.a.f. (repeat); Coventry Corporation, mechanical coal and ash-handling plant with overhead coal and ash bunkers and antomatic weighing apparatus; also a repeat order for six Bennis-Miller-Bennett chain-grate stokers.

BUSINESS NOTICES.

The works of the Metallic Seamless Tube Co., Birmingham, will be closed for annual stocktaking from June 29 and will re-open July 8.

Messrs. W. F. Dennis & Co., 49, Queen Victoria-street, London, E.C., have been appointed sole agents in the United Kingdom and the Colonies for "Kryptol," a material largely used in electric heating apparatus for domestic, industrial and laboratory purposes, &c. Telegrams, "Fredennis London"; telephone, 343 Bank. (For a description of "Kryptol" see *The Electrician* for Nov. 17, 1905, p. 180, and Feb. 9, 1906, p. 689.)

The head office of the British Aluminium Co. has been removed to 109, Queen Victoria-street, E.C. Telephone, 4,315 London Wall (three lines).

Messrs. Mawdsley's (Ltd.) Zone Works, Dursley, Glos., have appointed Messrs. Pooley & Austin, 25, Victoria-street, S.W. (telephone 3,373 Victoria, telegrams "Octopede") sole London agents for the sale of their patent Zone dynamos and motors.

The business of C. Jost & Co., electrical engineers, Bombay, will in future be carried on by Jost's Fans Supply & Engineering Co., Ltd., of which Mr. C. Jost is managing director.

BANKRUPTCIES, LIQUIDATIONS, &c.

A receiving order has been made against Richd. Sutcliffe Blackburn, electrical engineer and contractor, Osborne-street, and Ribstone Works, Hebden Bridge.

Weldite (Ltd.) is being wound up voluntarily. Mr. G. B. George, 11, Lansdowne-road, W. Didsbury, near Manchester, is liquidator.

Sale by Auction.—By order of the Welsh Crown Spelter Co., Mr. Geo. N. Dixon will sell by auction on *Monday next*, 17th inst., at 3:30 p.m., at the Law Association Rooms, Cook-street, Liverpool, the whole interest in the Welsh Crown Spelter Co.'s blende and lead mines, which are situate about 3½ miles from Trefriw, on the Foxdale and Cymanog estate, subject to royalties varying from one-twelfth to one-twenty-fifth. The property consists of about 1,000 acres, and is well equipped with pumping, transport and dressing plant and ample water power for all purposes. Further particulars from the auctioneers, 89, Hanover-street, Liverpool. See also an advertisement.

Agents Required.—Mr. Carl Cordes, Magdeburg, Germany, advertises that he requires a sole agent for Great Britain for his insulating compounds, filling-in compounds, &c.

An agent is wanted by a German founder of brass sheets and wire, especially used for the manufacture of lamp fittings, hooks and eyes, pins, &c.

Ames' Tarmaciser.—We have received from Tarmaciser (Ltd.) a sheet containing illustrated particulars of Ames' patent tarmaciser, for which it is claimed that it is the only apparatus on the market which fulfils all the conditions necessary for the proper application of tar to roads. The particulars supplied are interesting.

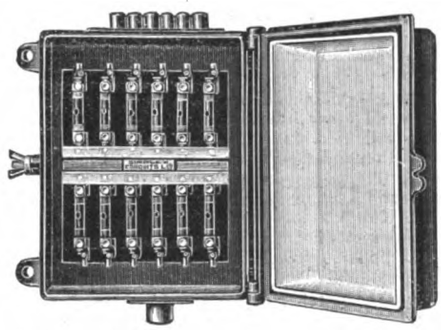
CATALOGUES, &c.

Regenerative Control.—We have received from Raworth's Traction Patents (Ltd.), 2, Queen Anne's-gate, London, S.W., a copy of a pamphlet describing in simple language the advantages of regenerative control.

Sirocco Fans.—We have received from Messrs. Davidson & Co. (Ltd.), Sirocco Engineering Works, Belfast, a copy of their bulletin No. 2,003A, dealing with "Sirocco" electric propeller fans for direct and alternating currents. The "Sirocco" electric propeller fans, which are well known in engineering circles, are built in a number of different sizes, with capacities varying from 880 to 43,000 c.f. of air per min., and are supplied with direct or alternating-current motors, suitable for connecting up to circuits of standard voltages and periodicities. The bulletin contains much information about "Sirocco" fans, and includes prices, tables of capacities, approximate dimensions, weights, &c.

Large Telephone Exchanges.—A booklet has been issued by the British Insulated & Helsby Cables (Ltd.) showing, in a series of excellent illustrations, a large number of trunk or toll line exchanges erected by the company for the Post Office, and also of several exchanges of the National Telephone Co., including a fine general view of the National Co.'s Birmingham exchange. The booklet gives a good idea of the company's experience in this special branch of work, and of the facilities which the company possesses for handling this class of manufacture. It is well stated in the booklet that "these large telephone exchange equipments are rarely seen by the general public, either during the process of manufacture or in operation, and consequently few people realise the vast amount of intricate detail work and engineering skill involved in their design and construction."

Simplex Water-tight Ironclad Fuseboard.—A new type of fuseboard has been introduced by Simplex Conduits (Ltd.) and is claimed to be worthy the attention of electrical engineers who are anxious that all material they instal is of the highest possible class, as the board has several features in design which go to make it the highest grade distributing board on the market. The cast-iron box has a deep cover which is fitted with a flange and rubber band in order to obtain a watertight job when closed, and front connections are arranged for throughout. The fuses are the company's patent "Blotter" type and are fitted with end shields to prevent any accidental contact when replacing. The two poles, mounted on separate slate bases, are fixed to the case through insulating battens so that at no place is the slate less than 1¼in. away from the iron case, in this way obviating surface leakage and any chance of an arc on to the cover. The boards are made in all sizes up to eight-way, and a glass inspection front can be provided if desired. The appearance of the board is shown by the accompanying illustration, and we believe that every care has been exercised in its design to produce a perfect article both electrically and mechanically.



"SIMPLEX" WATER-TIGHT IRONCLAD FUSEBOARD.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during May, 1907, and (*b*) during the current year from Jan. 1 to May 31, with the increases or decreases compared with the corresponding periods of 1906:—

Electrical machinery, (*a*) £50,706 (increase £19,835), (*b*) £245,076 (increase £11,975); telegraph and telephone cables, (*a*) £21,252 (increase £5,136), (*b*) £142,922 (increase £73,086); telegraph and telephone apparatus, (*a*) £23,393 (decrease £15,981), (*b*) £152,516 (decrease £46,066); other electrical wires and cables: rubber insulated, (*a*) £5,984 (increase £1,145), (*b*) £41,412 (increase £8,093); with other insulations, (*a*) £3,295 (decrease £714), (*b*) £34,745 (decrease £1,433); other electrical goods and apparatus, (*a*) £43,552 (increase £6,785), (*b*) £221,423 (increase £12,929). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £97,476 (decrease £3,629), (*b*) £546,952 (increase £46,609).

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from June 5 to 11, with the ports of destination:—

Africa—Alexandria, £327 (including £59 telegraph material); Delagoa Bay, £235; Durban, £49. *Argentina*—Buenos Ayres, £6,017 (telegraph material); Rosario, £1,267 (telegraph material). *Australasia*—Adelaide, £352; Brisbane, £118; Christchurch, £12; Fremantle, £472; Lyttelton, £64; Melbourne, £499; Otago, £140; Perth, £111; Sydney, £1,934 (including £107 telegraph material); Wellington, £250. *Belgium*—Brussels, £151; Ghent, £77; Ostend, £104. *British Guiana*—Demerara, £16. *Burma*—Rangoon, £32. *Canada*—Toronto, £2,013. *Ceylon*—Colombo, £68. *China*—Shanghai, £540. *Denmark*—Copenhagen, £113. *France*—Boulogne, £100; Le Treport, £65. *Germany*—Bremen, £6 (telegraph material); Dusseldorf, £8. *Greece*—Piraeus, £20. *Holland*—Amsterdam, £98; Rotterdam, £421. *Hong Kong*, £154. *India*—Bombay, £204; Calcutta, £1,656; Madras, £364. *Italy*—Genoa, £562. *Japan*—Kobe, £851; Nagasaki, £557; Yokohama, £1,314. *Malta*, £13. *Mauritius*, £140. *North Atlantic*, £7,950 (telegraph cable). *Norway*—Christiania, £1,949. *Portugal*—Lisbon, £7. *Straits Settlements*—Penang, £130; Singapore, £53. *Sweden*—Gothenburg, £200; Malmo, £1,242 (including £800 telegraph material). *Turkey*—Constantinople, £80. *Uruguay*—Monte Video, £10. *U.S.A.*—Boston, £114; New York, £67. Total, £33,296, against £23,355 for six days last year (June 7 to 12).

According to official returns for May, 1907, the value of electrical goods and apparatus (other than machinery and telegraph and telephone wire) exported from the United Kingdom was £129,334, compared with £130,468 in the corresponding month of 1906 and with £151,083 for May, 1905, a decrease of £1,134 compared with 1906 and a decrease of £21,749 compared with 1905. For the five months of 1907 the total value of these goods was £767,979, compared with £958,488 for 1906 and with £801,557 in 1905, showing decreases of £190,509 and £33,578 compared with 1906 and 1905 respectively. The value of electrical machinery exported in May, 1907, was £78,095, compared with £88,992 in May, 1906, and £72,758 in May, 1905, a decrease of £10,897 compared with May, 1906, and an increase £5,337 over May, 1905. The total value of electrical machinery for the five months ended May 31, 1907, was £381,076, compared with £360,586 in 1906 and £274,583 in 1905, increases of £21,490 and £106,493 respectively.

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COMPANIES' MEETINGS AND REPORTS.

ALTRINCHAM ELECTRIC SUPPLY (LTD.)—At the annual meeting last week, Mr. H. Wolfenden moved the adoption of the report, which showed that the progress of business up to the end of 1906 had been satisfactory. Of the year's profits, after meeting loan and debenture interest, the directors proposed to put £2,000 to reserve for depreciation, and to recommend a dividend of 5 per cent. on the ordinary shares. The motion was agreed to.

FELTEN & GUILLEAUME-LAHMEYERWERKE A.G.—The directors report for 1906 states that all departments were fully occupied throughout the year. There was an increase in the orders of about 25 per cent. over the previous year, and the profit was 15,022,820m. (about £751,141), compared with 12,052,935 m. (£602,647) in 1905. Notwithstanding the increase of capital during the year a dividend of 11 per cent. was declared, compared with 10 per cent. The company has acquired a controlling interest in the Maschinenfabrik von Escher, Wyss & Co., Zürich and Ravensburg.

LISBON ELECTRIC TRAMWAYS (LTD.)—The report for 1906 states that after payment of debenture and other interest, and other expenses, the net profit was £96,118; added to £16,096 from last year, £112,213. £35,000 is placed to depreciation and £5,000 to exchange reserve account. The available balance (£72,213. 19s. 2d.) is applied to paying preference dividend (£25,533. 3s. 8d.), and a dividend of 5 per cent. for the year on the ordinary share capital (£29,709. 8s.), leaving £16,971. 7s. 6d. to be carried forward. Capital expenditure of £47,000 was incurred for the completion of new lines, additions to power plant, and increased rolling stock.

MADRAS ELECTRIC SUPPLY CORPORATION (LTD.)—The directors' report for 1906 states that the site for the generating station has been acquired, the erection of the buildings is progressing, and the contractors have made a satisfactory commencement of the work of laying the mains. In consequence of pressure in the demands for current, temporary plant has been purchased and forwarded to Madras, where it is expected to be erected and set to work in the course of the present month. The directors have ordered a number of electric fans, which it is proposed to hire out or to sell at moderate prices. From the number of enquiries which have been received the directors have every confidence in the future success of the corporation,

SHEERNESS & DISTRICT ELECTRIC POWER & TRACTION CO. (LTD.)—The report for 1906 states that the receipts from the light railways amounted to £3,206 and from electricity supply to £2,939. Expenses (including interest) amounted to £6,683, a loss of £498. The debit balance is now £676. The capital expenditure is £64,800. Owing to reduction of staff at the dockyard traffic receipts on the light railways were adversely affected, and notwithstanding efforts to reduce expenses the result has been disappointing. Excluding the traction demand, there has been an increase of £107 in the sum received from sale of current, and the installations connected to the mains represent the equivalent of 9,017 8 c.p. lamps, compared with 7,120 at the end of 1905. Arrangements have been made with leading manufacturers in Queenborough to use electricity in place of steam power, and the directors decided to extend the mains and to make the necessary additions to the power house. These extensions are expected to be in operation by the end of July.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

ROTHWELL'S PATENTS SYND. (LTD.) (93,634.)—Reg. June 6, capital £2,000 in £5 shares, to acquire from E. Rothwell the benefit of certain existing inventions relating to improvements connected with electric railways working on the third rail or surface-contact system, and to carry on the business of electrical and general engineers, dealers in wires, cables and lines, suppliers of electricity, manufacturers of electrical apparatus, &c. First directors, B. C. Law, J. Stone, S. B. Ambler, M. B. Mountain, G. M. Gibson, J. C. Hearne, G. Ross, R. Jackson, J. E. Muir and O. O. Rothwell.

"Z" ELECTRIC LAMP SYND. (LTD.) (93,625)—Reg. June 5, capital £56,000 in £1 shares (36,000 A and 20,000 B), to adopt an agreement with A. Schmitz, H. Petitidier and A. R. Norbert, and to carry on the business of manufacturers and vendors of and dealers in incandescent lamps and component parts thereof, makers of and dealers in electrical apparatus, fittings and plant, dealers in scientific apparatus, &c. First directors, J. G. B. Stone (chairman), F. R. Reeves and A. R. Norbert. Reg. office, 20, St. Helen's-place, London, E.C.

STATUTORY RETURNS.

BRITISH RAILWAY TRAFFIC & ELECTRIC CO. (LTD.)—In return to April 8 capital is £100,000 in £1 shares, of which 70,000 have been taken up. £1 per share has been called up on 100 and 10s. per share on 69,900, and £35,050 has been received. Mortgages and charges, nil.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—Return to March 27 (filed April 29) gives capital as £1,200,000 in £10 shares (40,000 preference), of which 70,595 ordinary and 40,000 preference have been taken up. £10 per share has been called up, resulting in the receipt of £1,105,950. Mortgages and charges, £800,000.

GENEVA TRAMWAYS CO. (LTD.)—The capital in return to April 2 (filed May 6) is £550,000 in £1 shares, of which 453,390 have been taken up. £453,390 is considered as paid. Mortgages and charges, £300,000.

GENT & CO. (LTD.)—The capital in return to May 6 is £50,000 in 20,000 preference and 30,000 ordinary shares of £1 each, of which 4,427 preference and 20,876 ordinary have been taken up. £1 per share has been called up on 957 preference and 5,930 ordinary and £6,887 has been received. £18,416 is considered as paid. Mortgages and charges, £20,500.

HOWARD ASPHALT TROUGHING CO. (LTD.)—According to return to April 4 capital is £20,000 in £1 shares (1,000 deferred), of which 1,007 ordinary and 1,000 deferred have been taken up. £7 has been paid and £2,000 is considered as paid. Mortgages and charges, nil.

LAURENCE, SCOTT & CO. (LTD.)—Return to April 10 gives capital as £50,000 in 50 shares of £1 each and 4,995 shares of £10 each, of which 45 £1 and 2,106 £10 shares have been taken up. £1 per share has been called up on 45 and £10 per share on 723 shares, and £7,275 has been received. £13,830 is considered as paid on 1,383 £10 shares. Mortgages and charges, £22,200.

WITNEY ELECTRIC SUPPLY CO. (LTD.)—In return to April 8 the capital is £10,000 in £1 shares (5,000 preference), of which 2,849 preference and 2,802 ordinary have been taken up. £1 per share has been called up on 2,829 preference and 1,802 ordinary, and £4,629. 2s. 6d. has been received, leaving £21. 17s. 6d. in arrears. A further £3. 2s. 6d. has been paid on 25 forfeited shares. £1,000 is considered as paid on 1,000 ordinary. Mortgages and charges, £3,500.

MORTGAGES AND CHARGES.

D. SANTONI & CO. (1906) (LTD.)—Issue on June 3 of £1,650 6 per cent. debentures, part of series created May 21, 1907, to secure £2,750, charged on company's undertaking and property, present and future, including uncalled capital. Holder, Mrs. M. I. Power. No trustees. No previous issue of same series. A memorandum of satisfaction in full of a mortgage debenture bond dated Feb. 25, 1907, securing £1,000, has also been filed.

CITY NOTES.

MEMORANDA (June 13).—**Bank rate 4 per cent. (since April 25, 1907). Price of silver** 30$\frac{1}{16}$d.—**31d. per oz. Consols** 83$\frac{1}{8}$—83$\frac{1}{8}$ **for money,** 83$\frac{1}{8}$—84$\frac{1}{16}$ **for account; 2$\frac{1}{2}$ per cent. annuities** 82$\frac{1}{4}$—82$\frac{3}{4}$. **Consols Pay Day, July 3; Stocks and Shares Continuation Days, June 25 and July 10, Ticket Days, June 26 and July 11; Pay Day, June 27; Mining Share Carry-over Day, June 24.**

AKKUMULATORENFABRIK AKTIENGESELLSCHAFT (Berlin and Hagen).—A dividend of 12$\frac{1}{2}$ per cent. has been declared for the past year.

BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LIMITED AND REDUCED).—A petition to confirm the reduction of the capital of this company from £3,250,000 to £1,875,000 will be heard by Mr. Justice Swinfen Eady on July 2.

CANADIAN GENERAL ELECTRIC CO.—The directors have declared the usual quarterly dividend of 2$\frac{1}{2}$ per cent.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and register of holders of the 5 per cent. first debenture and the 4$\frac{1}{2}$ per cent. second debenture stock will be closed from 17th to 30th inst. inclusive.

COMPAGNIE EGYPTIENNE THOMSON-HOUSTON (SOC. ANON.)—This company was recently formed in Brussels by the Cie. d'Electricité Thomson-Houston de la Mediterranée with a capital of 5,000,000fr. for the exploitation and development of the Thomson-Houston patents in Egypt.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The transfer books and register of holders of the debenture stock will be closed from 17th to 29th inst. inclusive, preparatory to the payment of interest due July 1.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The following dividends have been declared for the past four months: 4s. per share (less tax) on the preference shares, making, with previous distribution, a total dividend on those shares at the rate of 6 per cent. per annum (less tax) for the period of 13 months, and 6s. 2d. per share net on the ordinary shares, making, with previous distributions, a dividend of 5$\frac{3}{4}$ per cent. net for the year, which formerly ended April 30, plus 8d. per share in respect of May, representing one-third of the interim dividend of 2s. usually paid in the first quarter of the new financial year, carrying forward £26,000.

INTERNATIONALE ELEKTRIZITÄTS GESELLSCHAFT (VIENNA).—For 1906 a dividend of 8 per cent. has been declared.

STOCK EXCHANGE NOTICES.—The Stock Exchange Committee have been asked to appoint a special settling day in a further issue of 175,000 £1 fully-paid preference shares of the *Victoria Falls Power Co. (Ltd.)* and to allow a further issue of £11,000 5 per cent. debenture stock of the *Madras Electric Tramways (1904) (Ltd.)* to be quoted in the official list.

R. WAYGOOD & CO. (LTD.)—The directors recommend a further dividend at the rate of 7 per cent. per annum for the six months ended March 31, making 6 per cent. for the year on the ordinary shares.

WESTERN TELEGRAPH CO. (LTD.)—The directors on Wednesday declared an interim dividend (payable on June 24) of 3s. per share, or at the rate of 6 per cent. per annum, tax free, for the quarter ended March 31. The transfer books will be closed from June 17 to 22 inclusive.

YORKSHIRE (WEST RIDING) TRAMWAYS CO. (LTD.)—A circular has been issued to the shareholders stating that, in view of the completion of the Normanton, Castleford and Pontefract tramway and for paying the balance due to the contractors, the company require to raise about £30,000. The board anticipates being able to arrange this at 6 per cent. per annum, they or some of them proposing to lend a part of it. The net profit for 1907 is anticipated to be not less than £25,000, of which £12,375 is required for debenture interest.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 5	917	...	‡1	947	...
Airdrie	May 31	237	+ 7	21	4,726	+ 25
Anglo-Argentine	June 10	16,522	+ 1,474	23	380,327	+ 34,744
Ashton-under-Lyne Corp	,, 8	359	- 150	11	4,299	+ 491
Ayr Corporation	,, 8	282	- 43	4	986	- 46
Baker St. & Waterloo Ry.	,, 8	2,450	+ 1,006	12	30,780	+ 11,933
Barnsley	May 31	144	- 23	21	3,423	- 19
Barrow	,, 31	278	+ 37	21	4,878	+ 147
Bath Electric Trams, Ltd.	June 5	780	- 507	23	16,700	+ 31
Birkenhead Corporation	...	...	...	...	...	...
Birmingham Corporation	,, 8	5,931	...	10	59,018	...
Birmingham & Mid.	May 24	1,188	...	20	15,822	...
Blackburn Corporation	June 5	954	- 509	§10	11,630	+ 755
Blackpool Corporation	,, 6	710	- 1,543	9	8,409	+ 161
Blackpool and Fleetwood	,, 8	408	- 1,505	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 9	2,327	- 492	10	22,591	+ 850
Bournemouth Corporation	,, 5	1,497	- 764	¶9	15,914	+ 97
Bradford Corporation	,, 8	4,487	- 2,367	10	45,906	- 458
Brighton Corporation	,, 9	837	- 561	10	8,823	- 755
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 7	4,952	- 2,499	17	83,003	- 3,801
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 8	1,173	- 407	10	10,862	- 156
Burton Corporation	,, 9	294	- 99	10	2,829	- 226
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	,, 8	R16,510	+ R2,615	22	R1,135,243	+ R18,488
Camborne-Redruth	,, 8	119	- 80	23	2,637	+ 60
Cardiff Corporation	,, 8	2,058	- 856	10	20,596	+ 16
Cavehill	May 31	90	- 1	21	1,563	+ 76
Central London Railway	June 8	5,795	- 301	23	140,340	- 14,479
Chatham & Dist. Lt. Rys.	,, 6	695	- 258	¶22	15,076	+ 1,011
City & South London Rly.	,, 9	3,102	+ 669	23	68,156	† 3,079
City of Birmingham	May 31	2,912	...	21	58,285	...
Colchester Corporation	June 5	196	- 125	...	...	...
Cork Electric Trams Co.	,, 6	482	- 91	23	9,778	- 231
Croydon Corporation	,, 7	1,380	- 743	‡10	13,920	- 1,085
Devonport & Dist. Trams	May 31	446	+ 28	21	9,393	+ 231
Dover Corporation	June 8	216	- 128	10	2,181	- 227
Dublin & Lucan Railway	,, 7	112	+ 82	23	2,351	- 14
Dublin United	,, 7	5,723	- 655	...	114,488	+ 6,735
Dudley Stourbridge	May 31	755	- 56	21	17,537	+ 520
Dundee Corporation	June 5	1,078	- 41	3	3,312	+ 112
East Ham Council	,, 8	883	- 402	10	9,058	- 317
Exeter Corporation	,, 7	304	- 118	10	3,098	+ 276
Falkirk and District	,, 5	259	...	10	2,850	...
Gateshead & Dist. Trams	May 31	957	- 27	21	20,912	+ 864
Glasgow Corporation	June 8	17,220	- 1,480	1	17,220	- 1,480
Glossop	,, 8	126	- 48	23	3,099	+ 66
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	May 31	232	- 6	21	4,843	+ 224
Great Northern & City Rly.	June 8	1,759	+ 59	23	41,825	+ 151
Gt. Northern, Piccadilly, &c.	,, 8	4,310	...	23	89,529	+ 2,92
Greenock & Port Glasgow	May 31	765	+ 85	21	13,490	+ 263
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 31	257	- 53	21	5,519	- 204
Hastings Elec. Trams Co.	June 6	905	+ 320	23	19,557	...
Hong Kong	,, 8	$7,668	+ $595	10	$176,478	...
Huddersfield	,, 8	1,525	- 653	10	15,748	+ 438
Hull Corporation	,, 8	2,371	- 203	10	23,511	+ 1,237
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 5	131	- 74	10	1,406	+ 122
Ipswich Corporation	,, 8	387	- 310	10	3,829	- 352
Isle of Thanet Co.	,, 8	510	- 451	36	11,615	+ 156
Jarrow	May 31	109	...	21	2,453	...
Keighley Corporation	June 6	151	- 65	49	7,406	+ 531
Kidderminster & District	May 31	98	- 4	21	2,189	+ 59
Kilmarnock Corporation	June 8	147	- 14	3	570	+ 9
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 6	1,153	+ 141	23	24,699	+ 5,198
Lancashire United	,, 5	1,124	- 37	23	26,848	+ 7,721
Leamington	May 31	170	- 12	21	3,106	- 27
Leeds Corporation	June 1	5,941	- 211	9	57,737	+ 4,430
Leicester Corporation	,, 8	2,208	- 858	23	50,282	+ 1
Leith Corporation	...	...	...	...	...	...
Lincoln Corporation	,, 8	118	- 53	10	1,137	- 73
Liverpool Overhead Rly.	,, 9	1,434	- 345	23	32,900	+ 388
Liverpool Corporation	,, 1	11,064	+ 200	22	231,607	+ 4,745
*London County Council	,, 1	30,810	+ 6,849	9	273,147	+ 40,984
London United	,, 7	6 283	- 1,769	‡23	132,682	+ 2,630
Lowestoft	,, 9	174	- 31	36	5,599	+ 753
Maidstone Corporation	,, 8	102	- 47	10	1,018	- 49
Manchester Corporation	,, 8	14,370	- 3,573	10	144,419	+ 12,243
Mersey Railway	,, 8	1,827	- 89	23	42,153	+ 2,097
Merthyr	May 31	265	+ 6	21	4,380	+ 329
Metropolitan Dist. Railway	June 9	8,182	- 175	23	180,973	- 4,062
Metropolitan Elec. Trams	May 31	4,557	+ 1,170	21	88,857	+ 21,837
Middleton	,, 31	552	+ 217	21	7,189	+ 468
Nelson Corporation	June 8	131	- 59	11	1,576	+ 45
Newcastle-on-Tyne Corp.	,, 8	4,066	- 265	10	40,328	+ 781
Newport (Mon.)	,, 8	1,504	+ 6.2	10	7,591	+ 1,184
Northampton Corporation	,, 7	411	- 299	‡10	4,240	- 160
Oldham, Ashton & Hyde	May 31	688	+ 139	21	12,611	+ 976
Oldham Corporation	June 9	1,892	- 289	11	21,235	+ 1,577
Perth (N.B.) Corporation	,, 5	176	- 10	3	488	+ 12
Perth (W.A.) Elec. Trams	,, 7	1,355	- 79	23	33,584	- 922
Peterborough	May 31	105	- 13	21	2,424	† 76
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	June 8	1,869	- 1,110	10	18,807	- 439
Potteries	May 31	1,833	- 17	21	39,275	+ 957
Preston Corporation	June 5	701	- 473	10	7,507	+ 115
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 6	569	- 233	†10	5,663	+ 713
Rothesay	May 31	148	+ 16	21	2,051	+ 43
Salford Corporation	June 10	4,833	- 1,666	10	47,628	+ 817
Sheerness	May 29	56	- 2	21	1,092	- 5
Sheffield Corporation	June 9	5,641	- 976	11	60,255	+ 2,186
Singapore Trams	,, 8	$8,957	+ $1,136	10	$97,823	+ $16,979

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	June 5	1,16[illegible]	- 85	...	...	...
Southend Corporation	,, 5	335	- 234	10	3,359	- 163
South Metropolitan	May 31	772	...	21	15,295	...
Southport Tramways	,, 31	390	+ 99	21	5,502	+ 97
South Staffs	,, 31	794	+ 27	21	18,858	+ 1,842
Stalyb'dge, Hyde, &c., Jt. Bd	June 8	731	- 446	10	7,927	+ 181
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	...	...	...	...	...	...
Sunderland and District	,, 5	421	- 242	23	9,648	+ 1,195
Swansea Trams	May 31	863	+ 77	21	17,466	+ 846
Swindon Corporation	June 5	153	...	...	...	...
Taunton	May 31	41	- 2	21	863	- 46
Tynemouth and District	,, 31	191	- 46	21	3,803	- 267
Tyneside Trams Co.	June 5	388	- 264	23	9,3o1	+ 581
Victoria, Elec. Supply Co. of	May 5	821	+ 80	6	6,013	+ 624
Warrington Corporation	...	...	...	...	...	...
Wallasey District Council	June 8	807	- 328	10	8,073	+ 176
Walsall Corporation	,, 8	506	- 288	23	11,017	- 566
West Ham Corporation	,, 6	2,169	- 701	10	23,689	+ 850
Weston-super-Mare	May 29	134	+ 40	21	1,358	+ 220
Wolverhampton Co.	,, 31	407	+ 5	21	9,312	+ 670
Wolverhampton Corpn.	June 5	801	...	20	17,396	...
*Worcester	May 31	269	- 1	21	5,438	+ 51
Wrexham	,, 31	96	+ 3	21	2,072	+ 16
Yorkshire W.R. Trams	June 9	1,207	- 282	23	25,486	...
Yorkshire Woollen District	May 31	870	- 51	21	19,886	+ 1,508

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., June 12.	Rate % Yield-ed.	Dividend Due.	Business Week to June 12. High-est.	Business Week to June 12. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	7⅞—8⅛	4 15 6	Ap, Oct	8⅛	7⅞
5	2/9	Do. 5½ per Cent. Cum Pref.	5¾—6	4 12 0	Ja, Jul	5⅞	5¾
St.	6%	Do. Permanent 6% Deb. Stock	135—136	4 8 8	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	101 —107	4 13 6	Ja, Jul	..	..
5	2/0	†Brisbane Electric Trams. Invest. Ord.	2⅞—3⅛	3 4 0	May ..	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	4½—5	5 0 0	My, Nv	4⅝	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	98 —102	4 8 0	Ja, Jul	9⅞	..
St.	7%	British Columbia El. Ry. Df. Ord.	123 —127	4 14 8	Mr, Spt	124½	124
St.	5%	† Do. Pref. Ord. Stock	103½—108½	4 12 0	My, Nv	106½	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	102 —1 6	4 14 3	Ja, Jul	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	99 —101⅞	4 8 0	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	103 —105	4 5 6	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	3⅜—4⅛	8 12 6	Ap, Oct	4	3⅞
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4⅛—4⅜	5 11 6	Ap, Oct	..	..
5	3/0	Do. "B"	4½—5½	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	Ju, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	98 —101	4 19 0	Ja, Jul	..	..
10	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	100 —104	5 5 9	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	106 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7½—8	5 0 0	Mr, Spt	7¼	7⅛
100	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5½	4 7 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	104 —107	4 4 0	Ja, Jul	105½	105
St.	..	Cape Electric Tram Shares	⅜ ½	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —100	5 0 0	My, Nv	98	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 —90⅞	5 11 0	Fb, Aug	..	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	91 —95	5 5 0	Ja, Jul	..	..
		Do. 6 per Cent. "B" Ditto	81 - 85	7 1 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅞	3 9 6	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅞	5 1 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	98 —101	4 19 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	93 —101	4 19 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	102 —104	4 6 6	Fb, Aug	..	..
St.	4%	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	Ja, Jul	103	102
..	$%	Sao Paulo Tramway, Light & Power Co. $100 Stock	123 —128	3 2 6	..	..	..
..	5%	† Do. 5 per Cent. 1st Mt. $500 Db	92⅝—94⅞	5 6 6	Ju, Dec	93½	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¾—5¼	5 14 0	Mr, Spt	..	..
10	3/1¼	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8⅛	5 15 0	..	8⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 —98	4 11 9	Ja, Jul	96½	96½
5	5/3	Calcutta Elec. Supply Ord.	7½ - 8½	5 2 0	Ap, Oct	8⅛	..
5	2/3	Do. £4 paid	6 —7	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2¾	..	Fb, Aug	..	..
		Do. 5 per Cent. Deb Stock	88 —92	5 8 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	97 - 99	5 1 0	Ja, Jul	98	97¾
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 —109	5 10 0	Ja, Jul	..	..
1	0/3⅓	†Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	34 - 37	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½—97½	5 2 6	Ap, Oct	97½	94½
1.	1/6	Rand Electric	1⅝—1⅞	..	..	..	..
1.	0/8	River Plate Electricity Co. Ord.	2⅜—2⅝	..	April ..	..	..
1	1 2⅔	Do. 6 per Cent. non-Cum. Pref.	1⅝—1⅞	6 8 0	May ..	2	1⅞
St.	5%	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5⅛	5 9 6	Ap, Oct	5⅛	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	100 —102⅝	4 13 0	Ja, Jul	101	99½

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHEET	LAST DIVIDEND	NAME.	Price Wed., June 12.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 12. High- est.	Low- est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord....	10 – 11	6 6 0	Mar, Sept,	10½	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝–10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1½ – 10⅝	5 11 8	Feb, Aug	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 101	4 6 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4¾ - 5½	5 5 0	April, Oct	..	..
St.	4½	Do. Do. 1st Debs.	97 –99	4 11 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord	8 – 9	5 11 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7½ – ½	4 6 0	Mar, Sept	..	..
St.	4%	†Central Elec. Sup. Co. 4% Guar. Db. Stock	99 – 102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¼ – 3⅝	6 13 3	Feb, Aug	3⅛	..
5	2/3	Do 4½ per Cent. Pref.	4 – 4¼	5 0 0	Feb, Aug	..	..
St.	4½	Do. 4 per Cent. Deb. Stock (red.).....	98 – 99	4 1 0	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ – 4½	5 9 0	Jan, July	3⅞	..
5	2/3	Chelsea Electric Supply Ord.	3⅛ – 4½	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	103 – 106	4 5 0	June, Dec	..	..
10	7/0	City of London Electric Lighting Ord...	9½ - 9⅝	6 3 0	Feb, Aug	9 1/16	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅞ – 12½	4 18 0	Jan, July	11 9/16	11⅝
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 – 124	4 0 9	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	4¼ – 4⅝	8 0 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 5	4 10 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅜ – 8⅛	5 17 6	Feb, Aug	7 15/16	7 15/16
10	6 0	Do. 6 per Cent. Cum. Pref.	10½ – 11½	5 4 0	Mar, Sept	11 5/16	11 5/16
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)....	1 6 – 1 0 9	4 2 6	Jan, July	107¾	1 7
St.	4½%	Do. Second Deb. Stock Prov. Certs....	93 – 96	4 18 9	May, Nov	£5	94½
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅞ – 5⅛	5 2 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 – 5⅜	4 11 0	Mar, Sept	..	..
St.	4½	Do. 4½ 1st Deb. Stock (red).....	99 –101	4 9 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	7 – 7½	6 0 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ – 9⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½ – 7	4 5 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 – 100	4 0 0	..	..	..
St.	4%	Kensington & Knigtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	10) – 103	3 17 9	April, Oct	..	..
3	2 4½	London Electric Supply Ord.	1⅞ – 2⅛	5 13 0	Mar, Sept	..	..
5	3 0	Do. 6 per Cent. Pref.	4⅝ – 5⅛	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	£5 – 98	4 2 0	Jan, July	..	..
5	4 0	Metropolitan Electric Sup. Ord.	6 – 6⅛	6 3 0	April, Oct	6 1/8	5 15/16
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 5 6	Jan, July	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 06 –109	4 2 9	June, Dec	..	..
St.	3½	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	9) – 93	3 15 8	Jan. July	..	..
100	4½	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98⅞	4 11 9	June, Dec	97 1/2	97 1/2
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	8⅞ – 9⅛	5 0 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	£9 – 101	4 10 0	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7⅛ – 7⅞	5 8 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	1⅛ - 1⅜	4 10 1	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 – 100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	1 – 1 1/16	2 16 6	Mar, Aug	..	..
100	4½	Do. 4½ per Cent. Deb.	100 –101	4 10 0	Jan, July	..	..
10	9 0	Notting Hill Electric Ord.....	12 – 13	5 15 0	March ..	..	..
5	4 6	Oxford Electric Ord.	6 – 6⅛	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 – 98	4 1 6	Jan. July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord	7¾ – 8⅛	6 1 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¼ – 7⅛	4 18 0	Feb, Aug	..	..
St.	3½	Do. 3½ per Cent. Deb. Stock (red.) ...	88 –98	3 15 8	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	1¼ – 2⅛	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 – 77	5 4 0	Feb, Aug	..	..
5	3 0	South London Electric Supply Ord.....	2 – 2⅛	6 12 0	April ...	2⅛	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝ – ¾	3 6 9	..	..	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.....	1⅛ – 1⅜	4 15 0	Feb, Aug	1 1/16	1 1/16
St.	4½	Do. 4½ 1st Db. Stk. Red.....	100 –103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1¼ – 2⅛	10 0 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	2⅛ - 3⅛	7 3 0	April, Oct	..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
5	6 6	Westminster Elec. Sup. Ord.	9¼ £3	6 8 0	Mar, Sept	1 1/2	0 15/16
5	2 3	Do. 4½ per Cent. Cum. Pref.	5⅛ – 5⅜	8 13 8	Jan, July	1 1/8	1 1/16
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 – £5	4 4 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅞ – 7/8	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅞ – 1	5 0 0	Jan. July	1 1/16	31/32
St.	4½	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	April, Oct	..	..
St.	4½	B'ham & Midland Trams 4½ 1st Db. Stk.	96 – 99	4 11 0	Jan, July	..	..
10	9½	Bristol Tramways & Carriage Ord.	14½ – 14¾	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 – 9⅛	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	10) – 10 2	3 18 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	3 – 3⅛	..	June, Dec	3	2 15/16
10	6/0	Do. 6 per Cent. Cum. Pref.....	7 – 7⅜	8 0 0	Feb, Aug	7 3/8	7 1/4
St.	5%	Do. 5 per Cent. Perpetual Debs.	101 – 104	4 16 0	April, Oct	105	1 2
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	79 –82	5 9 6	May, Nov	80½	..
St.	4%	Central London Ordinary Stock.....	73 –75	5 6 9	Feb, Aug	74¾	70 3/4
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	Feb, Aug	94	..
St.	4%	Do. Deferred Stock	53 – 56	7 2 8	Feb	54½	£4½
100	4%	Do. 4 per Cent. Debs.	103 – 106	3 15 6	Jan. July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	82 –85	4 14 0	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	£8 – 1 01	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ..	41 –43	4 13 0	Feb, Aug	42	41
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 –121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 – 119	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent, Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13¾ – 14¼	4 2 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	13 – 14	4 5 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%	¼ – 2⅜	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	84 – 87	4 12 0	Jan. July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	93 – 101	4 9 0	April, Oct	1 8 1/2	..
10	9%	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11½	5 6 6	Mar, Sept	..	..
St.	4½	‡ Do. 4½ per Cent. Debs.	99 – 101	4 9 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref	1 – 1⅛	..	Mar. Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 – 73	5 9 6	Jan, July	..	..
St.	4%	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 –98	..	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅜ - 1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 –£0	4 9 0	Jan. July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	5⅜ - 5⅝	5 14 8	Jan. July	5⅝	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 85	4 11 0	Jan, July	85	..
St.	..	Mersey Con. Ord. Stock	2 – 4	..	Feb, Aug.	..	..
St.	..	Do. 8 per Cent. Perp Pref.	3 - 6	–	..	..	..
1	..	Metropolitan Elec. Tramways Pref.	3/32 – 5/32	..	April....	3/32	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3/32 – 5/32	5 3 0	Feb, Aug	3/32	..
St.	4½	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0	Jan. July	98	96 1/2
..	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½ – 1½	..	May	..	–
10	8/0	Potteries Electric Traction Ord.	3½ – 6½	6 8 0	April, Oct	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 – 7⅛	6 18 3	Feb, Aug	..	..
St.	4½	Do. 4½ per Cent. Deb Stock	95 – 98	4 11 9	May, Nov	..	..
1	3/16	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref	5/32 – 1/4	5 16 6	Feb, Aug	..	..
St.	3½	Do. 4 per Cent. Deb. Stock	84 – 86	4 13 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	86 –90	5 11 0	Jan. July	88	..
..	5%	‡ Underground Elec. Rys. Co. of London...	£8 – 71	7 1 0	June, Dec	70½	(£3
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1⅛ – 1⅜	–	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛ – 3⅜	–	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 – 94	4 15 9	Jan, July	–	..

SHEET	LAST DIVIDEND	NAME.	Price Wed., June 12.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 12. High- est.	Low- est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅛ – ¼	..	..	..	..
1	0 7½	Do. 6% Cum. Pf.	⅜ - ½	8 0 0	April, Oct	..	..
1	9/4½	Babcock & Wilcox Ord.....	3½ – 4	5 0 0	April, Oct	3⅝	3½
1	0/7½	Do. Pref.....	1 1/16 – 1 1/8	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅛ – 6¼	7 8 0	July, Feb	6 3/16	..
5	3/0	Do. 6 per Cent. Pref.	5¼ – 6⅛	4 16 0	Jan, July	6⅛	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 – 1 5	4 5 9	Jan. July	..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1½	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£3 – 67	5 19 3	Jan, July	..	..
2	..	Brush Electrical Engineering	¼ - ⅜	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜ – ½	4 16 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	8 – 91	4 19 0	Mar, Sept	8⅝	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 –78	5 14 6	Jan, July	..	..
5	5 0	Callender's Cable Con. Ord.....	10 – 11	6 15 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ - 5⅜	4 7 0	Jan, July	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106 – 108½	4 3 0	Nov, May	..	..
1	0/9⅜	Casiner-Kellner Alkali Co.	1⅛ – 1½	6 0 0	May, Nov	1 3/32	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	Feb. Aug	..	..
1	0 9⅜	Chadburn's (Ship) Telegraph Ord.	1 3/32 – 1 1/8	7 5 0	March ..	1 1/8	1 3/32
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16 – 1 1/8	5 4 0	April, Oct	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 51,000).....	1 1/8 – 2 1/16	3 12 9	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96⅞ – 99⅞	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16 – 1 1/8	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16 – 1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 – 105	4 5 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1 – 1⅛	10 2 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛ – 2⅜	4 11 6	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	86 – 87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 –92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅛ – 1⅛	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅛ - 2⅛	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	78 – £3	5 8 0	Jan, July	..	..
2	..	Electric Construction Co.....	⅛ – ⅞	..	Jan, July	..	..
2	2/93	Do. 7 per Cent. Cum. Pref.	1⅜ - 2	7 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	79 – 3	4 16 3	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	£4–9	5 11 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 95	4 4 0	Mar, Sept	12 1/16	12⅛
5	10/0	Henley's Telegraph Works Ord.....	11½ - 12⅜	6 0 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5⅛	4 2 0	Feb, Aug	5 1/16	5⅛
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb. Stock	105 –107	4 4 0	Mar, Sept	..	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15 –16	6 5 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 –99	4 1 0	April. Oct	98	..
1	1/32	Richardsons, Westgarth & Co., Ltd. Ord.	3/32 – 1/8	7 6 0	Nov ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1/16 – 1	6 0 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 – 100	4 10 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	30⅛–31⅛	5 14 8	Mar, July	3 1/4	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	101 – 104	3 18 6	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅜ – 2 7/16	6 1 0	..	2⅜	2 5/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1 5/16 – 1 3/8	4 1 0	..	1⅜	1 5/16
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 – 117	4 5 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 – 104	3 17 6	June, Dec	103½	103½
100	4½%	† Do. 4½ per Cent. 2nd Mort. Deb. (red.)	1 3 – 105	4 5 6	June, Dec	1 5	104
10	6 0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½ – 10	5 0 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	1¼ – 1⅜	..	Apr, Oct	1⅜	..
5	..	Do. 6 per Cent. Cum. Pref.	2½ – 4	..	Apr, Oct	3¾	..
100	4%	† Do. 4 per Cent. 1st Mort. Debs.....	78 – £2	4 17 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 –91	5 10 0	June, Dec	..	..
St.	15/0	Anglo-American	6 1/4 – 6 3/4	6 0 6	F,My,Ag,N	..	..
St.	20,0	Do. Preferred	107¼ – 108½	5 11 0	F,My,Ag,N	108	107½
St.	11¾	Do. Deferred	19⅜ – 20	4 7 6	F,My,Ag,N	20 1/4	19 7/16
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 –94	4 5 0	Jn,Ap,Jy,O	93¾	93
10	5 0	Cuba Submarine Ord.....	7¾ – 8¼	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15¾ – 16¾	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜ – 3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅜ – 9½	5 8 0	April, Oct	8⅝	..
50	4½%	Do. 4½ per Cent. Deb.....	100% – 103%	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	1¼ – 1 5/16	5 17 6	Ja,Ap,Jy,O	1 5/8	..
100	4½%	Direct West India Cable 4½% Bg. Db. (rd.)	100 – 102	4 8 0	June, Dec	..	..
St.	£5/0	Eastern Ordinary	128⅜ – 1 0 6	4 19 6	Ja,Ap,Jy,O	130½	128⅜
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 – 91	3 17 0	Ja,Ap,Jy,O	90	89½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104 – 10 1/8	3 15 0	May, Nov	105	104½
10	£/6	†Eastern Extension	13⅛ - 13⅜	5 2 0	Ja,Ap,Jy,O	13⅜	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock	103½ – 106½	3 15 0	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –101	3 19 0	Feb, Aug	99¼	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	18½ – 100	4 0 0	May, Nov	..	..
10	3/0	G.N. (of Copenhagen), with Coupon 70..	24 –26	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.	1 0 – 102	4 8 0	June, Dec	..	..
25	£2/6	Indo-European.....	56 – 58	5 12 0	May, Nov	..	..
100	4%	Mackay Companies Common	71 –73	5 8 6	Jan, July	..	..
100	4%	Do. Preference	69 –71	5 12 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜ – ½	..	April	..	..
10	4%	Pacific & European Tel. 4% Guar. Dbs. (red.)	102 – 104	3 19 6	June, Dec	..	..
10	4/0	†West African Telegraph Shares	10 –10½	3 16 0	June, Dec	..	..
22	1/3	West Coast of America	1⅜ - 1⅝	3 12 9	May	1⅝	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅜ – ½	..	May, Nov	..	..
10	8/0	† Do. 6 per Cent. 1st Pref. Ord. Certfs.	7⅜ - 7⅞	7 12 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅛ – 7⅛	..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	100 – 103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	14 – 14⅛	4 18 6	Mr,Jn,O,D	14⅛	14⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	102 – 105	3 16 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 –94	4 5 0	Jan. July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 –101	4 19 0	Mar, Sept	..	..
5	3 0	Chili Telephone	£3–7½	5 11 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1⅜ – 1 1/16	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞–1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	108 –110	5 9 0	Feb, Aug	1 0 1/2	10 6 1/2
St.	5⅞%	Do. Def. Stock.....	105 –107	5 2 6	Feb, Aug	1 0 1/4	10 1/4
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11½ – 12½	4 9 0	Feb, Aug	11⅝	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	11⅝	..
5	2/0	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5 1/16 – 6 1/16	4 10 0	Feb, Aug	6⅛	5⅞
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	95⅛ – 97⅛	3 11 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 0	Jan, July	101⅛	1 0
1	0/93	Oriental	1 1/16 – 1 1/8	4 17 6	April, Oct	..	..
1	0 7½	Do. 6 per Cent. Cum. Pref.	1⅛ – 1¼	4 16 0	April. Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 –98	4 2 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	£9 – 102	4 7 0	Jan. July	..	..
5	3 0	United River Plate.....	£3–7½	5 9 6	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	June, Dec	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	108¼ – 110¼	4 9 9	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	4 –5	6 0 0	Jan, July	..	..
10	2 0	Globe Telegraph & Trust.....	11¼ – 11⅜	4 16 9	Ja,Ap,Jy,O	11	10 15/16
10	8/0	Do. 6 per Cent. Pref.....	13¾ – 14⅛	4 5 0	Ja,Ap,Jy,O	13⅛	13⅛
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..

In calculating the yields, allowance has been made for accrued interest but n for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Engineering Conference.

THE Fourth Engineering Conference of the Institution of Civil Engineers, which concludes to-day, is being run on the same lines as its predecessors, which have been held at intervals during the last 10 years. Unlike other conferences, Papers, in the usual acceptation of the word, are not read, which probably accounts to some extent for the success of the gathering. When elaborate Papers are read, so much time is generally taken up by the Papers themselves that the discussions are wanting in vigour. The Papers presented to the Engineering Conference, on the other hand, are so brief that the time occupied in their reading is comparatively short, and they serve simply as pegs on which to hang discussions. In this way good discussions are obtained, the more so because people seem willing to make a greater effort to attend a general gathering of this kind, where there is a good deal of variety, than to be present at the reading of any particular Paper at one of the engineering institutions, however important the Paper may be.

Municipal Trading.

WE have received from the Industrial Freedom League a copy of a leaflet on Municipal Trading. The leaflet, which is devoted to electric light undertakings, purports to give a summary of the results of 217 undertakings for the year ending March 31, 1906, and, in addition, some particulars are given of a few selected London and provincial undertakings. It is rather a pity that the information could not have been issued earlier, for in the case of some of the undertakings referred to (for example, Sheffield) the accounts for 1906-7 have now been published, and these show a great improvement upon the previous year. In the next place, it is scarcely fair to select a few cases where, for local or other reasons, the financial results have not been brilliant. Many instances might be cited of successful municipal management, and where the undertakings have been very successful from every point of view. From time to time we have ourselves freely criticised certain aspects of municipal trading; we have repeatedly emphasised the necessity for proper reserve and depreciation funds, &c., and we have deprecated the increasing tendency to allocate sums in relief of rates before the actual results of the current year's working are known. Still, we consider that nothing is gained by a partial representation of the picture.

THE mistake made by most non-technical writers in dealing with points of this kind is that no distinction is drawn between the early years and the subsequent career of an undertaking. It is not realised that even a company, just as much as a municipal enterprise, must work at a loss during, at least, its first year, and that many companies have failed to pay a dividend for several years after a supply has been given. Nevertheless, that is no reason why large municipal undertakings, after several years of working, should be run at a loss and should make no proper provision for depreciation. Unfortunately there are several cases of this kind round the metropolis and in the provinces.

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Tube Railway Fares.

FOR some time past it has been evident that the present fares charged on many of the underground railways of London are not remunerative to the companies in the case of long-distance passengers. Owing, however, to the competition between the several tubes and the motor omnibuses, the travelling public have benefited at the expense of several of the companies. This state of affairs, however, is likely to be to some extent remedied in the immediate future, for we learn that the District, the Metropolitan, the Central London and other tube railways have agreed on a working arrangement whereby the fares between the West End and the City will be increased in the case of the longer distances. As regards the Central London Railway, it is reported that the extent of the twopenny fare will in future be from the City to the Marble Arch, and from Shepherd's Bush to Tottenham Court-road, all greater distances being charged for at the increased fare, the other tubes raising their fares to correspond. No doubt there will be an outcry against this policy by those who consider that dividends are quite superfluous to the satisfactory carrying-on of an undertaking, but to those who take a broader view this course will appear to be the only one that is possible. It remains to be seen whether the omnibus companies will adopt a similar policy. As far as they are concerned, the short-distance traffic is the more important, and it is that which is the most attractive to the public, so that short-distance fares, where it is a case of competition with railways, might be raised without much chance of loss in the number of passengers. But where it is a case of competing against the London County Council tramways the position is different, and it is difficult to see how remunerative competition can be carried on over short distances unless the motor omnibus can show a very decided improvement in average speed over that of the tramcar.

Junior Institution of Engineers.—The summer meeting of the Junior Institution of Engineers will be held in the Clyde district from June 29th to July 6th.

Royal Society.—At the meeting of this Society yesterday afternoon, the Bakerian Lecture was delivered by Dr. T. E. Thorpe, C.B., F.R.S., on "The Atomic Weight of Radium."

Obituary.—We regret to record the death of Herr Andreas Mechwart von Belecska, who died on the 14th inst. at Budapest. The deceased was for many years the vice-president and general manager of the well-known firm of Ganz & Co. He was also connected with the Austrian Bank and many other companies.

Conversazione of the Institution of Electrical Engineers.—The annual Conversazione of the Institution was held on Tuesday evening at the Natural History Museum, South Kensington. The guests were received by the president, Dr. R. T. Glazebrook, and Mrs. Glazebrook, and the president-elect, Lord Kelvin, and Lady Kelvin. Among the guests were Sir Patrick Manson, K.C.M.G., F.R.S., Prof. Blanchard, Dr. Ehrlich and Prof. Nocht, delegates to the Sleeping Sickness Commission. A programme of music was performed by the string band of the Royal Engineers, and also by the Alexandra Ladies' Quartette.

Cable Interruptions.

	Date of Interruption.
Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907
Trinidad—Demerara	June 18, 1907

Personal.—Prof. A. Schuster, F.R.S., has accepted an appointment as honorary professor of physics at Manchester University, thus retaining his connection with the work of the department.

Amongst those on whom the Senate of Liverpool University have decided to confer the honorary degree of D.Sc. at the forthcoming graduation in July are Sir Oliver J. Lodge, F.R.S., Sir William Ramsay, K.C.B., F.R.S., Sir Henry E. Roscoe, F.R.S., and Prof. W. Ostwald,

Institution of Electrical Engineers, Students' Section.—It is announced that the following students have been elected to represent the various colleges on the Committee of the Students' Section of the Institution of Electrical Engineers during the session 1907-8: Messrs. B. A. M. Cooper and F. R. Unwin (Central Technical College); C. E. Abell and C. Garland (Finsbury Technical College); A. H. M. Campion (King's College); J. A. Mannas-Smith and C. W. Short (Faraday House), and C. Richardson and R. Rigby (University College). Messrs. J. A. Cook, B. A. Tubini, W. B. Thompson, G. C. Shadwell and G. H. Stevens will represent the extra-collegiate students.

Engineering Standards Committee.—We are informed that a revised edition of the British Standard Specification for Portland cement has been prepared and will be issued to-day (Friday). Copies of this report may be obtained from Messrs. Crosby Lockwood & Son, or from the offices of the Committee. The chief points which have been altered are: (1) The percentage of sulphur anhydride has been slightly raised; (2) the quantity of cement to be used in the test for fineness and the period for which it is to be sifted have been specified, while the residue to be left on a sieve 180 × 180 has been somewhat reduced; (3) the grading for the increase of tensile strength in the neat test has been further extended; (4) the maximum final time for the "slow setting" cement has been increased, and (5) the expansion under the Le Chatelier test has been reduced.

Royal Society Conversazione.—At the conversazione held on Wednesday evening last only a few of the exhibits were of electrical interest. Mr. A. A. Campbell Swinton showed some pretty mechanical effects of canal rays in causing the rotation of mill-wheels in Crookes tubes. These mill-wheels were shown in rotation under the influence of canal rays alone, or under the combined influence of canal rays and cathode rays. In the latter case a mill-wheel of mica was seen to rotate in the opposite direction to one of aluminium. Photo-micrographs were also shown by Mr. Swinton of the bubbles developed by the sudden heating of portions of the glass walls of Crookes tubes, the bubbles being due to the occlusion of the residual gas during prolonged use. A microscopic examination of the gas from these bubbles showed in two cases that it was hydrogen and helium respectively. Electric discharge on the glass in a vacuum tube produced the same formation of bubbles, apparently due to the local heating. Mr. C. E. S. Phillips exhibited samples of his electrically conductive glass, and an electroscope in which the gold leaf was replaced by a fibre of this glass, the latter being hinged so as to move readily when charged. By this means an instrument is obtained which can be observed very conveniently by a telescope, the deflections being very definite. Mr. Phillips also exhibited an ingenious little electroscope charger, consisting of a rod of celluloid so mounted that it could be electrified by the rubbing of a split brass tube lined with flannel. Celluloid being a poor insulator, the charge travels to the end, where there is a metal pointer, and can be readily utilised. A single movement of the brass tube was sufficient to give a charge to an electroscope. Mr. W. Duddell, F.R.S., exhibited experiments upon the production of persistent electric oscillations of the same kind as he showed at the conversazione last month.

A Speaking Condenser.—In a recent number of the *Comptes Rendus* M. T. Argyropoulos describes a similar arrangement to that of the singing condenser, which he calls the speaking condenser. The difference is that the secondary of the transformer is connected to a fairly high voltage circuit. A high-resistance microphone and a transformer, made up of laminations to a thickness of about 1¼ in., and wound with two coils

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of wire 0·1 in. diameter and about 230 ft. long, were used. One of these coils was connected in series with the microphone and a battery of four accumulators. The other was connected to a 220 volt circuit through a condenser formed of tin and paper, and with a capacity of about 7 mfd. The microphone was placed in one room, the transformer in another, and the condenser in a third, all the rooms being entirely separated from each other. Everything spoken into the microphone was heard in the room where the condenser was placed. The loudness of the sounds given out increases with the voltage, while the capacity and construction of the condenser also have an effect. In a further note on this subject M. M. Deprez shows mathematically that raising the secondary voltage increases the intensity of the sound in proportion, due to the vibration of the condenser plates. The small varying force caused by the alterations in the microphone circuit attracts or repels the condenser plates, and is proportional to the secondary voltage; thus the amplitude of the movement of these plates, and, therefore, of the sound given out, is increased by increasing the secondary voltage. M. P. Séve also comments on this arrangement. He repeated the experiment of M. Argyropoulos by connecting the two coils to the terminals of the Secteur de la Rive Gauche or with an alternator of frequency 500. Sounds of a frequency 84 or 1,000 were heard, whilst by superposing a continuous-current voltage of about 270, fundamental sounds with a frequency of 42 and 500 were obtained respectively, and with a much greater intensity. The apparatus used was slightly different from that of M. Argyropoulos. The condenser had a lower capacity and the ratio of transformation was five instead of one.

Engineering Periodicals and the Card Index.—In an address given on this subject before the students of the Society of Mechanical Engineers, Sibley College, Cornell University, Mr. H. Wade Hibbard deals with the importance of keeping a good record of the information appearing in engineering periodicals, and of so arranging the subjects by means of a card index that any data required may be quickly obtained. He states that "to take knowledge into one's hand temporarily, and then not afterwards have that knowledge for desired use, is as foolish as once to have seen a life-preserver and not to be able to find it at a midnight collision. It is well to form the habit of regular perusal of the weekly *Machinist* or *Engineer*. Sibley student life is called full by those in it; but it is leisure personified compared to the megaphoned fulness of the high-pressure life of the successful engineer in harness. Let, then, the student distrust his ability to commence reading the technical papers after graduation, unless he has learned to read them before. Scepticism is the normal state of the scientific mind. It is ever looking for something better, not satisfied that the present is perfect. The reading of articles over the names of famous engineers, afterwards to find them severely criticised, is good for the confiding student who perhaps has supposed that all engineers and professors are agreed. It is just as well for him to learn not to believe all that is in print, unless there are good reasons presented. Independent investigation is promoted by reading the papers. A printed controversy stimulates anyone who loves a fight. Blessed be the man whose engineering eye is fired and mettle aroused by the prospect of a battle royal between men of fame. Perhaps he, too, can put in a lance, if extra spare hours or thesis subject will permit. A subscription to a paper should not be made in a hurry. And yet the reading from the start should be carried on with that end always in view. After the different papers become known, then the heart of the very human editor should be gladdened by a little note of appreciation—with some of that necessity for which he works, though not chiefly. A *good* engineering paper should be one of the life partners, ready at hand when moments of leisure permit its instruction and enjoyment, better understood and liked as the years roll on, acquaintance or perhaps friendship formed with editor, contributions made, suggestions given and taken, some share had in its mighty influence in the engineering world." The second part of the Paper deals with the advantages of the card index over all other methods of recording information, and actual details of some ways of making it up are given. One practical hint is that it is very essential to have all the cards in one pack of the same vertical dimensions, as in fingering the index it is almost impossible to catch a low card between two high ones. Hints on indexing the subject matter are given, and the additional uses of the index as regards clippings, drawings and correspondence are also given. The author concludes by saying that "it is for each individual student, and even the greatest engineer is still a student, to declare which portion of the paper's usefulness he will accept at once and the day following. Can he afford to neglect the Sibley opportunity of becoming acquainted with all the papers? Form a good habit, it will cling. Learn to doubt; you will afterwards believe better. Feed on the plains of the nations rather than always in your own manger. Share your good things and unite forces; and some day a leader, know how best to lead. Engineering periodicals and the card index are not the fabled philosopher's stone, turning all metals into gold, but an unfading love for our profession can use them, among the other reagents, to bring out the measure of true worth within the capacity of each man."

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 21st (to-day).

Institution of Civil Engineers.—Engineering Conference.*

10 a.m. Meeting of Sections IV. and VII. (Mining and Metallurgy and Applications of Electricity) in the Theatre. Papers on "Electro-metallurgy," by Mr. B. Blount, and on "Modern Applications of Electricity to Mines," by Mr. C. P. Sparks.

Meeting of Section V. (Shipbuilding) in the Reading Room. Paper on "The Welding of Structural Materials in Place," by Mr. H. A. Ruck-Keene.

1:45 p.m. Visit to the Greenwich Generating Station of the L.C.C. Tramways and Messrs. Siemens Bros'. Works, Charlton.

Visit to the Greenwich Generating Station of the L.C.C. Tramways and Deptford Generating Station of the London Electric Supply Corporation.

Visit to Messrs. Vickers, Sons & Maxim's works at Erith.

TUESDAY, June 25th.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

10:30 a.m. Meeting at the Town Hall, Sheffield. Presidential Address by Mr. S. E. Fedden. Paper on "Extension of Electricity Supply to Outlying Districts," by Mr. R. L. Acland.

2 p.m. Visit to Messrs. Vickers, Sons & Maxim's River Don Works.

FARADAY SOCIETY.

8 p.m. Meeting in the Library of the Institution of Electrical Engineers, 92, Victoria-street. Papers on "The Thermo-chemistry of Electrolysis in Relation to the Hydrate Theory of Ionisation," by Messrs. W. R. Bousfield and T. M. Lowry; on "The Influence of Non-electrolytes and Electrolytes on the Solubility of Gases in Water. The Question of Hydrates in Solution," by Mr. J. C. Philip; on "The Dissociation of Hydrates as indicated by their Equilibrium Curves," by Mr. A. Findlay; and on "Hydrates in Solution: Discussion of Methods Proposed for Determining the Degree of Hydration," by Mr. G. Senter. A Discussion on "Hydrates in Solution" will follow.

WEDNESDAY, June 26th.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

9:15 a.m. Excursion to the Dukeries.

THURSDAY, June 27th.

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

10 a.m. Meeting at the Royal Victoria Hotel, Sheffield. Annual General Meeting.

2:30 p.m. Meeting at the Royal Victoria Hotel, Sheffield. Papers on "Cheap Power Supply by Municipalities," by Mr. C. E. C. Shawfield; on "The Costs of, or Charges for, Electricity Supply," by Mr. H. R. Burnett; and on "Depreciation," by Mr. C. H. Yeaman.

7:45 p.m. Annual Dinner.

FRIDAY, June 28th

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

10 a.m. Meeting at the Royal Victoria Hotel, Sheffield. Paper on "Alternating-current Distribution," by Mr. A. J. Cridge.

2:15 p.m. Visits to Kelham Island Tramway Power Station and to Neepsend Power House.

PHYSICAL SOCIETY.

5 p.m. Meeting at the City and Guilds Central Technical College, Exhibition-road, S.W. Agenda—(1) Demonstration of the Uses of his Hot-wire Oscillographs and Hot-wire Wattmeters, by Mr. J. T. Irwin; (2) "A Cosine Flicker Photometer," by Mr. J. S. Dow; (3) "Some Phenomena in Colour Vision," by Mr. J. S. Dow; (4) Description and Exhibition of Students' Apparatus for Measuring Permeability and Hysteresis, by Prof. W. E. Ayrton and Mr. T. Mather; (5) "Design of Chokers," by Prof. W. E. Ayrton and Mr. T. Mather.

* The above announcement of the Papers to be read and the visits to be paid at the Engineering Conference do not include all the Papers and visits, but only those of special interest to electrical engineers.

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ELECTRIC TRACTION ON RAILWAYS.*

II.—SOME FINANCIAL CONSIDERATIONS IN CONNECTION WITH ELECTRIC RAILWAYS.

BY PHILIP DAWSON.

(*Continued from page 336.*)

Summary.—After referring to the character of an electric railway load on the generating station, the Author discusses two main causes which conduce to electrification of existing railways, viz. (1) reduction in working expenses and (2) the desire for the better utilisation of existing facilities. A steam locomotive in suburban work consumes fuel for about 76 per cent. of its life, but does useful work only during about 28 per cent. Detailed figures are given for running costs of steam locomotives. Another basis of comparison is by weight and carrying capacity, which often apparently tells in favour of steam owing to the internal arrangement of coaches adopted for electrical working. Running costs are given for a number of railways, including the Mersey Railway, which is a good example for comparative purposes. Finally, the general results obtainable are discussed and illustrated by examples taken from the London, Brighton & South Coast Railway.

The first part of this article appeared in our last issue.

In comparing the cost per train-mile of steam and electricity it must be borne in mind that steam trains are, on the average, composed of seven cars, having a capacity of 350 passengers. Whereas now, when operated by electricity, according to the time of day, the number of cars per train vary from two to five, the average being about three, and the capacity on the average can be taken per car, the average seating capacity of an electric car being taken as 55 passengers, as compared to the average seating capacity of steam cars of just under 50 passengers.

These figures clearly demonstrate the great benefit which railways will get by electrification of their suburban systems. For it shows that they will, owing to the high rate of acceleration, be able greatly to increase the average speed, and therefore the number of trains, and thus to utilise better the existing facilities, both as regards tracks and termini, and consequently largely augment their earning capacity without increasing their present total working expenses. And as Mr. Aspinall (the general manager of the Lancashire & Yorkshire Railway) has always maintained, the object of electrification is not so much to decrease the expenditure of a railway company as to increase its earning power. The enormous losses which many railways are at present suffering owing to electric tramway competition are too well known to require comments. Nothing but a greatly accelerated and more frequent service can enable them to hold their own, and it is only electric traction that will provide this acceleration. That frequent and rapid service does, in most cases, provide an efficient remedy is clearly shown by the satisfactory results obtained both in the case of the Lancashire & Yorkshire Railway and of the North-Eastern Railway. The latter is a particularly good example, because the electric lines between Newcastle and Tynemouth suffer from the most acute tramway competition, but notwithstanding this fact, the profits are considerably greater now on this railway than they were in the days before there existed any electric tramway competition. This is clearly shown in Table XII.

Table XII.—*North Eastern Railway Electrification Results.*

Items.	Half-year ending 1903. Steam operation.	Half-year ending 1905. Elec. operation.	Percentage of increase.
Gross earnings.....	£129,000	£151,000	17·1
Running costs.....	42,761	47,779	11·7
Ratio of costs to receipts	33·2 per cent.	31·8 per cent.	...
Loco. costs per train mile	14·5d.	6·75d.	...
Passengers carried	2,844,000	3,548,000	24·8

In reading the above table it must be borne in mind that the figures given as running costs for steam operation, are if anything, too low. An exact figure is unobtainable owing to the difficulty of differentiating between the costs for local service and the total locomotive costs for the whole service. But even on the supposition that the comparison is a fair one, it affords a most satisfactory proof of the advantages to be obtained from electrification, particularly in view of the fact that electric tramway competition has very largely increased of late, which shows that the electrification of the railway has, therefore, not only enabled it to hold its own, but also to increase its traffic.

Messrs. Stillwell and Putman, in a very interesting Paper before the American Institution of Electrical Engineers, have considered the subject of electrification of railways, and some of the figures they mention are of interest as a check and for purposes of comparison with those which have already been given previously in this series of articles Perhaps the best way to present these figures is more or less in tabular form, as follows :—

Table XIII.

——	Steam.	Electric.
Renewals of permanent way in per cent. of total operating expenses...	6·63 per cent.	5·0 per cent.
Repairs and renewals of buildings in per cent. of total operating expenses	2·36 ,, ,,	1·8 ,, ,,
Repairs and bonding of track in per cent. of total operating expenses...	0·0 ,, ,,	0·8 ,, ,,
Repairs of overhead construction and third rail in per cent. of total operating expenses.....	0·0 ,, ,,	2·5 ,, ,,
Repairs of steam locos. in per cent. of total operating costs	7·51 ,, ,,	1·05 ,, ,,
Maintenance of locomotives per train-mile	2·1d.	1·05d.

Perhaps a few general remarks as to how the electrification of suburban systems is to be considered may be useful at this point.

For this purpose the train service of any line proposed to be electrified must be carefully considered, both as regards its carrying capacity per hour, its number of trains per hour, and its average travelling speed in miles per hour, stoppages included.

For this purpose we will first consider the comparative costs per train-mile for steam and electricity on the basis of a seven-car steam train weighing empty with locomotive 210 tons, with a seating capacity of 520 passengers, and a three-car electric train with a seating capacity of 210, or a seating capacity of 41 per cent. of that of the steam train. The following figures (Table XIV.) will not be far out :—

Table XIV.

Item.	Steam. Cost per train-mile seven-car train with seating capacity of 520 passengers.	Electric. Cost per train-mile three-car train with capacity 210 passengers in London.
Fuel or current	6·96d.	5·00d.
Water, oil, waste and stores .	0·90d.	0·09d.
Maintenance and repairs ...	3·41d.	0·85d.
Wages	3·25d.	1·58d.
Lighting	0·85d.	included in current
Total	15·37d.	7·52d.

Ratio of locomotive costs of electricity to steam 48·5 per cent. (including current and capital charges on conducting and distributing system).

From the above table it will be seen that on the train mile basis the locomotive costs for electric traction, maintenance and capital charges in electrical distributing included, are less than half the cost per train mile if operated by steam.

Against this, however, would have to be placed the fact that the capacity of the steam train is more than double

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Table A.—*Comparison of Times taken by Steam Trains, Electric Tramcars and Electric Trains.*

Name of Place or Station.	*Steam Trains* to and from Victoria. Down Trains. Maximum run'ng time of journ'y	Down Trains. Maximum interval between trains.	Down Trains. Maxim'm combined running time and interval.	Up Trains. Maximum runn'g time of journ'y	Up Trains. Maximum interval between trains.	Up Trains. Maxim'm combined running time and interval.	*Electric Tramways.* Victoria.	Westminster.	Propos'd *Electric Trains* to and from Victoria. Max'm run'ng time to and from Victoria.	Maximum interval between trains.	Total time to & from Victoria, incl'd'g wait.	Best times of steam trains to and from Victoria (minimum wait and journey combined). Down trains.	Up trains.	Best steam trains, running time only to Victoria. (*a*) Down.	Up.
	Min.	Hs. min.	Hs. min.	Min.	Hs. min.	Hs. min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Clapham Road	19	2 23	2 33	19	2 9	2 28	21	22	6	8	14	17	23	9	11
Clapham Junction ...	13	0 38	0 45	18	0 39	0 49	28	29	7	8	15	9	10	6	8
Brixton.....	23	2 23	2 57	23	2 9	2 32	22	23	8	8	16	21	27	13	15
Denmark Hill.....	25	2 23	2 40	29	2 9	2 38	22	23	10	8	18	24	31	16	19
Balham.....	27	0 33	0 51	39	0 43	0 53	31	32	12	8	20	15	17	10	9
Streatham Hill	23	0 53	1 73	28	1 0	1 22	32	33	14	15	29	15	22	11	19
Queen's Road	33	2 23	2 47	33	2 9	2 42	31	32	14	8	22	31	38	23	25
Streatham Common..	24	2 21	2 43	27	0 43	2 27	47	48	16	15	31	23	27	15	17
West Norwood	29	0 53	1 17	30	1 0	1 26	39	40	17	15	32	27	29	16	18
Thornton Heath	30	2 21	2 50	34	2 9	2 34	51	52	20	15	35	30	33	20	22
West Croydon	62	0 59	2 1	80	2 3	2 40	58	59	27	23	50	46	55	27	32

(*a*) Many of these trains are fast trains with but one or no stop.

Table B.—*Comparative Timing and Speeds of Present Steam and Proposed Electric Trains.*

Station.	Distance in miles.	*Steam Trains.* Running time between stations.	Approx. stopping time at stations.	Average speed between stations. Including stops.	Not including stops.	*Electric Trains.* Running time between stations.	Stopping time at stations.	Average speed between stations. Including stops.	Not including stops.
		Mins.	Mins.	Miles per hour.	Miles per hour.	Mins. Secs.	Secs.	Miles per hour.	Miles per hour.
Victoria	...	...	...	...	...	...	...	...	...
Grosvenor Road	0·8	3	1	13·7	16·0	2 1	20	22·0	28·8
Battersea Park	0·5	1	1	15·0	30 0	1 20	20	18·0	22·4
Clapham Junction ...	1·425	4	1	17·1	21·4	2 31	30	29·0	34·0
Wandsworth Common	1·3625	3	1	20·45	27·25	2 33	20	29·0	34·3
Balham	0·6	2	1	12·0	18·0	1 29	20	20 0	24·1
Streatham Common...	1·95	4	1	23·4	29·25	3 40	20	29·0	31·9
Norbury	0 8	2	1	16·0	24·0	1 40	20	24·0	28 8
Thornton Heath	1·275	3	1	19·1	25·5	2 14	20	30·0	34·2
Selhurst.....	0 7125	2	1	14 25	21·375	1 35	20	22 0	27·0
New Croydon	1·1125	3	1	16·7	22·25	2 20	20	25 0	28·6
South Croydon	0·9375	3	2	12 5	18·75	1 55	20	25·0	29·3
Purley Oaks	1·175	2	1	20·15	35·25	2 10	20	28·0	32·8
Purley.....	0·9625	2	1	19·25	28 875	1 57	20	25 0	29·8
Stoats Nest	1·4625	4	...	19 5	21·95	2 21	...	32·0	34·9
Totals and averages	15·0625	38	15	17·05	23·8	29 56	4′ 30″	26·3	30·1
Streatham Hill	1·05	3	1	15·75	21·0	2 4	20	26·0	30·5
West Norwood	1·2875	3	1	19 3	25·75	2 15	20	30·0	34·3
Gipsy Hill	0·925	2	1	18·5	27·75	1 52	22	25·0	29·7
Crystal Palace	0·7375	2	1	14·75	22·125	1 39	20	22·0	26·8
Norwood Junction ...	0 4875	4	1	5·85	7·325	2 50	20	28·0	10·3
New Croydon	0·6625	4	2	7·23	9·95	3 7	20	29·0	12·74
South Croydon	0·9375	3	1	12·5	18·75	1 55	20	25·0	29·3
Purley Oaks	1·175	2	1	23·5	35·25	2 9	20	28·0	32·8
Purley.....	0·9625	2	1	19 25	28·875	1 56	20	25·0	29·8
Stoats Nest	1·4625	4	...	19·5	21·95	2 31	...	32·0	34 9
Totals and averages	16·375	42	15	17·2	23·2	32 2	4′ 52″	26·5	30·7

Table C.—*Comparative Table of Steam and Electric Trains Running to and from Victoria and Various other Stations.*

—	Stoats Nest.	Purley.	Purley Oaks.	Sth. Croydon.	New Croydon.	Selhurst.	Th'rnton Heath	Norbury.	Str't-ham Com.	Balham.	West Croydon.	Norwood Junc.	Crystal Pal.	Gipsy Hill.	West Norwood.	Str't-ham Hill.
Steam Trains.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Maximum time occupied in journey ...	1 8	1 5	1 3	1 0	0 55	0 37	0 34	0 30	0 27	0 39	1 20	0 46	0 43	0 34	0 30	0 28
Minimum „ „ ...	0 46	0 32	0 41	0 27	0 18	0 20	0 20	0 20	0 15	0 9	0 31	0 27	0 22	0 22	0 16	0 11
Maximum interval between trains	3 14	2 10	3 14	3 10	3 10	2 21	2 21	2 21	2 21	0 43	2 3	1 11	1 2	1 12	1 0	1 0
Minimum „ „	0 6	0 2	0 6	0 2	0 2	0 1	0 1	0 1	0 1	0 1	0 5	0 2	0 2	0 3	0 3	0 1
Max. comb. time of waiting & journey..	4 5	3 2	4 0	3 48	3 43	2 53	2 50	2 46	2 43	0 53	2 40	1 47	1 33	1 42	1 26	1 22
Minimum wait & journey	0 52	0 52	0 47	0 42	0 25	0 33	0 30	0 26	0 23	0 15	0 46	0 42	0 28	0 31	0 27	0 15
Electric Trains.		Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
Maximum time occupied in journey ...	0 37	34	32	30	27	22	20	18	16	12	27	24	21	19	17	14
Minimum „ „ ...	0 34	32	29	27	25	22	20	18	16	12	25	24	21	19	17	14
Maximum interval between trains	0 23	23	23	23	23	15	15	15	15	8	23	15	15	15	15	8
Minimum „ „	0 7	7	7	7	7	5	5	5	5	2	7	5	5	5	5	2
Max. comb. time of waiting & journey..	1 0	57	57	53	50	37	35	33	31	20	50	39	36	34	32	22
Minimum wait and journey	0 41	39	39	34	32	27	25	23	21	14	32	19	26	24	22	16

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that of the electric train under consideration. But there is the additional important consideration that the costs given for electric service are for an average acceleration more than double that obtained with steam, and consequently that the average speed of travelling with the electric train as provided is nearly double the maximum that stopping local steam trains can attain.

It must be borne in mind that it would be impossible with steam haulage to increase effectually the speed of stopping trains. In order to make a fair comparison, one must take as the average speed for electric trains the same as that of the present steam trains, and on that basis the same number and power of motors that are required to drive the three-car train, as per the previous table, would be amply sufficient to operate a seven-car train, and if the trailer and rolling stock were the same as that at present in use with steam haulage, the carrying capacity of the train should easily equal that of the present steam trains, and the table previously given would then very closely represent the comparative cost of operating by steam and electricity under the same conditions.

From this it will be seen that, when compared on the same basis, the cost of hauling suburban trains by means of

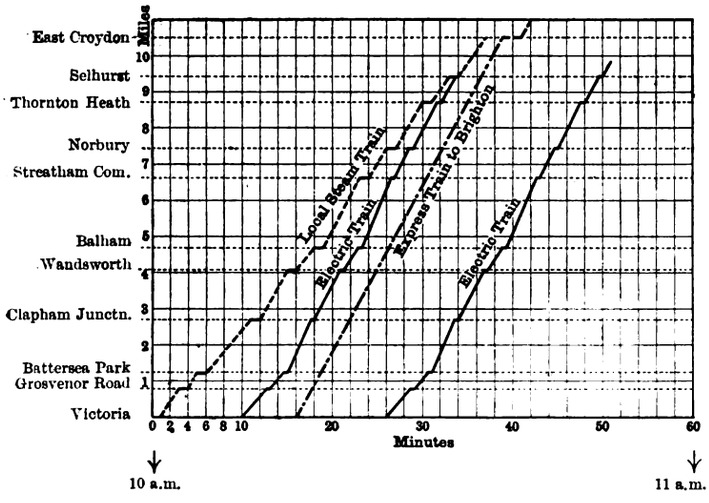

FIG. 3.—DIAGRAM SHOWING RELATIVE ADAPTABILITY OF STEAM AND ELECTRIC LOCAL TRAINS IN SANDWICHING WITH EXPRESS STEAM TRAINS TO GREATER DISTANCE. **Electric train consists of three motor coaches and two trailers.**

electricity is less than half that of operating by steam, with the additional advantage thrown in of the saving of time effected at termini, owing to the use of motor cars and multiple unit control.

But there remains another and most important factor to take into consideration, and that is the better use of the seating capacity per hour if run by smaller and more frequent trains instead of fewer and more capacious trains.

Thus it has already been stated that there is little difference between the locomotive cost of hauling a train having a seating capacity of 200 and a train having a seating capacity of, say, 600 passengers, whereas with electricity the locomotive cost is practically proportional to the seating capacity, and, besides this, on a suburban service, with stopping places, say, on an average ¾ mile apart, the average speed of electric trains could be nearly double the average speed attainable with steam trains, or, in other words, a very much better distribution of seating capacity per hour is possible with electricity than with steam.

The accompanying Table A has been prepared so as to show the great benefits which can be derived by electrification of suburban lines, and clearly indicates the reasons which have caused the railways in and round London to suffer so severely from the competition of the London tramways. It will be seen that, taking Clapham-road as an example, whereas a stopping steam train takes 19 minutes to get to Victoria and an electric tramcar takes 21 minutes, electric traction would enable this distance to be run in 6 minutes on the railway. The existing steam haulage requires nearly the same time to get to Victoria as an electric tram, whereas an electric train would take less than a third of the time.

This is only one example out of many that can be ascertained from the table.

Table B summarises the results of present steam traction compared with those which would be obtainable with electric haulage. The great advantage of electricity allowing a more frequent service is clearly brought out by Table C, wherein is shown the very long intervals which exist between trains, and which, without any extra expense, could be very greatly reduced by more frequent and smaller train units being adopted for electric traction. How electric traction on a proper basis would compare with the present steam local service is clearly brought out in this table. In looking through these tables the fact must not be lost sight of that it is the much higher average speed of through steam trains, which in many cases travel on the same tracks with local trains, which govern the arrangement of the time-tables, and make it necessary, under present conditions, for a considerable time to elapse between two local trains. This is seen from Fig. 3, which shows the present time occupied by a local steam train, the time occupied by an express steam train, and the actual time for the local stopping train actuated by electricity to run the distance.

From this diagram it will be seen that if an express train follows the local steam train on the same lines between Victoria and East Croydon, 15 minutes must elapse between the local and the express train to Croydon, for the reason that the average inclination for the local steam train is much greater than the express steam train.

With the electric stopping service, owing to rapid acceleration, the average speed of the electric train is nearly as great as the average speed of the express train, and five minutes is probably the maximum which would have to be allowed between the starting of a local and express train.

It must not be overlooked that the average speed of express trains whilst running through the suburbs is limited by local conditions, but the average speed is, notwithstanding, fairly high as there are no stoppages, and, as far as local lines are concerned, it is, therefore, quite possible to run express steam trains and local stopping electric trains on the same lines without fear of their interfering with each other.

(To be continued.)

THE SEPARATION OF THE IRON LOSSES IN ASYNCHRONOUS MACHINES.

BY THOS. F. WALL, M.SC.

Summary.—**In the first part of this article it is shown how the iron losses in asynchronous machines may be separated without the use of retardation curves, and the results of experiments on a 5 H.P. motor are shown. A method is then given whereby the moment of inertia of the rotating parts may be found by means of the circle diagram. From this and a retardation curve, the friction loss is found for the same motor as was used in the first part, and a comparison of results is made.**

It has been shown in a previous article how the iron losses in asynchronous machines may be separated by the use of retardation curves, and the results of a test made in this way of an induction motor have been given. (*The Electrician*, Vol. LVIII., p. 752.)

The method there described applies quite well for machines with ball bearings, but is not altogether satisfactory when brass bearings are used. In the first place the rotor comes to

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rest comparatively quickly owing to the high friction losses, and in the second place the moment of inertia of the rotating parts cannot be found by the simple method of oscillations; moreover, in general it is not very easy to draw the tangent to a curve by means of which the loss is deduced from the retardation.

In view of these considerations the following method has been developed, which is applicable for the separation of the friction and iron losses in all cases, and only requires readings of the wattmeters, voltmeter and ammeter to be made.

It was pointed out in the article already referred to that the subsidiary losses in the stator and rotor teeth caused by the alternate passing of a tooth of either part over a slot and a tooth of the other part are due to flux pulsations of high frequency and cannot therefore be directly supplied by the electrical power given to the stator, but must be considered as an addition to the friction loss.

Now the true friction loss is, of course, for a given speed, independent of the pressure, while all the iron losses must diminish when the flux is diminished. If, then, the machine is allowed to run light with short-circuited rotor the power supplied to the stator will be absorbed in iron losses, friction losses, and copper losses. If this power is measured for a given frequency and different values of the applied pressure, starting from a pressure above the normal and proceeding to as low a value as possible consistent with steady running, a curve may be drawn which, when produced back to the ordinate axis, will give the friction loss as the intercept on this axis. It should be noted that the copper losses ought to be subtracted before plotting the curve, since the current does not vary uniformly with the pressure.* The method of correcting for the current losses will be explained later.

By this means the constant friction loss can be found for approximately synchronous speed, and, subtracting from the values as given by the curve, the total iron losses will remain.

It becomes then necessary to separate the iron losses due to the various causes, and for this purpose the following may be considered: The curve just mentioned refers to the short-circuited rotor, and the power necessary to drive the rotor against the retarding torque due to friction and pulsations in the teeth is supplied from the stator winding. Suppose now a reading is taken with the rotor winding switched open when the rotor is running at full speed. This will give the power supplied to cover the stator loss and hysteresis torque on the rotor. It is then at once clear that if the stator loss and hysteresis effect are separated and the former subtracted from the readings taken with short-circuited rotor, the total power transferred to the rotor to supply the friction loss and loss due to pulsations in the teeth remains. The friction loss is already known, and, therefore, the loss due to pulsations may be immediately deduced. This may be done for a given frequency and different values of the flux density, and a curve thus obtained showing the dependence of the pulsation losses on the strength of the field.

The readings taken for the rotor circuit open have given the stator losses plus the power due to the hysteresis torque, and all that remains is to separate these.

This may be done as follows: The rotor winding being open, the rotor is driven at different speeds and power is supplied to the stator. For speeds below synchronism the hysteresis produces a driving torque and for speeds above synchronism it has a retarding effect. Further, the hysteresis torque may be considered as independent of the speed. Therefore on passing through synchronism the power given to the stator changes instantly by an amount equal to twice the hysteresis torque multiplied by the synchronous speed. Thus, by taking a few readings above and below synchronism and drawing a curve, a break is shown at the synchronous speed, and half this break measures the power due to the hysteresis torque at this speed. By proceeding thus for a series of pressures at a constant frequency a curve may be drawn which will be complementary to the curves already found.

All the iron losses and friction losses have now been separated and the whole process may be performed comparatively quickly. Care should be taken that the motor runs steadily without end play or knocking, otherwise the accuracy of the results will be impaired.

The proceedure may be summarised thus:—

1. Current is supplied to the stator at different voltages, starting from some voltage higher than the normal and diminishing the value as much as possible consistent with steady running; the power absorbed is measured, the rotor being short-circuited. The stator resistance losses are subtracted—the effective resistance of the winding being used, which is somewhat greater than that found by measurement with direct current. A curve is then plotted from the resulting values and produced back to cut the ordinate axis.

This gives curve A A, Fig. 1.

The rotor copper losses have not been taken into account, and the result is as follows:—The rotor has a certain amount of slip and the friction losses are equal to the torque produced by the rotating field × rotor speed, the copper losses being equal to the same torque × rotor slip. If the friction torque were constant the intercept on the ordinate axis would give the friction loss at synchronous speed. Since, however, the torque due to friction increases with the speed the intercept on the axis gives the friction loss at the speed of synchronism minus slip, together with the rotor copper losses. The rotor copper losses are, however, very small, and no practical error will result from taking the intercept to give the friction loss at the speed of synchronism minus slip.

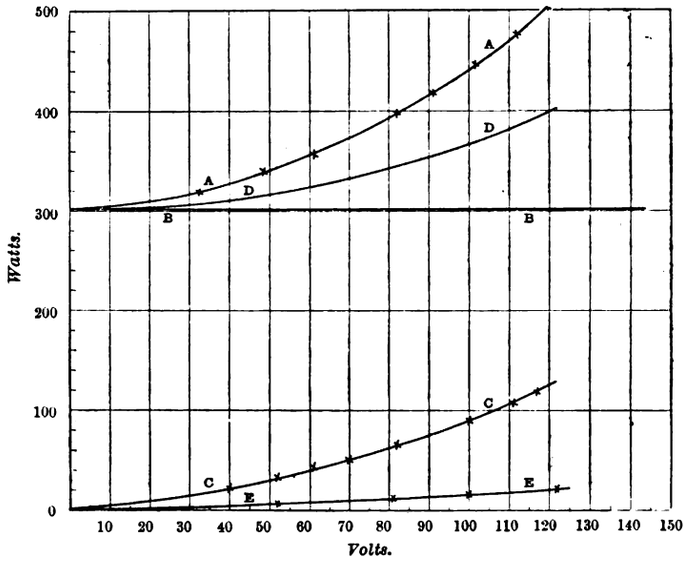

FIG. 1.

Curve A. Total Iron Losses and Friction Losses.
" B. Friction Losses.
" C. Stator Iron Losses and Hysteresis Power Torque.
" D. Pulsation Losses, measured from B as Abscissa.
" E. Hysteresis Power Torque.

2. The rotor winding is kept open and when running at full speed the power supplied to the stator is measured for different voltages. This may be done by driving the rotor; or the measurements may be taken simultaneously with those for (1) by switching the rotor winding open after every reading for the curve A A and noting quickly the readings of the instruments.

This gives curve CC, Fig. 1, the iron losses in the stator and the power due to hysteresis torque.

3. The power corresponding to the hysteresis torque is found for the various flux densities, and the curve EE, Fig. 1, is drawn.

Subtraction of the values given by the curve AA and the stator iron losses gives the losses due to pulsation and friction, or, since the friction loss is known as the horizontal line BB, the curve DD gives the losses due to pulsations in the teeth, when read off from BB as abscissa.

In order to see what sort of agreement there would be between the results obtained by the foregoing method for deter-

* This method of determining the friction losses was given by Hissink, E.T.Z., 1901, p. 226.

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mining friction and those found from retardation curves, experiments were made on the same machine as used for the above measurements, and the retardation curve due to friction, shown in Fig. 2, was taken.

Now to deduce from this curve the watt loss due to friction it is necessary to know the moment of inertia of the moving parts. As previously mentioned, this cannot be found in the case of machines with brass bearings by the simple method of oscillations, since the friction is too great. There are, however, other ways of determining it, and the one adopted was to use the circle diagram of the motor.

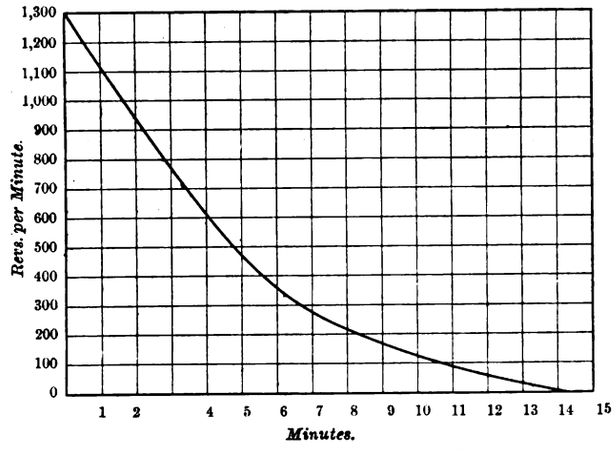

FIG. 2.—RETARDATION CURVE DUE TO FRICTION.

Suppose that, current being applied to the stator, the rotor is closed through a resistance. There will then be a torque on the rotor causing it to run up to speed and the corresponding acceleration curve may be drawn. The net torque thus acting on the rotor will not, however, be the true electrical torque on the conductors as found from the circle diagram, since there is an accelerating moment due to hysteresis and eddy currents, and a retarding moment due to friction and pulsations in the teeth. To find the acceleration which really corresponds to

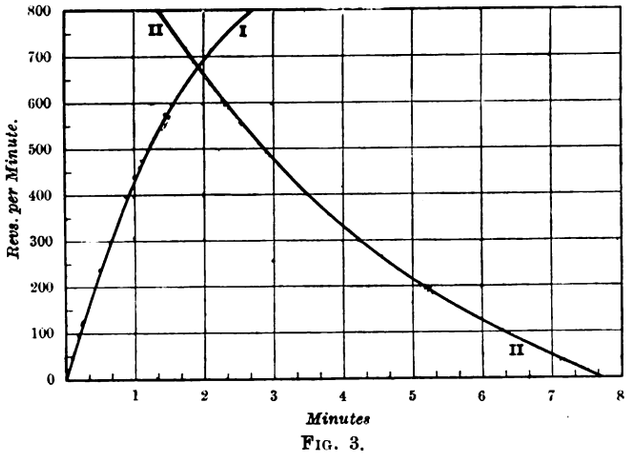

FIG. 3.

Curve I. Acceleration Curve. Rotor Winding closed through a Resistance.
„ II. Retardation Curve. Rotor Winding open. Flux same as for Curve I.

the electrical torque on the rotor conductors acting solely against the inertia of the moving parts an addition must be made to this acceleration curve.

Suppose for the same flux-density the machine is allowed to *run down* with the rotor winding open. The retardation will then correspond to the combined effect of the torque due to friction, pulsations in the teeth, hysteresis and eddy currents, and will therefore give the amount which must be added to the acceleration curve.

Hence by taking an acceleration and a retardation curve for the same flux-density and combining the two, an acceleration curve is obtained which corresponds to the turning moment, as found from the circle diagram, acting on the inertia of the moving parts.

In this way the curves in Fig. 3 were taken, and from them the resultant acceleration curve in Fig. 4 deduced.

The circle diagram shown in Fig. 5 was then drawn.

The point P_0 corresponds to a condition of pure no load—*i.e.*, the rotor running at full speed with its winding open. The point P_s is the short-circuit point, and was taken by running the rotor at 100 revs. per min. in both directions and taking the mean of the readings in the two cases. The point P_R is the standstill point for the rotor closed through the same resistance as was used for the acceleration curve. Therefore,

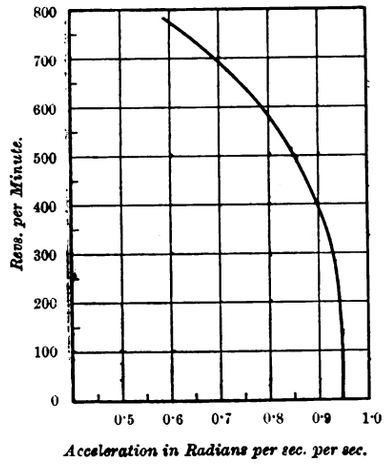

FIG 4.—ACCELERATION CURVE DEDUCED FROM CURVES I. AND II., FIG. 3.

the part of the circle from P_R to P_0 gives the working range of the diagram in this particular case, P_R corresponding to 100 per cent. slip and P_0 to synchronous speed.

To deduce the turning moment from the diagram the following construction is made: A tangent is drawn to the circle at P_0 and through P_s a parallel line cutting the abscissa axis in A. Then P_sA measures the power supplied to the machine at short-circuit and gives, therefore, the scale for power. The line P_sA is divided at T, so that the ratio of AT to TP_s is the same as the ratio of the stator resistance to the resistance of

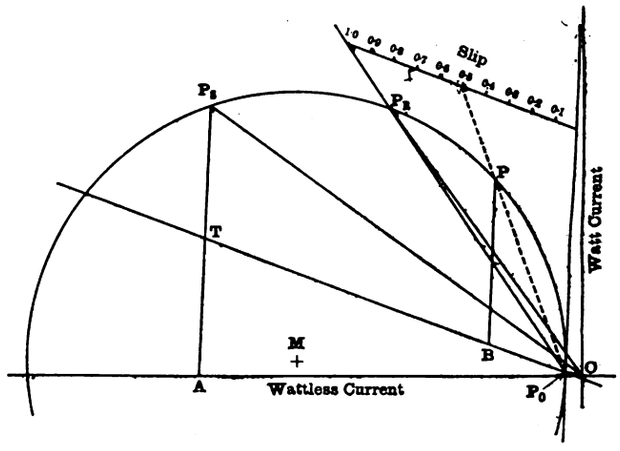

FIG. 5.—CIRCLE DIAGRAM OF THE MOTOR.

the rotor reduced to the stator turns, and joining T to P_0 the line of turning moments is obtained—*i.e.*, for a point P on the circle the distance PB from the line P_0T measured in a direction parallel to the tangent at P_0 is proportional to the turning moment.

For the scale of turning moments it may be noticed that the distances of points on the circle from the line P_0T, measured as before parallel to P_sA, give the power supplied to the rotor—*i.e.*, the turning moment multiplied by the synchronous speed, a quantity which is often called the turning moment in synchronous watts. The power scale is known, and therefore dividing this turning moment in synchronous watts by the synchronous speed the turning moment in cm. dynes multiplied by 10^{-7} is obtained.

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For the slip a line is drawn parallel to the turning moment line TP_0, and the intersection of this line with rays drawn from P_0 shows the speed—*i.e.*, such that the ray P_0P_R corresponds to 100 per cent. slip and the tangent to the circle at P_0 to synchronous speed.

As an example the following measurements were made: —

1. *No Load.*—The rotor running at full speed with open winding. 100 volts, 3·22 amperes, 96 watts, $\cos\phi = 0{\cdot}17$.

2. *Short-circuit.*—20·7 volts, 19·3 amperes, 410 watts, $\cos\phi = 0{\cdot}59$.

3. *Standstill* with same resistance in the rotor as was used for the acceleration curve: 39 volts, 26·1 amperes, 1,432 watts, $\cos\phi = 0{\cdot}81$.

The acceleration curve was taken with a pressure of 37·8 volts, and therefore the above readings must be reduced to this pressure.

Then, for short-circuit, the reduced values become: 37·8 volts, 35·2 amperes, 1,360 watts.

Hence the line P_8A corresponds to 1,360 watts.

The resistance of the rotor winding = 0·292 ohms.

The resistance of the stator winding = 0·153 ohms.

$$\frac{\text{Number of turns in stator winding}}{\text{Number of turns in rotor winding}} = 0{\cdot}71.$$

Hence resistance of rotor reduced to stator turns

$$= 0{\cdot}71^2 \times 0{\cdot}292 \text{ ohms.}$$

$$= 0{\cdot}147 \text{ ohms.}$$

$$\therefore \quad \frac{TA}{TP_8} = \frac{0{\cdot}153}{0{\cdot}147} = 1{\cdot}04.$$

For the point P.

The line PB represents a turning moment of $\frac{PB}{P_8A} \times 1{,}360$ synchronous watts, or $\frac{PB}{P_8A} \times 1{,}360 \times \frac{10^7}{125{\cdot}8}$ cm. dynes, since the synchronous speed was 125·8 radians pro sec—*i.e.*, PB represents a turning moment of $\frac{PB}{P_8A} \times 10{\cdot}80 \times 10^7$ cm. dynes.

In this way the following table has been deduced from the circle diagram, Fig. 5, and the curve of accelerations, Fig. 4.

The moment of inertia is determined from the equation—

Turning moment = moment of inertia × angular acceleration.

Table.

Speed.	Slip.	Turning moment in cm. dynes.	Angular acceleration.	Moment of inertia in kg.-meter units.
600	0·5	$6{\cdot}55 \times 10^7$	0·785	8·3
480	0·6	$7{\cdot}22 \times 10^7$	0·863	8·4
360	0·7	$7{\cdot}43 \times 10^7$	0·915	8·1
240	0·8	$7{\cdot}67 \times 10^7$	0·940	8·2
120	0·9	$7{\cdot}78 \times 10^7$	0·947	8·2
0	1·0	$7{\cdot}80 \times 10^7$	0·948	8·2

The mean value of the moment of inertia is thus found to be 8·2 in kilogramme-meter units.

The speed of the rotor when running with the lowest flux-densities, as given in Fig. 1, was about 1,170 revs. per min.

At this speed the retardation due to friction, as given by the curve in Fig. 2, was 0·322 radian per second.

Therefore, loss due to friction at this speed is

$$\frac{8{\cdot}2 \times 1{,}170 \times 0{\cdot}322 \times 2\pi}{60} = 323 \text{ watts.}$$

From Fig. 1 the friction loss is found to be about 300 watts.

Considering the fact that the friction loss is subjected to changes depending on the temperatures of the bearings, &c., the agreement is perhaps as good as could be expected.

In conclusion, the author would like to express his indebtedness to Prof. O. S. Bragstad for the valuable advice he has so readily given, and the kindly interest he has shown in the production of this article.

The experiments were carried out in the Electrotechnical Institute, Karlsruhe, Baden.

ENCLOSED ARC LAMPS.*

BY W. WEDDING

The first series of tests herein described was carried out in the laboratory at the Polytechnic at Charlottenburg in March and April, 1906.

The length of time that the carbons will last in enclosed lamps depends on the use to which they are put. If they are used intermittently and for short periods at a time, the carbons burn away faster owing to the atmospheric oxygen which enters when the lamp is extinguished. Consequently the general statement that a lamp will burn for 100 hours or more is not capable of any very precise interpretation. The following test illustrates this point. Two lamps of different makes were used; of these, the one called A had been in use for some time, while the other, called B, was new. Lamps A and B were run off a battery which gave 110 volts, as follows: (1) for 98·5 hours in all on six different occasions; (2) for 43·25 hours in all on three different occasions; and (3) for 17 hours in all on two occasions. The hourly consumption of the carbons was as follows (it being noted that in (3) the carbons supplied with the two lamps were interchanged). In lamp A the hourly consumptions of the positive carbon were 1·1 mm., 1·295 mm. and 1·265 mm. respectively; and of the negative carbon 0·213, 0·52 and 0·500 mm.; whereas for lamp B the figures respectively were 1·1, 1·1 and 0·97 mm. for the positive carbon, and 0·244, 0·382 and 0·177 mm. for the negative carbon. The following table gives the result of photometric observations:—

Lamp.	V'tage at lamp terminals.	Current.	Mean lower hemi. c.p.	Watts per Hefner c.p.	Watts per Hefner c.p., reck'ned from network terminals.	Remarks.
A.	77·4	5·76	331	1·34	1·92	Carbons 13 mm. diam.— with opal globe; Current density 0·0436 amp. per sq. mm.
	78·8	5·56	283	1·55	2·16	
	76·5	5·81	266	1·67	2·40	
	77·6	5·89	492	0·95	1·34	with clear globe
B.	77·5	5·88	400	1·14	1·62	Carbons 13 mm. diameter— with opal globe; Current density 0·0449 amp. per sq. mm.
	77·7	5·83	316	1·44	2·03	
	78·2	5·81	378	1·21	1·69	
	77·6	6·18	475	1·01	1·43	with clear globe

Further tests were made in September and October, 1906, on two new lamps, C and D, of different makes, having carbons 10 mm. in diameter. C was fitted with an opal globe, and took 6·05 amperes at 75·3 volts; it gave 562 Hefner candle-power as the mean lower hemispherical candle-power, being at the rate of 0·81 watts per candle-power. Similarly D took 6 amperes at 79 volts, and gave 438 Hefner candle-power, being at the rate of 1·08 watts per candle-power. The average consumption of the carbons during 24 hours' steady run was at the rate of 2·06 mm. per hour for the positive, and 0·21 mm. for the negative. An enclosed arc lamp, taking 6 amperes with carbons 10 mm. in diameter, will take 1 watt per mean lower hemispherical Hefner candle-power, as referred to the lamp terminals, and 1·4 watts as referred to the network pressure of 110 volts. The photometric curves, showing the distribution of the illumination at different angles, are apt to show very uncertain results, owing to the constant variation of the light. Lamps of different makes are not very easily compared; even practised observers are apt to arrive at different results, owing to the irregularity of the arc, and the many errors which arise in consequence. Consequently a spherical photometer gives better results, and has the further advantage of requiring only one reading. Even with such a photometer, considerable variations are noticed. If the readings are taken every 20 minutes during three hours, the figures are likely to vary by 10 per cent. on either side of the mean values. Moreover different types of lamps vary in different ways; some go through small periodical oscillations, whereas others perhaps go through a cycle every 10 minutes.

The following figures refer to further tests. Lamp E gave 301 Hefner c.p. and took 3·41 amperes at 71 volts, being at the rate of 0·8 watt per c.p.; it had an opal globe about 12 cm. in diameter, and cored carbon of 5 mm. diameter, the current density being 0·174 amperes per square millimetre. The positive carbon burnt at the rate of 4·08 mm. per hour, and the negative at 2·12 mm. per hour. The length of the positive carbon was 200 mm. and of the negative 70 mm., and as the lamp was arranged to burn out when the negative was 35 mm. long, it would only burn 16·5 hours. Lamp G gave 509 c.p. and took 5·38 amperes at 71·2 volts, being at the rate of 0·75 watt per c.p., with a current density in the carbon of 0·274 amperes per square millimetre. Contrary to expectation, the specific consumption may be lower in a lamp taking a smaller current. Much depends on the current density in the carbons, and conse-

* Abstracted from *Elektrische Kraftbetriebe u. Bahnen.*

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quently on the diameter of the carbons. If 13 mm. carbons are used in a 6 ampere lamp the current density is 0·045 amperes per square millimetre; in a 4 ampere lamp with 6 mm. carbons it is 0·142 amp. per square millimetre; in a 3·4 ampere lamp with 5 mm. cored carbon it is 0·174, and in a 5·4 ampere lamp with 5 mm. cored carbon it is 0·274. With increase of current density the carbons tend to give out more light. The ends are hot over the whole surface, and remain hot, even while the arc wanders so that the distribution of illumination is more uniform. The polar curves show this clearly; the measurements on the photometer are more easily made, and less liable to the various errors which are inevitable when larger carbons are used. The polar curves show that in every way they are more suitable for the ordinary purposes of electric lighting owing to the more even distribution of the illumination. Alternate current lamps were also tested, but the specific consumption was about twice that of a direct-current lamp. With a high current density the light is very steady, but the higher consumption of energy makes them for the present much inferior to lamps of the other type.

Following on the preceding experiments, an examination was made of the effect of the exclusion of air on the illumination Arrangements were made by which a lamp could be tested in the spherical photometer under the following conditions: (1) with complete exclusion of air, (2) with natural ventilation through open valves, each 28 sq. mm. in area, and (3) with the introduction of air through a hole 8 sq. mm in area at the bottom of the globe, the valves being open as before. The effect on the illumination was practically negligible, and such differences as were noted were probably due to errors of observation. Consequently the perfect or imperfect exclusion of air produces little or no effect upon the light emitted by an enclosed lamp. The consumption of the carbons and, consequently, their cost and the expense of the necessary attendance are the only items affected by the entrance of air into the lamp. It may also be stated with confidence that, in so far as specific consumption is concerned, enclosed lamps at present on the market are very little inferior to those of the open type. Even in small sizes, if a sufficient current-density is used in the carbons, it is possible with opal globes to reach an efficiency of 0·75 watt per Hefner candle-power. This is probably due to the fact that the temperature of the enclosed gases is so high as to make it possible to produce the same light as in an open arc with the same economy.

A new field for arc lighting might probably be found in its use in factories, which are specially liable to fire risks; as, for instance, in those industries in which benzine is used. It has been pointed out that occasionally a lamp explodes, but this can only be due to an accumulation of carbon monoxide and the subsequent introduction of air. Consequently, lamps have been constructed which are packed tight with rubber washers, and with a ring-shaped piece of wire gauze above the globe. This is not altogether sufficient. But if a sufficiently long and narrow path through metallic bodies is allowed for the passage of the burning or exploding gases from the inside of the globe into the open air the danger is to a large extent avoided and may even cease to exist. For this purpose an ordinary 10 ampere lamp, with spherical globe 350 mm. in diameter, was closed with an airtight joint to a cylinder of 200 mm. diameter and 75 mm. long, which was placed above the globe. The cylinder was closed with two pieces of wire gauze and with two metal rings provided with passages for the gases. The metal rings were placed between the pieces of wire gauze. The inner piece of wire gauze had 1¼ meshes per square millimetre and the outer four meshes per square millimetre. The passages in the rings were 5 mm. broad and 35 mm. long, and were staggered in such a way that the gases could not pass from one direct to the other. Tests which had been made without metal rings had led to violent explosions. For the purpose of the present experiments some benzine was poured into the globe of the lamp, which was hung in a vat containing a small amount of benzine. After allowing sufficient time for the benzine vapour to diffuse the lamp was lighted, with the following results:—

First trial: Very violent explosion; inner wire gauze very hot opposite the opening in the inner metal ring, and darkened in colour; outer wire gauze cool.

Second trial: Slight explosion. Wire gauze as in first trial.

Third trial: Slow explosion, but violent enough to lift off the cover of the vat. Inner gauze very hot; outer gauze cool.

Fourth trial: Explosion took place some time after lighting the lamp; inner gauze very hot, and outer gauze just warm to the hand.

Fifth trial: Slight explosion: wire gauze as before.

Sixth trial: Explosion with a marked whistling sound; inner gauze very hot, outer gauze warm to the hand.

This seems to show that an arrangement of this kind can be fitted to a lamp so as to make it suitable for burning in places where the fire risk is great. Similar results have also been obtained under similar conditions with enclosed motors, and there seems no reason why enclosed arc lamps should not be capable of such adaptation as to fit them for use under the same circumstances.

RECENT CONTRIBUTIONS TO ELECTRIC WAVE TELEGRAPHY.*

BY PROF. J. A. FLEMING, M.A., D.SC., F.R.S.

(*Concluded from page 352.*)

We may consider in the next place another problem of great practical importance, towards the solution of which some considerable progress has been made, viz., that of locating the direction of the sending station and giving direction to the emitted radiation sent out from it. The early attempts to do this depended upon the use of parabolic mirrors, or some arrangement of vertical rods equivalent to it. But although comparatively short electric waves of a few feet in wave-length can be directed in this manner in the form of a beam, it is out of the question for electric waves hundreds of feet in length, because reflection can only take place when the dimension of the mirror is at least comparable with that of the wave-length.

The ordinary vertical antenna, of course, radiates equally in all directions, and when it is so far off as to be below the horizon a corresponding receiving antenna may respond to it, but cannot locate the position of the sending station.

It seems to have been noticed by several persons that if the antenna is not vertical it radiates rather more in one direction than another, and the same for a non-vertical receiving antenna. It is more receptive to waves coming from one direction than another. Various observations on the operation of non-vertical, looped, or duplex antennæ have from time to time been made by Zenneck, Sigsfeld, Strecker, Slaby and De Forest, whilst methods for locating the sending station or directing the transmitted waves were described in patent specifications by De Forest, Garcia and Stone. Although claims were made for arrangements said to be effective, these various researches were not pressed to such logical issue as to disclose any definite general scientific principle, whilst in some cases the results said to have been obtained are clearly in contradiction to well-ascertained facts.

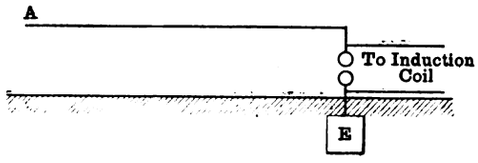

FIG. 17.— MARCONI BENT ANTENNA.

Time will not permit further reference to these early and inconclusive observations.

In March last year Mr. Marconi communicated to the Royal Society a Paper on the radiation from an antenna having a short part of its length vertical and the greater part horizontal, and on the receptive powers of a similar antenna in various azimuths (see Fig. 17). He found that such a bent antenna emits a less intense radiation at any given distance in the direction in which the free end points than in the opposite direction. Also, since the law of exchanges holds good for electric radiators, a similar form of antenna receives or absorbs best electric waves which reach it from a direction opposite to that to which the free end points.† Hence two similar bent antennæ when set up back to back—that is, with their free ends pointing away from each other—form a system of radiator and receiver which has greater range in that position than in any other for the same distance, and hence has directive qualities not possessed by the ordinary vertical antennæ.

Although I have given the mathematical explanation of the reasons for this in another place, it is not difficult to translate the common sense of it into non-symbolic language. Imagine a square circuit of wire half buried vertically in the earth (*see* Fig. 18). Let a current be supposed to flow round it in clockwise direction. Then it creates a magnetic field, the direction of which along the surface of the earth in a direction at right angles to the plane of the circuit and at equal distances from the centre is towards the spectator on both sides. Suppose then that a wire equal in length to one side of the square is placed in contiguity to one vertical side, and that it carries a current opposite in direction to that in the side of the square (say the right-hand side) to which it is in proximity; then the magnetic field of this straight current is from the spectator at the right-hand side, and to the spectator on the left-hand side. Accordingly the total field on the right-hand side due to the currents in the

* A Friday Evening Discourse delivered at the Royal Institution of Great Britain, Friday, May 24, 1907.

† This is an extension to electric radiation of the principle known as Prevost's Theory of Exchanges as amplified by Balfour Stewart and Kirchhoff, which forms the basis of spectrum analysis laid down be Stokes, Kirchhoff, Bunsen and others.

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closed and open circuits together is less than that on the left, because the individual fields are added on one side and subtracted on the other. Since the two oppositely-directed currents in the adjacent wires may be imagined to come so close as to annul each other, and since the parts of the remainder below ground may be considered to be removed without affecting the field above ground, we arrive at the conclusion that an antenna partly vertical and partly horizontal radiates most strongly in the direction opposite to that in which the free end points.

Mr. Marconi discovered this fact experimentally, and made measurements of the currents induced in receiving antennæ placed at equal distances round this bent transmitter, and plotted the results in the form of a polar curve (*see* Fig. 19). As a quantitative receiving detector he made use of a Duddell's thermal ammeter. In repeating and confirming these experiments on a smaller scale last

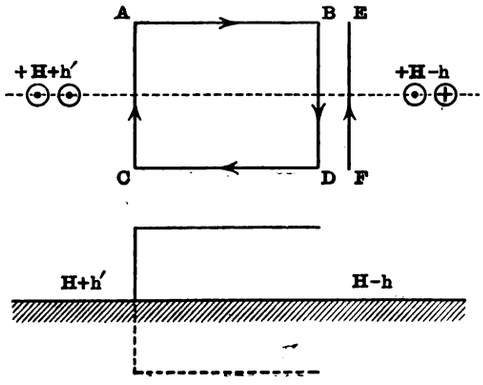

FIG. 18.—THEORY OF MARCONI BENT ANTENNA.

summer in the grass quadrangle of University College, I employed a form of thermal ammeter of my own design, made as follows: A vacuum vessel made like those which Sir James Dewar devised for storing liquid gases has four platinum wires sealed through the bottom of the inner test tube (*see* Fig. 20). One pair of these is connected in the vacuous space by an extremely fine constantin wire, and the other pair by a fine tellurium-bismuth thermo-junction with the junction resting on the fine wire. When a galvanometer of suitable resistance is connected to the terminals of the thermo-junction and the constantin wire inserted in the circuit of the receiving antenna, we have an arrangement which enables us to measure as well as detect the intensity of the electric waves incident on the antenna. This detector, skilfully made by my assistant, Mr. Dyke, proved very useful. I was thus able to confirm Mr. Marconi's observations and my own theory of them, and, furthermore, noticed

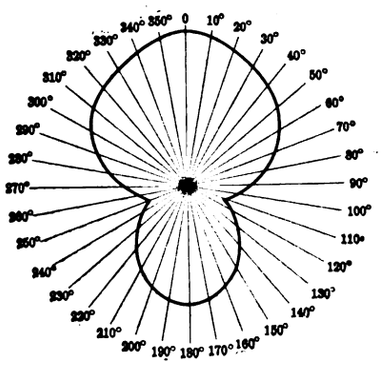

FIG. 19.—RADIATION IN VARIOUS AZIMUTHS FROM MARCONI BENT ANTENNA.

that when the non-vertical part of the transmitting antenna was bent so that it was not horizontal, but pointed downwards, a very remarkable non-symmetry of radiation occurred, quite, however, accounted for by theory (*see* Fig. 21). Mr. Marconi has made very effective practical use of the bent receiving antenna to locate the position of a ship or station sending out electric wave messages when so far off as to be below the horizon.

In this case he arranges the receiving antenna so that a very short part is vertical and the greater part horizontal, and, furthermore, permits the horizontal part to be swivelled round the vertical part as a centre. In the vertical portion he places his magnetic or some other detector. If then there be a distant station in correspondence with this receiver, the direction in which the transmitter lies can be determined within a few degrees by swivelling round the receiving antenna and noting the position in which it picks up signals or picks them up best from this transmitter. The transmitter then lies in the direction opposite to that in which the free end of the receiver wire points. If it is not convenient to swivel round the horizontal portion then Marconi arranges a number of horizontal receiving antennæ like the spokes of a wheel all having a common shorter part vertical at their centre. In the vertical part a magnetic detector is inserted, and by means of a switch any one of the horizontal radial antennæ can be put in connection with it. By finding which radial gives the strongest signals the direction of the sending station is easily located (*see* Fig. 22).

It will be seen, therefore, that two well-defined principles had been arrived at by Marconi, first, that the non-symmetry of the radiation and reception depends upon the employment of antennæ having their horizontal portions large compared with the vertical,

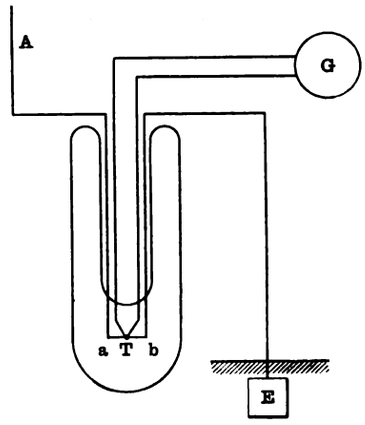

FIG. 20.—FLEMING THERMAL DETECTOR.

and, secondly, that the maximum radiation is in the direction opposite to that in which the free end of the horizontal part points. These observed effects rest on a sound scientific basis and, as I have shown, are immediately derivable from first principles.

Previously to Marconi's experiments no definite guiding principles as to directive telegraphy had been published, but a number of unconnected observations made, not always correctly interpreted or even described, and in any case with limited application.

Meanwhile, however, Prof. F. Braun, of Strasburg, had been engaged on a different plan for directing the radiation from antenna.

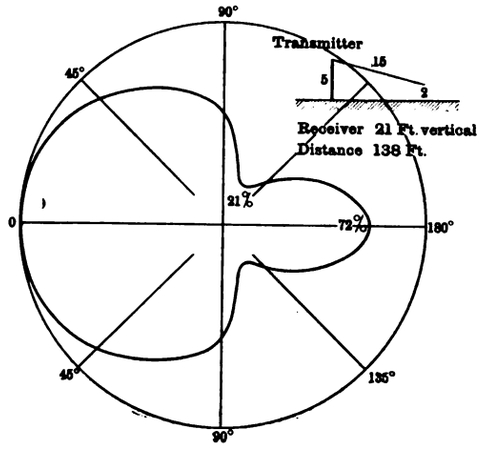

FIG. 21.—POLAR CURVE SHOWING INTENSITY OF RADIATION IN VARIOUS DIRECTIONS ROUND A BENT ANTENNA.

Briefly stated his method is as follows: He erects three vertical antennæ at the corners of an equilateral triangle or four at the corners of a square, the sides of which are about equal to the height of the antennæ, and he creates in them electrical oscillations which have a defined and constant difference of phase by methods contrived by him, Drs. Papalini and Mandelstam, not yet fully described. It is found that the waves sent off from these three antennæ interfere with each other in an optical sense, exalting each other in some directions and nullifying each other in other directions in accordance with their relative amplitude and phase difference. The resultant effect can be so arranged that the radiation is extremely unsymmetrical, being much more towards one side than the other. The intensity in various azimuths may be represented by the radii vectores of a sort of oval or heart-shaped curve, the triple transmitter occupying a position on the cusp or apex of the curve (*see* Fig. 23).

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It will be seen therefore that popular notions on the subject of directive telegraphy are wide of the mark. Whilst we cannot yet project a narrow beam of long wave electric radiation in any required direction or focus it entirely on a given receiving station at a great distance, much can be done to prevent radiation being sent out from transmitters in directions in which it is of no use or not desired.

At coast stations communicating with ships at sea something has already been done to achieve this result. Mr. Marconi has for some time past employed such directive antennæ at his large power station at Poldhu and elsewhere.

These, then, are a few of the contributions which have recently been made by practicians and theorists to this fascinating and progressive subject. But whilst we may congratulate ourselves that progress continues to be made, there still are large districts of it in

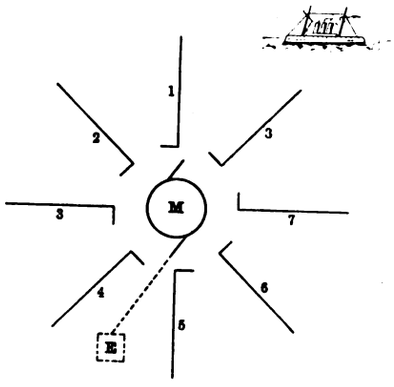

Fig. 22.—Marconi Localising Antenna.

which our knowledge is most incomplete. One matter having a very practical bearing is the necessity for systematic study of the causes which vary the transparency of space to long electric waves. You will continually see references in the daily papers to isolated feats of communication between ship and ship, or ship and shore, over unusually large distances. Ships equipped with what is called short-distance apparatus, that is intended to send and receive over 200 miles or so, are able occasionally to communicate with others 600, 800 or even 1,000 miles away. This is not altogether a matter of personal skill or of apparatus. Our terrestrial atmosphere varies from day to day and hour to hour in its transparency to long telegraphic electric waves, just as it does to the short light waves. One reason, and probably a valid one, which has been advanced for this is the ionisation of the atmosphere by sunlight, radio-active matter, or

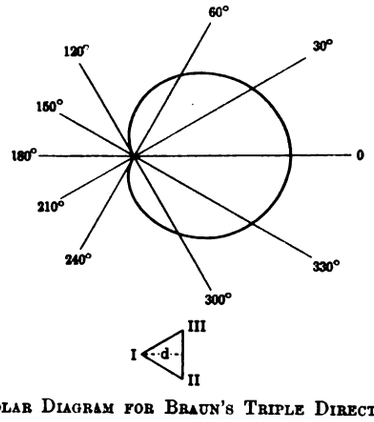

Fig. 23.—Polar Diagram for Braun's Triple Directive Antenna.

matter electrically charged reaching our earth from the sun or cosmical space. These ions or electrically-charged particles suspended in the air are set in motion by the electric force of long electric waves passing through the region. This, however, involves energy which must be taken from the wave and hence the wave passes on so much the weaker. This effect is altogether different from the disturbing effects of atmospheric electricity on the receiving antenna. As first noticed by Mr. Marconi on one of his Atlantic voyages, the atmospheric transparency for long electric waves is decreased by daylight, and this reducing effect of light on the wave energy takes place chiefly near the transmitting antenna where the electric force is largest. It fluctuates from hour to hour and month to month according to laws as yet undetermined and has no doubt secular and irregular fluctuations superposed on its regular variations. The subject of long-distance wireless telegraphy is yet too young to provide observations for any safe generalisations on this matter, but doubtless these will be accumulated in course of time.

Wireless telegraphy has now reached a position of such importance, especially in connection with supermarine communication, that scientific research for its advancement should have the utmost possible encouragement, subject, of course, to the consideration that there is only one æther for us all. Whilst we derive satisfaction from the thought that so much valuable discovery and invention has already rewarded the labours of workers in many lands, we have but to glance around us to see in all directions in connection with it unsolved problems, untrodden paths, wide fields of knowledge ripe for harvest in which the sickle of the reaper has never yet been moved.

THE FARADAY SOCIETY.

At the meeting of the Faraday Society held on May 28, Prof. A. K. Huntington in the chair, a Paper entitled

"Contributions to the Chemistry of Gold,"

by Mr. F. H. Campbell, M Sc., was read in abstract by Mr. N. T. M. Wilsmore, M.Sc.

Aurous iodide, AuI, was prepared by the author, and found to decompose at 25 deg., according to the equation

$$2AuI \rightleftarrows 2Au + I_2.$$

Since this equation contains only one variable, namely, the iodine, there must be a particular pressure of iodine at which AuI, Au, and I_2 are in equilibrium. This was found to be 0·943 of that of pure iodine; any solution of iodine will therefore act on gold if more than 0·943 saturated, but not if below this strength.

When gold is acted on by a solution of KI and iodine, part is converted into insoluble AuI and part dissolves. The experimental results with various solutions agree with the equilibrium equations only when the gold is assumed to enter the complexion in the monovalent condition—*i.e.*, to yield AuI_2 ions.

The action $3AuCl = AuCl_3 + 2Au$ was found to occur at ordinary temperatures and in absence of moisture.

Dry chlorine and AuCl combine at ordinary temperatures to form $AuCl_3$.

Aurous oxide, Au_2O, was obtained after considerable difficulty, and its solubility in nitric acid determined. The oxidation potentials of various nitric acid solutions, saturated with aurous oxide, were then measured, and from these figures the normal potential for the tendency

$$Au \rightarrow \text{metallic gold}$$

was calculated, and found to be +1·5 volt against the hydrogen standard.

The small affinity between gold and iodine, the tendency to form a complexion with iodine, the high oxidation potential of Au ions, and the very low solubility product of Au_2O all agree to confirm the assumption that Au forms very weak positive ions.

Prof. Dr. R. ABEGG (communicated) referred to the general question of the stability of the various peroxides and their oxidising powers, and pointed out that the low oxides of the noblest metals could show as high an oxygen pressure as the peroxides of the less noble metals.

Dr. H. BORNS drew attention to Wohlwill's work on the electrodeposition of gold from the chloride solution.

Dr. F. Mollwo Perkin read a Paper on

"Reduction of some Oxides and Sulphides by means of Metallic Calcium."

The author first referred to the well-known powerful reducing action of aluminium, as, for example, its use in the preparation of chromium, ferro-silicon, and other metals and alloys, and its use in the form of "thermite" for welding purposes. He finds that metallic calcium is a still more powerful reducing agent than aluminium. For example, when molecular proportions of aluminium and ferric oxide are mixed together and ignited by means of a fuse of aluminium and barium peroxide, intense reaction ensues, and continues until all the oxygen has been removed from the ferric oxide, and aluminium oxide and metallic iron produced in its stead. When metallic calcium in the form of fine turnings is mixed with ferric oxide and ignited in a similar manner, the reaction is so intense that the mixture is in large part ejected from the crucible. The reaction can be brought under control by mixing 30 to 40 per cent. of calcium fluoride or 10 to 20 per cent. of calcium oxide with the contents of the crucible. Boron can be obtained by igniting a mixture of boron trioxide with the calculated quantity of calcium and 5 to 10 per cent. of calcium oxide. If no calcium oxide is added the reaction is too violent. It is, however, very difficult entirely to free the boron from calcium even after standing over hydochloric acid for weeks; the boron invariably contains considerable quantities of calcium which is probably present as calcium boride. When borax is carefully dried and mixed with calcium, and the mixture ignited by a fuse,

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the reaction completes itself without undue violence. On treating the reaction mixture with hydrochloric acid, brown amorphous boron is obtained in almost theoretical quantities; the product, however, always contains calcium, but can be used for preparing boron chloride and similar compounds. Rather anomalous results were obtained when sand (silicon dioxide) was ignited with calcium. Unless considerably less than the theoretical amount of calcium was used, not silicon but probably calcium silicide was obtained, because when the reaction mixture is placed in hydrochloric acid, large quantities of a spontaneously inflammable gas are given off; this gas is probably silicon hydride. The product remaining behind is silicic acid and calcium chloride. The results were the same when a mixture of aluminium and calcium was employed.

Attention was also drawn to the difficulty experienced in causing silica in the form of fine sand to react with metallic aluminium which was in the form of a rough powder. A similar difficulty was met with in the case of boric anhydride and aluminium. Galena does not yield metallic lead and calcium sulphide, but a greyish mass which gives off sulphuretted hydrogen when acted upon with acids, lead in the form of a salt being left in solution. Red phosphorus and calcium unite with explosive violence. Sulphur and calcium also react with great vigour. Manganese dioxide and calcium require to be mixed with 80 to 40 per cent. of calcium fluoride, when a regulus of manganese can be obtained; otherwise the reaction is too violent. This is also the case with chromium oxide. When the experiments were first tried it was found that the reaction mixture always stuck to the crucible, and it was invariably necessary to break the crucible in order to obtain the product. Subsequently the difficulty was got over by lining the crucible with a paste made from slaked lime and a strong solution of sodium silicate (water glass); in the case of boron the solution used was generally borax. The crucible and lining were thoroughly dried and were then ready for use. With crucibles so prepared there was never any difficulty in getting out the reaction product in the form of a lump without breaking the crucible.

Mr. F. E. WESTON said that he had succeeded in reducing silica in the form of kieselguhr by means of aluminium. He had recently used aluminium in the reduction of titanium compounds.

Mr. W. P. DIGBY asked whether calcium would, like aluminium, prevent segregation in steel castings.

Prof. A. K. HUNTINGTON said that the state of division of the materials in these experiments was of paramount importance. He believed, answering Mr. Digby, that calcium had not proved a successful substitute for aluminium in pouring steel; the calcium oxide seemed to remain in the metal.

CAPACITY MEASUREMENTS AND EXPERIMENTS WITH CURRENTS OF TELEPHONIC FREQUENCY.*

BY BÉLA GÁTI.

By introducing various improvements into Kennelly's barretter method—such as the use of stronger measuring currents, a galvanometer of lower resistance, gold instead of platinum in the Wollaston's wire, &c.—the author has rendered the measurement of ordinary speaking currents by means of galvanometers possible.

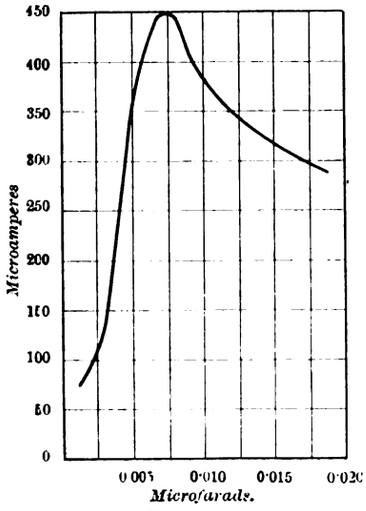

FIG. 1.

In Fig. 1 is shown the resonance curve of the Siemens high-frequency (2,210~) alternator. The resonance point is clearly defined, and this feature renders the machine very useful for capacity measurements. The method of procedure is as follows: The resonance curve shown in Fig. 1 having been obtained by the use of various known capacities, the capacity to be measured is connected across the terminals of the alternator and the current found from the galvanometer deflection. By reference to the curve of Fig. 1 the value of the capacity is read off directly. Measurements of capacity with high-frequency currents, therefore, become very simple.

It is found that the capacities determined by using alternating currents are less than those obtained by the use of continuous currents.

The author has tested a number of microphone transmitters with regard to their power of transmitting tones of high pitch. The source of sound was a Galton's whistle, through which air was blown at constant pressure. It was found that while the transmitter of the Telephon-Fabrik A.-G. (formerly J. Berliner) gave much better results at the lower frequencies than the transmitter of the Mix & Genest A.-G., the latter instrument was almost equally effective at all frequencies It may be possible to construct transmitters which will respond more powerfully to tones of higher frequency, in which case the distortion brought about by the line would be reduced.

The above measurements with telephone transmitters were carried out by adjusting the secondary current to the resonance maximum.

The author was surprised at the want of sensitiveness of the human ear towards intensity of sound. He found that the current could be increased tenfold without producing more than a slight increase in the apparent loudness of the sound, while a change of a few per cent. in the current is quite imperceptible.

* Abstracted from the *Elektrotechnische Zeitschrift*.

FOURTH ENGINEERING CONFERENCE, JUNE 19-21, 1907.

In opening the proceedings of the Engineering Conference of the Institution of Civil Engineers, the President, Sir Alexander B. W. Kennedy, F.R.S., remarked that the first of these Conferences was held in 1897, just 10 years ago, under the Presidency of Sir John Wolfe Barry. It was sad to notice that among the Sectional Presidents in that year were no less than four distinguished members of the Institution who had now passed away—namely, Mr. Hayter, Sir Frederick Bramwell, Mr. Mansergh, and Sir Benjamin Baker. The second Conference was held under Sir William Preece in 1899, and the third under Mr. Clarke Hawkshaw in 1903. The President laid stress upon the essential catholicity of the aims of the Institution. In the early days engineers had been inclined to attach too much importance to the sort of work which they happened to be doing at the time, and they were disposed to be somewhat too exclusive in their classification of civil engineers. This attitude, however, was certainly contrary to the spirit and to the letter of their charter, which appeared to cover in definite words every branch of engineering which was in existence at the time when it was drafted—namely, in 1828. At that time railways had not come into existence and electricity was as yet unborn, but, nevertheless, it was clear that all branches of engineering fell within the interest of the Institution, and therefore that everybody working within such departments and having attained a certain degree of knowledge, of responsibility, and of technical capacity, was a civil engineer, and ought, therefore, to be a corporate member of the Institution. The Conference had many objects, but probably the idea of catholicity was really the fundamental one on which it was based. Judging from the programmes which had been arranged in the different sections, there was no doubt that matters of great interest and importance were to be brought forward. Objections might be taken to the formation of sections at all, but there were certain advantages in having them which seemed to justify their formation. He hoped, however, that members would not be so narrow-minded as to confine their interest and their presence to only those sections of the Conference with the business of which they were concerned in everyday work. It was a mistake to limit one's interest to any particular branch, for such limitations were a hindrance to that broadmindedness, which as citizens and as men of the world they sought, at any rate in theory, to cultivate. By taking advantage of the wide area covered by the different sections, members had a chance of finding out how far ahead of them their friends might be in any particular branch, and also how very interesting were all other branches

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of engineering, and how much more easy it was to form dogmatic, and doubtless accurate, opinions on other people's work than on their own—an excellent mental training and discipline for all.

At the close of his address the President declared the Conference to be in session, and the sections adjourned to the various meeting rooms for the opening of discussions.

In Section VI. (Waterworks, Sewerage and Gasworks) the only Paper of electrical interest on Wednesday, was :—

COMPARATIVE COST OF PUMPING BY STEAM, INTERNAL-COMBUSTION ENGINES AND ELECTRICITY, BASED UPON ACTUAL WORKING.

BY C. HAWKSLEY AND H. DAVEY.

To compare the actual cost of pumping by the various methods named is difficult for want of sufficient comparable examples. The thermal efficiency of the prime mover may be very high, and its consumption of fuel per work done also very high, because of mechanical losses. The real economy is the sum of the thermal and mechanical efficiencies in work done. It is only on this basis that a true comparison can be made. The commercial costs are not dependent on the fuel-costs alone, but also on other working expenses and maintenance.

For public water supply, the drainage of mines and land and certain other purposes, the power required is generally considerable and continuous, and it is to those applications that we propose to direct attention. In such operations the cost of fuel per pump-horse power (P.H.P.) is the most important item.

The two important questions in pumping operations are cost of fuel and continuous working. Pumping engines have sometimes to run for many months without stopping, and should maintain their efficiency for 30 to 40 years with little outlay on repairs. Since the days of Newcomen no steam engine has been more economical than the low-speed pumping engine. The best waterworks and mining engines of to-day give 1 P.H.P. per hour with 12 lb. to 20 lb. of steam, depending on the nature of the engine and its application.

The mechanical efficiency of the steam engine and pump combined varies from 80 to 86 per cent. The steam consumption is 10·5 lb. to 16 lb. per indicated horse-power hour, being as low as that of any high-speed or other steam engine used to produce electric current. The comparison, then, of the steam pumping engine with electric pumping plant as regards fuel becomes reduced to a question of the comparative mechanical efficiencies of the two systems, expressed in terms of pump-horse power. Thus :—

Direct-acting steam pumping engines and pumps :—		
Mechanical efficiency per P.H.P.	83 per cent.	
Electric :—		
Engine and dynamo, mechanical efficiency	85	,,
Cables ,, ,, ...	95	,,
Motor ,, ,, ...	80	,,
Gearing and pumps ,, ,, ...	75	,,*
Total mechanical efficiency per P.H.P.	48·45	,,*

The relative fuel economy in the above example is as 10 to 17 in favour of direct steam pumping.

It would appear that establishment charges and maintenance would be greater with electric plant. Electric current might, however, be supplied from a public source ; we must then assume the cost per unit. The actual cost at the Neasden station of the Metropolitan Railway is said to be as low as 0·3d. per unit, not charging repairs or interest on capital. We know of no public supply as low as 0·5d. per unit, but will adopt that figure. Taking the efficiencies given above of the cables, motor and gearing and pumps only, 1·31 electrical units would be required per P.H.P. This at 0·5d. per unit would represent £24 per P.H.P. per annum for electrical energy alone. The cost of coal varies with the situation, but generally speaking, in an ordinary steam-pumping establishment it does not exceed £5 to £8 per P.H.P. per annum (see following table), or less than one-quarter of the cost of electricity at a half-penny per unit.

We have a record of the total working-cost of a not very modern coal mine pumping engine and the average cost of fuel for 10 years' continuous working has been £5. 6s. 10d. per P.H.P. per annum. During the 10 years the engine has averaged 264 P.H.P. continuously. At ½d. per unit electricity would have cost £24 per annum per P.H.P. In the same district, a colliery one, the charge for electrical energy is ¾d. per unit, supplied from an electric power supply station. It thus appears that electric pumping plant cannot be economical in fuel, as compared with steam pumping engines of moderate economy.

As regards the internal-combustion engines, it will be necessary, in estimating the fuel economy, to take into consideration not only the mechanical, but also the thermal efficiency. Gas engines, having a higher heat efficiency than steam engines, naturally have an advantage in fuel economy, all o her things being equal. With gas engines of, say, 200 H.P., the consumption of bituminous coal is, taking the engine maker's estimate, 1·75 lb. per B.H.P. The total capital outlay on engines and producers for 1,000 B.H.P. is practically the same as that for compound condensing engines and boilers of similar power.

For driving machinery direct, there appears, from the above figures, to be an economy in fuel alone in a gas engine over a steam engine ; but for pumping purposes, the mechanical loss in gearing between the engine and pumps would probably more than counterbalance the apparent saving. Assuming the mechanical efficiency of the gearing and pumps to be 70 per cent., then the 1·75 lb. per B.H.P. would become 2·5 lb. per P.H.P. There would also remain to be considered the reliability of the plant in continuous working, consumption of lubricants and other details.

Looking at the question of consumption of fuel from a thermal efficiency point of view, and making a comparison, we have :—

	Per cent.
Mechanical efficiency of direct-acting steam engine and pumps combined	83
Mechanical efficiency of gas engine alone	80
,, ,, gearing and pumps	70
,, ,, gas engine and pumps combined	56
Heat efficiency of steam engine, say	15
,, ,, gas engine	25
The total efficiencies are then—	
Steam engine and pumps combined	12·45
Gas ,, ,, ,, ...	14

There remain to be considered the relative cost of coal, the additional cost of lubricating oil for the gas engine, and also cost of maintenance and reliability in continuous working.

Having already exceeded the length allotted for the introduction of a subject at this Conference, we can only remark, in regard to oil engines, that we know of no examples that compete with such plant as we have been considering. Oil engines generally require, under usual working conditions, about 1 lb. of oil per B.H.P.

Waterworks Pumping Engines.

(Some examples of the annual cost per P.H.P.)

	Engines working both well and distribution pumps, thus pumping the water twice.				Engines with distribution pumps only.	
	A.	B.	C.	D.	E.	F.
T'tal h'ght of lift, ft.	485	563	483	370	205	93
Av. P.H.P. taken over whole year (8,760 hours)	144	125	178	125	91·5	72
Boiler pressure, lb. per square inch	100	60	60	70	130	140
Price of coal delivered in boiler-house yard, coal used being local slack, per ton	8s. 5d.	7s. 5d.	8s. 1d.	9s. 3d.	9s. 8d.	8s. 1d.
Actual annual cost of coal per P.H.P. (8,760 hours)	£ s. d. 7 1 0	£ s. d. 7 7 0	£ s. d. 7 7 3½	£ s. d 8 12 6	£ s. d. 6 9 0	£ s. d. 5 2 4
Total actual annual cost of coal, stores, oil, wages and repairs, per P.H.P.	12 16 6	12 5 10	11 4 5½	13 9 8	19 13 10	15 13 3

DISCUSSION.

The Chairman (Sir G. LIVESEY) remarked that the Paper related chiefly to slow-running engines, and although the authors made a comparison with gas engines, the capital cost had been left out, and that made a very material difference in some cases.

Mr. NOBLE ANDERSON said the Paper seemed to him to have a very British character. The British had a certain amount of bias in favour of old friends and the direct-acting pumping engine was, he believed, the oldest friend of the mechanical engineer. The most recent pumping engines with which he had done experimental work gave a duty of 150,000,000 ft.-lb. per 1,000 lb. of steam. For some sewage pumping engines which he had designed for use in New Zealand it had struck him that a centrifugal pump would suit the business best. The centrifugal pumps on the market were of rather low efficiency, and he looked about for the most efficient pumping engine and obtained a pair of Diesel engines. These were guaranteed to give 1 H.P.-hour for a consumption of 4 lb. of oil of a calorific value of 19,000 B.T.U. The run on which the test was made, and which occupied one month, resulted in their doing a little better than the guarantee. He thought this showed that oil engines had made a startling advance within the last few years. The Diesel engines gave a thermal efficiency of 40 per cent., instead of the 24 or 25 per cent. credited to the ordinary gas engine. The efficiency

* These are variable quantities depending on the nature of the gearing and the speed at which the pumps may be driven.

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of the centrifugal pump for that class of work was fairly good—about 60 to 65 per cent.—and combining the two efficiencies one got a duty of about 190,000,000 ft.-lb., corresponding on the thermal basis to duties used in the previous tests mentioned, where with the best steam engines they got about 150,000,000 ft.-lb. He would have liked to have said a word or two about electric pumps with which he had had experience. Though the results had been rather better than what the authors said, they could not compare with the direct-acting steam engine.

Mr. BALDWIN LATHAM said the Diesel engine was better than suction gas-driven plant for sewage pumping because in that class of work there were certain hours of the day and night when the machinery had to stand still. On work with which he was connected they now used a triple-expansion engine which was very satisfactory, and he thought it would pay all those on similar work to put in the most modern machinery.

Mr. CHAS. SPARKS said he thought there was a discrepancy in the Paper as regarded the draining of mines inasmuch as the electric pump was compared with something totally different that might have 83 per cent. efficiency compared with the electric efficiency of 48 per cent. If the steam plant were on the surface and the pump below ground there would be a heavy loss in conveying the steam to the pump, and he would not be prepared to accept the figure of 83 per cent., although it might be fair to take that figure for surface pumping where the engine might be put close to the pump. The efficiency of the electric pump he would put at from 55 to 60 instead of 48 per cent. With regard to motors, in place of 80 per cent. efficiency, 90 per cent. could be obtained without difficulty. The mechanical efficiency of the gearing and pumps depended on the type. With a centrifugal pump the efficiency would probably be from 59 to 74 per cent., and with three-throw pumps with ordinary gearing from 75 to 77. The cost of electric power included many matters, such as capital cost, compared with the cost of fuel only in other cases. He had had offers for supply of current at considerably under ½d. per unit, not for the whole year, but for a considerable portion of the year, and he thought ½d. per unit might be taken as an outside figure for the classes of pumping considered in the Paper.

Mr. DUGALD CLERK said his experience had been confined to pumping plants driven by relatively small gas engines. He did not think the large gas engine could be fairly compared with the highly-developed steam engine of to-day. For instance, one of the requirements assumed in this Paper was that the engine should maintain its efficiency for 30 or 40 years with little outlay on repairs. If anyone bought a gas engine with that anticipation he feared they would be disappointed. It was quite common to have efficiencies of 14 per cent. (the figure given in the Paper) in pumping with gas engines of 20 H.P. The heat efficiency of gas engines was put at 25 per cent. in the Paper but in no modern gas engine would it be so low. The thermal efficiency of the suction gas plant might be taken at full load as 86 per cent. of the fuel given to the engine.

Dr. EDWARD HOPKINSON said that coal consumption of a gas engine was put at 1·75 lb. of bituminous coal per B.H.P.-hour. He thought 1¼ lb. would be more accurate and he thought Mr. Davey's own figures would bear out his remarks. Taking the heat efficiency of the gas engine as 25 and of the steam engine as 15 per cent., and working out the B.H.P.-hour, it appeared the consumption would be 2·3 lb. per I.H.P.-hour. He hoped Mr. Davey would see his way to correct the figure of 1·75 lb. The mechanical efficiency of the gearing and pump was put at 70 per cent., but that figure could no doubt be considerably improved upon. The efficiency of the most modern forms of centrifugal pumps rose to 76 or 78 per cent., so there was on that point also something more to be said in favour of the gas-driven pump than would appear from the figures in the Paper. It was hardly fair when making comparisons between electrically-driven and direct steam-driven pumps to include the loss in the cable.

Mr. F. R. PHIPPS said that at Worcester he had had the opportunity of obtaining electrical pumping figures. They had two sets of single-phase alternating-current motors pumping 10,000 gallons per hour a height of 300 ft. The current consumption came out practically the same as given in the Paper—1·31 units per P.H.P.-hour. They found that to compete with the steam engine they had put down it would have been necessary to have current at 0·45d. The steam engine was a 130 H.P. engine, and the fuel was half coal and half coke with blowers, and the cost by that method came out at 0·208d. per P.H.P.-hour.

Mr. LLEWELLYN ATKINSON supported the remarks of Mr. Sparks and Dr. Hopkinson. He said it was obvious that only methods that were to do the same thing should be compared. Many undertakers produced at less than 0·3d. per unit, including repairs, and if they had a pumping load would produce at 0·2d., or a little over, and that would therefore be a fair figure to take if it were assumed that the user was taking current from his own plant. If that figure were taken and the rectifications of efficiency proposed by Dr. Hopkinson and Mr. Sparks it brought the figure to almost the same as direct-acting steam plant. Those who had electricity at hand were saving money by using electric instead of direct-acting pumps. There were several undertakers who were willing to make contracts at a great deal less than ½d., more especially as it might be possible to arrange that the pumping should only be done at night. He was connected with a power company which would certainly supply power at 0·3d. or 0·35d. to a consumer who undertook to take the power only at night.

Mr. H. A. HUMPHREY said, as regards the use of gas, he had designed a pump of an entirely new kind, in which the explosion took place immediately on contact with the water. The pump had no piston, flywheel or crank shaft, and none of the ordinary things that belonged to a pump as they knew it to-day. He though it would be possible with this pump to do away with the intermediate gear and let the explosion act straight on to the water, and that the percentage of efficiency would range much higher than was given in the Paper.

Messrs. W. Hunter, A. H. M. Thompson, T. Duncanson, W. Binnie, Geo. Gore and E. L. Benjamin also made a few remarks.

In Section VII. (Applications of Electricity) the following Papers were read and discussed on Wednesday:—

ELECTRICAL TRANSMISSION-GEARS ON MOTOR-VEHICLES.

BY A. A. CAMPBELL SWINTON.

In view of the somewhat barbarous method of gear-changing at present in vogue on most petrol-driven motor vehicles, and of the fact that, crude as it is, this method continues to hold its own against all other mechanical devices, it is not surprising that attention has been turned to electrical arrangements for arriving at what is required, especially in the case of the heavier description of vehicles.

Apart from the mere transmission of the motion of the engine crank shaft, usually with a considerable reduction in the number of revolutions per minute, to the road wheels, the chief requirements are: (1) an easily operated and preferably automatic variability of gear ratio, so that full advantage may be taken of the maximum effort of which the engine is capable without over-running in obtaining the highest possible acceleration and speed for the vehicle under varying conditions of gradient, load and surface and other resistances; (2) perfect control of the speed of the vehicle under different conditions beyond the variations of which the petrol engine is capable; (3) ready disconnection of the engine from the road wheels, so that the former can continue to run while the latter are at rest, coupled with means for gradual re-connection, so that the vehicle may start smoothly and without shock.

Important considerations that have to be taken into account in comparing electrical and mechanical methods of arriving at the above requirements are ease of working, reliability and freedom from breakdown and derangement, weight, efficiency in terms of the power lost in the transmission, first cost, cost of upkeep, quietness, and freedom from vibration.

Several arrangements of electrical transmission have been adopted, and, with varying details, may be shortly described as follows:—

1. The engine, which is preferably fitted with a governor, drives a dynamo which supplies energy to an electric motor, which in turn drives the road wheels through the usual mechanical differential gear. An electrical controller of some description is fitted so that the electric current can be varied as to regulate the speed of the motor, while, either by means of the controller, or automatically by special windings on the dynamo and motor, the full power of the engine at its most efficient speed can be employed to generate constant watts made up of either a large current at low voltage, such as is required for starting and on steep gradients, or a small current at a higher voltage for running the vehicle at high speed on the level, with corresponding variations under intermediate conditions.

2. Similar to No. 1, excepting that the axes of the dynamo and motor being arranged in line, a clutch of some description is arranged between them so that at top speed they can be mechanically connected together and electrical driving and all consequent losses dispensed with, the armatures of dynamo and motor acting merely as fly-wheels. In this arrangement the electrical drive is only employed for starting, and at other times when the power of the engine is insufficient to propel the car on the direct drive.

3. The engine drives a dynamo as in the previous cases, but instead of one motor two or more are employed, each driving a separate wheel. The mechanical differential is thus dispensed with, but the direct drive as in No. 2 cannot be arranged for. The two or more motors can either be arranged in the hubs of the wheels, when all gearing is dispensed with, or can drive the wheels through chain or toothed-wheel reduction gear. The latter are the arrangements usually employed, as unless some form of speed reduction is used the motors are of necessity relatively very heavy. The employment of two or more motors enables the series-parallel system of control, so much used on electric tramcars and trains, to be adopted.

4. A storage battery of comparatively small capacity, but capable of giving large discharges for short intervals, can be employed with any of the above mentioned systems, the arrangement being such that for starting, or on hills, the battery discharges and assists the engine and dynamo in driving the motors, while at other times a part of the power of the engine is absorbed in charging the battery, the change being automatically effected by the relative voltage of the dynamo on the one hand and of the battery on the other.

5. In another method, in which a storage battery is used to assist the engine when required, there are no separate dynamo and motors, but on the shaft of a mechanical transmission is fixed the armature of a machine which performs the functions of both dynamo and motor as required, automatically charging the battery when the engine has power to spare and the speed increases, and taking a discharge from the battery and acting as a motor so as to assist the engine when the latter becomes overloaded and the speed diminishes.

These systems with auxiliary batteries possess the advantage that, as the battery affords a ready means of starting the engine, the latter can always be stopped when the vehicle is at rest.

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Where storage batteries are employed, continuous currents are necessary, and apart from this, most of the systems so far used have been on the continuous-current principle, which gives large changes in gear ratio more readily. On the other hand, multi-phase alternating currents have already been employed with some measure of success, and are a matter of considerable interest, as with them commutators and brushes, and their attendant troubles and expense, are avoided, except in the case of the comparatively small exciter dynamo that is usually employed.

The chief scope for electrical transmission on motor vehicles seems to be on heavy vehicles such as motor omnibuses, lorries and the like, and especially on large motor coaches on rails, such as several of the railway companies are now running on suburban lines.

Though considerable success has already been attained with the electrical system of transmission in its various forms, there is obviously still much room for development and improvement.

DISCUSSION.

Mr. E. W. HART said he had given the matter some attention, and found that great difficulties had to be overcome when direct current was used. He therefore designed an induction motor for this purpose, and found that, power for power, it was lighter, stronger and cheaper. Many people said that electric transmission was too extravagant in petrol consumption. With the system he had adopted he was able to beat the ordinary geared 'bus. He started without any shock whatever, and much more readily than with ordinary gearing. He had been running an average of 6½ miles to the gallon of petrol, which he thought compared very favourably with any other 'bus running at the present time.

Mr. W. H. STEVENS said the system he advocated was the continuous-current, with a motor driving each back wheel. The dynamo he used was of the interpolar type. He used a controller which was "fool proof." The operator was not able to change the controller until he had broken the circuit between the dynamo and the motors. The series motor had a large starting torque, which gave it an advantage over the alternating-current motor. The governor he used was a solenoid in series with the shunt windings of the generator, so that increased current in the shunt windings acted on a plunger which worked the throttle, and on the other side of the throttle was a spring controlled from the steering column. The tension was regulated so that any other voltage could be obtained. This gave a ready means of controlling the speed, and also of economising petrol, because in running, owing to the action of the shunt-wound generator in dropping its voltage when the current increased, the throttle opened and when the current decreased the throttle closed, so that the engine was always doing its best up hill, and down hill went slower and economised petrol. He used a safety device to prevent the dynamo starting up by accident. Under the driver's seat he had devised a switch which could only be closed by the driver seating himself on the seat and depressing it. The method he used to drive was by a worm gear fixed to each road wheel, which ran on the dead axle, so that they had the advantage of the dead axle, and the worm wheel took the place of the chain wheel on the ordinary 'bus. The worm was above the worm wheel and was driven by a motor fixed outside the frame of the 'bus. The motors in this way were easily got at, and could be renewed or replaced very easily. The commutators could be got at, and there were several advantages in connection with this worm drive, as it was a direct drive, and there was no intervention of gear. Messrs. Tillings were putting a 'bus on the road on this principle, and they would have the advantage of seeing the result of the actual running in traffic during the next two or three months. On a light car of 14 H.P. the consumption of petrol was 18 to 20 miles per gallon.

Mr. R. B. MATTHEWS said he had made a report on this subject for the General Electric Co. of the United States. One of the earlier cars made by this firm was used for railway shunting purposes in the freight-sorting yard at Cleveland. They used an ordinary four-cylinder petrol engine, direct connected to a dynamo without interpoles, with a very simple control, and alongside the controller was placed a lever which worked an accelerator for the engine. There were two motors, and the control was of the simple resistance series type. As a result of experiments on the Cleveland and other cars, they had adopted interpole dynamos with separate exciters, chain-driven off the main shaft. In the Delaware and Hudson railway car, which was very successful, the engine and generator were mounted over the double truck at one end, and the motors on the same truck. There were no motors in the rear. Electric transmission formed a very convenient method for giving control at either end, so that the car could be driven with equal facility in whichever direction it might be running.

Mr. H. A. MAVOR described an interesting system of regulation by means of varying the frequency. We hope to give a description of this in our next issue.

Mr. W. MORDEY referred to the pioneer work of Mr. Hermann and Mr. Ward-Leonard, and said he had himself made some tests about six years ago on a single-phase locomotive in Switzerland which served to illustrate the advantage of a large torque.

Mr. B. HOPPS said that he was interested in the continuous-current system. In devising a petrol-electric system the primary fact to be borne in mind was simplicity of control. There were some disadvantages attendant on the use of this system, but these were far out-balanced if it was designed so that the control was used in its simplest form. In a continuous-current system it was essential that the generator should deliver a large current at the lowest voltage, so that when the vehicle approached a gradient and more current was demanded, the generator would deliver that current, but the voltage would decrease in inverse ratio, so that the load on the petrol engine remained constant and the power remained constant. No form of direct connection between the engine and the road wheels had been adopted, as the utility of the petrol-electric system was in large cities where traffic was congested and stops and starts very frequent. The direct drive was of little advantage if it could not be used for any length of time.

Mr. A. A. CAMPBELL SWINTON said there was very little that called for any reply from him in the remarks that had been made. Some of the speakers had mentioned the number of miles run to the gallon of petrol, but unless they knew the circumstances the figures were of little or no value. In towns it was a question of the traffic, and if the 'bus was run in the country it could be run without stopping, and totally different results would be obtained. Another matter was the question of weight. Petrol-electric drives for vehicles run upon ordinary roads would be different from those employed for running on rails. The petrol-electric drive was always rather heavier than the plain petrol mechanical drive, which had an important bearing on the question of the upkeep of the tyres.

Col. R. E. CROMPTON (chairman) said the subject was one in which electrical engineers were greatly interested. They had seen how electrical transmission had revolutionised workshops and had made the cost of manufacture much less than it used to be, as it enabled them to get exactly the speeds and the power required at the points where it was actually required. The difficulty regarding locomotion, both on the railway and on the highway, had been to obtain from the modern high-spee motors the higher torque required for propulsion, more particularly on the roadway. They must not put into the hands of ordinary road engineers a too difficult problem, and must not call upon them to learn electricity in two branches, which was necessary if they included the care and upkeep of accumulators. He thought they must set aside the accumulator system, even auxiliary accumulators, for the present as not of such value as other systems. The means, after all, greatly depended upon the weight, compared with sufficient transmission efficiency, and No. 2, in which transmission was only used temporarily, appeared to give the greatest advantages. Whether alternate or continuous currents were used, in both cases it would be found that, if the number of parts were counted and the weight of the whole taken into consideration, that No. 2 was best.

THE APPLICATION OF ELECTRICITY TO THE WORKING OF RAILWAY POINTS AND SIGNALS.

BY L. DE M. G. FERREIRA.

The working of railway points and signals by electricity has not, up to the present, taken such a prominent position in England as it deserves, although this is one of the many uses to which electrical power transmission may be profitably applied. The adoption of some form of energy, and some method of transmitting it to work the points and signals, other than muscular effort of the signalman conveyed by rods and wires, has, during the last few years become almost a necessity at many large stations.

Electrical transmission is generally acknowledged to be an ideal method of control in all signalling operations, and there seems little reason for employing a second source of power, such as compressed air, when the controlling force in itself offers every advantage for doing the whole of the work.

The hesitancy in adopting electrical working has, no doubt, been due to the comparatively high first cost, or doubt as to the reliability and life of motors, switches, &c., when subjected to the admittedly unfavourable conditions obtaining on the permanent way, such as wet, dirt and vibration.

Before proceeding to deal with this subject, it will be convenient if I enumerate the principal conditions which are considered essential in modern signalling. They are: (1) Safety in working, mainly secured by the mechanical interlocking between the levers in the cabins, and the locking by plunger bolts and detection of all facing points. (2) The correspondence in position of all points and signals with the levers that operate or control them. (3) Breakage or failure of any part of the gear should render dangerous operations impossible, and in all such cases signals should assume the danger position. (4) The intended movement of any signal, or points, shall not be wrongfully communicated to or operate any other than the correct one corresponding with the lever operated. (5) The efficient protection, or entire removal, of all above-ground connections between signal cabins and points or signals. (6) Immunity from breakdown, total or partial, causing delays to traffic.

These conditions are not all fulfilled in the usual manual and in many of the power systems, but there is no reason why they should not be met in an electric system.

The railways have already had great experience with the various mechanisms for interlocking, and detecting and locking facing points, and have practically standardised the fittings on each line. In an electric system such standard fittings may be utilised, the motor being arranged to first lift the locking bar, the bar on reaching its highest point withdrawing the bolt, thus unlocking the points; continued movement of the motor reverses the points, and the bar, returning to its former position with its end close to the point tongue, inserts the bolt and thus locks them. Only after the whole of these movements have been correctly made should the bolt

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by suitable means complete the circuit of the return indication, the latter being also dependent on the correct position of each tongue of the points. This is not the arrangement usually adopted in power systems, but it is, without question, the one that gives the greatest security, as any breakage of mechanical connections is immediately detected.

Signals may be operated either by long-pull magnets, solenoids, or motors. A force of 50 lb. to 80 lb. is required to be applied to the rod for working a standard signal, the amount of movement being about 4 in. A long-pull magnet must therefore exert a great force, and as its action is practically instantaneous, the amount of copper and iron must also be large, and a heavy current is required. This means using conductors of comparatively large size, and some method of reducing the current during the time the signal is off is essential, or the magnet will get too hot. The switches for opening the circuits of such magnets present difficulties in overcoming arcing due to the high self-induction, and the insulation of the coils and cables must also be such as to withstand the sudden rise of potential which occurs when the circuit is opened. I believe that in many signals so operated the counterweight for taking the signal to danger is reduced or partially balanced to lessen the work demanded of the magnet. I think, in view of the fact that snow may accumulate on the blades, or a high wind pressure increase the friction of the fulcrum shaft, such reduction may easily reach a point where the factor of safety becomes too small for absolute safety in working. I consider that, for semaphore signals at least, the best way of operating is by motor. As the most mechanical and compact form of gear for the reduction of the high speed of the motor is some form of worm gearing, a means must be found for disengaging the signal to allow it to go to danger without having to revolve the motor. Some form of electro-magnetic coupling must therefore be provided, but by suitably arranging it the work required of the magnet may be reduced to a minimum. The gearing may be so arranged that a small high-speed motor can be used, and the whole mechanism can be made lighter, and cost less, than a long-pull magnet to do the same work, while the current required is also very much reduced and consequently the size of the conductors. The switches can also be simplified. Semaphores always work through the same angle and give correct "danger" and "clear" signals, by night as well as by day.

Electrical working offers the simplest means for ensuring that the points or signals are in correspondence with their levers by means of return indication currents permitting the completion of movement of the levers and so releasing the mechanical locking. In the Siemens system, as installed on the Midland and Great Western Railways, such return-indication currents are permanently flowing through electro-magnetic relays with multiple contacts. The levers do not require to be checked in an intermediate position, as the necessary combinations of contacts in the circuit to free, say, a signal-lever and operate the signal, are made automatically in correspondence with the mechanical locking between levers, and actually form an electrical interlocking network between the various points and signals themselves. This permanent-control current system uses more electrical energy than is required to work the points and signals, although the low E.M.F. of 32 volts is used for the control, and entails a somewhat complicated network of internal connections and contacts in the locking frame. These disadvantages are thought by many engineers, especially those on the continental railways, to be more than counterbalanced by having permanent indications in the cabins and avoidance of checklocks on the levers.

Dangerous movements through breakage or failure of any part of the apparatus or mechanical gear in an electrical system may be safeguarded by arranging matters so that all safe operations are dependent on the presence of current, any failure of the same putting the signals to danger.

The independence of each point and signal movement and the risk of operating other than the proper apparatus is of course dependent on the insulation of the connecting leads or cables. Elaborate arrangements to obviate the effects of contacts between leads have been devised, but the simplest and best way is to arrange the switches and detector contacts so that all leads except those actually carrying current are earthed in such a way that any stray current passes direct to earth without affecting the apparatus.

It is obvious that, as all the cables can be placed underground and in very restricted areas, an electrical system leaves the permanent way quite clear and eliminates accidents due to rods or wires. By the removal of the point rods it is possible in some cases to get more tracks in a given space.

Immunity from breakdown is dependent on the reliability of the source of energy and on the design, materials and workmanship of the apparatus. The continuity of supply of energy is best maintained by the provision of storage batteries, whilst the question of design, &c., must be largely left to the experience and integrity of the manufacturer.

A few words as to cost may not be out of place. In the manually operated systems the capital charges are limited to the building of the cabin, the locking-frame, signal-posts and arms, point-locks and bars, and their connecting wires and rods with the necessary pulleys, rollers, or other guides, and efficient covering. In an electric system motors will have to be provided at the points and signals, and a source of energy provided in addition, but the rods and signal-wires will be replaced by electric conductors. As the amount of electricity used is so small, the question of efficiency of the motors and gearing does not appear to have received much attention in the past. The efficiency will, however, affect the first cost to a larger extent than is generally supposed. The higher the efficiency, the smaller the motors, cables, switches and storage-batteries can be to do the same work. As the first cost of the cables is a considerable item, it is important to design the apparatus to take a small current for a given time in preference to a large current for a shorter time. This argument also applies to the storage batteries, as the size of cells required is not governed so much by the total ampere-hours required as by the maximum discharge required at any one moment. If this point is attended to when designing the plant the average storage battery will be found very economical in maintenance and give practically no trouble. The locking frame can be made so much smaller that there will be a considerable economy in the cost of the cabin required. As the outcome of some years' experience and careful consideration of the problems involved, I have recently designed an electric system embodying the conditions above laid down, which will cost very little, if any, more to install than the usual mechanical signalling plant.

The maintenance of an electric system should not cost more than that of the manual system, as the money spent in cleaning, oiling, painting and renewing rods and wires is saved, and will be found to cover the cost of the electricity used, if an economical system is adopted.

DISCUSSION.

Mr. E. DE M. MALAN said he was in hearty agreement with all the author had said in comparing the electrical system with the manual system. The author had stated there was little reason for employing a second source of power such as compressed air. He would like to speak of the electro-pneumatic system, in which compressed air was used for working the points of the signals, and the valves were moved by small currents of electricity. The currents they used were quite small—75 milliamperes at 12 volts. The air pressure took the place of the higher pressure used in Siemens' and other systems for working the points of signals. The pressure generally used was 45 lb. to 60 lb. per square inch. In a worm gear there was a certain amount of wear and tear and loss of energy in the conversion, and a clutch had to be put between the electric motor and the points, whereas in the electro-pneumatic system there was no necessity for an intermediate clutch. He was in agreement with Mr. Ferreira as to using solenoids. It was very necessary to be able to increase the current and power quickly on, say, a frosty morning. With air this was very easy; you simply altered the regulator and pumped to a few pounds higher pressure, but with an electrical system you would have to have accumulators constantly charged, although required perhaps only two or three times during the year. He thought there was some difficulty in locating a fault with the electrical system of signalling, whereas in the electro-pneumatic system, owing to check locking, the fault was quickly located.

Mr. A. T. BLACKALL said that his company (the Great Western Railway Co.), after having carefully considered all the systems on the market, had come to the conclusion that they preferred on the whole a purely electric system. Having electric power always available, it seemed unnecessary to use that power to produce another form of power. The experience of the purely electric system on the Great Western Railway had been that failures were practically nil, and that the cost of maintenance was not excessive. They were told that with an electric system they would require an altogether more intelligent class of man to the ordinary signalman, but they had found that any intelligent signalman was able to do the work after a little instruction. The cost of maintenance and working was, therefore, not heavy. As to a permanent control system, such as referred to by Mr. Ferreira, this would appear to involve a complication of wiring.

Mr. ALEX. SIEMENS said he wanted to make it quite clear that there was a distinct difference between the German system and the system which was proposed by Mr. Ferreira in his Paper. The German Government, which owned and governed all the railways in the country, insisted upon the positions of all points and signals being constantly indicated to the signalman by the display of flags. As the representative of the Westinghouse Brake Co. had pointed out, it was necessary to make quite sure that the points had gone over and that the check locking was all in order. Without a permanent indication of the position of the points there was no indication in the event of a point being tampered with. The main thing in signalling was that if there was any disturbance of any kind the signal should go to danger. The interruption of electric current was a very simple matter, and this was the best way of ensuring the signal going to danger. There was nothing like electricity for signalling, as it could be easily adapted to all kinds of conditions. It was reasonably cheap in first cost and cheap in maintenance.

Mr. B. H. PETER said he was afraid that his knowledge of the subject as set out by the author was very small, as his experience had, up to the present, been solely with electro-pneumatic work. It seemed that there was a lot to be said against the all-electric system as compared with the electro-pneumatic. His experience with electric motors, especially small

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ones, was that they needed a lot of maintaining. On the District Railway they had now rather over a thousand electro-pneumatic motors of different sizes. These were making over 40 million movements per year, and yet the average number of motors repaired did not exceed one in three months. In many cases the motors had to make 400 movements each per day, and he was inclined to think that an electric motor which had to make over 120,000 starts and stops per annum under the rough conditions that were bound to prevail on the track would require a considerable amount of attention. He had found that their electro-pneumatic motors could be relied on to make at least 400,000 movements before requiring any attention other than oiling; and probably all that would be required then would be a new piston leather, which could be put in within 20 minutes at practically no cost. He would very much like to hear some figures quoted for all-electric signalling installed, not on a main line where the number of movements per signal per day was comparatively small, but under conditions such as have to be contended with on the local railways in and around London. On the railways built and electrified by the Underground Electric Railways Co., 1,870 electro-pneumatic motors had been installed, and he thought that after working for some little time longer they would form a valuable example of that class of work. He considered that the electro-pneumatic motor, giving, as it did, a straight push and pull at the piston jaw, was very much more suited for the working of points, as no rotary gear for altering the direction of movement was required. As both points and signals were controlled electrically, all the precautions which could be taken with all-electric signalling could be quite as easily applied to the electro-pneumatic system. The ease with which an electro-pneumatic motor could be applied to a signal was far in advance of the average electric motor attachment, with the necessary gearing and clutches. He noticed that the author was in favour of a small high-speed electric motor for operating signals. He would imagine that the wear and tear for a signal that had to be operated, say, 400 times a day must in a year or two be very great as compared with a pneumatic motor with a 3 in. piston and a 3 in. stroke. This moved the signal arm off in the same time, say two seconds, but the amount of actual apparatus movement on the signal was very small indeed, and, consequently, there was practically no wear. There again the absence of rotary gearing and the possibility of using the direct push of the motor was greatly in favour of pneumatic power.

Mr. J. P. ANNETT said he had had no experience of electrical work. The system adopted on his line, the London & South Western Railway, was the low pressure pneumatic. The cost of this was higher than the ordinary manual but they were perfectly satisfied with its working.

Mr. J. W. JACOMB HOOD said it was distinctly anomalous that two systems should be used where one would do as well. In his opinion sooner or later they were bound to come to electricity for signalling on all railways. One of the principal difficulties had been got over by the Siemens system and by other electrical systems. He considered the employment of permanent signals in the signalmen's boxes unnecessary, an indication that the signal had gone over to the desired position was really all that was necessary. A most important point was the question of stray currents. Mr. Ferreira got over that difficulty in an apparently simple manner, but in a way that he thought was rather dangerous. As to the question of cost, he would like to know if an electric system could be worked as cheaply as the ordinary manual system.

Mr. SIEMENS replied that it could.

Mr. HOOD, continuing, said that it was undoubtedly a great consideration. The manual system worked out at between £40 to £50 per lever, whereas the cost of electrical systems appeared to be about half as much again.

Mr. H. E. MORGAN said that his company (Sykes' Interlocking Signal Co.) used check-lock levers. It had been said that electrical signal motors required reversing to send a signal to danger but a chain-geared motor did not require reversing. He was in agreement with Dr. Siemens that an indication was wanted as well as a check lock. The system with which he was connected provided that indication, the points being shown in the normal condition, and also whether they were bolted or unbolted. They worked 257 signal levers from one set of accumulators, 32 accumulators comprising each set, and the cost of maintenance worked out at about 2s. per week, which he regarded as a very low cost.

Mr. H. B. HOLT said that the system installed on the Midland Railway had been working now for over two years without a single fault. Some small failures had occurred but these were such as were welcomed, as they indicated faulty points. They had had no trouble at all with stray currents. Their system enabled one man to do what two previously could hardly carry out. As to the question of the unreliability of the solenoid, no single instance of failure of the solenoid had occurred on their line. As to wear and tear of motors and brushes, they had never yet had to change a brush in the two years and seven months during which the system had been working. They had had no trouble at all with motors. There was a certain amount of complication in the wiring, but not sufficient complication to justify doing away with the permanent control system in favour of check locking.

Mr. THOS. PARKER said he was pleased to see the way in which the permanent-way engineers were taking the matter in hand. When they saw a signalman labouring heavily with signal levers they must see that there was room for very great improvement.

Mr. FERREIRA in reply said there was no more difficulty in reversing a motor than working with an air cylinder. As to continental systems, they had no fixed bar coupling up the points as in this country and therefore the conditions were entirely different. As to signal motors, it was merely required to have a simple disengaging device which could be depended upon to disengage. The ordinary magnetic clutch was found to be quite suitable for the purpose. There was no more risk of one of these clutches sticking than an air cylinder sticking. As to the greater power necessary to get over such resistance as was set up by snow, electric motors adapted themselves very comfortably to changing conditions. They might do the heavier work more slowly and take more current, but still they did the work required. As to the danger of contacts failing to act, he had tested half a million contacts, but had not had a single case of failure.

UPKEEP CHARGES ON LARGE ELECTRIC GENERATING SETS.

BY H. R. J. BURSTALL AND J. S. HIGHFIELD.

In the expenses of generation of electricity it is necessary to include the cost of the repairs and maintenance of the plant; usually this is stated in terms of the units generated or sold, and in most cases the amount charged for repairs and maintenance is considered to vary with the number of units generated. This part of the question will be considered later. In the published accounts the sums charged to repairs and maintenance are the total for the whole of the plant and mains, and it is in most cases difficult to obtain a subdivision. As a general rule, and apart from accidents, &c., the repairs and maintenance on mains and switchboards may be taken as sensibly the same in most large systems, and as boiler and steam-pipe practice is now much standardised, the repairs and maintenance from the boilers to the engines should also be nearly the same in the larger stations. In the generating plant, however, the systems in use present wide differences in speed and type of prime mover and generator, and it is the object of this Note to elicit as much information as possible as to the differences which may exist in the charges necessary to cover the repairs and maintenance of large electric generating sets.

In dealing with the amount to be charged for repairs and maintenance, the fact that such charges do not depend entirely on the energy generated by the plant is at once brought into prominence. In any station in which extensions are not continuously going on, a special staff has to be kept for repairs. The expense of this is practically a constant quantity, and as such staff has to be of sufficient size to deal with an ordinary breakdown with expedition, it is generally larger than is absolutely necessary. Where extensions are going on regularly, men can be shifted from capital work to repairs, and so the standing expense can be reduced; but this condition cannot be dealt with.

It is evident, therefore, that a large portion of the upkeep charges is constant, independent of the units generated or hours run, and dependent approximately on the maximum output of the machines. The only part of the expense which will vary in any way with the hours of running will be the stores and materials expended. It would be of great interest if information could be obtained as to the number of men required for different stations of varying sizes.

Considering, now, the details of the upkeep charges, we have to separate the electric generators from the prime movers, and to point out where the charges may be expected to arise.

Electric Generators.—Leaving out the charge necessary to provide against breakdown or burning out, which will vary with the pressure and system, the only true upkeep expenses are: For direct-current machines, principally renewal of brushes and commutator repairs, which will vary greatly. If proper attention is given to providing the right quality of carbon in the brushes, and especially the right quality of mica in the commutators, the cost of upkeep of these is small. For alternating-current machines the cost of upkeep is negligible. Our experience of large alternating-current generators is that, in a properly constructed machine well looked after, the bearings may be taken to last as long as the machine, and that, in machines exceeding 500 kw. output, and working with a maximum pressure to earth not exceeding 4,000 volts, the risk of breakdown is very small; but with machines working at higher pressures than this, the risk, though still small, increases at a faster rate than the pressure. In connection with this we wish to express the opinion that at present it is impossible to construct a machine with closed slots which will work at a pressure of 10,000 volts to earth.

Steam Engines.—With reciprocating engines the upkeep charges appear to be independent of the type and speed, and the risk of breakdown is now very small. With steam turbines the upkeep charges should be smaller still, but there is little information available; some of the earliest turbines which were put to work in London showed no appreciable wear after years of work. The breakdowns of large turbines have hitherto been more frequent and of greater magnitude than in reciprocating engines, although probably with improved design and methods of manufacture this state of affairs will be reversed.

The cost of upkeep of water-turbines is almost entirely in the replacement of bucket wheels, and depends largely on the quality of the water used; it has been found that, in addition to the buckets being worn on the front side by sand, &c., in the water, considerable corrosion takes place on the back, due to the oxygen in the water. The upkeep charges on water-turbines will vary more with the hours run than for other types of plant, owing to the bucket wear. We have been fortunate in obtaining the actual up-

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keep charges for a water-driven station which has worked for a number of years.

Gas Engines.—The figures available show that the parts which wear are the same as in a reciprocating steam-engine, but that the upkeep costs are somewhat higher in some types of engines, owing to the complexity of the valve gear.

Maintenance Costs of Steam and Water-driven Electric Generators.

1. High-speed Steam Alternators, Vertical Compound Engines.
   Load factor, 19 per cent.
   Maximum load on plant, 10,000 kw.
   Output (average for three years), 16,000,000 units.
   Size of each unit, 1,500 kw. to 3,000 kw.
   Average cost of labour (over three years), £1,899 = £633 per annum.
   ,, ,, material (over three years), £782 = £261 ,, ,,
   Standing charge for labour, £0·0635 per kilowatt-year.
   Running charge in pence per unit, 0·004.
2. High-speed Direct-driven Steam Generators.
   Load factor, 38 per cent. (over five years).
   Maximum load on plant, 755 kw.
   Output averaged for five years, 2,500,000 units.
   Size of each unit, 100 kw. to 300 kw.

	Engines.	Generators.	Total.
Average cost of labour over five years..	£38	£5	£43
,, ,, material ,, ,, ..	31	10	41
Extra charges, average ,, ,, ..	40	26	66
			£150

   Standing charge, including ex tras, £0·144 per kilowatt-year.
   Running charge in pence per unit, 0·0039.
   Extra charges include a broken crankshaft and the re-winding of field coils on one machine.
3. Water-driven Direct-current Generators.
   Load factor, 90 per cent.
   Capacity of plant, 5,000 kw. (machine of old type).

	Pence per kw.-year.
Average cost of labour on repairs (for four years)	4·34
,, ,, copper brushes	2·70
,, ,, renewal of mechanical parts.....	1·33
,, ,, renewal of armatures and commutators..	10·30

   On two modern machines the repairs over two years are 2s. per kilowatt-year for renewal of brushes.

With large generating-sets, the upkeep charges may be taken to depend mostly on the output of the set, and a small proportion of the total charges only vary with the units generated. The table gives figures for some typical machinery, but these, of course, are not to be taken as averages. A comparatively large proportion of the upkeep charges are really for examination and overhaul, which should be done periodically, and bears no proportion at all to the hours of running; and it is to be remembered that it may cost several times as much to take down and re-erect a machine as it does to effect the repairs necessary owing to wear. In our opinion, repairs and maintenance should be worked out on the normal power of the station and not on the units generated, and should be compared on this basis. Any allowance for risk of breakdown, which is of the nature of insurance, would also naturally fall into the same category.

The cost of maintenance may therefore be divided under two heads:—

(1) Charges which may vary with the capacity of the plant, which are—(*a*) Capital charges, in which may be included repair-shops, tools, and possibly overhead travellers; (*b*) Wages of workmen, including supervision; (*c*) Painting and cleaning of engines, &c., and cost of all materials in connection therewith; (*d*) Insurance; and (2) charges which may vary with the hours run or units generated, and are: Materials and wages for renewal of parts (piston-rings, packings, bushes, brasses, &c., and dynamo-brushes).

DISCUSSION.

Mr. W. W. LACKIE said he thought the table given by the authors put the cost of labour enormously high compared with the cost of material. The number of men which it would be necessary to keep at different stations for repair work would depend on the men's capabilities and the character of the plant. The number was not necessarily regulated by the capacity of the plant.

Mr. LL. ATKINSON said that the keeping of sufficient men at hand to cope with any breakdown or other emergency was a source of considerable expense, and occasioned the keeping of more men than would otherwise be necessary. He thought that for stations up to 4,000 kw. or 5,000 kw. they should be able to call on an insurance staff held for emergencies, the cost of which could be averaged between several such stations. There was no relation between capital expenditure and the units generated. In some cases quite a different sum per kilowatt would be shown to that given in the Paper. The item for repairs also required classifying.

Mr. J. J. BELL said he had come to the conclusion that the personal character of the repairing staff had most to do with the cost. In one case with which he had been connected there had been a large repairing staff and the cost was very heavy, but by employing only the most expert men they had been able to reduce the number and to work much more economically. It was most difficult to get at the exact cost of repairs and maintenance.

Mr. A. GOODWIN said on the point of upkeep he had had under his notice a turbine of 750 kw. capacity which had been working for 2½ years, one week working and one week at rest, the working week comprising 24 hours per day; nothing had been spent on this set since its erection.

The CHAIRMAN (Col. R. E. B. Crompton) said he was quite in agreement with Mr. Bell that the cost of repairs depended mainly on the adaptability or suitability of the repairing staff. At his works he had a very old plant running, but notwithstanding its age the cost of repairs was very low owing to the fitter in charge being thoroughly acquainted with the plant's peculiarities, and he was able to keep it going at an exceptionally low cost. The returns of companies and local authorities were unreliable from the engineer's point of view. It must not be forgotten that repairs costs included in most cases items for improvements. He would warn them that experience gained on this subject in this country would not apply to practice in other countries, where the conditions of working were in most cases quite different. Thus great trouble was experienced in Calcutta with lightning and with insulation, and the attendants were constantly unwell owing to the climate. The conditions of working generally being thus bad, the cost was, naturally, comparatively exceptionally high.

Mr. H. R. J. BURSTALL, in replying, said, with regard to Mr. Lackie's remarks, that the figures given in the table compared very favourably with the figures given by companies with which he (the speaker) was connected. As a matter of fact it was exceedingly difficult to get definite figures for repairs and maintenance. He quite agreed with Mr. Bell as to the personal factor in the repairing staff, which might halve or double the figure for repairs and maintenance; but he did not think that made any difference in the way of looking at it.

(ENGINEERING CONFERENCE *continued on page 396.*)

PARLIAMENTARY INTELLIGENCE.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

The Hybrid Committee of the House of Commons appointed to consider this bill sat again on Friday last week, with Mr. D. A. THOMAS presiding.

The Hon. W. R. W. PEEL, chairman of the Parliamentary Committee of the London County Council, was re-examined by Mr. Clode, and said that under the Tramways Act, 1870, a local authority taking powers is bound to transfer, and under the 1882 Electric Lighting Act "any local authority which has obtained a licence, order or special act may contract with any company or person for the execution and maintenance of any works needed for the purposes of such supply," and there was, therefore, a precedent for what they were proposing in this direction. With regard to the suggestion that had been made that the Council might have in view reinstating the Administrative Company, there was no understanding implied with any company or body of persons who were prepared to become transferees under the proposed act. They would all have to tender for the privilege, and all the circumstances would be inquired into. The whole object of their promoting the bill was to obtain a cheap supply, and they were advised that the only way to do this was by working on a large scale. They would defeat the object of the bill if they split up the area into small sections. With regard to Mr. Moon's question whether the Council would work the undertaking if no transferee were forthcoming, if no transfer were made within a certain time the powers lapsed, and their feeling was that, as electricity supply was greatly developing, it would not be wise for the Council to embark upon it until the system had been worked out. It had been suggested that, having bought up one undertaking out of two in an area, they might injure the other by treating it on unequal terms, but the proposed act showed that the Council must give equality of treatment to authorised distributors. Whatever the intentions of the transferee might be he would be bound by the statutory provisions. He did not think the point as to rate-aided competition arose, because they proposed to transfer the powers and could not resume them until 1931. It was a question of policy whether London should get the whole benefit in the shape of cheap current for manufacturing and other purposes or whether there should be a more direct advantage to the ratepayers in relief of rates.

With regard to the question raised by Mr. Vesey Knox whether you were fulfilling the requirements of para. 14 and 15 of the special report of the House of Commons Committee on your bill of last year, I want to make clear what the situation was at that time. The bill you had then introduced put you under no obligation to supply?—No.

Clause 35 was to give you power to revise the whole of the prices for lighting?—That was so.

The Board of Trade reported on the subject that they considered that the Kitson clause of 1900, under which a consumer could get a supply from the central undertaking if he could not obtain it at reasonable rates from the local undertakers, might be embodied in the London County Council's Bill. Was that the reason that induced you to adopt the Kitson clause as the basis of your present bill?—Yes.

It preserves to the present undertakers, except as regards the percentage of the power supply which may be used for lighting, all their powers with regard to lighting?—Yes.

And with regard to competition for power supply it places the Board of Trade between them and any other undertaker so as to prevent unfairness?—Yes.

You were examined by Sir Ralph Littler as to the position of the City of London. Now the generating stations which supply the City of London are outside the City, and therefore the City authorities are not in a

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position to purchase those generating stations whatever other rights they may have?—No, that is so.

And therefore all they would get inside the City is a network of mains?—And the transforming station.

Assuming they did purchase the mains which were in the City area, it would be convenient for them to take bulk supply?—They would probably be compelled to do so from somebody.

Sir Ralph Littler also wanted us to assume that there were no factories or manufactures in the City of London?—The number of factories in that area is 1,157. The horse power is 13,138, and the number of persons employed is 42,777.

As to the suggestion that you should have a draft lease appended to the bill. What do you say?—It would not be practicable.

Until this Committee has decided upon the schedule prices for current, &c., it would be difficult to draft any such lease?—It would.

Mr. Blennerhassett took exception to the words "not exceeding 50 years from the date of transfer," and suggested that in a year or two the Council might re-purchase from the transferee and work the undertaking themselves. Do you consider that possible?—It is not possible unless we promoted an Act of Parliament to do it. It would be absurd to enter into a lease with a company and, before their works were started, promote a bill to re-purchase.

It was suggested that the Kitson clause was not applicable to your case because there were so many authorities in the area?—I think it rather an argument in our favour.

Mr. JOSEPH NOLAN (a member of the Committee): I wish to ask you a few questions of a general character with regard to the position which the London County Council propose to take up. What is your proposal?—Our proposal is that the financial and other risks of the undertaking should not fall upon the County Council and the ratepayers, but should be taken by a company or by private enterprise in some form to be decided upon for a certain period.

And you have told us that there are no negotiations up to the present with any possible or probable lessee company?—None whatever. There have been discussions with two or three parties, but nothing in the nature of negotiations.

The Council has set apart £100,000 in connection with these proceedings?—Yes, mainly for the purchase of sites. The cost of the Parliamentary proceedings are outside that. We have no notion as to what these proceedings will cost the Council. If there is no opposition in the House of Lords after a full hearing here, the cost will be materially reduced.

I suppose you have satisfied yourselves that, in the event of your getting the bill through, you can find a company to lease the undertaking from you?—Yes, our experts and financial advisers have gone into the question very carefully as to whether an undertaking of this kind would pay. If, however, it should turn out that we can get nobody to undertake it, I presume that would be a sign that it would be as well that it should not be undertaken, and it would certainly be a warning against the London County Council undertaking it themselves.

Your lessee company would be required to have a certain amount of capital, of course?—We should have to assure ourselves of that.

How much?—The estimate in our bill is £4,500,000.

Do you propose to offer any evidence to the Committee as to the financial means of the company to which you propose to sublet?—I cannot, of course, do that, as we do not know what company it will be.

So we may take it from you that you will be able to find a company with the necessary capital? This Committee is supposed to satisfy itself that the money will be found for carrying out the undertaking if the bill passes?—Yes, I think we can go so far.

But you do not propose to submit any evidence upon that point direct?—The London County Council would, I suppose, be able to find the money, on terms, of course.

The Council manufactures electricity now, and in the bill I think you suggest it should also supply electricity in bulk?—The object of that is this: we have a generating station at Greenwich, which has a limited power of expansion owing to the difficulties with the authorities there. At the present moment, I think I am right in saying, we can produce more power, or shall be able to in a short time, than is actually wanted at present for the supply of the tramways. We think, therefore, it would be useful to have liberty to hand over our surplus power to our transferee during the early stages of construction. By the time he has completed his construction work and is able himself to supply, it is calculated that we shall be wanting the full load of our Greenwich station for the tramways.

At any rate for a time you would manufacture electrical energy and supply?—Yes.

And there will also be a number of other authorities making and supplying electrical energy within your area—16 boroughs and 13 companies, with an invested capital of about £19,000,000 to £20,000,000?—Yes.

You will exercise over all these concerns the jurisdiction which the Board of Trade now exercises with regard to electric lighting matters in the metropolis?—There are certain powers of inspection which we now possess.

It was stated by your counsel, Mr. Freeman, that an inquiry was held in 1889 and that at that inquiry it was suggested that the jurisdiction which the Board of Trade then exercised with regard to electric lighting matters might be transferred to the County Council. Have these powers been transferred?—I am advised that those particular powers were not transferred.

Can anyone say if there is any probability of these powers being transferred to the Council at any time within the next 50 years, because you can see the situation would be a rather complicated one?—Yes, it might be, and that no doubt would be considered if the question of transferring those powers to the County Council did arise.

You have no opinion to give the Committee upon that point?—No.

As a matter of phraseology, do I understand that the term "electric lighting matters in the metropolis" includes what is now termed bulk supply?—I can only answer that we have no intention of promoting any Bill to obtain the power referred to.

Major RENTON (a member of the Committee): Why have you limited yourself to one year? Would you rather be limited to this period, or have it extended to 18 months?—We think a year is a fair time to make a bargain of this kind, but if it were made 18 months we should have no serious objection. We think, however, 12 months is sufficient.

Was this question of electrical supply before the electors at the last County Council election?—Acutely.

Sir ALBERT SPICER (a member of the Committee): In connection with the present authorised undertakers, their powers are transferable, some of them, at least, in 1931?—Yes.

Have you considered any scheme by which these new powers might be transferred so as to be transferable at the same period, namely, 1931?—We have had suggestions made to us and have considered this possibility.

I take it that you have been advised by your experts with regard to various schemes?—We have had a good deal of advice from our experts.

May the Committee see some of these alternative proposals?

Mr. FREEMAN: May I say that I propose to call as the next witness the engineer to the Council, and he will give all information.

Mr. A. E. DUNN (a member of the Committee): Can you tell me whether any powers have ever been granted by Act of Parliament to a local authority where the local authority has merely to transfer and not to themselves exercise those powers?—Yes, under the Electric Lighting Act, 1882, sec. 11.

Mr. FREEMAN (answering): There is an absolute precedent in the case of the Rhondda local authority in South Wales. They obtained powers and were authorised to transfer them direct to a company.

Mr. VESEY KNOX: That was power to construct and lease, which is entirely different.

Mr. DUNN: I am asking for an authority where the only power is to lease or transfer.

There was no answer to this question.

Mr. W. HOWELL DAVIES (a member of the Committee): You have stated very clearly throughout that the desire of the London County Council is that the consumer should be protected, and I presume you have reports from your official advisers that they will be as well protected under this bill as under the bill of last year. Will there be any objection to that report being handed to us, as we should like to know upon what grounds the Council has changed its policy from direct supply to control only?—We have a great number of reports and there is no objection to your seeing any of these. Frankly, it was the desire of the ratepayers that their money should not be, I will not call it hazarded, because that might deter a possible transferee, but invested in such an undertaking.

Therefore it is you, and not the engineers, who ought to justify the change of policy?—The change of policy, certainly.

You are asking us for powers which will enable your transferee to obtain considerable control almost over the borough councils' present undertakings as well as the companies', and we really ought to have a form of lease under which you propose to acquire these properties or make this transfer?—I think that if you insist upon the detailed terms of the lease you will seriously hamper us in regard to any business negotiations into which we might enter.

But you are asking for considerable powers over the companies and over the borough councils, and they have obtained their Parliamentary powers, and we ought to protect them as far as we possibly can when granting fresh powers?—The London County Council has very large duties. We spend something like £11,000,000 a year and our jurisdiction is over a population larger than that of Ireland.

Just one more question: You do not contemplate, under any circumstances, leasing the power station at which you generate current for your tramway system?—Not at present, certainly.

Do you contemplate putting conditions into the proposed lease by which all London consumers may obtain power upon equal terms, simply differentiating between wholesale and retail users? You promised to give us a full list of the prices at which the various companies are supplying current.—We should have no objection to a clause leaving it absolutely beyond doubt that there will be no undue preference.

Mr. J. WARD (a member of the Committee): The bill of the Administrative Co. contained most of the objects you are asking powers for?—Yes.

And you are now introducing them under the auspices of the County Council?—And under the suggestions of the Select Committee of this House.

Ought we, under these circumstances, to look upon this bill as though it was a private bill of your lessee or proposed lessee?—I think not.

I think you have stated that the Administrative Co. are negotiating with the Council as to the provision and powers of this bill?—No; what I said was we had had two informal discussions.

Is there competition among certain companies for the powers which you are seeking?—Yes, no doubt there is.

Seeing that probably by 1931 the whole circumstances of ownership of the existing electricity undertakings may be changed, do you not think the County Council in its lease should make a condition under which they could revise and review the situation at the end of that period?—We retain powers in the bill to do that. Our only difficulty is that in being anxious for full control in 1931 we may lose the main object of this bill—namely, the supply of cheap electric power in bulk for London. If we say to a company that we must purchase in 1931 (in 24 years from the present moment), seeing that they would not be able to pay any dividends out of earnings for perhaps four or five years, the question arises whether any body of undertakers would start on a work of this kind unless they obtained much better terms of purchase than are suggested under the Electric Lighting Acts, and it might greatly hamper the Council

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if the terms of purchase were different from those proposed in the Electric Lighting Acts.

I can see it is perhaps almost impossible to state the terms of the lease before you have obtained your powers, but will there be any objection, provided you have these powers, to promote a bill next session with the lease set out?—There would, I think, be two very great objections to the course, one is that if the actual lease itself had to go through the ordeal of the House of Commons and of the Committees I think we should find any business person very loth to enter into such a lease, and, secondly, I presume that all the different interests which are represented here to-day would have the opportunity of again being represented, and we should have exactly the same fight in a perhaps acuter form.

You have put down £100,000 in your bill for the purchase of land and expenses incidental thereto. Do you think if you have to compensate Messrs. Curtis's & Harvey for the removal of their business will £100,000 still be sufficient?—We should have to say to our lessee or transferee, in that case, "We have had these expenses put upon us and we must, as one of the conditions of the lease, be reimbursed for this amount."

With regard to the change of opinion of the members of the London County Council, you think any further change is unlikely?—Yes.

But there was an election some years ago when the working of the tramway system was put to the vote, and as a result the Northern Tramways were leased to a company?—I believe that was so.

And the Council have since had to buy out the company at a heavy cost?—Yes.

It has been suggested that in a few years the character of the Council may change, and they may wish to resume their powers for working the business of electricity supply themselves?—I believe the people of London will be satisfied with the present proposals for control.

But will you have much control if you lease the whole thing to some private company?—I think we shall have all the control that is really necessary, as we shall entirely control the price to be charged for electrical energy and the quality of the service.

You have already a generating station at Greenwich which could supply a considerable amount of energy beyond what is required for the Council's tramways?—Yes, we could supply a certain amount.

And it is proposed by this bill to let the ducts already laid for the purpose of cables, &c., to the new company?—I do not say it is proposed to do so, but power is reserved for this purpose. But the engineer will be best able to deal with this point.

Your ducts are very extensive, are they not, so that a big business might be commenced immediately after the passing of the bill?—Our ducts are laid primarily for tramway supply. Whether they will be equally convenient for general electricity supply I should not like to say.

The CHAIRMAN: My colleagues have anticipated any question I might have wished to ask you, but we feel that your clause 66A hardly sufficiently carried out the mandatory instructions we received from the House of Commons. Perhaps you could amplify the information given? You might give us some form of lease—something which will be guiding you in your negotiations.

Mr. FREEMAN: This request shall receive the fullest consideration on our part, and when we meet on Tuesday next we shall have gone as far as we possibly can in endeavouring to meet your wishes.

The Committee then adjourned until Tuesday, when

Mr. FREEMAN (counsel for the London County Council, promoters of the bill) said: We have spent considerable time in preparing a document which I would describe as the heads of the lease or agreement which I think should meet the requirements of the mandatory order of the House of Commons. I propose that this document should be expounded to you through the evidence of Mr. Rider, the electrical engineer to the Council, whose evidence I now propose to take.

Mr. J. H. RIDER said he was electrical engineer to the London County Council tramways, and had held the position since March, 1891, having previously been borough electrical engineer for Plymouth for six years and for Bolton for three years. He had had 20 years' continuous experience in electrical engineering work, and during the last 14 years had been designing, constructing and conducting electricity works for lighting, power and tramways, the value of the works exceeding £1,500,000 sterling. In his present capacity he designed the County Council generating station at Greenwich, which is the largest municipal electric generating station in the world, and also the entire system of underground high-tension transmission and low-tension distribution.

Replying to Mr. CLODE, Mr. Rider said the electricity supply in the metropolis covered practically the entire area of the County of London, and powers for this supply are held by 16 local authorities and 13 companies. Most of the orders were obtained in 1889. In some of the areas there were competitive supplies, but he did not think there was a single case of similar competitive supply in any part of the Kingdom outside London. Competition exists in Bermondsey, parts of Camberwell, Chelsea, part of Finsbury, part of Greenwich, part of Holborn, a small part of Lambeth, Southwark, and in the cities of London and Westminster. Probably the most important feature of the powers held by companies was that the right of purchase was given to the local authorities at Aug. 26, 1931, or at any subsequent period of 20 years from that date. The companies were all allowed to charge a maximum of 8d. per unit for current, subject to revision by the Board of Trade every seven years. Any consumer within the area can demand a supply, but no undue preferential rates are allowed to be given. The supply can be used for any purpose—lighting, heating, power, traction, &c. In some districts supply is given on a competitive basis, and in others there is no competition.

What do you regard as the general requirements for a satisfactory scheme for this area?—The most important is that a large generating station shall be established, situated where water carriage for coal is available and where a large amount of water can be obtained for condensing purposes. Except in very few instances, all existing stations in London fail in these fundamental requirements. The generating units should be of very large size, so that the area of the generating station buildings may be kept down as far as possible. Electric energy should be supplied at a low price in order to encourage its use, and a low charge is only possible under the conditions I have named, enabling the station to obtain what is called a high or large load factor, by which is meant the proportion of units actually sold from a given amount of plant in commission to what would be sold if that particular plant were kept working at its full power the whole time—that is, if you have a station of 10,000 H.P., and you can work that station for the whole 24 hours at its full output, the load factor is 100 per cent. If the station works for only 12 hours the load factor is 50 per cent., or if you work the station at only half load for 24 hours the load factor is 50 per cent. By knowing the load factor you can judge the use to which the plant in the station is being put. In order to obtain this large load factor the character of the load dealt with by the station must be of a diversified kind, and this point comes into consideration when you are choosing the site for your station buildings. In our case we have the Council's tramways, which supply is kept separate, but there are a number of tramways in the outskirts of the Council's area which could be very well supplied under the Council's scheme. With regard to power for manufacturing purposes, there would be a large demand for such power if this could be given not only at a low price, but of the right kind suitable for motors. At the present time manufacturers in London are limited to steam, to hydraulic power and to gas in addition to electricity, whereas if a cheap and reliable supply of electric energy were given many of the existing forms of power would be given up in its favour. Some authorised distributors are already supplying energy for power, but some also are supplying on a system which is not altogether suitable for electric driving. For electric heating also a cheap supply would be popular. At present it does not pay to adopt electric heating at existing lighting rates, and even power rates are none too low to ensure a rapid increase in the demand.

In obtaining railway custom will you be depriving any existing undertakers of that class of custom?—No. Few of the existing undertakers have Parliamentary powers for the purpose.

But you will take some of the companies' lighting load when you deal with railways under your Kitson clause?—Yes. But we limit ourselves to 20 per cent. of the energy being used for lighting, and it is quite impossible to supply energy to railway companies for train working without, at the the same time, using a portion of it for lighting the trains. In the case of our tramways the lighting load amounts to 1,000 H.P. every night in addition to the traction load, but I consider that competition is justifiable.

Would it be necessary to lay a special main for a railway?—I consider it would, because the supply that would be required would be very large indeed compared with the ordinary output of the authorised distributor. As to the stations, those existing would not be equal to cope with the load, and it would be undesirable to develop them piecemeal, or in the positions in which they are now situate, because these are not positions making for a cheap supply. I consider the scheme which will be before the Committee in all respects equal to meet the requirements of a cheap supply of electricity in the scheduled area.

To some extent, I suppose, current is now supplied for power at the cost of those who take it for light?—I think so. In many cases the authorised distributors have treated the power load as a sort of by-product and have been able to charge low rates because they have kept up the price for private lighting and street lighting, whereas, in my view, all should be charged on a common basis—that is to say, each kind of supply should be charged in accordance with its proportion of standing charges and running costs. The Council's scheme has been developed by myself, along with Mr. A. L. C. Fell, the Council's chief officer of tramways, Mr. H. F. Parshall, Mr. Robert Hammond and Mr. J. F. C. Snell, and we are all jointly responsible for the scheme, the area of which is 451 sq. miles, 117 miles within the County of London, and about 334 miles outside, which compares with 387 sq. miles in the scheme of last year.

(PARLIAMENTARY INTELLIGENCE *continued on page 400.*)

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ELECTRICITY SUPPLY IN PARIS.

At the present time, when the supply of electrical energy in the London area is exercising the minds of county councillors and engineers alike, it is of some interest to note the way in which this problem is being solved in Paris. Considering that Paris has strong Socialistic tendencies, it might have been expected that a municipal solution would have been adopted, but this is not the case, possibly because the municipal leaders have not been able to make up their minds in time before the crisis arrived. Up to the present, electrical supply in that city has been in the hands of companies, and the concessions have been so drawn up that at the times of expiration, which occur during this and next year, the networks become the property of the Municipal Council and the generating stations remain the property of the companies. The result is that the Council are finding themselves possessors of a network of mains without any means to supply them.

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Another curious feature of the bargain is that the networks become the property of the Council, not by right of purchase as is usual in this country, but without any payment whatever. To the municipal mind this may appear to be an advantage, but the fact that the assets of a company become reduced to nil at the end of a comparatively short concession cannot fail to have a bad effect upon the general advantages of the supply. Nominally, of course, the companies still have assets, because they retain their generating stations, but the value of a generating station without a distributing network is comparatively small, and the Council will probably erect their own generating stations, or purchase those of the companies at a scrap value. Consequently electrical energy has been sold at such a price as to allow of the whole of the capital being repaid in a short time; and considering that the companies have had to pass through that period during which the difficulties of pioneering work were experienced, it is only natural that the price charged should have been very much higher than would otherwise have been the case.

The difficulty with which the Council was faced has been met for the time being by a new company, which is to take over the generating stations of the old companies and thus preserve the continuity of supply. Since, however, the mains will now be the property of the Council, this new company is to have the use of them in return for a yearly payment to the Council of 20 fr. per kilometre of mains and 10 per cent. of the gross receipts, and current for public purposes is to be supplied at a discount of 30 per cent. off the price for private lighting. Moreover, if the prosperity of the company increases, the payment to the Council also increases, and in no case is the payment to the municipality to be less than £120,000 per annum. When all this is taken into account it is perhaps surprising that the maximum price permitted is not higher than 6·7d. per unit for lighting and 2·9d. for heating and power purposes. These maxima will hold for the first six years, after which time the former charge will be reduced to 4·8d.

Having regard to the recent strike at the Paris Electricity Works, it is interesting to note the provisions that are to be made for providing old age pensions for the workmen. Not only is a certain sum to be deducted from the wages of each workman and invested in the national securities which may be realised when the workman leaves—but this sum is to be increased by a payment on the part of the company in many cases amounting to 7 per cent. of the employé's salary. Undoubtedly methods of this kind for providing old age pensions are excellent, but if the sum so provided may be easily withdrawn it is difficult to see how any permanent good effect can be secured. In the year 1940 the Council will take over the whole of the machinery, buildings and mains without any payment being made for them, and as the company is to erect two new generating stations having a capacity of at least 25,000 kw., and possibly 50,000 kw., and is to make extensions of mains as well, it will be recognised that a really cheap supply of electrical energy is almost out of the question. The one aim of the Council appears to be to hamper the undertaking as far as possible, and to drive as hard a bargain as can be driven, quite irrespective of what the ultimate effect may be.

OBITUARY.

WILLIAM EDWARD LOUIS GAINE.

Last week we announced the postponement of the annual staff dinner of the National Telephone Co. owing to the serious and quite unexpected illness of the general manager of the company, Mr. W. E. L. Gaine. It is with great regret that we now learn of the death of Mr. Gaine, which occurred on Tuesday last, from an attack of pneumonia following upon a chill. Mr. Gaine was in his customary good health at the beginning of last week, so that it is hardly possible for his friends to realise that so active a man could have passed from amongst us after so short an illness. His loss comes as a shock to a very large circle of friends and acquaintances, who have followed with interest his strenuous career for the past score of years.

Mr. Gaine was born in London in 1851. After leaving school he was articled to Mr. Compton Smith, solicitor, of Lincoln's Inn Fields, and after serving his articles was admitted a solicitor of the High Court. He very soon gave evidence of his abilities, and was appointed, at the age of 23, Town Clerk of the County Borough of Blackburn, Lancs. (and subsequently Clerk of the Peace), an appointment which he held until 1892. During the whole of this period he was one of the best-known and most able municipal officers in the county, and no one who knew him at that time was surprised when they learned of his being appointed to the important and most responsible position of general manager to the National Telephone Co. The board of directors of the company recognised in Mr. Gaine a man of strong individuality and administrative ability, and he was given from the first a free hand to organise and develop a business which even in those comparatively early days gave promise of great expansion. Mr. Gaine's first work in his new appointment took the form of concentrating telephonic enterprise in this country, and within a short time the three local telephone companies which then existed in different parts of the United Kingdom became absorbed in the National Telephone Co., until the National Company became, except for some slight competition from the Post Office, the sole provider of telephonic communication in the kingdom. The acquisition of the competing companies at once compelled attention to the necessity for organisation, which at that time was lacking, and it became Mr. Gaine's duty, as it was his pleasure, to set about the work of thorough organisation and regulation of the telephone service. The labour involved was enormous, and few men could have withstood the physical strain for which this huge undertaking called; and we have heard Mr. Gaine express the view that he was successful beyond his greatest expectations.

In this great work Mr. Gaine's early training in the law, and the system and regularity necessary in his position as a high municipal official, had well prepared him for his task, and those who have been present on many memorable occasions when he has presided at the pleasant annual functions associated with the National Telephone Co. will remember how readily he expressed his appreciation of the great assistance he had always received from the members of his staff, and how grateful he was for the confidence placed in him by his directors throughout the entire period of his onerous labours.

Mr. Gaine eminently combined the qualities of the negotiator with those of the pleader, and in the attacks made from time to time upon the National Company he was always to be relied upon to put the case for the company with dignity and conciseness, and in the majority of cases where litigation, arbitration or hard fighting had to be undertaken his efforts on the company's behalf proved successful. In the prolonged and fateful negotiations with the Post Office, it has been generally recognised by those behind the scenes that Mr. Gaine's strenuous endeavours and his skill in negotiation have served the company to great advantage. His guiding hand and close acquaintance with the points at issue between the parties will be sadly missed by all who have a financial interest in the National Company.

To Mr. Gaine's family, to the staff of the company, and to the directors and shareholders we offer our sincere condolence.

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ILLUMINATION AND SOME ILLUMINANTS.*

BY J. D. MACKENZIE.

In the following remarks I am not bringing forward anything original or even novel in itself, but have endeavoured to discuss what seem necessary qualifications for successful illumination and how these may be attained in practice. Notwithstanding the vast amount of electrical energy which is used for power purposes, and that so much attention is devoted—and justly so—to what may, generically, be termed heavy electrical engineering, I yet venture to assert that no part of the immense ground covered by electrical science is so constantly and prominently in the public eye as that of electric lighting; and hence it is only right that a little more attention should be shown to the best methods of illumination. A good deal has lately been written about the "Newer Incandescent Lamps," giving details of improvements and suggestions for more improvements, but one finds that very little has been said about how to place even the "doomed" (?) carbon filament lamp so as to improve its efficiency as an illuminant.

The author describes the construction of the human eye, and shows that there is one peculiarity of the eye which it is essential to notice, and that is the fact that it is always attracted to the brightest object in the field of vision. Also, if there are a multiplicity of bright objects, such act as a distraction to the eye and prevent the feeling of restfulness so essential to full and free vision.

Some Illuminants.—Having seen how light is rendered into human vision, it becomes necessary to consider some of the various illuminants in general use, in so far as their properties affect the question of efficient illumination. The commonest form of illuminant we have is the paraffin or stearine candle, which gives a yellowish-coloured light with an intrinsic brilliancy of about 3 c.p. to 4 c.p. per square inch.

In acetylene gas we have an illuminant with a spectrum very closely approaching that of sunlight, consequently giving a white light whose intrinsic brilliancy is from 75 c.p. to 100 c.p. per square inch.

Incandescent gas gives us a spectrum in which green rays tend to predominate, and it has an intrinsic brilliancy of 20 c.p. to 40 c.p. per square inch.

The carbon filament electric incandescent lamp, giving a spectrum in which yellow and orange rays predominate, has an intrinsic brilliancy of from 200 c.p. to 300 c.p. per square inch.

The metallic filament lamps, with a rather whiter light, have an intrinsic brilliancy varying from 400 c.p. to 600 c.p. per square inch.

The Nernst lamp, a whitish light with an intrinsic brilliancy of bare glower of about 1,000 c.p. per square inch.

The mercury vapour lamp shows a spectrum without any red rays, and chiefly comprising the yellow, blue, violet and green rays, and has an intrinsic brilliancy of about 5 c.p. to 10 c.p. per square inch.

The Moore tube light, with rose or orange-tinted light, has an intrinsic brilliancy of about 1 c.p. to 1·5 c.p. per square inch.

It must be borne in mind that all the values given for intrinsic brilliancy are at best only rough approximations, and those for the metallic filament, mercury vapour and Moore tube are especially so, as they are calculated from very insufficient data.

Intrinsic Brilliancy—By this is meant the value obtained by dividing the total candle-power emitted by the area of the illuminant emitting it. It has a most important bearing on illumination, and is generally the factor most often ignored or forgotten in the whole scheme. Remembering that the eye is attracted to the brightest object in the field of vision, and that the iris adjusts itself to suit the maximum intensity of light emitted by this object, it will be readily seen that the inclusion of an illuminant of high intrinsic brilliancy in the field of vision may cause the iris to contract so far as to actually make surrounding objects almost invisible to the eye.

Absorption, Diffusion and Reflection of Light.—Now, the usual methods employed to overcome the very apparent fault of too high an intrinsic brilliancy of illuminant are to obscure the lamp bulb or to enclose the lamp in obscured, opalescent or prismatic globes, or even to enclose it in shades of fabric such as silk, or mica, or horn, &c. These substances, however, absorb a very considerable amount of the total light produced in the illuminants.

Now, although this method gives us a light-emitting globe of a relatively lower intrinsic brilliancy, still it is at the cost of greatly reducing the efficiency of our lamps, and in order to indicate what such reduction of efficiency amounts to, I have calculated the equivalent efficiency, allowing for a lamp, giving 1 c.p. for every 1·7 watts, being placed inside such globes.

Reflection is a most useful factor in interior illumination. The light—from the illuminant—which falls on walls, floors and ceiling is reflected backwards and forwards in an infinite number of rays, each of which tends to increase the actual illumination of the room. The effect produced in any given case is expressed by the following formula:—

Let C = candle-power of illuminant and k = coefficient of reflection of surrounding walls, &c.; then total light, $L = C\left(\frac{1}{1-k}\right)$.

This is shown in the table, where the actual increase in illumination is calculated for various values of k.

Table.—*Increase of Illumination due to Reflection.*

k.	$L(1/1-k)$.	k.	$L(1/1-k)$.	k.	$L(1/1-k)$.
0·95	20·00	0 60	2·50	0 20	1·25
0·90	10·00	0·40	1·66	0·10	1·11
0·80	5·00	0·30	1·42	0·05	1·05
0·75	4·00				

These figures indicate that in an ordinary room under ordinary conditions it is quite possible that the diffuse reflection from walls and ceiling may easily double the illumination due to the illuminant alone.

Artificial Illumination.—Having considered the various factors determining the application of light to illuminating purposes, the next point is to investigate how best to carry these principles into practical effect. My opinion is that our principal aim ought to be the getting of a fairly close imitation of daylight. My principal reason for this is that no artificial illumination yet produced is so easy and pleasant to the eyes as daylight, and, therefore, although we can never hope to reach a perfect daylight effect, it is something surely worth aiming for.

In order to imitate daylight we must conform to some necessary conditions: (1) The spectrum of the light should approximate to that of daylight. (2) The illuminant must not be anywhere within the usual field of vision. (3) A larger degree of diffusion must be obtained. (4) Perfect diffusion must be avoided. (5) Direct reflection of the light must also be avoided. (6) The intensity of the illumination must not exceed a definite amount.

The effect of (1) is to place certain illuminants at once out of the field, were we to insist strictly on adherence to such a condition. The eye, however, can bear a greater amount of yellow- and orange-tinted light than it can any other, and hence illuminants giving off a preponderance of such rays seem to strain the eye less than others. An instance is the flame arc lamp with its yellow- or orange-tinted light; although the intrinsic brilliancy of the lamp is much greater than that of the ordinary open arc, the eye can look longer and with less fatigue at the flame arc lamp.

The considerations necessitating (2) have already been explained, and it is scarcely necessary to mention that only in the very rarest cases is this condition fulfilled in ordinary domestic illumination. There seems a very general belief that the indirect method of illumination is most wasteful. Reference to tables will show that 50 per cent. of the light given by an illuminant is lost in passing through an opal globe, while a whitewashed wall or ceiling will reflect light with a loss of only 20 per cent. Of course with indirect illumination there must be a double reflection—namely, a direct reflection from reflectors of the highest class (placed behind the illuminant) on the ceiling, and then the diffused reflection from the latter, assisted by similar reflection from the walls and floors, gives the resultant illumination. At the same time in actual practice it will be found that the difference in efficiency of the two methods is not so great as many are inclined to think.

As regards (3) and (4), it is certainly necessary to obtain a great degree of diffusion such as we possess in ordinary daylight, but it is just as necessary to avoid perfect diffusion such as takes place with daylight enshrouded in a white fog. Such a state of matters is very trying to the eye, owing to the fact that the light and shade effects are nullified, and hence everything appears so flat that the eye is strained in an endeavour to distinguish the forms of objects. In this matter of too much diffusion many of the installations carried out on the indirect method have failed owing to the appearance of flatness obtained by light falling on objects in every direction. To obviate such a defect the correct method will be found by adhering closely to the primary condition laid down at the beginning, "to imitate daylight." In an ordinary room the light comes in through windows placed at one end and perhaps one side, and hence objects in the room appear bright on the side next the source of light and in shadow on the other side. If now the illuminants intended to replace the daylight are grouped more closely about the windows then a greater effective illumination will be given in one direction than in another.

Conditions (5) and (6) are also very necessary, but are often ignored. Unfortunately for our eyesight, and for the eyesight of the rising generation, there seems to be a craze for increased illumination, and the effect is seen in the alarming increase in ophthalmic disease. Even Mr. Swinburne, in his recent Paper, has made the startling remark that the new high-efficiency lamps will lead to consumers replacing their 16 c.p. lamps by others of 25 c.p. to 50 c.p. We should strenuously endeavour to prevent such a calamity.

Having indicated the faults of present methods of illumination,

* Abstract of a Paper read before the Glasgow Local Section of the Institution of Electrical Engineers.

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and the several conditions necessary for successful treatment of any given case, this Paper would not be complete without some indication being given as to the ideal method (in the writer's opinion) of applying the illuminants to their proper purpose. Take, for example, a show window on some business thoroughfare; here the object aimed at is to give a brilliant illumination of the goods, and the method familiarised by the Linolite system is on right lines, and eminently satisfactory wherever it has been properly installed. In such a case as this it is quite unnecessary to guard entirely against direct reflection, because in the case of jewellery, for example, direct reflection is desired in order to properly exhibit the articles.

In domestic lighting it is suggested that high-efficiency lamps, such as the tantalum, should be arranged in straight tubes, backed by reflectors and placed along behind a deep frieze moulding; the principal intensity of illumination to come from one definite direction, preferably from the direction in which daylight enters; the ceiling from which the diffuse reflection is desired to be of a white matt surface and walls preferably of light tints. These high-efficiency lamps could be arranged in lengths of, say, 12 in., giving four in series on 200 to 250 volts; the total number of lamps being installed according to the highest intensity of illumination desired, and such switching arrangements made as would enable two or more combinations to be made whereby this intensity might be reduced.

For halls and public buildings, where ceilings are high, a combination of direct and indirect illumination might be necessary, and it is impossible to set down any definite rule for such cases. At the same time, attention to the conditions set down would go far to give a satisfactory result artistically and physiologically.

THE DIELECTRIC CONSTANT OF ICE.*

BY F. BEAULARD.

The method employed consists in measuring the moment of the couple to which the dielectric substance is subject in a Hertzian field when given a suitable form, which is not symmetrical with respect to the direction of the field.

The ellipsoidal shape is perfectly suitable; the couple experienced tends to turn the dielectric in such a way that the direction of the greatest dimension of the body coincides with that of the field. The rotation of the suspended system provokes an elastic reaction, and there is equilibrium when the moment of the couple of torsion equals the moment of the rotating couple.†

The relation given by Graetz and Fomm is—

$$C\alpha = \frac{\chi^2 \phi^2 v (L - M) \sin 2(\theta - \alpha)}{2(1+\chi M)(1+\chi L)},$$

where θ is the original angle between the field and the major axis of the ellipsoid; α is the rotation of the system; $C\alpha$ is the torsional couple; L,M,N, are constants depending upon the size of the axis; they are the partial derivatives of a definite elliptic integral, and are known for a given ellipsoid; K is the dielectric constant, and equals $1+4\pi\chi$; v is the volume of the ellipsoid, and ϕ the field intensity.

The length of spark at the micrometer gives the maximum P.D. V_m, whence the effective P.D. and the value of the field

$$\phi = \frac{1}{\sqrt{2}} \frac{V_m}{d},$$

where d represents the distance between the two condenser plates confining the Hertzian field. The wave-length $d = 85$ m.

The experiments concern pure ice and water in the neighbourhood of the freezing point. The water was introduced into an ellipsoidal vessel of thin glass, and the system remained for a whole winter's night exposed to the temperature of the laboratory; in the morning there was no freezing, but it could easily be brought about with suitable precautions against breakage by a jet of methyl chloride.

Measurements were carried out with (1) ice; (2) a mixture of water and ice; (3) melted ice; the glass envelope was allowed for by a preliminary measurement with the vessel when empty.

The following are the results:—

1. Ice from pure water	K = 1·455
2. Mixture of ice and water	K = 1·987
,, ...	2·280
,, ...	2·477
,, ...	2·586
3. Water (near 0 deg.)	K = 3·072

It follows from this:—

(*a*) That the dielectric constant of ice is of the order of magnitude of the square of the refractive index ($n^2 = 1·71$).

(*b*) That the specific inductive capacity of water near 0 deg. is notably below the value (K = 11) which I previously communicated to the Academy. This reduction of the dielectric constant is entirely due to the diminished solubility of glass in water at the lower temperatures, as I have directly verified.

* Translated from the *Comptes Rendus* for April 29, 1907.

† See *Comptes Rendus*, p. 656, 1905, II.

USE OF CONDENSER BATTERIES.

In our issue of January 4, 1907, we gave a description of a new type of condenser designed by M. Moscicki and suitable for high voltages. These condensers are made by the Société Générale des Condensateurs Electriques of Fribourg (Switzerland). The condenser elements are made of glass tubes with thickened necks, and have a chemical deposit of silver inside and out, over which is a thicker layer of copper. The following notes on the utility of such condensers are based on an interesting pamphlet on the subject issued by the makers:—

The principal uses of condensers are in connection with lightning arresters, wireless telegraphy and on alternating circuits. With regard to the first, existing lightning arresters for the protection of overhead lines may be divided into two classes: (1) Arresters with a spark-gap and with or without resistances; (2) Arresters only with resistances.

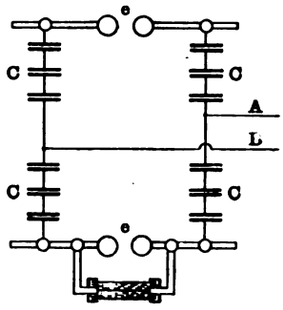

FIG. 1.

The former type cannot be adjusted with safety for a smaller gap than 6 mm., corresponding to a pressure of 16,000 volts, which means considerable increase of pressure on some circuits, and, moreover, it is necessary to connect a resistance in series to limit the flow of current to earth to a small value. This type also causes excessive voltages at the instant of breaking the arc. Lightning arresters with liquid resistance allow atmospheric discharges to flow to earth, but the current is necessarily limited to small amounts, although experiments have shown that atmospheric discharges can attain several hundred amperes. By the use of condenser batteries it is, however, possible to protect circuits simultaneously against induced high-frequency currents, against static charges and against excessive voltages produced by the sudden variations of the load on the machines and by the working of the switches.

The principle of the working of these lightning arresters is based upon the fact that the flow through a condenser is proportional not

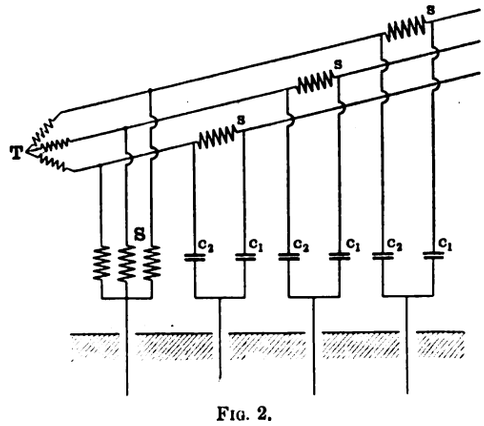

FIG. 2.

only to the difference of potential between the two plates, but also to the frequency of the current. If, therefore, we take a battery of condensers through which a current of 0·1 ampere passes to earth under the influence of the normal voltage of the line and assuming that the frequency of the line current is 50, a current of 1,000 amperes will be sent through the same battery, if the frequency of the line current is 500,000, without the voltage being any higher. Atmospheric discharges have frequencies of this kind, and the flow to earth can be enormous without the pressure in the line exceeding the normal.

By arranging the installation, as shown in Fig. 1, where A and B are feed wires coming from a high-pressure generator having a frequency of 50, C, C condenser batteries, *e*, *e* the balls of the air-gap, it is possible to regulate the capacities so as to obtain in the circuit formed by the four batteries and the two air-gaps resonance currents

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of very high frequency, for instance, 500,000 to 600,000. Now place as a shunt in one of the gaps a resistance constituted by a german silver wire enclosed in a glass tube full of water. Let the resistance of this wire be 7 ohms. If the circuit is caused to resonate, sparks will be produced between the balls of the gap when the balls are placed at such a distance apart that the arc corresponds to a voltage of 14,000 volts. Since this figure also represents the voltage at the terminals of the resistance, it follows that for a moment a maximum current of about 2,000 amperes is passing through the resistance. This maximum is, however, produced only during an exceedingly short time.

The cases in which it is impossible to find on the apparatus of the circuit (generators or transformers) a sufficient number of neutral points for completely protecting it are very rare. In such cases the method shown in Fig. 2 is adopted, consisting in inserting a choking coil branched direct between the conductors of the circuit. The working will be the same, but the apparatus will be more expensive. Condenser batteries must be installed at each entrance to a station, but one choking coil will be sufficient to protect a circuit with a radius of about 30 km. to 35 km. against the static charges.

The agents in this country are Messrs. Isenthal & Co.

CORRESPONDENCE.

TIME'S REVENGES—INSULATED RETURNS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Ten years ago I was endeavouring to persuade the engineers of tubular electric railways that they were really just as much interested in having insulated returns in their tubes as were the workers in scientific laboratories; and having obtained a promise from the promoters of one of these tube railways that the return should be insulated, a very well-known engineer in Victoria-street remarked to me: "If I had had anything to do with the Brompton and Piccadilly Circus Railway you would not have had your way." To this I pointed out that "if the return be insulated (*Jour.* Inst. Elec. Eng., May 20, 1897, p. 529) a much larger drop of pressure can be used with the return conductor, that the electric railway companies will be freed from trouble following from interference with telegraph lines, interference with telephone lines, damage to pipes through electrolysis, will diminish the risk of breakdowns, the risk of employés receiving shocks, &c."

And I mentioned (bottom of page 528) "that, of course, it is very difficult, when you represent a scientific college, to make people understand that you may be just as much interested—not necessarily in the pecuniary sense, but really just as much interested—in the success of electric railways as in the success of the experiments carried out by students in your laboratories."

Another well-known engineer urged that, as you had to lay down rails to carry the trains, it was a pity not to use the same conductors to carry the current. To that I replied (*Jour.* Inst. Elec. Eng., April 28, 1898, p. 472) that nobody used the sheathing of our electric light cables as a return conductor, or even as part of it, and I asked the question, "Why not use them as the railway companies do, use the rails for the trains to run on, and, if you want to do something else, use something else to do it with?"

I pointed out that "it was a very old-fashioned idea that you must do everything by the same means. We used to have a hole in the roof of our houses to let out the smoke, and let in the light, and do the ventilation, but now we have abandoned this universal method; we differentiate."

But, of course, ten years ago it was only by Act of Parliament that you could induce electric railways to employ what was best for themselves, viz., an insulated return, and on May 20, 1897, I was able to report at a meeting of our Institution (Vol. XXVI., p. 528, of the *Journal*) "that in the case of the three lines (1) to run between Hammersmith and the City; (2) the line to run from South Kensington to Piccadilly Circus (now extended to King's Cross and Finsbury Park); and (3) the express line to run in a deep tunnel under the inner circle of the District Railway (in which deep grave the undertakers appear to have buried the quick with the dead) whether these lines be worked on the two or the three-wire system, whether the current be direct or alternating, the return shall be insulated throughout to the satisfaction of the City and Guilds of London Institute and of the Science and Art Department, or what will shortly be conjointly known as the Imperial College of Science and Technology at South Kensington.

The first new electric railway actually opened after the passing of these Acts of Parliament was the King's Cross and City line, and I remarked to the engineer on its completion, "I see that, although you were compelled by *no* Act of Parliament, you have used an insulated return." "Yes, we have adopted the system you recommended," he replied. On the opening of the next, the Bakerloo, I made the same remark, and this engineer's answer was: "Yes, we are beginning to think there is something in what you urged on us some years ago." To-morrow, Saturday, the 22nd inst., when the last of the present group of underground electric railways, the Hampstead tube, is opened, doubtless the reply that will be made by the engineer regarding the utilisation of an insulated return will be: "Oh, yes! don't you know the newest and best way of constructing a tubular electric railway? This is the latest American practice."—I am, &c.,

W. E. AYRTON.

Central Technical College, June 21.

ELECTROLYTIC COPPER TUBES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of May 10 last contained the description of a new method of making seamless copper tubes by electro-deposition, yielding smooth and compact layers in consequence of an addition to the solution of fine-powdered, sharp-edged matters, as, for example, silicious sinter, which grind the surface of the revolving cathodes, thereby smoothing and cleansing it.

In a letter directed to *The Electrician* and published in your issue of May 17, Mr. Sherard Cowper-Coles compares this new process with another invented by him and having the same aim—*i.e.*, the production of smooth and strong copper tubes by electro-deposition, but having as only means for the smoothing of the stratum of copper the fast rotation of the cathodes, and comes to the conclusion that his process is far superior to the new one. The arguments, however, which he presents to that effect seem to be intended for the novices in electro-deposition among the readers of your paper, for the figures given by him cannot stand a serious and expert consideration.

First, he states that his method allows the use of far higher current-densities—up to 200 amperes per square foot—and therefore permits the production of tubes in a shorter time than that required by the new process. This assertion, however, is completely erroneous. It would be possible to apply such intensities with the new method, but it is not done because of practical reasons. We can only suppose that Mr. Cowper-Coles applies these intensities only when he exhibits his method, but never when he practically executes it. It must always be borne in mind that the application of such high-current densities will very easily cause disturbances, especially excessive heating of the electrolyte, and that therefore their use cannot be considered as rational.

If Mr. Cowper-Coles further assumes that his method requires much lower tension than the new method—0·75 volt instead of 2·5 volts—we may say that this is a comparison whereby an expert can never be influenced. Everyone who has experience in electro-deposition knows that the tension in those cases does not depend on the method, but only on the distance between the electrodes and on the quality of the copper employed as anodes. Taking as anodes sheets of chemically pure copper, and placing the electrodes very near together, it would occasionally even be possible to work with currents of still lower tension than that cited by Mr. Cowper-Coles—and that not only with his method, but with any method whatever. The question is only what object is desired.

In case it is only intended to exhibit an apparatus, it will be of no importance whether cheap raw copper or expensive pure copper be employed as anodes, and if less stress is laid upon certainty of work than upon saving in power, it will be admissible to place both electrodes even at the highest speed at a minimum distance apart. That can be done equally well

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with one method as with another, and the fact that in one or the other case the process is a different one is no proof of the difference of the methods but only of the different conception about the surest and most practical arrangement and execution of the work.

Comparing these two methods with each other without bias and prejudice, you will find that the fundamental idea of both is the same—*i.e.*, to prevent the noxious formation of gas and roughness of the deposit due to this on the cathode, by a constant rotation of it. With the new process—solution with silicious sinter—the fine powdered substances added to the solution will always be stirred up by this rotation so that they grind the surface of the cathodes, thereby removing all inadmissible deposits. The speed of rotation may under ordinary circumstances be a moderate one, as substances like silicious sinter are very easily kept in suspension in the electrolyte.

The old method of Mr. Cowper-Coles removes the gas bubbles and other noxious deposits only by the action of the solution on the rotating cathode, but in order to attain this effect a very high speed of rotation is required—according to the statement of Cowper-Coles himself, 50 to 100 times as great as that of the new method with silicious sinter. Which of the two methods will be the best for a practical application, that at a low or that at a high speed of rotation, is a question which need not be replied to by us, but which gives the reply itself.

A further question is, which of the two methods yields really the best and most satisfactory results? The reply is very easily given. The product obtained by means of the new process, according to most searching trials made in State laboratories, is one of first-class quality and of a tensile strength and resistance far higher that those required, for instance, by the naval authorities. For the tubes produced by the old process of Mr. Cowper-Coles testimonials are not to be had, and consequently no proof whatever is given that the effect pursued with the high speed of rotation may be really obtained.—We are, &c, G. Langbein & Co.

Leipzig-Sellerhausen, June 13.

BRONZING AND PLATING FINISHED FITTINGS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As manufacturers of electrical accessories, we note with regret that a matter showing considerable want of thought amongst contractors, art metal workers, platers, &c., is now greatly on the increase.

We refer to the treatment electrical accessories receive when any special bronzing has to be matched or plating work done, more particularly in regard to switches, wall connections, &c., and think it is about time some protest was made, as otherwise decent workmanship and materials will continue to be spoilt.

It appears that when plating or any special finish is required, the whole article is plunged into the cleaning, plating or bronzing bath, as the case may be, without thought as to the ultimate result, instead of separately treating the parts before they are assembled.

These hot, corrosive, acid and alkali solutions remove the protecting coat of tin from steel springs and produce rust, creep under terminals, contact springs and between insulated surfaces, &c., the ultimate result being verdigris or oxide, which produce a rotting of the parts, resistance, heating and consequent breakdown of insulation, besides rendering the user liable to shock; in addition to these defects the articles present a very dilapidated appearance, discrediting those who are in no way responsible for their inefficient "finished" condition. The client pays an extra price for a special finish, but it is obvious that he obtains instead an inferior article where such methods are in practice, and we cannot think that architects, consulting engineers or their clients are aware of the prevalence of this haphazard method of carrying out their instructions when dealing with what would otherwise be decent material. We would respectfully suggest that a closer inspection be made of the metal parts of finished goods, when such slipshod work would be quickly brought to light and the blame placed in the right quarter.—We are, &c.,

London, June 12. A. P. Lundberg & Sons.

CORRUGATION IN TRAM RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I do not wish to evade the questions by "Road Inspector," but my last letter being so long was my reason for not replying. As regards the "straight" line, in the instance I referred to they appear as straight as it is practicable to make them, but by the way the corrugations dodge from one side to the other, I admit that "Road Inspector's" explanation appears the correct one, and that they are not truly straight; they are on a slight up-gradient which gives the necessary slip, and I think my explanation as to "the absence of corrugations on the inner rail," on p. 190, accounts for the rest. He also asks, do I think my suggested remedy will "help the outer wheel to gain" the 30 ft.? I intended my figures to show that if, instead of 5,409 skids to the circle of 0·065 in. each, by strengthening the frame and axle we could make the outer wheel take (twice the number) 10,818 skids of 0·0325 in., and thereby reduce the pitch from 2¼ in. to 1⅛ in., the wheels by bridging would prevent corrugation forming. I do not suggest that my remedy will assist by reducing the friction when rounding curves, as there will be exactly the same amount as before, but, by pushing the lagging outer wheel along by a frame that is rigidly backed up, I should hope to prevent the continuous partial skid of a new or uncorrugated rail breaking up into the intermittent skids which are necessary to produce or increase corrugation.

I account for corrugations appearing when hand brakes are applied by the fact that the hand-brake spindle being on one (the right) side, this is more effective on the right-hand wheel by reason of the direct pull of the connecting rod, consequently the left wheel is retarded more by its axle than its rim, and the springy torque of the axle is brought into play much the same as in the end drive.—I am, &c.,

Leeds, June 17. J. H. Briggs.

"INTERPOLES."

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As your paper has a more than journalistic reputation in literature I am sorry to notice a lapse from legitimate English in your pages, as well as in those of other technical publications.

The word "Interpole" has come into our vocabulary quite unbidden, and it would be as well to inquire as to its right there before it acquires the sanction of long use.

Words like "interruption," or "interference" convey a definite idea of a definite thing, and make sense when translated into good Anglo-Saxon. "Interpole"—"a pole between"—on the other hand means nothing, as the meaning is not completed. What is the pole between, or what is it doing there? "Intermediate pole" or "interpolar pole" would make sense, as in one case *state* and in the other *position* is defined.

"Inter," in fact, has not a complete meaning in itself, and should only occur in conjunction with a word defining condition, motion, or position.

I hope life is yet long enough to allow us to speak of "intermediate" or "auxiliary poles" and save technical literature from yet another crime.—I am, &c., S. E. G.

[We fear that the term "interpole" is too convenient to be dropped. It is probably not so much loss of time as loss of energy that will prevent people from speaking of "intermediate pole" motors, or "interpolar pole" motors, when "interpole" motors will do. Moreover, is not something to be taken as understood in this term just as much as in the accepted word "intersection"?—Ed. *E.*]

PATENTS IN 1906.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your admirable review of the report of the Comptroller-General of Patents for last year just issued you make a little slip to which you will pardon my drawing your attention. You say: "It is also noticeable that whereas in the 10 years prior to 1905 the average annual number of applications which became void due to corresponding complete specifications not being filed was 196; in 1905 no less than 1,374

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became void in this way. This, no doubt, is due also to the official investigations."

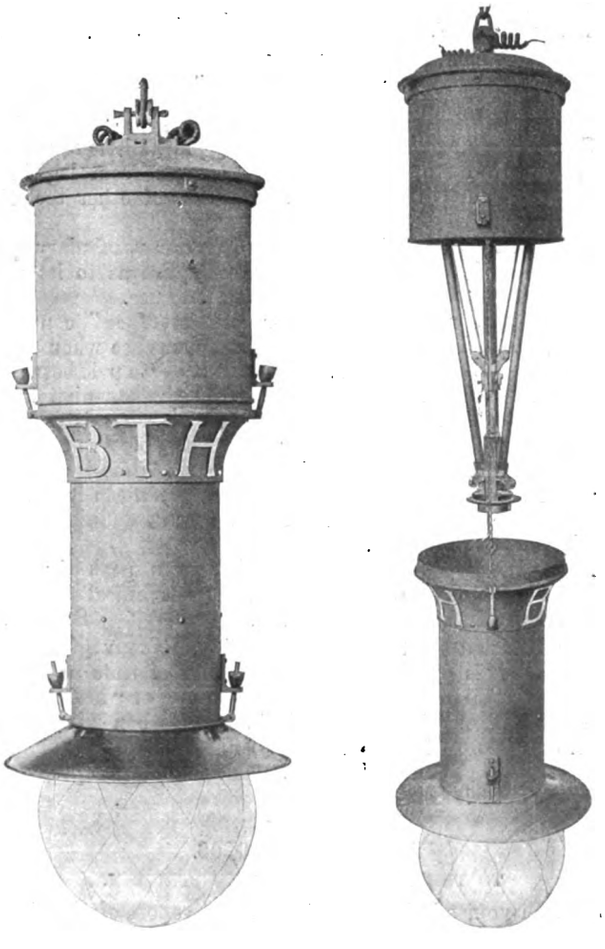
As this percentage is so opposed to my own experience, and as the suggested cause would leave your readers to infer that the official search is made prior to the complete being filed, viz., after lodging provisional—which, unfortunately, is not the case—I am taking the liberty of referring you to the actual report itself, from which you will see that this increase in applications which became void was due to corresponding complete specifications not having been accepted within the statutory period. The completes were filed and the stamp fees paid, but after getting an adverse report on novelty the would-be patentee either gave up the idea of obtaining a patent with a "reference," or abandoned the application through ignorance of or inability to comply with the official requirements, whilst in many cases my practice shows that these applicants wisely supplanted such abandoned applications with new completes, so drawn up that, with improvements therein, they constituted an advance upon the state of the art disclosed by the 50 years search, and so probably secured better title deeds than would have been the case had they permitted the abandoned first completes to pass forward to allowance.—I am, &c.,

BENJ. T. KING.

165, Queen Victoria-street, E.C.,
June 20.

B.T.-H. FLAME ARC LAMPS.

The new types of B.T.-H. flame arc lamps are made for either continuous or alternating-current circuits, and are claimed to be weather-proof, dust-proof, and suitable for outside or inside use.



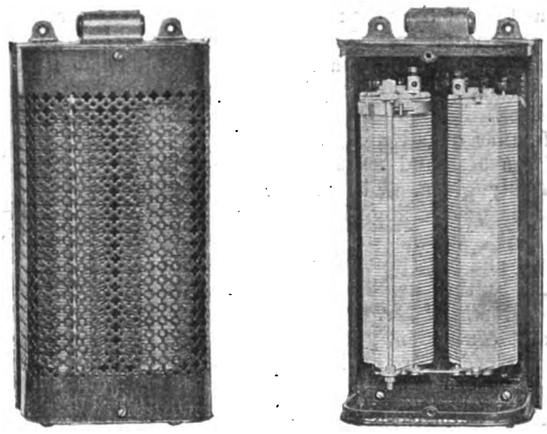
It is claimed that they do not give off objectionable fumes, and the deposits from the carbons are not allowed to reach the working parts.

The differential method of control, with shunt and series magnets, is used. The shunt magnets are wound with wire having a patent enamel insulation which does not deteriorate with heat or moisture. The carbons are arranged at an acute angle, and are fed by gravity, the feeding mechanism being simple in construction. The design is simple, and is without clockwork, spiral springs or stampings, and mechanical and electrical adjustments can be made without returning the lamps to the factory.

Standard D.C. lamps are made for a current of 8 amperes, and A.C. lamps for 10 amperes and 50 frequency. Lamps suitable for other currents and frequencies can be supplied on special order. For series burning, 50 volts per lamp should be allowed. Both A.C. and D.C. lamps are made in two sizes. The longer takes 24 in. carbons and burns 17 hours; the shorter takes 16 in. carbons and burns 10 hours.

Line resistances are made of special non-expansive wire, wound on porcelain cylinders. A substitutional resistance and cut-out is required for each D.C. lamp when the line voltage exceeds 230. In case of failure of a lamp from any cause an equivalent resistance is automatically switched in, and the remaining lamps burn without interruption. The standard form is weather-proof, and arranged for hanging directly above the lamp, but, on special order, they can be supplied on brackets for mounting in a pole base or on a wall.

Compensators are required for A.C. lamps when the voltage is above 120. The primary is connected across the line, and two



lamps are connected in series across the secondary. Special compensators can be supplied for any usual line voltage or number of lamps.

The globes are of light opalescent glass, 10 in. in diameter, and are fitted with wire netting to hold the globe together in case of breakage.

FOURTH ENGINEERING CONFERENCE, JUNE 19–21, 1907.

(*Continued from page 387 of the present issue.*)

On Thursday the following Paper was read in Section II. (harbours, docks and canals). The other Papers in this section were not of electrical interest.

DOCK-EQUIPMENT; INCLUDING THE RELATIVE ADVANTAGES OF ELECTRIC AND HYDRAULIC APPLIANCES.

BY W. W. SQUIRE.

Certain appliances such as gates, caissons, and sluices, appliances for mooring vessels, navigation lights and signals, dry docks and other items of equipment relating specially to the safety, handling and convenience of vessels, are generally speaking common to most docks and are independent of the kind of trade to be accommodated.

The particular kind of equipment in relation to cargo is governed partly by the description of cargo imported and exported, the demand for direct shipment and ex-ship delivery, the bulk of cargoes and the speed of working to be provided for, and to some extent also by the conditions of climate, mode of conducting business and other circumstances at the ports of shipment and discharge respectively.

For direct shipment and delivery of cargo, roads, railway-lines and accommodation for lighters may be necessary each in a greater or less degree. For cargo in transit accommodation is required either in the open or under cover. For storage, open spaces and warehouses are provided, together with various mechanical appliances for shipping, discharging and handling cargo. For general purposes, provision must be made for inside and outside lighting and for the supply and distribution of power.

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In these days of large cargo-vessels and quick despatch, the arrangement of railways and transit sheds is perhaps the most important question, and next comes that of the most suitable appliances for the mechanical handling of cargo. For discharging very large vessels rapidly means must be provided for removing some of the cargo from the wharf almost as soon as landed, *e.g.*, grain can be conveyed to granaries; food produce to cool or cold chambers, and timber to stacking grounds, all situated at a distance from the wharf where sorting and delivery can be done without impeding the work alongside the vessel.

The important question for discussion is the advantage of working the machinery in connection with the gates and sluices, the various cranes, transporters, lifts, hoists and capstans required for the mechanical handling of cargo, electrically or by hydraulic pressure.

Though endeavours have been made to apply electric machinery to the opening and closing of dock-gates and the opening and closing of large sluices, it seems to me that for actuating slow moving machinery of this description on a large scale the advantage is decidedly in favour of hydraulic pressure even though the pumps for supplying the water should themselves be driven electrically.

For cranes and lifts, especially when the loads normally approximate the maximum, the advantage in working appears to be about evenly balanced, though the first cost of hydraulic appliances of this description is somewhat lower.

Electric working is eminently suitable for conveyor-bands, and all kinds of special lifts, ventilating fans, refrigerating machinery, and generally for plant to which rotary engines are applicable.

On the other hand, although hydraulic machinery is applicable to some of these purposes, there are others to which it is quite unsuitable. In cases where it is suitable hydraulic machinery works with less noise and without risk of fire. For all such purposes as those referred to electric appliances are more compact, more easily operated, and if necessary, can be made more readily portable. There is no risk of damage to cargo by escaping water. The transmission cables occupy less space and are more easily fixed than hydraulic-pressure pipes, but, on the other hand, it is necessary to take special precautions to ensure protection against fire. In working with variable loads the advantage is decidedly with the electric appliances. For workshop equipment in connection with the docks, electric appliances are proving their superiority.

With regard to distribution of power to all the various machines, electric cables are less costly than hydraulic pipes for conveying the same amount of energy, and when worn out have a larger proportion of scrap value. There are instances of hydraulic-pressure pipes being used for upwards of 30 years without renewal. There is perhaps not sufficient experience to gauge the life of electric-power cables with any certainty. Electric cables are more easily laid, adapt themselves more readily to inequalities and settling of the ground, are not liable to complete fracture and consequent stoppage of work, and are unaffected by frost.

But in addition to working the various mechanical appliances electricity can be employed throughout the year for internal and external lighting—an important advantage when we consider the question of the main power-station. Hydraulic machinery, on the other hand, can be employed for supplying water for fire extinguishing purposes, which, however, is an advantage not often required.

In order to secure the greatest economy in the main power station the plant should be capable of meeting the maximum demand for power, and the work it is called upon to perform should be such as to provide as high a load factor as possible. If we admit that electric appliances are more advantageous than hydraulic for the general handling of cargo in variable loads on the wharves and in the sheds, that they are more suitable for working refrigerating machinery in connection with cool chambers and cold storage, and take into consideration lighting the whole premises by electricity, it would appear to be reasonable to conclude that a more favourable load can be provided for an electric generating plant than for a hydraulic pumping plant of the same capacity, and that in consequence greater economy in working will result.

It is difficult to institute a comparison between the cost of an electric generating station, capable of supplying light as well as power, with the cost of a hydraulic pumping station which will supply power only, but for two stations containing plant of equal horse power the advantage of first cost is in favour of the electric machinery.

With regard to storing energy, one of the most valuable adjuncts to the hydraulic system, the accumulator, has so far no such satisfactory counterpart in the electric system. The storage battery cannot be compared with this simple contrivance as regards cost, reliability, and ease of maintenance.

In conclusion, the tendency towards the use of electric appliances referred to in a note on this subject at the last conference is decidedly on the increase, and the advantages are such as to indicate still further development with increased experience.

DISCUSSION.

Mr. E. B. ELLINGTON agreed that there were a number of matters in docks in which electric power was more suitable than hydraulic, but he thought it was agreed that there were also matters in which hydraulic power was most suitable. The most important matter in connection with the central station was the maximum demand at any short period of time. The maximum demand was in all matters where hydraulic power was used much greater than in the case of electric distribution, and that was an important result in the working of private plant. If the maximum demand was greater because a particular system of supply was adopted the cost of working would be increased, even if in certain applications there was less power actually used. The general result of experience was that the electric machine at full load was not so economical as the hydraulic machine. When hydraulic plant was carefully designed having regard to the work it had to do, there would not be in a long series of trials much difference in the two systems. The comparisons in the paper were for equal power throughout, but one never got equal power. The hydraulic apparatus at the station would always be worked at a higher load factor; that was, less plant was wanted to do the same work than if it was done electrically. That was the effect of the hydraulic accumulator, which reduced the horse-power required in the engine and boiler. At low load factors, such as were necessary in docks, hydraulic power had a great advantage over electric, because reduction of the load factor in the hydraulic pumping engine did not reduce the efficiency of the machine to anything like the same extent as it did when the engine was driving a dynamo. As to the question of lighting, this was in docks largely arc lighting, and the lighting load increased the load factor. A Paper by Mr. Raven read before the Institution of Mechanical Engineers on Electric Cranes at Middlesbrough stated that when the lighting load was put on, the cost of the electric energy was considerably reduced.

Mr. A. G. LYSTER said Mr. Squire's statement that electrical equipment could not perform every operation required from dock machinery seemed to point to a combination of electric and hydraulic power, whereas hydraulic power could perform practically everything. He did not say as economically in every case, as, undoubtedly, with rotary machinery and varying loads electricity had an advantage, but in other respects the hydraulic appliance was simpler and required less attention and repairs. He was not sure whether it was really economical to combine the two, or whether it was more economical if one had the hydraulic system to add to the load rather than introduce an electrical generator which would require a new set of conductors, and whether the two generating systems would not spoil each other's load. The proportionate cost of hydraulic power would be diminished if the output were increased. For intermittent loads, such as graving-dock work, he thought the gas engine was more economical than the electric motor.

Dr. CORTHELL said he came to Europe from America in 1891 to examine harbours, ports, &c. He doubted if there was an electric crane in operation at that time. Since then they had been introduced at Havre, Rotterdam, Hamburg, and many continental ports. From 1900 to 1902 he was consulting engineer to the Argentine Government. The question was then introduced what power was to be used at Rosario Docks, and as the result of a visit of two of his assistants to Europe to examine electric and hydraulic appliances, it was decided to adopt electric working. At Para, Brazil, also everything was being operated by electric power, and at Pernambuco everything would be electric. Electricity seemed to do the general work better than purely hydraulic. The chief engineer of Santos told him they were preparing to take out the hydraulic installation and work everything by electricity. At Rio Grande they had a large coal deposit and were handling the coal electrically at the rate of 100 tons per hour. They had also a refrigerating apparatus, which would also be worked electrically, and the machine shops in the States were drifting into electricity, because cranes, elevators, &c., could be worked by electric power better than any other. In calculating the power needed for a port it should be remembered that the lighting was a feature which was used at night when the power was not used so much for cranes.

Mr. WALTER PITT said Mr. Squire, in saying there had been an extraordinary development during the last three years, put the matter very temperately. This development was due to flexibility. For new ports he distinctly held that it would be wise to have an electric station, and new ports were in nearly all cases adopting electric power.

Mr. W. H. HUNTER said he had electric and hydraulic cranes working at Manchester docks. There were something over 70 hydraulic and nearly 70 electric. Some years ago when considering a proposed extension which included the provision of a large grain elevator, they decided to adopt electricity because the grain elevator could not be worked by hydraulic power, and he said unhesitatingly that if they were called upon to repeat the proceedings to-morrow he would not, except for one item of equipment, consider that the question was still a subject for discussion. They had found the electric appliances so much more convenient and more flexible that he could not think that anyone who had to begin *de novo* would hesitate now to adopt it. For working dock gates hydraulic power was undoubtedly more suitable and economical, the load being practically constant; the same applied to capstans. Some years ago he made a test as to the cost of handling a given number of bales of cotton by electric and by hydraulic cranes, and the cost was in the former case 13·82d. (exclusive of cost of plant) and in the latter 13·56d. (including cost of plant and mains). In each case the weight handled was 160 tons. This test, however, did not allow for the flexibility of electric working, as both cranes were working with twice their average load. He found the first cost of hydraulic plant was about 60 per cent. less than that of electric, but the maintenance of electric plant was generally less than that of hydraulic, so there was something like equilibrium between the cost of the two systems. So far as convenience was concerned, there was a decided preponderance on the electric side, and men in the holds of ships could work better because there was less noise made by electric cranes, which enabled the men to hear directions from above.

Mr. C. S. MEIK said the engineers for the new King's Dock at Swansea

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had lately been considering the power to be adopted there, and had collected some statistics. Hydraulic power at Middlesbrough in 1903 was equivalent to electricity at 2d. per unit, as 1,000 gallons of high-pressure water were practically equal to 6½ units. At Glasgow in 1903 water was costing 17·67d. per 1,000 gallons, equivalent to electricity at 2·71d. per unit. Coming down to the present time, at Swansea, for the whole of 1906, he found that hydraulic power cost 8·41d. per 1,000 gallons, equal to electricity at 1·29d. per unit. It appeared to him that at Swansea at the present time they were producing hydraulic power at a lower price than any other dock, and, he thought, at as low a price as it would be possible to produce electricity. At Swansea in 1906 the cost per ton of goods handled by hydraulic cranes, including interest and depreciation but exclusive of power, was 1·411d. per ton. The cost of power, including interest and depreciation, was 0·377d. per ton, making a total for cost of power, including interest and depreciation, of 1·788d. per ton. Mr. Raven had given him some figures of the cost of handling the goods by electric cranes at Middlesbrough. The cost worked out at 2·522d. per ton, considerably more than the hydraulic, but Mr. Raven suggested to him in a letter that the extra cost was due to the fact that the electric cranes at Middlesbrough were lifting goods considerably higher than was the case at Swansea. He thought Mr. Hunter would find that as electric cranes got older they would be as costly as, if not more costly than, hydraulic cranes to maintain. There was no question as regarded flexibility that electricity had the advantage over hydraulic power. For cranes distributed over a large area there was no question that electricity was best. For coal hoists, however, hydraulic power was more economical, and the maintenance of hydraulic hoists was less than that of electric hoists.

Mr. C. A. BRERETON agreed with other speakers that hydraulic power was more suitable for heavy and electric power for lighter work, such as grain elevators, conveyors and cranes, and said this policy was being adopted at the new Avonmouth Dock.

Mr. S. HOMFRAY said when he visited the United States three years ago he was surprised that the ore-discharging appliances on the lakes were hydraulic, and was told nothing else would work them. By far the greater number of elevators were also hydraulic, and he was told "the electric ones cannot work to schedule time."

Mr. G. N. ABERNETHY agreed as to the suitability of hydraulic and electric power for heavy and light work respectively, and said that, as electricity for docks could be obtained from the town supply, the installation of electric generating plant as well as hydraulic plant was not necessary.

Mr. W. STOKES was doubtful whether the hydraulic accumulator would be so helpful as was supposed. A hydraulic accumulator which would store up to 500 H.P. for one minute was a big thing. A 10 per cent. overload on a 500 kw. electric generator would give for an appreciable time a power equal to that which a hydraulic accumulator would give for only 10 minutes.

Mr. C. E. VERNON said the hydraulic accumulator was necessary in the engine house, but ¼ mile or ½ mile away they were more or less of a snare and delusion. At the London Docks his company found it necessary to have both powers. The works costs for electric energy were something under 1d. per unit and for hydraulic power something under 6d. per 100 gallons.

Mr. J. J. ROBSON said he had ascertained by inquiries that hydraulic engineers would maintain hydraulic cranes at £5 each per annum, whereas electric cranes after three or four years would cost probably about £20. Handling heavy cargo, hydraulic power cost 1·5d. per ton, against 2·5d. per ton for electricity.

Mr. C. COLSON, C.B., brought forward the subject of the use of compressed air, and said that power was useful in cold countries where hydraulic power was impracticable.

Mr. H. C. M. AUSTEN suggested means of prevention of freezing of hydraulic mains.

The CHAIRMAN (Sir Wm. Matthews) agreed with the working of dock gates, sluices and capstans and other heavy work by hydraulic machinery, and that for cranes and the lighter descriptions of work electric appliances might be adopted with advantage in many cases.

In Section I. (Railways) three Papers were read of general interest to electrical engineers, the first of these being:—

THE ACTION BETWEEN WHEEL AND RAIL.

BY H. R. A. MALLOCK, F.R.S.

No one who has observed the rails of any of the tube railways at present working in London can have failed to notice how much the rails become worn, especially just after they are laid; and it seemed to me that it might be of some use to examine the mutual action between the rails and wheels from a theoretical point of view. In this Note I give a short account of the conclusions to which this examination has led me, and the general course of reasoning by which I have arrived at them. It is obviously impossible, in a short communication like this, to enter into the mathematical details.

It is clear that if a wheel is to roll on a rail without either causing permanent set or distortion in the other, the deformation, caused at the contact between the two, must be entirely within the elastic limits of the material. The first step in the investigation, therefore, was to determine what is the radius and effective width of tread of a wheel which will just carry a given load without any permanent alteration in shape.

I assume that the wheel and the rail are made of the same steel, and that such steel will bear a load of 20 tons per square inch on its surface before deforming. Hence, if we suppose that each wheel carries a load of 4 tons, there must, at any rate, be more than ⅕ sq. in. of contact between the rail and the wheel, for ⅕ sq. in. would be required if the pressure was uniformly distributed over the whole area; but in the actual case the pressure is greatest at the middle of the contact-area, and it can be shown that the maximum pressure is half as large again as the mean.

The next question is, if a steel cylinder of a certain radius and width rests on a flat steel rail of the same width, and carries a definite load, how much will the cylinder depress the rail and how much will the rail flatten the cylinder?

It appears that, over the area in which they come in contact, the profile of the rail and wheel are both arcs of the same circle, and that the radius of this circle is twice the radius of the wheel. It appears also that the depression produced at the mid point of contact is about $\frac{1}{240}$ of the square root of the area of contact per ton per square inch, it being assumed that the square root of the area of contact is small compared with the depth of the rail. If, therefore, the maximum permissible load is 20 tons per square inch, the greatest allowable indentation is $\frac{20}{240}$ × (square root of the area of contact).

Now the area of contact is the width of the effective tread multiplied by the length of the arc of contact, and this latter varies as the square root of the radius of the wheel for a constant depth of indentation.* If, therefore, the area in contact is to be constant, the width of the tread must vary inversely as the square root of the radius.

It can be shown that the total elastic reaction between a cylinder and a surface originally plane is two thirds of the maximum pressure between them multiplied by the area of contact. Hence if the total load on the rail is four tons, and the maximum pressure the steel will bear without permanent deformation is 20 tons per square inch, the area of contact must be not less than $\frac{4}{20} \times \frac{3}{2}$, or 0·3 sq. in.

The square root of 0·3 is 0·53, therefore the indentation at mid-contact must not exceed $0{\cdot}53 \times \frac{20}{240}$ in., or $\frac{1}{250}$ in; and I find that, in order to get the required area and not exceed this indentation, the diameter of the wheel must be not less than 5 ft. if the tread is 1 in. wide.

Any wheel of less diameter, unless the tread was wider than 1 in, would cause a permanent flattening of the rail. Most of the wheels now in use on railways are less than 5 ft. in diameter, and when both wheel and rail are new, they certainly do not have a bearing surface an inch wide. I conclude, therefore, that there is some permanent flattening down of the rail each time a wheel passes over it.

I can make some estimate of what the flattening is in the case of a wheel whose diameter is given, by finding in the first place what load that wheel would carry by purely elastic reaction, and then finding how much deeper the wheel would have to sink into the rail to carry the extra load, taking the reaction over that part of the depression which exceeds the elastic limit to be constant and equal to 20 tons per square inch. As an example, take a wheel of 40 in. diameter; such a wheel on the supposition above made, would carry elastically 3·2 tons. This leaves 0·8 ton to be made up by deformation, which is in part permanent, and I find that the permanent part of the deformation is about $\frac{3}{10000}$ in. On the supposition that the width of the tread was 1·38 in. instead of 1 in., the 40 in. wheel would carry the four-ton load by elastic deformation only.

Five millionths of an inch does not seem a very large quantity; but if we take the case of a railway on which there is a two-minute service of trains for 12 hours a day, and suppose each train made up of six eight-wheel carriages, it will be seen that this wear is $\frac{4 \times 5 \times 360 \times 365}{1000000} = 2{\cdot}60$ in. per year, for a 40 in. wheel with a 1 in. tread, whereas, with a tread of about 1·4 in., there would be no wear at all, the load in like cases being four tons.

Without attaching much importance to the actual figures, this example, and the formula in the footnote, show how much the width of the tread affects the flattening, and that it is to be expected that wear will be very rapid at first, and will almost cease when the wheels and rails have adapted themselves to one another. It seems possible, therefore, that if the rails were rolled with a slightly different cross section, a considerable part of the initial wear might be avoided.

In all these remarks I have considered only the wear which would occur on a straight railway, and where there is no slipping between

* The general formulæ connecting the radius of the wheel (r), the length of arc (a) in contact with the rail, the width of the tread (b), and the total elastic supporting force of the rail (F), are

$$a = c_1 r^{\frac{3}{4}} b^{\frac{1}{4}} \quad F = c_2 r^{\frac{1}{2}} b^{\frac{1}{2}}.$$

If the units are tons and inches, and assuming that 20 tons per square inch is the greatest load which can be laid on a plane of the material without causing permanent set, and that the compression produced by a pressure of 1 ton per square inch is $\frac{1}{240}$ of the square root of the area over which it is applied, $c_1 = 0{\cdot}0165$ and $c_2 = 0{\cdot}46$.

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the rail and wheel. On a curve there is necessarily slipping on one or both rails, and slipping must occur even on the straight, unless the diameter of the wheels on the same axis is identical.

The wear due to slipping is quite distinct from the flattening or crushing which I have considered hitherto; but it is to the slipping we must look, I think, for the origin of the ripple-like marks which are often to be noticed on rails over which small wheels are run. The length of each of these ripples is 2½ in. to 3 in., and they often extend over a considerable length of line. The question arises, what settles the wave length? Is it something which depends only on the distance the wheel travels and not on the velocity (as would be the case if it was the result of the toothed gear-wheels of the motors), or is it a real period, *e.g.*, something which recurs in a constant time? I think the latter is the true explanation, and the only period likely to give rise to these marks is the period of the torsional vibration of the wheels on their axles. Such torsional vibrations are sure to be set up at certain speeds if the wheels slip on the rails, and may be compared with the vibrations of a bowed string, or more closely with chattering a wheel or disc when mounted on a slender axis and turned in a lathe. The subject is rather complicated, and I can only mention this explanation here without giving any details.

DISCUSSION.

Mr. F. E. ROBERTSON said that it had been agreed during the past five or six years that the rails now made were not so good as they used to be. This was, however, not the case, as he had proved by a long series of experiments, which had shown that new and old rails were practically identical in character, there being as much difference between the rails in the same group as between new and old. He thought Mr. Mallock's theory of roaring rails was the truth of the matter.

Mr. A. W. SZLUMPER said he would like to point out that the wear on the rails was not phenomenal on the straight portions, but simply on the curves. He knew of rails that had been in use for nine years on straight sections with heavy traffic, but which were not appreciably worn—certainly not more than $\frac{1}{16}$ in. The wear of the wheels was really quite as great as that of the rails. The use of carefully adjusted check rails on curves reduced the wear considerably. As to the use of hardened rails, he pointed out that if rails with high percentages of silicon and manganese were to be introduced the trouble with the wear on the wheels would be magnified. The author had suggested that it would be desirable to alter the tread of the rail to fit the tread of the wheel, but their experience had been the reverse of this. They found that at first there was hardly any wear, but so soon as the rail and wheel became worn to fit more closely to each other the wear was sufficient to be noticeable.

Prof. CARUS WILSON said he had made a number of experiments with the view of ascertaining what was the actual stress on the surface of rails by a wheel of a given diameter, and the results were very similar to those which Mr. Mallock gave. The main stress was on the top of the rail, and not at the bottom, as would be ordinarily assumed, the tendency being to break the top fibres of the rail, the stress going, of course, right down through the rail, but getting less and less as it descended. In conjunction with corrugation a series of small cracks were found. These cracks were on the surface of the rail and extended downwards and corresponded to what one would expect to find in the case of heavy downwards stresses. It was not safe to invert a corrugated rail, as when inverted it broke.

Prof. B. HOPKINSON said that as to the downwards strain, the wheels on a train running at a moderate speed exercised a strain on any particular part of a rail only for only about one-thousandth part of a second, and when experimenting with rolling wheels on wire he found there was practically no injury to the wire from the downward strain. He would like to know if the wear on rails was greater or more marked on sections where the trains ran slowly than where a fast traffic was maintained.

Mr. R. M. BURNETT said he thought a reduction in the wear of the rail might be brought about by more attention being given to the rolling stock. An unusual amount of stress occurred on curves owing to the axles not taking the curves accurately.

Mr. V. H. SHORTT said the wear and damage on curves was most marked where the radius of curves was exceptionally short, which would appear to show that the axles did not take the curves at a correct angle. The wear was most marked on the outer rail of curves, this outer rail taking about three-quarters of the total load. Excessive elevation of the outer rail decreased the wear on the rail, and a lower elevation increased it, but had little effect on the wear of the wheel. He thought it a great advantage to have a long wheel base for the bogie. The check rail was of great service in reducing wear on the outer rail of curves. He thought the principal cause of excessive wear was a short wheel base.

Prof. W. E. DALBY said there was one point as regards the wear on rails, especially on tube railways where many stoppages were necessary and the braking therefore frequent. How long in such cases did the wheel keep really circular? His own experience with locomotives was that the wheels required periodical turning up on account of the braking effect. If all the wheels of a train were not actually round that would naturally increase the wear on the rail.

Mr. GEO. HARBUD said it was usually assumed that the rims of the wheels and the rails were the same kind of steel. This was not so, the wheels being much the harder metal. He could quite appreciate that engineers were chary of hardening their rails very much, owing to the danger of transferring the exceptional wear from the rails to the wheel tyre; but in America, where hardened rails were used, no difficulty was experienced with the wheels, and the wear on the tyres was not materially greater. For wheel tyres in most Continental countries they used a steel containing 0·35 per cent. silicon, and these tyres gave very excellent results.

Mr. D. D. COATH said he had thought the difficulty arose entirely through having the flanges on the inside instead of on the outside of the rails. He had experimented with the outside flanges extensively, and found that with that system curves of 8 ft. radius could be rounded easily. Those to whom he had shown his system agreed that it was the best, but was about 70 years too late.

Mr. WILLOX said that excessive wear of rails and corrugations were most erratic. Sometimes they occurred after a few months, sometimes not for a year or two and sometimes not at all. They occurred where the subsoil was clay and sometimes on sand and under all sorts of conditions. The trouble appeared about the same with all kinds of trucks. If the flanges of wheels could be done away with the difficulty would probably be solved.

Mr. E. BENEDICT said one peculiarity of corrugations was that the hollows were dark and the ridges bright. He thought rubbings of the rails to see if the ridges moved backwards or forwards would throw some light on the subject. He compared a steam railway to a rack railway, the driving wheels causing grinding and tearing. This was the cause of the trouble, the rest of the wheels of the train merely having a rolling motion.

Mr. T. D. TWINBARROW said the remarks of the last speaker would appear to be correct if corrugation were greater on steam railways than on electric, but as a matter of fact the reverse was the case, corrugation occurring more on electric than on steam railways.

Mr. R. J. HOWLEY said that his company (the South-Eastern Railway) had not been troubled very much with corrugation, but had experienced it in a small way. This corrugation had, however, occurred on straight lengths as well as on curves, on down grades as well as on up grades. The effect on the rail appeared to be similar to that which occurred to the sands on the seashore—rolled up in ripples. He had had many rails analysed, and in almost every case roaring rails were found to contain a low percentage of carbon and manganese.

The CHAIRMAN (Mr. W. R. Galbraith) said, with regard to the excessive rail wear on the City & South London Railway mentioned in the Paper, that the gauge on that railway was what was known as "tight," and it was found that a tight gauge led to heavy rail wear, which in the case of that railway was really serious.

The other Papers in this Section will be dealt with in our next issue.

PARLIAMENTARY INTELLIGENCE.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

(Continued from page 389 of the present issue.)

Mr. Rider pointed out on a map the different areas which had been omitted or extended since last year, and at this stage a set of 40 tables dealing with capital expenditure, working expenses, maximum and average charges, statutory powers, revenues of existing undertakers, analyses of capital and particulars of the existing bulk supplies within the area were put in, together with a table of power requirements in the City of London, and with a general outline description of the Council's scheme. In this outline it was set out that the capacity of the proposed generating station at Barking (to be built in sections as demand arises) is to be 120,000 kw., the overload capacity 150,000 kw., supply to be transmitted to 21 control stations, and thence to be distributed to 160 points of supply, the systems of supply being (*a*) 15,000 volts, three-phase, 50 cycles; (*b*) low-pressure, three-phase, 50 cycles; (*c*) low-pressure, direct-current. The area of supply comprises, besides the county of London, portions of Essex, Kent, Surrey and Middlesex, as under:—

Essex.—County borough of West Ham; borough of East Ham; urban districts of Barking Town, Chingford, Grays Thurrock, Ilford, Leyton, Romford, Waltham Holy Cross, Walthamstow, Wanstead and Woodford; the parishes of Dagenham, Havering-atte-Bower, Hornchurch, Noak Hill, Rainham and Wennington, in the rural district of Romford; and the parishes of Aveley, Chadwell St. Mary, Little Thurrock, Stifford, West Thurrock and West Tilbury, in the rural district of Orsett.

Kent.—Boroughs of Bromley and Gravesend; urban districts of Beckenham, Bexley, Chislehurst, Dartford, Erith, Foots Cray, Northfleet and Penge; the parish of Mottingham, in the rural district of Bromley; the parishes of Crayford, Darenth, Southfleet, Stone, Swanscombe and Wilmington, in the rural district of Dartford.

Surrey.—County borough of Croydon; boroughs of Kingston-upon-Thames, Richmond and Wimbledon; the urban districts of Barnes, Ham and the Maldens and Coombe; and the parishes of Merton and Mitcham, in the rural district of Croydon.

Middlesex.—Boroughs of Ealing and Hornsey; and urban districts of Acton, Brentford, Chiswick, Edmonton, Enfield, Finchley, Friern Barnet, Hendon, Southgate, Tottenham, Willesden and Wood Green.

Mr. CLODE (to witness): Your estimates have been prepared on the basis of a capital expenditure of £4,500,000? Yes. And the tables show in what manner it is proposed to incur this expenditure. The Barking generating station is the one we propose to put up first, and the estimated costs are set out fully in the tables. The site is a good one, as it fulfils the two principal conditions previously mentioned by me. In addition to these advantages there is plenty of spare land available for extensions if required, and the situation is such that no possible nuisance can arise from the working of the station. The plan which is before the Committee shows the general scheme of the

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power station. Each of the five boiler houses will be about 145 ft. long by 82 ft. wide, and at right angles to the boiler house is an engine room 420 ft. long by 80 ft. wide. Coal bunkers with an accommodation for 5,000 tons of coal are placed over each boiler house, making 25,000 tons in all. The chimneys will be about 200 ft. high and 15 ft. diameter inside. The framework of the buildings will be of steel, to be filled in with brick work. The engine room will consist of 10 steam turbo generators, each for a rated capacity of 12,000 kw., but capable of working up to 15,000 kw. on overload. Each of the five boiler houses will contain two lines of boilers, each boiler being capable of evaporating 215,000 lb. of water per hour under normal conditions. Economisers, superheaters, feed pumps and all other necessary apparatus will be supplied to make the generating plant complete. In addition to the coal accommodation over the boilers (equal to about 3¾ weeks' supply) there will be about three weeks' supply available outside. This coal will be brought by steamers, for which there is excellent accommodation, and two steamers can lie alongside a pier (which it is proposed to build) at the same time. In this way we get the cheapest possible freight and handle our coal in the best possible way.

What is the cost per kilowatt of plant?—The estimated cost is £12·26 per kilowatt, which includes engineering expenses and contingencies. On the overload rating the cost per kilowatt is estimated at £9·81. These figures have been carefully calculated by my colleagues and myself, and have in many cases been taken from actual figures obtained from responsible firms.

With regard to the Erith site?—This is the second station scheduled in the bill, but there is no provision in the present estimates for this station. The Erith site may not be required for a very long time, because the Barking site is large enough to double the proposed Barking station.

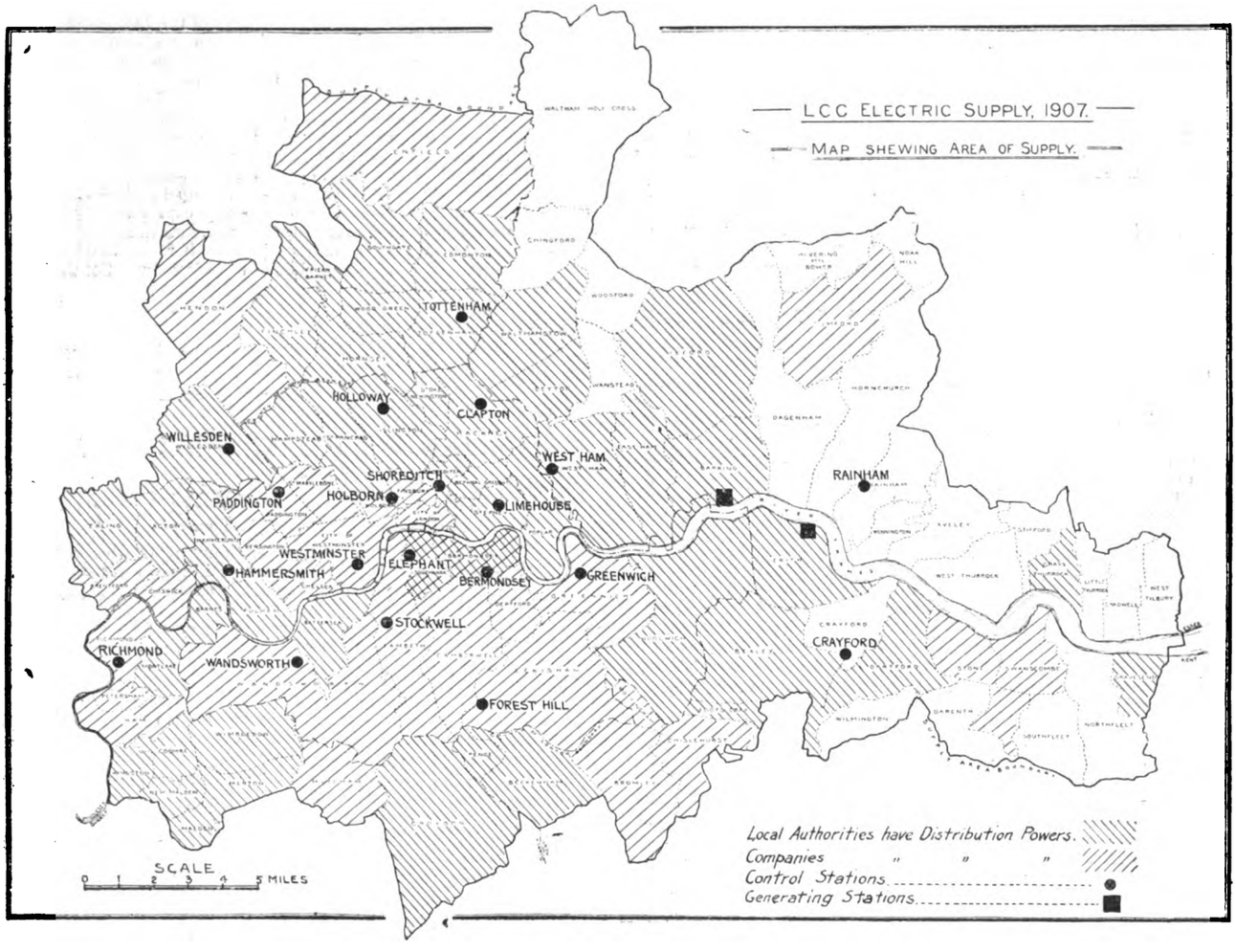
As to the transmission and distribution system from Barking?—From Barking trunk cables would go to 13 control stations within the County of London and to eight control stations outside. Control stations would be fed by the high-pressure trunk cables, and supply given by three-phase alternating current at 15,000 volts pressure and 50 cycles per second. There are two independent trunk mains to each control station from Barking and spare ducts for future cables. The arrangement of the cables and their size are such that, not only can a supply be maintained to each station if one cable were to break down, but even if a whole route of cables were put out of action, as the control stations are connected together by inter-connecting cables between the stations. In addition to the trunk and inter-connecting cables there are branch cables going from the control stations to a number of points, which represent authorised distributors' existing generating or sub-stations, or proposed sites for local power sub-stations.

Last year some criticism was made upon your proposed system?—Yes. But these criticisms have been entirely met by the scheme now proposed. With regard to our facilities for crossing the river, we have the Blackwall Tunnel, the Rotherhithe Tunnel, and London, Westminster, Battersea and Hammersmith Bridges. The Council is the owner of all these except London Bridge, and the fact that the Council owns these means of crossing the river is, I consider, of great importance.

You have made for 160 transforming sub-stations on the premises of the authorised distributors?—Yes. I consider the transmission system as proposed adequate and fully capable of dealing with the whole output from Barking with facilities for a great many more cables if necessary. We have provided in our estimate £330,000 for these works: £190,000 of this is for control and sub-station buildings, or about £3,000 each.

Mr. HOWELL DAVIES (a member of the Committee): And those buildings, including land, are only to cost £3,000 each?—Yes.

Mr. CLODE: Now, as to the rates and method of charging?—It is proposed to give three kinds of supply: (1) At the same pressure as it would be generated at Barking at the rate of £3. 15s. per annum per kilowatt, plus 0·22d. per unit; (2) transformer supply of alternating current at a little higher rate than the above to cover expense of transformation; (3) a low-pressure direct-current supply at a still higher charge because the cost of transformation would be greater. A higher price is also provided for to be charged to power users other than authorised distributors, because where we have to deal with the individual power user the distribution costs mount up.



Mr. Rider then explained to the Committee the system of charging so much per annum per kilowatt plus so much per unit, and said that this method of charging does not depend at all upon whether a man is a large or small consumer, as the small user is treated just as fairly as the large, the system taking only into account the use which the user makes of the supply in proportion to his maximum demand upon it. That is to say, the greater the load factor or the greater the use the consumer makes of the supply, once he has taken it the cheaper is the price per unit. I consider this the only fair way of charging, as any other method, not taking into account the standing charges on the one hand and the running costs on the other, gives an unfair benefit either to one class of consumer or the other. The charges I have set out are the maximum charges, but there are reductions upon these amounting to some 25 per cent. As to the estimates generally, I consider they are all on the safe side. We have been generous in our allocations and the gross surplus is, I consider, sufficient to cover those charges which would occur after the station has been erected and before the actual load has been obtained for it. I have taken coal at 12s. per

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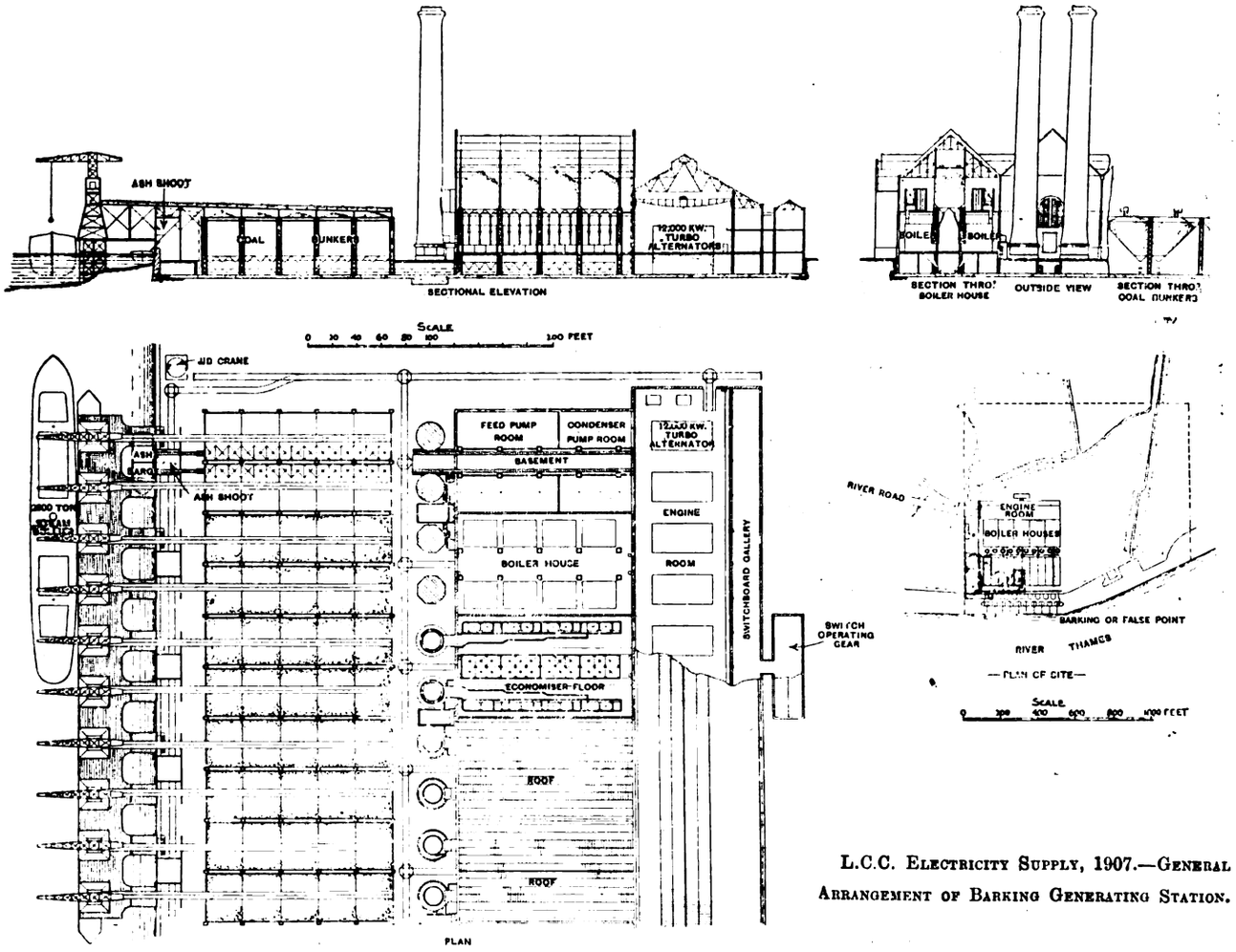
ton to be on the safe side. Our Greenwich experience assisted me in arriving at these conclusions.

Now as to the hire system?—There is provision for £150,000 made in the estimates for a hire system for electric motors. This will be spent in making and furnishing the office and showrooms, and in obtaining a supply of motors for power. We consider this should be a self-supporting department, organised with a view to assisting consumers who are desirous of using electric power, but who are unable at the moment to pay out the capital for the motors.

Mr. Rider then went through a number of the tables and explained the diversity of charges for current, and the kinds of supply given, the witness pointing out that the object of the comparisons which he had made in the tables was not to draw any improper comparisons, as in many cases the scattered area accounted for the differences. The tables were simply submitted to show what is being done at the present moment in the different areas of supply. Turning to the table dealing with capital costs per kilowatt at the generating station Mr. Rider said that for the local authorities the average was £37·88, as against the estimated cost at Barking of £12·26. For the companies the cost was about £49·51, or, taking companies and local authorities together, the average was £45·12. Taking both generating plant and the distribution systems, the combined average is £99·05 per kilowatt, as compared with the Council's estimate under this scheme of £36·25, which includes the power station at Barking and the transmission scheme up to the existing authorised distributors' stations. Witness explained further that, not only would the concentration of the generation of electrical energy at a centre like Barking effect a great saving in the capital expenditure, but it would also result in a great saving in cost of working, besides gradually removing from the London area a great source of smoke nuisance, and by the tables it is shown that the total amount expended throughout the year on buildings has been over £3,800,000, and this expenditure has only provided for about 201,000 kw. of plant. This emphasises the comparative inefficiency of small local generating stations, and we can get a plant capacity at Barking of 120,000 kw. at an estimated cost of only £394,000 for buildings and land. These are figures for 1905 for the companies and 1906 for the local authorities. With regard to the cost of generation, in the case of local authorities depreciation or sinking fund at the rate of 2¾ per cent. and interest at 3½ per cent. has been allowed. In the case of the companies depreciation at 2¾ per cent. and interest at 4½ per cent. has been allowed. Taking Islington as an example, the working costs for the year to March 31, 1906, was 1·06d. per unit, and adding the capital charges 0·75d., makes 1·81d. per unit. I therefore estimate that if the Islington station had been shut down and the existing capital charge of 0·75d. had been added to the Council's proposed charge of 0·75d. the resultant cost would have been ·31d. per unit sold less than the actual cost to Islington. This would have meant a saving on the 4,000,000 units sold by shutting up the station of over £4,000 for the year. I mention this as an example only, as in some other cases it would not have paid to shut up the existing stations.

Then as to the concluding table dealing with the powers of bulk supply that certain companies possess. This table sets out a list of existing bulk supply undertakings, and shows that in many cases there is already competition existing for bulk supply in certain districts, and, in my own opinion, such competition as would result from the introduction of the Council's scheme would be fully justified, not only from the point of view that in many cases supply is not given at this moment, but because many of the bulk supply powers are really held by authorised distributors as an addition to their distribution powers, and the adoption or the establishment of a large bulk supply scheme should only be allowed when the power stations are on proper sites, such as those indicated in the Council's present scheme.



L.C.C. Electricity Supply, 1907.—General Arrangement of Barking Generating Station.

As to the prospective demand for power within the area?—The increase in the demand has been from 57,000 kw. in 1901 to 130,000 k.w. in 1906, or 129 per cent., and the growth of the demand has been steady the whole time. The number of units actually sent out by the various undertakers has increased from 69,000,000 in 1901 to over 192,000,000 in 1906, an increase of 167 per cent. in the six years. This indicates an increase in the load factor, which has been from 13·8 per cent. in 1901 to 16·6 per cent. in 1906.

The CHAIRMAN: Can you suggest why the increase has been so much greater in the case of local authorities than in the case of the companies?—I think the local authorities are charging less all round for current than the companies.

Mr. CLODE: In making an estimate of the possible demand for power in various districts in this area what did you do?—We obtained statistics from the Home Office of the number of factories in the various districts, their character, the number of employés, and from these data prepared an estimate of the total horse-power at present existing within the area. In two districts the data were checked by a close personal canvass, and we were able to agree, or slightly modified our previous estimate. We found that there is at present something like 370,000 H.P. actually in use of steam, gas, hydraulic, &c., power. This we estimate would be sufficient to require, after allowing for the usual variation in load in each individual

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factory and the diversity which exists between the different classes of factories, sufficient demand to utilise about 180,000 kw. of plant at the generating station. This is in addition to the existing lighting loads in the area.

As to the probable requirements of railways and tramways?—There is a continual increase in the demand for electric power outside London for tramway purposes, and, in my opinion, there is a great prospective demand for power for railways.

How do you consider London compares with other interests in the use of electricity?—Unfavourably. I estimate that the units used per head per annum in London, including tramways and lighting, about 50, compared with Boston 343, New York 282, Chicago 198. I have not been able to personally verify these figures, but I have no reason to doubt their accuracy.

This concluded Mr. Rider's examination in chief

At the conclusion of his examination in chief, Mr. Rider was cross-examined by Mr. Wedderburn (for Shoreditch and Woolwich); by Sir Ralph Littler (for the City of London); by Mr. Reader Harris (for Ealing); by Mr. Balfour Browne and Mr. Moon (for the London Companies); by Mr. Balfour Browne (for Middlesex County Council and Croydon County Borough); by Mr. Vesey Knox (for Hornsey and other local authorities); by Mr. H. Lloyd (for Messrs. Curtis's & Harvey); by Mr. C. Munroe (for Wimbledon and St. Pancras); and by Mr. J. Shaw (for Coombe and the Maldens).

This evidence will be reported in our next issue.

During the cross-examination by Mr. Moon,

Mr. FREEMAN (appearing for London County Council) submitted the new clause 66A which the Chairman had intimated the Committee would require to meet the terms of the mandatory instruction of the House of Commons in appointing the Committee. The new clause is as under:—

New Clause 66a.

1. If, within one year from the passing of this Act, no transfer or assignment has been made by the Council of the powers of this Act with regard to the execution of works and the supply of electrical energy, or such transfer or assignment has been made in respect only of a part or parts of the area of supply, then at the expiration of that period if no such transfer or assignment has been made the power of this Act shall cease, or if a transfer or assignment has been made in respect of a part or parts only of the area of supply the portions of that area not comprised in such transfer or assignment shall cease to form part of the area of supply.

2. Every such transfer or assignment shall be by deed to be approved by the Board of Trade which shall set forth the consideration (if any) for the transfer or assignment and shall contain (inter alia) conditions to the effect stated in the fourth schedule to this Act and such other provisions as may be deemed necessary for securing control by the Council with regard to the powers transferred or assigned.

3. During the period prescribed by such transfer or assignment all the rights and authorities thereby purporting to be transferred or assigned shall by virtue of this Act and of the deed of transfer or assignment be vested in and be exerciseable by the transferees in lieu of the Council, and the transferees shall during the same period be subject in lieu of the Council to all the obligations by this Act imposed upon the Councilin respect of the powers transferred or assigned, but nothing herein or in any such deed shall make any of the provisions of Part V. (Finance) of this Act applicable to the transferees.

At the same time Mr. Freeman submitted the following as a Fourth Schedule to the Council's bill, dealing with the question of the proposed heads of agreement or lease between the London County Council and the lessee or transferee of the Council's powers under the bill:—

CONDITIONS TO BE EMBODIED IN DEED OF TRANSFER OR ASSIGNMENT.

1. The transfer or assignment to comprise all power under Part II., Part III. (so far as relates to the execution of works) and Part IV. of the Act and under the section of the Act of which the marginal note is "Power to supply electrical fittings, &c."

2. The generating station or stations to be constructed on the site or sites described in the first schedule to the Act or on such other site or sites as shall be approved by the Council.

3. If the site or sites described in the first schedule to the Act be acquired by the Council the transferees to accept a lease thereof terminable concurrently with the period of the transfer or assignment at a rent at least sufficient to provide for the payment of the interest and sinking fund in respect of the moneys borrowed by the Council for the purchase of such site or sites.

4. Every such generating station to be constructed and equipped in accordance with designs and specifications to be specified in the deed.

5. The system adopted for generating, transforming and distributing electrical energy to be subject to the approval of the Board of Trade.

6. The works to be constructed and carried out with all reasonable dispatch, so as to secure that a supply of electrical energy shall be afforded within the time prescribed by and in accordance with the provisions of the Act.

7. The transferees from time to time to make all necessary and proper extensions of the generating and distributing works machinery and plant to meet the demand for a supply of electrical energy.

8. The whole of the works to be kept and maintained in good order and repair.

9. The transferees in the exercise of the powers transferred to be subject to the obligations of the Act with respect to the supply to authorised distributors and others.

10. Subject to the provisions of the Act the maximum prices to be charged for electrical energy not to exceed those specified in the second schedule to the Act or for the time being in force under any revision thereof.

11. The amount of the dividend to be divided by the transferees to be regulated by the prices charged by them for electrical energy on a basis to be approved by the Board of Trade.

12. The maximum prices to be charged by the transferees and the basis of the relation between price and dividend to be subject to revision at the end of ten years and at the end of every subsequent period of seven years.

13. Except with the consent of the Board of Trade the transferees not to enter into agreements to supply electrical energy to authorised distributors except on such terms and conditions as to secure the supply by such distributors of electrical energy for power at prices not exceeding the maximum price for the time being authorised to be charged under the Act.

14. Provision to be made for the examination by the Council at any time of the books and accounts and works of the transferees and for the audit of accounts by an auditor appointed by the Board of Trade.

15. A proportion of the surplus profits beyond a fixed dividend to be specified in the deed to be paid to Council and be applied in manner to be prescribed by the deed for the benefit of the ratepayers in the area of supply.

16. Provision to be made for securing performance of obligations by transferees.

17. Matters in dispute between the Council and the transferees to be referred to the Board of Trade.

18. The undertaking established under or in pursuance of the transfer or assignment to be subject to a right of purchase by the Council within six months after the expiration of a period (not exceeding fifty years) to be fixed by the deed or after the expiration of any subsequent period of 10 years on the terms of the Council paying to the transferees the then value of the undertaking (such value to be ascertained in the manner provided by sec. 2 of the Electric Lighting Act, 1888) or within six months after Aug. 26, 1931, or within six months after the expiration of each period of 10 years from that date which shall expire before the expiration of the period to be fixed by the deed as aforesaid on such terms as may be provided for by the deed.

Yesterday (Thursday) Mr. Rider occupied the witness chair for the third successive day, and was cross-examined by Mr. Jeeves (for Kingston), Mr. E. Morton (for West Ham Corporation), Mr. Hutchinson (for Barnes District Council), and Mr. Williams (for Stepney). A full report will appear in *The Electrician* next week.

RADIO-TELEGRAPHIC CONVENTION.

The Select Committee of the House of Commons appointed to consider the question of the ratification of the Convention agreed to at the Berlin Conference of 1906 met again in private on Tuesday to further consider their report.

MISCELLANEOUS BILLS.

Brighouse Corporation Bill, which confers additional powers on the Corporation in regard to their electricity supply undertaking, has been passed by a Committee of the House of Lords. The bill had already been through the Lower House.

Huddersfield and Leeds Tramways.—A bill to confirm the Huddersfield and Leeds Tramways Provisional Orders has been passed by the Unopposed Committee of the House of Lords.

Arbroath Electric Lighting Order.—Last week a question arose before the Unopposed Committee of the House of Lords on the bill to confirm this electric lighting order. It was claimed that a clause should be inserted which had been agreed between the undertakers (the Burgh of Arbroath) and Messrs. Douglas Fraser & Sons (a local manufacturing firm) for securing to the firm the continuance of their present method of the supply of electricity generated by themselves to their own works situated in different parts of the town. The Board of Trade objected to the insertion of any such clause in the Confirmation Bill.

After hearing arguments, Lord Onslow refused to insert the clause.

MESSRS. CROMPTON & CO.'S WORKS AT CHELMSFORD.

At the invitation of Messrs. Crompton & Co. we paid a visit last Saturday to their works at Chelmsford on the occasion of the annual athletic and bicycle race meeting, which was held on the club grounds in the afternoon. In company with a large party of visitors we travelled down to Chelmsford, and on arrival at the works were conducted round by members of the staff.

It will be remembered that the present works have been in use since about 1898, the previous ones having been burnt down in November, 1895. They adjoin the main line of the Great Eastern Railway Co., a siding from which serves for bringing in the supply of raw material and the removal of finished machines.

The buildings now cover an area of about three acres and may be considered in two parts: 1. The main shops (Fig. 1), in which the heavier class of machinery is built and the power plant is situated. 2. The lamp shop, which is devoted to the manufacture of small motors, fans, projectors, arc lamps, switchboards, and instruments.

There are also a foundry, a casting store, and a pattern store, and, of course, a complete set of offices. An interesting addition to the usual buildings at similar works consists of a handsome

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club-house situated near to the works, and which is arranged for the use of the workmen and staff and for the entertainment of visitors.

The whole of the running machinery in the main shop, as well as in other parts of the works, is driven by electrical motors, the machines being in most cases grouped and driven from lines of shafting and in some instances fitted each with its own motor.

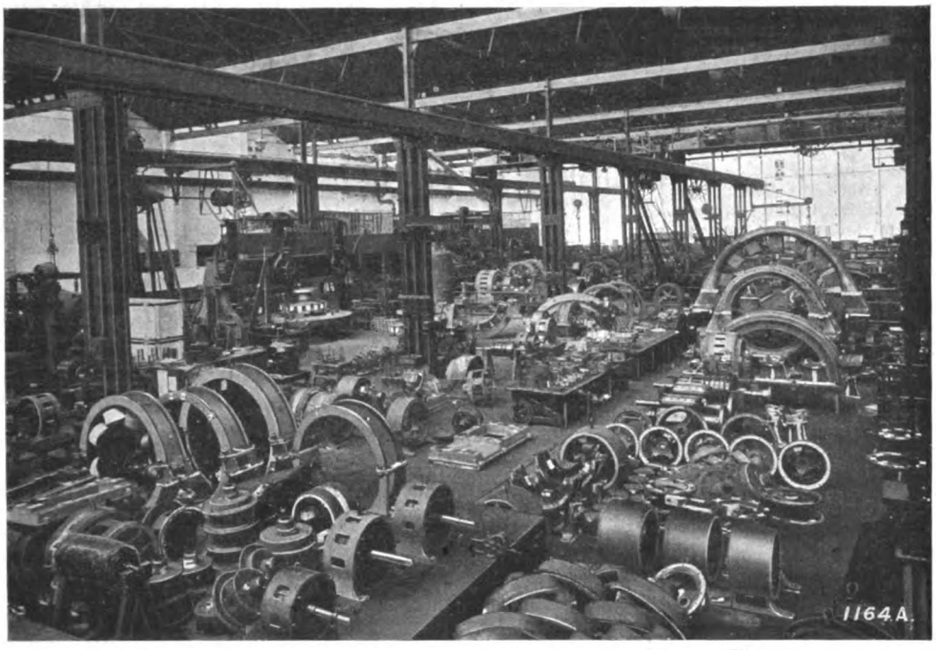

FIG. 1.—VIEW OF MAIN MACHINERY SHOPS.

These are usually placed out of sight in metal cases on top of the machines being driven, thus economising space and at the same time being guarded from the liability of damage. The power for these motors, as well as for the testing beds, is derived from two multipolar open-type direct-current dynamos, each having an output of 200 kw. direct coupled to slow-speed horizontal engines of the cross-compound Marshall type. There is also a dynamo coupled to a high-speed Willans engine, which is used when an additional supply of power is required for testing very large machines. The power is taken from these dynamos to a main switchboard on a gallery above the power plant. Distributors are taken from this board to the various motors, bare copper conductors being largely used in the distribution system.

The lighting of the shop is also supplied from this generating plant. Arc lamps with fluted glass lanterns are used throughout, the general lighting being so good that there is no need to use incandescent lamps for any of the machine tools or erecting work.

Steam is obtained from three Babcock boilers, and the exhaust is dealt with by an evaporative condenser placed on the roof. The auxiliary pumps, economiser scrapers, and chain-grate stokers are electrically driven.

The testing beds adjoin the power plant, and are fully equipped with dynamos and motors for obtaining the correct voltage and circuit conditions for testing the various machines made in this shop, and with instruments for recording the results of the tests. Every machine that is made is thoroughly tested before being despatched, and a certificate of test sent out with it. A complete set of records is kept of all details affecting the running of the machines.

The Hopkinson system, with modifications introduced to meet certain cases, is largely used in testing dynamos and motors, special beds and pits being provided to enable them to be conveniently and rapidly coupled together and connected to the power plant.

The instruments used in these tests are regularly checked against standards by means of a potentiometer fixed in the instrument room on the gallery over the test beds.

We noticed dynamos and motors of all sizes in course of construction, and understand that, amongst numerous others, some are in course of construction for the Madras Electric Supply Corpn., the Calcutta Electric Supply Corpn., the Norwich Corporation and Woolwich Arsenal. A large amount of alternating-current machinery is made for use in mining installations, and special attention has been given to single-phase motors.

The erection of the lamp shop was not commenced until 1901, and, as mentioned above, parts of this shop are also used for the manufacture of fans, small motors, switches, switchboards, projectors and instruments. A view of the erecting bay in the switch department is given in Fig. 2. A large number of projectors are being supplied to the British and foreign Governments. They are in use on the Ganges and other rivers for navigation purposes, in addition to their general use on vessels of the Navy.

After the luncheon, which was served in the club-house, Mr. John Trotter, chairman of the company, called attention to the fact that efforts were being made by the Chelmsford Corporation to include Messrs. Crompton's works within the borough boundary. He emphasised the importance of keeping the rates down to a low figure owing to the small margin of profit on which manufacturers were now obliged to work. He also wished that people would realise that capital and labour were one and the same thing. If capital could only be left alone confidence would be restored in the industries of the country, and the Company would be able to employ many more men.

The Mayor of Chelmsford, in replying to the toast of "The Visitors," congratulated the chairman on the probability of Messrs. Crompton & Co. being included within the borough. He did this because the rates in Chelmsford were only 7s. 6d., whereas in Writtle they amounted to 9s.

Col. Crompton mentioned that it was just 30 years since he had come to Chelmsford, where two years later he started in electrical work. The present situation of the works was the happy medium between a village, where it was impossible for a manufacturing works to be carried on, and a large town with all its evils of overcrowding. Their works were growing slowly, as they depended mainly on the families of the workpeople to keep up the supply of labour, and very few outsiders were being taken on. This was a great advantage as it led to the officials taking an interest in the employés.

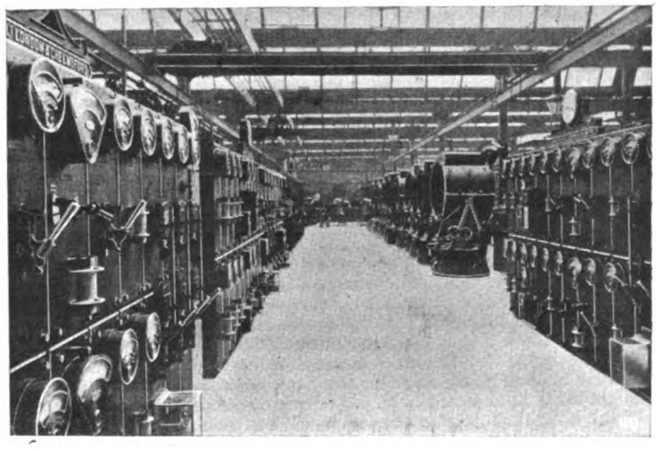

FIG. 2.—VIEW OF ERECTING BAY.

Electricity in Russia.—According to the *Elektrotechnische Zeitschrift*, the number of generating stations at work in Russia, excluding Finland, at the end of 1905 was 5,438. Their total capacity was 301,902 kw., and they generated 481,595,100 units during the year. The consumption of energy per head per annum was 3·44 units for the whole of Russia, while in St. Petersburg it was 54 units. These amounts are compared with those in other places, and it is shown that the consumption per head per annum is in Berlin 40 units, in Hamburg 26 units, in Moscow 34 units, in Stockholm 7·1 units and in Copenhagen 8·2 units.

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LEGAL INTELLIGENCE.

Rimmer v. Premier Gas Engine Co.

The Court of Appeal (the Master of the Rolls, the President of the Probate, Divorce and Admiralty Division, and Lord Justice Kennedy) on Thursday last heard an appeal of defendant company against an award of the County Court Judge at Birkenhead, as an arbitrator under the Workmen's Compensation Act, 1897. It appeared that a shipbuilding yard was being constructed, the owners deciding to use electrical energy both for light and power. In the generating station 10 gas engines had to be erected on land which was part of the shipbuilding yard. The Transmire Bay Development Co. were contractors for the whole of the works, and appellants were sub-contractors for the gas engines. Applicant, who was in the employment of appellants, in the course of his employment got his hand crushed by the machinery. The County Court Judge found that applicant at the time of the accident was employed on, in or about an engineering work, viz., a dock within the meaning of sec. 7 (1) of the act, and that appellants were undertakers of an engineering work within the terms of the act. He also found applicant was employed in or about a shipbuilding yard, and, therefore, a factory within the meaning of the Factory Act; and that appellants were undertakers of a factory within the meaning of the Workmen's Compensation Act, 1897. Further, that at the time of the accident the applicant was employed on, in or about an electrical station and, therefore, a factory within the meaning of the Factory Act, 1901, and that appellants were undertakers of a factory within the meaning of the Workmen's Compensation Act, 1897. He accordingly made his award in favour of applicant. Hence the present appeal of the employers.

After legal arguments, the MASTER OF THE ROLLS and the PRESIDENT held that there was no evidence on which the County Court Judge could find that the applicant was engaged "on, in or about the construction of a dock" and that the appeal should be allowed.

Lord Justice KENNEDY differed, and thought it was straining the language of the Act against the workman to hold that because the place where the accident happened was not within the wall of the dock, though it was within the same area as the dock, it could not be treated as a part of the construction of that which was intended to be an essential part of the dock. He could not see that the County County Judge had misdirected himself on the law.

By a majority of the Court the appeal was allowed.

Molesworth v. Horvath.

At Edmonton County Court on Wednesday this remitted action was heard. Plaintiff (Mr. R. H. Molesworth) sued defendant for £89 money lent. Plaintiff and defendant were formerly associated as directors of a company for the manufacture of incandescent electric lamps, which has been re-constituted under the style of the Britannia Electric Lamp Works (Ltd). Plaintiff says he advanced the £80 in September, 1905, at a time when defendant was being pressed under a bill of sale. Defendant admitted that he had the money, but he contended that plaintiff released him from the debt in connection with a share transaction, when additional money was brought into the company. Plaintiff, who said that he put £500 into the company when he joined it, and who has now left it, denied this.

Judgment was given for plaintiff for the amount claimed.

Curd v. Ferranti Limited

On Monday, in the Shoreditch (London) County Court, before Judge Smyly, K.C., and a jury, a jointer's mate named Curd, (through his father) sued Ferranti Limited under the Employers' Liability Act, to recover £337. 7s. damages for personal injuries.

Mr. MOYSES (for plaintiff) said that the accident occurred during the erection of the fittings in the high-tension chamber in the electricity substation of the L.C.C. in Rivington-street, Shoreditch. Plaintiff, aged 20, was earning at the time an average of a little over £2 a week, and was entitled to three years' wages at this rate (or such other sum as the jury might think fit to award). In one corner of the chamber (about 90 ft. by 60 ft.) a fire had been made, at which was boiling a quantity of composition for jointing purposes. Plaintiff's duty was to fill a can with this composition and pick his way across the chamber over an accumulation of material and waste. The place was badly lighted. Plaintiff stumbled and fell, upsetting the contents of the can over his hand.

For the defence it was submitted that there was no negligence on the part of defendants in the way, works, machinery or plant. Plaintiff knew material was lying about the floor, and should have used care to avoid it. Also there were four other firms, in different trades, who had contracted for various portions of the work, carrying out operations at the same time. If plaintiff had asked for more light he could have had it, as also gloves for his hands, or another utensil.

The jury, however, found for plaintiff for £125 and costs.

Norwich Tramway Arbitration.—The arbitrator in the dispute between Norwich Corporation and the Norwich Tramways Co. as to the liability for making up the junction or margin between the portion of the roadway laid and maintained by the Council and that maintained by the company (the Hon. Alfred Lyttelton, K.C.) finds that in certain roads laid and maintained by the Corporation the traffic, by reason of the tramways, had caused the surface adjacent to the paving of the company to become worn down below the level of the paving, so as to form a ridge inconvenient for the use of the road by the public. That wearing down arose at distances varying from 2 in. to 6 in. from the paving, and the repair of the roadway so worn down had involved the taking up of the roadway in certain cases to a distance of 18 in. from the paving. He finds as a fact that, by reason of the company failing to do the repairs (after due notice), the Corporation carried out the work at an expense amounting to £320. He holds, as a matter of law, that these expenses have been incurred in maintaining and keeping in good condition the junction of the paving laid and maintained by the company with the surface laid and maintained by the Corporation, and, if the inferences of law be correct, he awards the Corporation £320, the expenses reasonably incurred by them, and interest thereon at 5 per cent., and the costs of the arbitration and the award. If incorrect, he awards and declares that the Corporation do recover nothing from the company, and that the Corporation do pay to the company the costs of the arbitration and award. The total claim of the Corporation was £530. 5s. 6d.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Bristol Electrical committee have two vacancies for charge engineers at their Temple Back electricity works. Commencing salary 35s. a week, rising to £2. 10s. Applicants must have had good mechanical training, and experience of three-phase, single phase and d.c. working. Applications to the city electrical engineer (Mr. H. Faraday Proctor), Corporation Electricity Works, Temple Back, Bristol. See also an advertisement.

Oldham Corporation Electricity Committee invite applications for the position of junior assistant electrical engineer. Salary £80, advancing to £100 by annual increments of £10. Applications to the borough electrical engineer (Mr. S. Wilmott Newington) by July 1. See an advertisement.

The Council of University College, Bristol, invite applications for the position of lecturer in electrical technology. Particulars from the registrar, Mr. James Rafter. See an advertisement.

The governing body of the Northampton Polytechnic Institute (Clerkenwell, London, E.C.) invite applications for the appointment of junior lecture assistant in the electrical engineering department, full time. Particulars and forms of applications (to be returned by 26th inst.) from the principal, Dr. R. W. Mullineux Walmsley. See an advertisement.

Whitby Borough Electrical Engineer (Mr. L. H. King), has a vacancy for a pupil. See an advertisement.

A designer, used to high-tension switchgear is advertised for in another column.

An estimating engineer, with experience in the design of high-tension and extra high-tension switchboards, is required. See advertisement.

A transformer draughtsman is required for single and three-phase power transformers by Ferranti Limited. See advertisement.

Barrow-in-Furness Education Authority require a principal for their technical school. Salary £350 per annum. Application to Town Clerk by July 1.

An assistant lecturer and demonstrator in physics is required at Sheffield University. Salary £150 per annum. Particulars from the Registrar.

An assistant lecturer and demonstrator in physics is required at the University College of S. Wales and Monmouthshire (Cardiff). Particulars from the Registrar, to whom applications by June 22.

The Colchester Borough electrical engineer (Mr. A. R Sillar, M.I.E.E.), received 229 applications for the post of assistant engineer. Out of this number five gentlemen were invited to meet the committee, and ultimately Mr. P. H. Buzza, on the staff of the Leeds electricity supply department, was appointed. *Will the other applicants please accept this as an official notification*

Mr. T. W. Sampson has been appointed instructor in electric lighting and power distribution, &c., at Barnsley Technical and Evening Continuation Schools.

Asylum Lighting.—At the next meeting of the Joint Committee of Management of the Tyrone and Fermanagh Asylum, a report by Mr. R. V. Macrory (of Londonderry) on the proposal to provide an electric lighting installation at a cost of £3,370 will be considered.

Audenshaw (Lancs.)—The Council are negotiating with Ashton-under-Lyne Council for a transfer of the Audenshaw Electric Lighting Order, 1899.

Baker-street & Waterloo Railway.—The Edgware-road station of this railway was opened on Saturday.

Bermondsey (London).—In future consumers who use electric current for lighting in the day time are to be supplied at power rate, namely 1½d. per unit between midnight and sunset, and at lighting rate, viz, 3½d., from sunset to midnight.

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Bexhill.—An unopposed inquiry was held last week into the Council's application for sanction to borrow £5,700 for extensions of the electricity undertaking.

The cables are to be extended to Sidley.

Devonport.—The salary of the borough electrical engineer (Mr. J. W. Spark) has been increased from £450 to £500 per annum, by annual increments of £25.

The price of electric current for lighting has been reduced from 4½d. to 4d. per unit. The charge for power and heating has also been reduced.

The Electric Power committee have decided to adopt a "free" wiring scheme.

Dundee.—The Tramway committee have adopted a report of a sub-committee recommending the provision of a special telescope lifting jack (made by Geo. Stephen & Son) on 40 single truck cars, and that the offers of P. & W. M'Lellan and Robert Stiven & Co. for other types be also accepted. Some slight alterations of the jacks suggested by the manager (Mr. P. Fisher) are to be carried out. Six new cars are to be obtained.

The Council in committee recommend the increase of the salary of the city electrical engineer (Mr. Harry Richardson) from £500 to £600 per annum.

Ealing.—The Council have, we understand, notified the Metropolitan Electric Supply Co. that, having placed an order for machinery, they are not now in a position to consider any further offer for a supply of electricity in bulk.

Electric Capstans for Derry Harbour.—The Derry Port and Harbour Commissioners have adopted a report of a committee recommending the erection of two electric capstans on the harbour for haulage purposes. Electric current will be obtained from the Corporation.

Electricity in Mining.—The report of the Rhymney Iron Co. for the past year states that at the two Pengam pits the electric generating set and the picking and screening plant have been completed. The main turbine pumps are almost ready, and the equipment of the colliery will shortly be completed. In order to develop the lower 4 ft. coal in the New Duffryn pit the directors had placed an order for a 300 kw. electric generating set to be erected at Rhymney. The waste gases at the coke ovens will thus provide power very cheaply for hauling, pumping, &c., at New Duffryn, and for running the machinery in the workshops. Various alterations will also be made to enable the current to be economically utilised at the Mardy pit.

Farsley (Yorks.)—The Council are negotiating with the Yorkshire Electric Power Co. for a supply of electricity in bulk.

Grassington.—A public meeting was held last week to consider an electricity supply scheme, which is being prepared by Mr. H. W. Laycock (Messrs. Grace & Sutcliffe, Keighley), and a further meeting is to be called.

Gravesend.—By 10 votes to 8 the Council have abandoned the proposal to extend the electricity supply mains to Northfleet.

Hipperholme (Yorks.)—The Council have sealed the agreement with the Yorkshire Electric Power Co. for a supply of electricity in bulk.

Hornsey.—The central library is to be wired for the electric light There are now 1,124 consumers of electricity, representing the equivalent of 58,099 8 c.p. connected.

Leeds-Guiseley Tramways.—Rawdon, Yeadon and Guiseley Councils are urging Leeds Tramways committee to extend the Leeds tramway system to the three districts named.

Light Railway Commission.—The offices of the Light Railway Commission have been removed to Scotland House, New Scotland-yard, London, S.W.

London County Council.—At Tuesday's meeting it was agreed to lend £600 to Stoke Newington and £16,394 to Woolwich for electric lighting.

With regard to the latter loan the Finance committee stated that they had asked the Council to inform them of any further action which it might decide to take upon the suggestions contained in Sir Alexander Kennedy's report, and inform them that, before sanctioning any further loans in respect of the undertaking, they would require to be satisfied that the proposed capital expenditure was absolutely necessary and unavoidable.

Silent Pavement.—The Highways committee recommended that in cases where the Council is laying electric tramways, the portion of the track opposite schools and other educational institutions be paved with wood or other silent material.—Agreed.

L.C.C. Testing Fees, &c.—In reference to the L.C.C. proposed scale of testing fees, &c., the Fulham Law and Parliamentary Committee report that they are advised that the cost of providing a number of stations adequate for testing the pressure all over the distributing network would be enormous, and, therefore, every effort should be made to resist the action of the L.C.C., or at least to postpone the needless expenditure on testing stations until serious complaints are made of low pressure from consumers, and the L.C.C. are called upon to insist upon the erection of stations. Representations are, therefore, to be made to the Board of Trade and the borough representatives on the L.C.C. are to be requested to support the Borough Council's views in the matter.

Bermondsey Council have made a similar protest.

London Gas.—The South London Metropolitan Gas Co. has increased the price of gas in South London to 2s. 3d per thousand.

London Underground Railway Fares.—At recent conferences the Central London, the Metropolitan, and Metropolitan District Railway and the other tube companies agreed on a working arrangement to co-operate, as soon as details can be settled, in revising fares between Hammersmith, the West End and the City. The Central London fares will be increased to 3d. for the longer distances, and those of the Metropolitan & District will also be revised. Through bookings will be arranged to come into operation at an early date.

Luton.—Sanction has been received by the Council to a further loan of £14,460 for extensions of the generating plant, mains, &c.

Milan Exhibition Awards.—The complete list of awards in the British section of the Milan Exhibition, 1906, has now been published and includes the following:—

INDUSTRIAL EXHIBITORS.—*Hors Concours:* Sir W. G. Armstrong, Whitworth & Co. *Grand Prize:* Sir W. G. Armstrong, Whitworth & Co., Babcock & Wilcox, Cambridge Scientific Instrument Co., Chadburn's (Ship) Telegraph Co., F. Darton & Co., Doulton & Co., Elliott Bros., Alfd. Herbert, J. E. Hopkinson & Co, United Alkali Co., Vickers, Sons & Maxim, Willans & Robinson, Worthington Pump Co. *Diploma of Honour:* F. Darton & Co., Greenwood & Batley, Hele-Shaw Patent Clutch Co., Nalder Bros. & Thompson. *Gold Medal:* Berry, Skinner & Co., Blackman Export Co., British Electric Transformer Co., Combination Metallic Packing Co., Doulton & Co., Frictionless Engine Packing Co., J. E. Hopkinson & Co., A. P. Lundberg & Sons, Simplex Conduits, Stirling Boiler Co. *Silver Medal:* Armorduct Mfg. Co., N. Casella, Morley Fletcher, Frictionless Engine Packing Co., J. E. Hopkinson & Co., A. P. Lundberg & Sons, Sir David L. Salomons, Simplex Conduits, Stirling Boiler Co., Willans & Robinson. *Bronze Medal:* Armorduct Mfg. Co., Berry, Skinner & Co.

AWARDS TO COLLABORATORS.—*Diploma of Honour:* M. W. Duddell and Cyril Young (both Cambridge Scientific Instrument Co.), J. E. Hopkinson (J. E. Hopkinson & Co.), J. E. Shore (Willans & Robinson). *Gold Medal:* F. C. Darton (F. Darton & Co.), I. Magni (Worthington Pump Co.), A. H. Reed (Cambridge Scientific Co.). *Silver Medal:* E. H. Constantine and John Cowan (Stirling Boiler Co.), B. H. Howell and L. M. Waterhouse (Simplex Conduits). *Bronze Medal:* Hy. Berry (British Electric Transformer Co.), N. Romeo (Simplex Conduits).

Municipal Accounts.—The Departmental committee of the Local Government Board, which has been inquiring into the system on which the accounts of local authorities in England and Wales are kept, has concluded its investigations. Its report will be presented shortly.

It is stated that the committee finds that on the whole the accounts of local authorities are well kept, especially in the provinces, although there is a great lack of uniformity. They recommend, amongst other matters, that the accounts should be kept on the income and expenditure basis instead of on the cash receipts and payments system, as at present. They have prepared a series of over a score of model accounts for tramway, electric lighting and other undertakings, which they recommend might be used in future.

New Aluminium Works.—It is reported that the British Aluminium Co. has secured a site at Newcastle-on-Tyne for the erection of works for the manufacture of aluminium. The works will be capable of turning out nearly 2,000 tons per annum.

Oystermouth (Glam.)—The Council are prepared to negotiate with a company willing to establish electricity works.

Pontypridd.—In future long-hour consumers will be charged 7d. per unit for the first hour and 1d. per unit after.

Presentations.—The Plymouth district staff of the National Telephone Co. have presented a silver-plated tea-tray to Mr. P. F. Currall, district manager, who is leaving to take up a similar position at Dublin.

The chief officers of Devonport Corporation have presented an illuminated address and a silver rose bowl to Mr. Jas. Walter Spark, borough electrical engineer, on his marriage, which took place on Saturday.

The staff and employés of the Warrington electricity and tramways department have presented a case of silver fish-carvers and an inlaid mahogany barometer to Mr. F. W. Purse (chief assistant engineer) on his marriage.

Mr. Pakenham W. Beatty has resigned the position of resident engineer at Golders Green car sheds of the Underground Electric Railways Co. of London, and on Saturday he was presented with a travelling bag and liqueur case by the employés at Lillie Bridge and Golders Green sheds. Mr. L. W. Migotti presided at the presentation ceremony.

The officials and staff of the Manx Electric Railway Co. have presented a set of binocular glasses in case and a gold watch pendant to Mr. Harold Brown, late chief engineer, on his departure for Canada.

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Mr. Alex. B. Randall, manager and engineer of the Salisbury Electric Light and Supply Company, has been presented, on his marriage, with a set of fish knives and forks by the directors, and with a set of carvers, a barometer and a silver-mounted scent-bottle by the employés.

Prestwich.—The Council give notice of intention to lease to Salford Corporation (until Dec. 31, 1927) tramways 3¾ miles in length. The lessees are to provide and maintain the electrical equipment, and the lessors are to have the option of purchasing. The annual rent is £2,402. 17s. 4d., plus one third of the net profit of working the lines.

Provisional Order Revocation.—The Board of Trade have revoked the Romford Electric Lighting Order, 1900.

Repayment of Loans in the London Area.—Woolwich Council have agreed to support Stepney in their appeal to the L.C.C. to obtain longer periods for repaying loans for electrical plant and mains, and especially for services and meters.

Ship Lighting.—As might be expected, the new Cunarder, "Lusitania," which is approaching completion at the shipyard of John Brown & Co, Glasgow, will have a very complete electric lighting and power installation; electric bells, telephones, &c., are also to be fitted throughout the various rooms and corridors of the ship.

Southampton.—Application has been made for sanction to a further loan of £3,000 for mains extensions, house services and meters

Southwark (London).—*Correction.*—In our last issue (p. 360) we stated that the Council had accepted the offer of the County of London Electric Supply Co. to supply current for lighting the clock tower now in course of erection at St. George's Circus. The figures of the accepted tender were 1½d. per unit (not 3d. as given) for interior and exterior lighting with £54 per annum for maintaining 4 arc lamps. The London Electric Supply Corpn., quoted 3d. per unit plus 15s. per lamp per quarter for maintaining the arc lamps. On the assumption of 4,200 hours of lighting per annum the aggregates were £122 for the County of London Co. and £143 for the London Electric Supply Corpn.

Stepney (London.)—The Electric Lighting committee, which is considering the question of putting into force the powers conferred by the London County Council (General Powers) Act, 1906 to wire consumers' premises, &c., hopes to submit a scheme shortly to the Council, but in the meantime the committee has been authorised to carry out certain alterations to the wiring work on a large consumer's premises at a cost of about £120. This sum is to be repaid by monthly instalments in two years.

Switzerland.—The "Feuille Fédérale Suisse" of June 5 contains a copy of a concession granted to M. F. Simon, Ragaz, and M. H. de Gugelberg, engineer, Zurich, for the construction and working of a narrow-gauge electric railway from Landquart, viâ Ragaz, to the frontier of the principality of Liechtenstein.

Wigan.—The Tramways and Electric Light committee have decided to ask the Board of Trade to nominate two experts to inquire into the position and working of the department.

Dinner.—A complimentary dinner was given on Tuesday to Mr. J. Metcalfe, of the Bryant Trading Synd., who is leaving for the United States.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Brighton.—The traffic revenue of the tramways department for the past year was £48,898. 0s. 5d., compared with £50,148. 5s. 1d. in 1906, and the total revenue was £50,662. 16s. 11d., against £51,620. 18s. 2d.

Expenses were £34,499. 10s. (against £36,219. 7s. 9d.). Gross profit was £16,153. 6s. 11d., and after paying interest (£8,589. 5s. 9d.) and sinking fund (£5,164) the net profit was £2,410. 5s. 10d. (against £1,615. 9s. 8d.). The total capital expended is £274,905. 0s. 6d. 10,759,310 passengers were carried (against 11,026,811 in the previous year) and the car-miles run were 1,118.590 (1,172,933). The average traffic revenue per car-mile was 10·49d. (10·26d.) and the average per mile of single track £2,844 (£2,917.).

Carlisle.—There was a small net profit (£9. 2s. 4d.) on the past year's working of the electricity department.

Cleckheaton.—After paying all expenses (including interest and sinking fund) there was a deficit of £193 on the past year's working of the electricity department.

588,640 units of electrical energy were generated and 482,288 were sold at an average price of 2·15d., compared with 2·2d. in the preceding year. The works cost was 0·830d. per unit, and the total cost (exclusive of interest and sinking fund) 1·095d. The bulk of the current is taken by the local tramway company.

Colchester.—The accounts of the electricity department for the year ended March show capital expenditure £71,277, an increase of £3,739.

The total revenue for the year was £13,346 (against £12,814 in the previous year), and including £8,967 for 617,607 units supplied to private consumers, £936 for 102,272 units for public lamps, and £3,117 for 498,758 units at 1½d. supplied to the tramways. The total working and general expenses were £7,812 (£7,192). Gross profit was £5,534 (£5,621). Interest required £1,919 (£1,782) and sinking fund £2,391 (£2,082), and the net profit was £1,224 (£1,758). There are 42,871 (36,919) equivalent 8 c.p. lamps connected. 1,218,637 (1,086,083) units were sold, being, as in the preceding year, 17 units per lamp connected. The average price received for private supply was 3·48d. (3·94d.). The maximum load was 852 kw. (801 kw.) and the load factor 16·33 (15·48). The capacity of the plant is unchanged—1,280 kw.

The Council at last week's meeting approved the accounts, and £981. 19s. of the net profit was carried to depreciation, the remaining £500 being placed at the disposal of the Finance committee, with a recommendation that it be placed to credit of the next general rate.

Lincoln.—The income of the electricity department for the year ended March 31 was £11,646. 18s. 8d., including £6,732. 3s. 3d. from sale of current for private lighting, £795. 19s. 10d. from public lighting, £3,038. 15s. 10d. from power supply, and £1,026. 19s. 3d. from the tramways department.

Total expenses were £5,313. 12s. 2d., gross profit was £6,333. 1s. 6d., and after providing for interest, redemption of debt, &c., and transferring £223. 16s. 11d. to meet deficiency on tramways account for the past year, the net profit was £2,858. 16s. 8d., against £2,165. 0s. 2d. in 1905-6. The total capital expended is £64,144. 16s., an increase of £8,621. 14s. on the year. 1,485,406 units were generated; 65,460 units were supplied to the public lamps, 1,052,652 were sold by meter and 164,314 were supplied to the tramways department. There are 34 arc, 61 incandescent, 26 tantalum and 7 Nernst lamps for public lighting, and the total maximum supply demanded was 750 kw. There are 507 consumers, and the equivalent of 59,955 8 c.p. lamps is connected. The large increase in the units sold is due to the greatly increased demand made by Messrs. Clayton & Shuttleworth for power and to the traction load. The total works costs were 0·993d. per unit sold, against 1·350d. in 1905-6. It is proposed to reduce the charge for current to the tramways from 1½d. to 1¼d. per unit.

The total revenue of the tramways department was £5,845. 5s. 9d. Expenses were £3,828. 18s. 11d., leaving a gross profit of £2,016. 6s. 10d. to meet interest (£1,150. 6s.) and sinking fund (£1,368. 10s. 8d.). The deficit on the undertaking (£223. 16s. 11d.) has, as shown above, been met out of the profit on the electricity department. The gross capital expended is £39,231. 1,437,946 passengers were carried, 137,186 car-miles were run, and 164,314 units of energy (1,197 per car-mile) were used. Compared with 70 other municipal tramway undertakings, Lincoln is only 0·35d. above the average in costs, but as the car-miles run were below all those in the list, the Lincoln figures (6·698d. per car-mile run) must be (says the city electrical engineer, Mr. Stanley Clegg) considered satisfactory. Compared with Wolverhampton (the only other surface contact system in this country working over 12 months) the power and traffic expenses were lower, 1·797d. and 2·512d. per car-mile at Lincoln, against 1·99d. and 2·54d. at Wolverhampton. The total expenses were higher at Lincoln owing to the limited character of the undertaking, but Mr. Clegg thinks that with an increased mileage he could do equally well, if not better than Wolverhampton.

Norwich.—There was a net profit of £4,778. 9s. 6d. on the past year's working of the electricity undertaking. There were very satisfactory increases in the current sold for lighting and power and in gross receipts, &c. The new system of charging introduced by the city electrical engineer (Mr. F. M. Long) had diminished the receipts by only £210.

South Shields.—The annual report of the borough electrical engineer (Mr. J. H Cawthra) on the working of the electricity undertaking for the year ended March 31 shows that the total revenue was £22,700, compared with £17,831 in 1906.

Total costs were £9,397, against £7,211, and the gross profit was £13,302, against £10,120. Interest and sinking fund absorbed £10,163 (£9,263) and the net profit was £3,139 (£857). The maximum load was 1,790 kw. (970 kw.) and the load factor 14·61 per cent. (lighting and traction), against 16·93 (lighting) in 1906. There are 1,245 consumers (1,167), and the equivalent of 72,952 8 c.p. lamps is connected (62,927 8 c.p.), and the revenue per 8 c.p. lamp was 4s. 10d. against 5s. 6d. 2,291,612 units of current were sold against 1,438,921. The works cost per unit is 0·60d. (0·61d.), the total works cost 0·91d. (1·09d.), and the total cost (including interest and sinking fund) 1·98d. (2·63d.).

Mr. Cawthra attributes the improved financial position to the installation of plant for the supply of electrical energy for traction and power. The tramway load factor is only 11·11 per cent. (the lowest record within Mr. Cawthra's knowledge) and this is due to the abnormal demand made by the tramways during holiday times and on Saturdays. Already the department has a number of power consumers, nearly every trade and industry in the town being represented in the list, and current is being supplied to 1,184 H.P. of motors. The total capital expended is £172,851. 9s. 6d., against £163,047. 2s.

Stafford.—The capital expended on the electricity undertaking is £33,063. 5s. 2d., but £8,812. 18s. 4d. has been repaid.

The total revenue for the year ended March 31 was £3,971. 4s. 4d. Expenses were £1,526. 3s. 1d., leaving £2,445. 1s. 3d. to meet interest (£863. 14s. 4d.) and instalments of principal (£1,115. 3s. 7d.), &c. 368,347 units of electric current were generated; 298,734 units were sold to private consumers, 8,587 were supplied to the public lamps and 26,338 were used for pumping. There are 262 meters fixed for private consumers and the equivalent of 20,253 8 c.p. lamps is connected. Total working expenses were 1·192d. per unit sold, and after paying all charges (including interest and sinking fund) the net profit on the year's working was £354. 17s. 11d., or 0·277d. per unit sold.

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Swansea.—The net profit on the past year's working of the electricity department was £686.

Wolverhampton.—The total income of the tramways department for the year ended March 31 was £43,822. 10s. 11d., and the expenses (exclusive of renewals) £24,537. 1s. 11d, leaving gross profit £19,285. 9s.

After contributing £5,300. 11s. to renewals funds, paying interest (£7,742. 8s. 9d.) and sinking fund (£4,129. 11s. 5d.), and meeting deficit on the motor omnibus account (£281. 6s. 9d.), there was a net profit of £2,436. 15s. 1d. reducing the deficit to date on the undertaking to £1,291. 10s. 5d. 9,276,023 passengers were carried (compared with 8,844,424 in 1906), and 966,133 car-miles run (against 950,338), the receipts per car-mile being 10·680d. against 10·418d.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

The Education committee of the borough of *Portsmouth* invite tenders for (1) electric machinery and accessories for dynamo rooms and accumulators for the electrical engineers' department, and (2) experimental compound steam engine and condenser, feed measurement tanks, gas engine and suction plant, oil engine, petrol motor and electrically-driven machine tools for the mechanical engineers' department. Tenders, addressed to the chairman of the Higher Education Committee, Technical Institute, Portsmouth, by July 2.

Portsmouth Town Council invite tenders for the supply, delivery and erection of one 1,000 kw. turbo-alternator, with condensing plant and accessories. Tenders to the town clerk (Mr. Alexander Hellard), Town Hall, Portsmouth, by noon 24th inst.

Newport (Mon.) Electricity and Tramways committee invite tenders for low-tension switchboard, two motor alternators (d.c. to a.c., single-phase), one battery, extensions to switchboard gallery, cooling tower (steel) and battery reversing booster. Tenders to the Town Clerk, Town Hall, Newport (Mon.) by first post July 1.

Clacton District Council are prepared to receive tenders for supply of two 25 kw. 500 volt dynamos, two existing 100 volt Taunton machines (which can be viewed on application to the resident engineer) to be taken in part payment; also for additions to switchboard. Tenders to the clerk (Mr. G. T. Lewis), Town Hall, Clacton-on-Sea, by noon July 3.

The Electricity committee of *Stepney* (London) Borough Council invite tenders for supply during the year ending June 30, 1908, of (1) ampere-hour meters and demand indicators, and (2) arc lamp carbons. Specifications from the engineer and manager (Mr. Wm. C. P. Tapper, 27, Osborn-street, Whitechapel, E., where tenders must be delivered by July 1.

London County Council invite tenders for the manufacture of two 5,000 kw. three-phase turbo-alternators, with surface condensers, &c., to be delivered and erected at the tramways generating station, East Greenwich. Tenders, on official forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., to be sent in by 11 a.m. July 2.

Pontypridd Council invite tenders for supply and laying of about 3,000 yds. of tripple concentric feeder and distributing cables, paper-insulated. Tenders to Town Clerk by July 8.

Plymouth Guardians invite tenders for wiring their new workhouse infirmary buildings. Tenders to the Clerk, 13, Princes square, Plymouth, by July 2.

Southampton Corporation require a Babcock & Wilcox chain grate mechanical stoker for a water-tube boiler. Tenders by 24th inst.

The Deputy Postmaster-General, *Hobart* (Tasmania), will receive tenders until noon, Aug. 14, for supply of telegraph and telephone material. Specifications, &c., from the General Post Offices, Hobart, Sydney, Melbourne, Brisbane, Adelaide and Perth, and from the Commonwealth Office in London, 72, Victoria-street, S.W.

TENDERS RECEIVED AND ACCEPTED.

Woolwich (London) Borough Council have received the following tenders for carrying out wiring work on behalf of the Council in the parishes of Woolwich and Plumstead:—

*E. P. Allam & Co. (*accepted*) (1), wiring for six points (with main switches and fuses, cables, wood casing and capping, sub-boards, switches, fuses, plugs, ceiling roses, blocks, complete in every respect except fittings), **£4. 10s.**; (2) additional points, **12s. 6d.** per point; (3) wiring for six points (same as No. 1, *but with screwed steel tubing instead of wood casing and capping*), **£4. 19s.**; (4) additional points, **16s. 6d.**; (5) supplying and fixing six adjustable pendants, consisting as above, together with porcelain or metal counterweight, pulleys and shot, **£1. 4s.**; (6) additional pendants, **4s.** each; (7) additional percentage to cover office, &c., expenses **10** per cent.

*G. Weston & Co. (1), £4. 10s., (2) 13s., (3) £5. 14s., (4) 18s., (5) £1.10s., (6) 5s., (7) 20 per cent. *Lonsdale Engineering Co., (1) £2. 14s., (2) 10s., (3) £3, (4) 11s., (5) 18s., (6) 3s., (7) 5 per cent. *L. J. Allbright, (1) £3. 15s., (2) 14s., (3) £5. 2s., (4) 19s., (5) £2. 8s., (6) 8s., (7) 25 per cent. Charles Ross, (1) £6, (2) 16s., (3) £6. 18s., (4) 18s. 6d., (5) £6. 18s, (6) 3s., (7) 25 per cent. *E. G. Kelsey, (1) £5. 2s., (2) 15s. 6d., (3) £6, (4) 19s., (5) £5. 11s., (6) 17s., (7) 20 per cent. *†Reliance Electrical Co., (1) £2. 17s., (2) 9s., (3) £4. 13s. (4) 15s., (5) £1. 7s., (6) 4s. 6d., (7) 15 per cent. ‡H. J. Godfrey, (1) £3. 12s., (2) 11s., (3) £4. 19s., (4) 15s. 6d., (5) £1. 7s., (6) 4s. 6d., (7) 10 per cent. *Ward and Newman, (1) £3, (2) 10s. 6d., (3) £3. 12s., (4) 12s. 6d., (5) £1. 4s., (6) 4s., (7) 10 per cent. §Armstrong Power Co., (1) £3. 12s., (2) 11s., (3) £4. 10s., (4) 14s., (5) £1. 8s. 6d., (6) 4s. 6d., (7) 33½ per cent. §C. J. Wilkin & Son, (1) £3. 16s. 6d., (2) 11s. 9d., (3) £4. 10s., (4) 14s., (5) £4. 16s., (6) 15s., (7) 15 per cent. §C. Larkins & Co., (1) £4. 1s., (2) 10s., (3) £6 6s., (4) 17s. 6d., (5) £1. 1s., (6) 3s. 6d., (7) 40 per cent.

Tender on a basis of three pairs of lamps installed: §Sowerbutts & Rogers, (1) £4. 10s., (2) 15s., (3) £7. 10s., (4) £1. 5s., (5) £1. 1s., (6) 3s. 6d., (7) 20 per cent.

Representatives of each of the firms were interviewed, and Messrs. Allam & Co.'s tender has been accepted subject to their joining the N.E.C.A, and to their agreeing to pay their workmen employed in the borough the rate of wages adopted by the L.C.C. In the event of their declining to accept the conditions, the tender of the Armstrong Power Co. will be accepted, subject to the same conditions.

London County Council have accepted the tender of Heenan & Froude for 5 electrically-operated car-traversers at £3,675.

For 60 miles of high-tension electric cable London County Council received the following tenders:—

Siemen's Bros. & Co. (*accepted*).....	**£70,563**	9	7	W. T. Glover & Co.	£73,694	11	4
St. Helens Cable Co.	76,346	5	6	Callender's Co.	73,577	1	2
Johnson & Phillips..	74,598	2	8	British Insulated & Helsby Cables....	72,406	3	0
W. T. Henley's Co...	74,521	15	2	Western Electric Co.	71,710	2	1

Sunderland Corporation have definitely accepted the following tenders:—

British Westinghouse Co., plant for the new equipment required for Messrs. Laing's sub-station; H. Tonkinson & Son, for supply of steam and exhaust piping for Hylton-road sub-station; British Insulated & Helsby Cables, for supply of two feeders from Hylton-road to High-street West (corner of Garden-place) and from Pallion sub-station to the Sunderland Forge & Engineering Co.'s works, and for supply of three additional feeders to Whickham-street sub-station; and that of the Albion Clay Co. for ducts to Whickham-street sub-station.

Marylebone (London) Council received the following tenders for cables:

St. Helens Cable Co. (*accepted*) (1), 1,320 yds. 1 sq. in, **£1,381. 4s.**; (2) 880 yds. 25 sq. in., **£651. 16s.**; (3) 880 yds. 15 sq. in., **£424. 3s.**; (4) 440 yds. 1 sq. in., **£485. 8s.**; (5) 780 yds. 1·5 sq. in., **£1,179. 15s.**; (6) 180 yds. 1 sq. in., **£186. 15s.**; (7) 120 yds. 7/18 S.W.G., **£5**; W. T. Henley's Co. (1) £1,409, (2) £670, (3) £435, (4) £494, (5) £365, (6) £264. 15s., (7) £3. 17s. 6d.; W. T. Glover & Co., (1) £1,410, (2) £664, (3) £438, (4) £500, (5) £1,202. 10s.. (6) £191. 5s., (7) £5. 10s.; Siemens Bros. & Co., (1) £1,433. 5s., (2) £669. 10d., (3) £437 15s., (4) £501. 2s.; Callender's Co. (1) £1,452, (2) £721 12s.. (3) £450. 11s. 2d., (4) £506.

Marylebone Council have received the following tenders for repairs to old North-street battery (new negative plates throughout and exchange of glass tubes for wood separators):

Electoral Power Storage Co. (*accepted*), **£1,170**; Accumulator Industries £1,150. Positive Platess, Electrical Power Storage Co. (*accepted*), first

* Not members of the National Electrical Contractors' Association, and would open show rooms, &c.
† Would take stock off Council's hands.
‡ Members of the N.E.C.A., and would open show rooms.
§ Prepared to join N.E.C.A.

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100 £66, subsequent plates 9s. 3d. each. To cut to pieces the whole of the positives so as to clean and examine the boxes and reburn them, £120; to supply new acid, £90. Accumulator Industries (Ltd.) per 100, £45.

For the electric lighting installation, &c., at the Westminster Technical Institute London County Council received the following tenders:

J. Bryden & Sons (*accepted*)	£687	J. Barker & Co.	£944
Mercer, Rance & Co.	1,051	Aberdeen Elec. Eng. Co.....	857
S. G. Cozens	966	Pinching & Walton.....	761

Bolton Corporation have accepted the tender of Ed. Bennis & Co. (Ltd.) for complete coal and ash handling plant for the boiler extensions, with Bennis automatic measuring machinery, together with four Bennis stokers and self-cleaning compressed air furnaces of the latest (1907) type at £1,350

Walsall Council have accepted the tender of Babcock & Wilcox for dampers, &c., for new boiler flues at £18 10s.; that of Stewarts & Lloyds for steam and water pipes at £89 10s.; and that of Siemens Bros. & Co. for telephone cable at £11 18s. 9d.

Luton Council have accepted the tender of Ruston, Proctor & Co. for a Lancashire boiler at £784; that of the Worthington Pump Co. for condensing plant at £664; and that of R. H. Longbotham & Co. for coal bunkers, elevator and conveyors at £674.

Woolwich (London) Council have accepted the tender of Everett, Edgcumbe & Co. for an a.c. recording voltmeter at £9. 11s. 6d. (less 2½ per cent.), and that of the Bell Telephone & Electric Co. for wiring for motor for working economiser at Plumstead Baths, £15. 5s.

Southwark (London) Council received 21 tenders, varying from £191. 5s. to £301, for wiring the branch library at the junction of the New and Old Kent-roads, and that of W. G. Cannon & Sons (at £240. 11s.) was accepted.

The Compagnie Electrique Anversoise has accepted the tender of Ed. Bennis & Co., for a complete coal elevating automatic weighing and conveying plant for the Company's power station at Quai Cockerill, Antwerp, at 35.855fr.

Lanark County Council have accepted the tender of Johnson & Phillips for supply and erection of a 70 kw. motor generator, battery charging booster and switchgear for the Cambuslang electricity works extension.

Whitehaven Council have accepted the tender of D. Santoni & Co. for rewinding an armature at £78, and that of Cole, Marchent & Morley for a surface condenser at £820. 15s.

Bolton Electricity committee recommend the acceptance of J. Musgrave & Son's tender for a 2,000 H.P. vertical steam engine, and that of Messrs. Dick, Kerr & Co. for a three-phase alternator.

Blackburn Corporation have placed the contract for the supply of continuous-current motors for the ensuing 12 months with Newtons, Limited, Taunton.

Salford Corporation have placed an order with the Liverpool Electric Cable Co. for cables, and with Watlington & Co. and John Hall & Co. for tramcar accessories

Loughborough Corporation have accepted the tender of Manlove, Alliott & Co. for a refuse destructor at £1,362.

London County Council are recommended to accept the tender of Stanley Bros. for 400,000 stoneware ducts at £4,500.

Willesden Council have accepted the tender of Oliver Arc Lamps for 66 flame arc lamps at £668.

BUSINESS NOTICES.

The Union Electric Co.,' Park-street, Southwark, S.E., announce that owing to the completion and satisfactory working of their small machine department they can now allow increased discounts on direct-current motors and dynamos, sizes V 30a to V 60a (2¼ H.P. to 30 B.H P.

Mr. William Corin, M.I.C.E., M.I.E.E., notifies that, in order to confine his attention to his private consulting practice, he has resigned the appointment which he has filled for the past 11 years of city electrical engineer to Launceston (Tasmania) Corporation. Mr. Corin is prepared to report upon electric lighting or power schemes in Australasia or New Zealand, to prepare plans and specifications, advise as to tenders, &c., and his address is 7, Hill-street, Launceston. Telegrams: Corin, Launceston.

Messrs. R. J. Nicholson & Co.'s office for the Midlands is now at 3, New Street, Birmingham, where Mr. John E. Corby will give all information respecting the firm's "Ideal" electric lighting sets, pump combinations and marine motors.

Messrs. Adamson, Ramsbottom & Co, Birkenhead, have appointed Robinson & Jones, 21, Collingwood-street, Newcastle-on-Tyne, sole agents and representatives for the northern counties (including Northumberland, Durham, Westmoreland, Cumberland and Cleveland district of Yorkshire) for their electric and hand cranes, electrically-driven lifting machinery and hauling gears.

Firms who have business relations with Chili will be interested to learn that the Banco de Chile has established an agency at 14, Bishopsgate-street Within, London, E.C.

BANKRUPTCIES, LIQUIDATIONS, &c.

The statutory first meetings of the creditors and shareholders of the Improved Electric Supplies (Ltd.) were held at the London Bankruptcy Court on Tuesday. The accounts show liabilities £13,306, assets £7,668, and a deficiency of £15,637 to the contributories.

The company was formed on October 2, 1905, with a nominal capital of £15,000 in 5,000 7½ per cent. cumulative preference, 5,000 ordinary and 5,000 B shares, to acquire the goodwill and assets of the Improved Electric Glow Lamp Co. (Ltd.), and to carry on the business of electricians and electrical engineers. The company was promoted by Mr. W. Chamberlain, who had acquired the property from the liquidator of the old company in consideration of his undertaking to pay its liabilities, amounting to £4,808, and to discharge a debenture debt of £4,000. The new company agreed to pay him £19,001, made up of £4,200 cash, £4,808 by instalments and £9,993 by the allotment of shares. The company further guaranteed due payment by Mr. Chamberlain to the liquidator of the old company of the £4,808, and, on the other hand, Mr. Chamberlain agreed to subscribe for £2,500 6 per cent. second debentures of the company. Debentures for £6,587 were outstanding on March 6, 1907, when a resolution was passed for voluntary winding up and for the appointment of Mr. H. J. Snowden as liquidator. On the same date that gentleman was also appointed as receiver for the debenture-holders, and at once entered into possession of the property. The failure of the company is attributed generally to want of capital. The liquidation is in the hands of the official receiver and a committee of inspection.

Herbert Thompson Garvie (trading as the New Southgate Engineering Co.), 13A, Eastcheap, London, E.C., has been adjudicated bankrupt.

A first dividend of 3s. 4d. in the liquidation of McPhail & Simpson's Dry Steam Patents Co. (Ltd.) will be payable on July 1, by Mr. J. W. Close, North British and Mercantile buildings, East-parade, Leeds.

Claims against Geo. M. Sellick, electrical accessories manufacturer, 464, Romford-road, London, E., by June 29, to Mr. E. S. Grey, Bankruptcy-buildings, London, W.C.

The trustee (Mr. J. G. Burgess, 1, Berridge-street, Leicester) in the bankruptcy of Frank Johnson, electrical engineer, &c., Long-lane, Billesdon, has been released.

The Reversible Turbine Synd. (Ltd.) is being wound up voluntarily, and Mr. J. D. S. Bogle, 3, Great St. Helens, London, E.C., is liquidator.

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell will sell by auction at H.M. Dockyard, Portsmouth, on Tuesday, July 9, and following days, at 11 a.m., some old and surplus stores, including quantities of brass tubes and mixed metal, scrap white metal, old leads and zinc ashes, mild steel and steel and iron scrap, 70 tons electric cable, electrical gear and stores, 85 Brotherhood engines, old boilers, engineers' tools, &c. May be viewed three working days prior to and on morning of sale. Catalogues (6d. each) at the dockyard and of the auctioneers, 11, Billiter-square, London, E.C. See also an advertisement.

Plant for Sale.—Messrs. Horne & Co. have been instructed by H.M. Office of Works to receive tenders on Thursday, June 27, for two electric lighting plants, one at Osborne House and the other near London. The former includes an E.C.C. dynamo and an Elwell-Parker dynamo, switchboard, instruments, &c., 16 H.P. and 12 H.P. Crossley gas engines, belting, electric fittings, &c. The plant near London includes two 40 H.P. compound tandem Willans engines, two Siemens compound dynamos, Western dynamo, 56 storage cells, 12 H.P. Davey-Paxman compound vertical engine, 12 H.P. and 20 H.P. vertical boilers, &c. Particulars from the auctioneers, 8, Delahay-street, Westminster, S.W. See also an advertisement.

Plant Wanted.—Mr. Thomas Johnson, Prescott-street, Wigan, is advertising for a steam turbine, 350 to 400 revolutions, 600 H.P. to 800 H.P., 100 lb, pressure, or any other compact engine.

The "Journal."—Part 183 of the "Journal" of the Institution of Electrical Engineers is now ready, price 5s. For particulars of contents see an advertisement.

"The Progress of Electrical Enterprise."—This is the title given to a reprint of a series of 15 articles from the engineering supplement of "The Times." These articles are from the pen of Mr. Emile Garcke, M.I.E.E., and the author's position as managing director of the British Electric Traction Co. (a company which controls a number of important electric tramway and electricity supply undertakings, &c.) would of itself invest his opinions with authority when writing of the checks and hindrances to electrical engineering progress in this country: but, in addition, Mr. Garcke has been so long and intimately associated with the financial side of electricity supply that he is peculiarly well qualified to deal with the topics discussed in the present series. As might be expected, Mr. Garcke attributes the present depression in the industry to the aggressive attitude of local authorities, to unsuitable legislation and to the unsympathetic attitude of our legislators to the repeated demands made for the reform of the law relating to electricity supply, tramways and light railways, &c. We have ourselves repeatedly pointed out the need for changes in and the improvement of

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the law governing the electrical industries and to the necessity for some correspondence between the legislation governing electricity and its modern applications. We have also frequently called attention to and animadverted upon the jealous and frequently unfair attitude of local authorities towards private enterprise. We consequently find ourselves in agreement with most of Mr. Garcke's conclusions, and we advise all interested in placing the true state of the case for the electrical industry before the public to procure copies of this reprint, make themselves acquainted with the facts and figures set out by the author, and circulate copies of the booklet in quarters where it is essential the truth should be known. The subjects dealt with by Mr. Garcke are of vital importance not only to the electrical industries but to the community at large, and we hope the present work will focus public attention on the main causes of the present depression. The reprint is published at 1s. net by the Electrical Press (Ltd.), or copies can be obtained direct from *The Electrician* offices.

"**Cassier's Magazine.**"—We are informed that the interests of the English edition of "Cassier's Magazine" have been acquired by (amongst others) the following:—

Mr. C. S. Vesey Brown, Mr. W. H. Butlin, K.I.C., and Mr. E. G. King, who will act as directors. Mr. Vesey Brown is chairman of the board. The magazine will be conducted as heretofore, with Mr. King as managing director. The offices will remain as heretofore.

CATALOGUES, &c.

Union Specialities.—A useful pocket list of Union electrical apparatus has just been published by the Union Electric Co., Park-street, Southwark, S.E. It practically runs the gamut of the company's entire products. Specimen illustrations of each type are given, together with prices and full particulars.

Main Switches.—Verity's Limited are issuing publication No. 552, which gives complete illustrations and dimensional particulars of their quick break knife swtiches. The outline drawings in this pamphlet have been well done.

Storage Cells.—A new line in the shape of a series of small cells for country house lighting is being manufactured by the Chloride Electrical Storage Co., Clifton Junction, Manchester, and London. These cells are intended for use with lighting sets comprising small internal combustion engines (either petrol or oil) and dynamos such as are now being commonly supplied to country houses. To meet the growing demand for small batteries for plants of this description the Chloride Co. have standardised their P.G. and L.G types of accumulators. Circular No. 19 gives full details.

Kolben Plant.—Pelton wheels and mining machinery form the subjects of pamphlets 47 and 60 just issued by Kolben & Co., 24, Budge-row, Cannon-street, E.C. An illustration is given of a 100 H.P. Pelton wheel for a 425 ft. head, a 500 B.H.P. Francis turbine coupled to a polyphase alternator is also described and illustrated in pamphlet 45. Particulars of Kolben projectors are given in pamphlet 51.

Sun Fans.—The Sun Electrical Co. is publishing a very complete catalogue giving particulars of motor driven fans for ventilating, exhausting and blowing purposes.

Glover's Calendar.—Glover's calendar for 12 months commencing July 1 is made up to stand conveniently on a desk, or it may also be hung. The daily slips are mounted more conveniently than previously for tearing off, and a useful file to hang up is sent out with the calendar for the purpose of keeping any special extracts which may be required for reference. The arrangement is a great improvement on previous issues.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery which is not separately specified) from June 12 to 18, with the ports of destination:—

Africa—Alexandria, £369 (including £57 telegraph material); Beira, £118; Cape Town, £59; Durban, £489, and 21 tons iron telegraph poles; Kilindini, £11. *Argentina*—Buenos Ayres, £1,292 (including £915 telegraph material). *Australasia*—Auckland, £390; Bluff, £18; Christchurch, £10; Hobart, £1,298; Melbourne, £131; Napier, £37; Otago, £697; Sydney, £1,556 (including £450 telegraph material); Timaru, £366 (telegraph material); Wanganui, £450 (telegraph material). *Belgium*—Brussels, £186; Ostend, £106. *Burma*—Rangoon, £62. *Canada*—Halifax, £18; Montreal, £1,010; Toronto, £3,450. *Ceylon*—Colombo, £162. *China*—Shanghai, £4,200, (including £196 telegraph material). *France*—Boulogne, £10. *Germany*—Hamburg £15. *Gibraltar*, £21. *Holland*—Amsterdam, £166; Rotterdam, £492. *Hong Kong*, £226. *India*—Bombay, £16; Calcutta, £1,388; Madras, £603. *Japan*—Tokyo, £6; Yokohama, £25. *Malta*, £33. *Mauritius*, £34. *North Atlantic*, £286,687 (telegraph cable and apparatus). *Persia*—Balek Pappan, £93. *Russia*—Kurch, £648; St. Petersburg, £240 (telegraph material). *Seychelles*—£47 (telegraph material). *Siam*—Bangkok, £14. *Spain*—Bilbao, £75. *Straits Settlements*—Penang, £463 (telegraph cable); Singapore, £682. *Sweden*—Stockholm, £230 (telegraph material). *Uruguay*—Monte Video, £78. *U.S.A.*—New York, £66. *West Indies*—Jamaica, £295 and £991 (iron telegraph poles). Total, £309,190, against £34,272 in the corresponding week last year (June 13 to 19).

COMPANIES' MEETINGS AND REPORTS.

India Rubber, Gutta Percha & Telegraph Works Co. (Ltd.)

A half-yearly general meeting was held at the offices, Cannon-street, London, on Tuesday, for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend of 2½ per cent., or 5s. a share, free of income tax. Major L. DARWIN presided.

The SECRETARY (Mr. A. P. Crouch) having read the notice calling the meeting,

The CHAIRMAN said since the beginning of the financial year there had been a marked increase in the demand for some lines of the company's manufacture, and although others did not show an increase, and some even showed a falling off, yet the balancing of advances and shortages produced a substantial increase in their sales. While reporting this favourable feature the board were unable to state that the profit might also be accepted as proportional to this increase in sales. The shareholders, however, had an indication of the board's opinion by being asked to sanction the usual interim dividend. The price of raw material was lower, and it was probable that this lowering would be progressive, although they would doubtless have occasional set-backs. The period during the lowering of the price of raw materials was always an anxious time for the managers of an industrial concern when the price had remained high for a considerable time, owing to the fact that, where a stock of productions was kept, this stock had naturally been manufactured with high-priced materials, and could only be profitably sold if the scale of possible selling prices remained sufficiently long at the proper figures. The board had, however, had experience on different occasions of this state of things. Since he last addressed them they had secured an order for the manufacture and the laying of a submarine cable between New York and Havana. One-half of the length required was already manufactured. As they were now making motor tyres with improved machinery he hoped that their shareholders who were motorists, or who had friends who were, would make known the excellence of the Palmer cord and the Persan tyres. He was sure that, like the directors, the shareholders would be glad to see that Mr. Marsham was again seated with them. He arrived in the spring from Japan, where he would return in the autumn. The board were pleased to say that the company's manufactures enjoyed the best of reputations in Tokio and the other large cities of that country. He then referred to the excessively high rates which the company had to pay in the district where their works were situated, and said that, as far as the directors could estimate, the company were put at a disadvantage, directly and indirectly, of about £25,000 a year in comparison with works in the North of England. He had often alluded to this matter before, and intentionally, as, unless public attention were drawn to such subjects, the burden would go on increasing, with the most serious effect on industrial undertakings. The Metropolitan Water Board were asking for exorbitant Parliamentary powers, and the company and other manufacturers had been obliged to approach Parliament in opposition to the bill. He desired to refer to another matter of general interest to public companies. In reply to a communication from the Institute of Directors, the board decided that they would sign a petition in favour of the extension of the municipal franchise to joint-stock companies. In his opinion, however, the only effective additional safeguard was to be found in giving the public better means of ascertaining the facts. If the local auditors were made absolutely independent of the local authorities, if they were to report direct to the Local Government Board, and if these reports were to be published immediately in the district, more would be done towards safeguarding the interests of joint stock companies than could be effected by any system of franchise reform likely to be adopted. He concluded by moving a resolution sanctioning the payment of the interim dividend mentioned.

M. C. H. MOORE seconded the motion, which was unanimously adopted, and a vote of thanks to the chairman and directors terminated the proceedings.

BRITISH ELECTRIC TRACTION CO. (LTD.)—The net profit for the year ended March 31, after reserving £25,000 against depreciation of undertakings worked by the company, buildings and freehold land, doubtful debts and expenditure on undertakings not proceeded with, is £207,462. 0s. 3d. With this sum, which includes £17,136. 8s. 2d. brought forward, and also one-half of the remaining profits on the Bombay undertaking (£41,968. 4s. 5d.), the directors propose to pay interest on the 5 per cent. perpetual debenture stock (£73,682. 13s.) and on the 4½ per cent. second debenture stock (£23,802. 2s. 6d.) for the year, and also to pay the dividend on the 6 per cent. preference shares (£96,862. 4s.), leaving £13,115. 0s. 9d. to be carried forward. The aggregate par value of the investments in associated and other companies is £5,271,977, and they stand in the books at cost (£4,967,999). The yield for the past year has been £152,925, equal to 4⅛ per cent. on £3,275,364, cost of investments which are revenue earning. The yield shows an increase of £9,273 upon the preceding year, notwithstanding that the Brush Co., which gave a return of £13,711 for 1905, has paid no dividend for the past year. During the year investments of the cost value of £135,720, upon which no return was earned in 1905-6, have become remunerative. On the other hand, the list of unremunerative investments has been increased by shares of the cost value of £405,052. Of the latter amount the Brush Co. represents £219,957, and the balance includes South Metropolitan (£136,297) and Jarrow (£32,110), the lines of the companies having only recently been completed. The majority of the associated companies show increased profits for the past year, but

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the dividends paid by these companies have not been correspondingly increased, larger amounts having been placed to reserve or written off for depreciation. In some cases there have been additions to capital or increased rentals payable to local authorities and other like considerations affecting the net profits for the time being. The total gross profits of the associated companies, after debiting expenses, but before charging interest on capital or loans or rental of leased lines, were £539,455 in 1906, against £464,204 in 1905. During 1906, on the lines worked by the associated companies, 301,835,724 passengers were carried, and the receipts were £1,535,976, or an average of 1·22d. per passenger, and during the past six years there has been a constant downward tendency in fares, notwithstanding that with electric traction the fare stages have been extended, the speed has been increased and the general services have been markedly improved, while the capital expenditure has been considerably increased. The directors are considering means for resisting the constant demand for reduction of fares, and for obtaining an augmentation in cases where the service is unremunerative and the local circumstances permit. The report gives abstracts of some of the reports of the associated companies, but these have already appeared in *The Electrician*. The report of the Bombay Co. for the past year has not yet been issued, but the directors are informed that some of the lines were opened for working by electric traction during the past month with satisfactory results. The business of electricity supply is also developing satisfactorily. Most of the items for management and general expenses again show reductions upon those of the preceding year. The total is £48,689, compared with £54,467 in 1905-6, £61,436 in 1904-5 and £82,095 in 1903-4. The directors regret they are not able to recommend the payment of a dividend on the ordinary shares for the past year. Owing to the stringency of the money market and to the discouragement of electrical enterprise in this country, the profits earned during the past year from sources other than investments have been small. The inadequacy of the profits on the working of tramways is due mainly to the action during the past few years of municipal authorities, which has caused an increase of capital expenditure, while reducing the revenues and otherwise prejudicially affecting the enterprise and profits of companies. The Right Hon. H. O. Arnold-Forster, M.P., and Mr. P. D. Tuckett will join the board as directors.

ELECTRIC & GENERAL INVESTMENT CO. (LTD.)—The gross profit for the year to May 31 is £38,621. 12s. 3d. Deducting all general charges and interim dividends already paid on the preference and ordinary shares, and providing for proportion of final dividend accrued on preference shares, there remains £26,273. 17s. 10d. Of this the directors have carried to contingencies fund £20,273. 17s. 10d., leaving £6,000, out of which the directors recommend payment of a balance dividend of 3s. 6d. per share on the ordinary shares (£3,500), making a total distribution of 4s. 6d. per share, or 22½ per cent., for the year on these shares, and a dividend of £25 per share for the year on the founders' shares (£2,500). The trustees for the ordinary shares reserve fund propose to distribute 1s. per share out of the dividends received on the trust investments, making, with the above-mentioned balance dividend from the company, a total present distribution of 4s. 6d. per share, or, with the interim dividend already paid, 5s. 6d. for the year on each ordinary share. The trustees for the founders' shares reserve fund propose to distribute £10 per share out of the dividends received on the trust investments, making, with the above-mentioned dividend from the company, a total present distribution of £35 on each founders' share. The directors record with regret the death (on Nov. 2 last) of their late chairman, Mr. George Herring. Mr. Joseph Cecil Bull was elected a director on Oct. 1 last. The directors consider the present an opportune time for reconstructing the company, in order that the founders' shares may be extinguished and that additional capital may be raised to cope with the increasing and profitable business of the company. It is proposed to register a new company entitled the Electric & General Investment Co. (1907), Ltd., with a capital of £500,000 in £1 shares, and extraordinary general meetings of the various classes of shareholders have been called to approve the scheme of reconstruction. It is proposed to enlarge the board of the new company.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The report of the directors for the thirteen months ended 31st May, states that the net revenue, after deduction of expenses, amounts to £244,096. 15s. 11d., added to £4,499. 16s. 2d. brought forward, total £248,596. 12s. 1d. From this there has been distributed £131,769. 7s. 3d. in interim dividends, leaving £116,827. 4s. 10d. The directors now recommend the following final dividends, which on this occasion cover a period of four months to 31st May, viz.: 4s. per share, less tax, on the preference shares, making a total dividend on those shares at the rate of 6 per cent. per annum, less tax for the period of thirteen months; and 6s. 2d. per share net on the ordinary shares, making a dividend on these shares at the rate of 5¾ per cent. net for the year which formerly ended 30th April, plus 8d. per share in respect of the month of May, representing one-third of the interim dividend of 2s. usually paid in the first quarter of the new financial year. These dividends will absorb £90,261. 12s. 4d. and leave £26,565 12s. 6d. to be carried forward.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

COOPER & CLEGG (LTD.) (93,658.)—Reg. June 8, capital £2,000 in £1 shares, to acquire the business of Cooper & Clegg, and to carry on the business of electricians, electric light and power and mechanical engineers, manufacturers of and dealers in motor cars and waggons, makers of electrical apparatus, &c. First directors, J. K Cooper and H. H. Clegg. Reg. office, 34, Pall Mall, Manchester.

HANKOW ENGINEERING DEVELOPMENT SYND. (LTD.) (93,676.) Reg. June 10. Capital £1,000, in 5s. shares, to acquire and develop property and rights of all kinds and to carry on the business of electrical and mechanical engineers and contractors, suppliers of electricity, constructors of railways, tramways, waterworks, &c.

TRAMWAY SUPPLIES (LTD.) (93,698.) Reg. June 11. Capital £10,000, in £1 shares, to adopt an agreement between S. Dixon & Son (Ltd.), and to carry on the business of manufacturers of, agents for and dealers in electric tramway materials, tramcar trucks, motor equipments, car fittings, and all tramway specialities and requisites, &c. W. H. Turner is first managing director. S. Dixon & Son may appoint two directors, one of whom shall be chairman. Registered office, 31, Swinegate, Leeds.

TURBINE CORPORATION (LTD.) (93,753).—Reg. June 15, capital £150,000 in £1 shares, to carry on the business of turbine motor and engine manufacturers, mechanical engineers, machinists, electricians, founders, millwrights, tube makers, commission agents, &c.

MORTGAGES AND CHARGES.

ERNEST P. MOY (LTD.)—Particulars of £3,000 debentures, secured by a trust deed dated May 23, 1897, have been filed. The trust deed has also been registered. Property charged: Leasehold premises in Greenland-place and Bayham-street, N.W., and the company's undertaking and property, present and future, including uncalled capital. Trustees, J. Dyer and E. F. Moy.

MAXIM ELECTRICAL CO. (LTD)—Issue on June 11 of £1,100 5 per cent. debentures, part of series created by resolutions of May 16 and Nov. 29, 1906, to secure £15,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £11,200.

NEWQUAY ELECTRIC LIGHT & POWER CO. (LTD.)—Issue, on May 30, of a £100 5 per cent. debenture, part of series created June 30, 1906, to secure £4,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £3,600.

A. REYROLLE & CO (LTD.)—Issue of June 6 of £12,900 5 per cent. debentures, part of series created April 17, 1907, to secure £20,000 charged on the company's undertaking and property, present and future, except uncalled capital. No trustees. No previous issue of same series.

CITY NOTES.

MEMORANDA (June 20).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 30 1/16d.—31 1/16d. per oz. Consols 83¼—83⅜ for money, 83⅜—83½ for account; 2½ per cent. annuities 81½—82. Consols Pay Day, July 3; Stocks and Shares Continuation Days, June 25 and July 10, Ticket Days, June 26 and July 11; Pay Days, June 27 and July 12; Mining Share Carry-over Day, June 24.

SAO PAULO TRAMWAY, LIGHT & POWER CO.—The directors have declared a quarterly dividend of 2 per cent.

STOCK EXCHANGE NOTICE.—The Stock Exchange Committee have appointed June 26 a special settling day in a further issue of 175,000 £1 fully-paid preference shares of the *Victoria Falls Power Co. (Ltd.)* The committee have been asked to grant a quotation to a further issue of 2,000 £5 fully paid ordinary shares of the *British Aluminium Co. (Ltd.)*

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—On another page will be found an abridged prospectus inviting subscriptions to an issue of £300,000 4½ per cent. debenture stock of this company at par, redeemable at par in 99 years, or at any time on six months' notice at £105 per cent. Interest is payable half-yearly, in January and July. The company has an authorised capital of £1,000,000, of which £700,000 is subscribed and paid up, in addition to £164,247 5 per cent. debenture stock (which will be redeemed out of the proceeds of the present issue). This stock constitutes the first floating charge on the entire undertaking and assets of the company. The net profits for the year to March 31, 1906 (before the deduction of debenture interest), amounted to £78,982, or sufficient to pay the interest on the present issue of £300,000 nearly six times over, without taking into account the revenue anticipated from new business which the present issue will enable the company to undertake. The particulars contained in the prospectus of the company's operations for the past four years, 1903-1906, show a regular progressive increase in gross revenue, in net profit, and in the amount carried to reserve, while the dividend on the ordinary shares for the period has increased from 7 per cent. in 1903 to 8 per cent 1904-5-6, and the prospectus states that for the year to March 31, 1907 (the final figures being not yet available), the directors feel justified in stating that the profit will be greater than for the previous year. The company's reserve funds on March 31st amounted to £175,000. The demand upon the company's system has been greater than the capital available has been able to meet, and the new capital will be applied to meet this demand and to enable the company to afford increased facilities to telephone subscribers in the River Plate. Not the least important point in connection with the company is the constitution of the board of directors. Mr. John Irving Courtenay is chairman and managing director of the company, and is a leading figure in electrical circles: Mr. George Keith (as chairman also of the Chili Telephone Co.) has extensive knowledge of the telephone requirements of the River Plate; Mr. John Gavey, C.B., the late engineer-in-chief of the British Post Office, has recently joined the board, and is a specialist in telephone work; and Mr. Frederick Green and Mr. A. Le Rossignol complete a particularly strong directorate. The subscription list opened yesterday (Thursday) and will close on or before Wednesday next, June 26.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 12	1,477	- 7	‡2	2,424	- 322
Airdrie	,, 7	218	- 18	22	4,944	+ 7
Anglo-Argentine	,, 17	16,202	+ 2,516	24	396,529	+ 37,260
Ashton-under-Lyne Corp	,, 15	381	+ 13	12	4,680	+ 503
Ayr Corporation	,, 15	286	- 72	5	1,272	- 119
Baker St. & Waterloo Ry.	,, 15	2,490	+ 1,001	14	33,270	+ 12,934
Barnsley	,, 7	156	- 63	22	3,579	- 82
Barrow	,, 7	240	- 203	22	5,119	- 56
Bath Electric Trams, Ltd.	,, 12	810	- 89	24	17,510	- 54
Birkenhead Corporation	,, 16	1,043	+ 32	...	...	...
Birmingham Corporation	...	...	...	...	...	...
Birmingham & Mid.	May 31	741	...	21	16,563	...
Blackburn Corporation	June 12	1,090	- 32	§11	12,720	+ 695
Blackpool Corporation	,, 13	784	- 1,395	10	9,193	- 1,404
Blackpool and Fleetwood	...	...	...	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 16	2 161	- 153	11	24,752	+ 696
Bournemouth Corporation	,, 12	1,566	- 137	¶10	17 480	+ 40
Bradford Corporation	,, 15	4,901	+ 298	11	50,807	- 160
Brighton Corporation	,, 16	857	- 100	11	9,680	- 855
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 14	5,104	- 169	18	88,107	- 3,970
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 15	1,261	+ 54	11	12,123	- 102
Burton Corporation	...	...	...	...	...	...
Bury Corporation	May 26	1,513	...	9	9,521	...
	June 2	1,218	...			
Calcutta Tramways Co.	,, 15	R16,222	+ R3,580	23	₹1,121,465	+ R22,068
Camborne-Redruth	,, 15	110	- 101	24	2,747	- 32
Cardiff Corporation	,, 15	2,085	- 20	11	22,681	- 4
Cavehill	,, 7	66	- 61	22	1,629	+ 15
Central London Railway	,, 15	5,812	- 745	24	146,152	- 15,224
Chatham & Dist. Lt. Rys.	,, 13	808	+ 155	¶23	15,884	+ 1,169
City & South London Rly.	,, 16	3,069	+ 451	24	71,225	+ 3,533
City of Birmingham	,, 7	2,797	...	22	61,082	...
Cork Electric Trams Co.	,, 13	488	- 116	24	10,267	- 348
Croydon Corporation	,, 14	1,486	- 32	‡11	15,406	- 1,118
Devonport & Dist. Trams.	,, 7	454	- 165	22	9,818	+ 66
Dover Corporation	,, 15	218	- 24	11	2,400	- 250
Dublin & Lucan Railway	,, 14	134	+ 2	24	2,485	- 12
Dublin United	,, 14	6,157	+ 498	†24	120,645	+ 7,142
Dudley Stourbridge	,, 7	786	- 908	22	18,323	+ 388
Dundee Corporation	,, 12	1,158	+ 17	4	4,470	+ 129
East Ham Council	,, 13	906	- 17	11	9,964	- 333
Exeter Corporation	,, 14	313	...	11	3,111	.
Falkirk and District	...	...	...	...	...	...
Gateshead & Dist. Trams.	,, 7	992	- 141	22	21,904	+ 723
Glasgow Corporation	,, 15	18,102	- 270	2	38,949	- 4,727
Glossop	,, 15	137	- 1	24	3,236	+ 65
Gravesend—Northfleet	,, 7	223	- 163	22	5,066	+ 61
Great Northern & City Rly.	,, 15	1,767	+ 72	24	43,592	+ 223
Gt. Northern, Piccadilly, &c.	,, 15	4,500	...	24	94,029	...
Greenock & Port Glasgow	,, 7	648	- 175	22	14,138	+ 88
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 7	270	- 182	22	5,789	- 336
Hastings Elec. Trams Co.	,, 13	1,011	+ 359	24	20,598	...
Hong Kong	,, 15	$8,343	+ $1,110	11	$181,821	...
Huddersfield	,, 15	1,618	+ 136	11	17,396	+ 574
Hull Corporation	,, 15	2,478	+ 213	11	25,989	+ 1,150
Ilford District Council	,, 8	471	- 267	11	5,261	- 279
	,, 15	476	- 10			
Ilkeston District Council	,, 12	143	+ 17	11	1,550	+ 139
Ipswich Corporation	,, 15	407	...	11	423	- 351
Isle of Thanet Co.	,, 15	617	+ 12	37	12,232	+ 168
Jarrow	,, 7	110	...	22	2,563	...
Keighley Corporation	,, 13	168	+ 14	50	7,575	+ 515
Kidderminster & District	,, 7	102	- 188	22	2,291	- 129
Kilmarnock Corporation	,, 15	175	+ 15	4	745	+ 25
Lanarkshire Trams Co.	,, 13	1,263	+ 313	24	25,962	+ 5,511
Lancashire United	,, 12	1,338	- 26	21	28,186	+ 7,670
Leamington	,, 7	152	- 187	22	3,257	- 214
Leeds Corporation	,, 15	6,726	+ 353	11	70,936	+ 2,593
Leicester Corporation	,, 15	2,332	+ 4	24	52,613	+ 5
Leith Corporation	,, 8	512	- 55	‡5	2,377	- 75
	,, 15	549	+ 23			
Lincoln Corporation	,, 15	110	- 3	11	1,247	- 76
Liverpool Overhead Rly.	,, 16	1,513	+ 73	24	34,413	+ 461
Liverpool Corporation	,, 8	10,988	- 1,517	23	242,596	+ 3,228
*London County Council	,, 8	31,524	+ 805	10	304,670	+ 41,789
London United	,, 14	7,275	- 277	†24	139,957	+ 2,907
Lowestoft	,, 15	192	+ 35	37	5,791	+ 749
Maidstone Corporation	,, 15	102	- 22	11	1,150	- 70
Manchester Corporation	,, 15	14,874	- 901	11	159,203	+ 12,749
Mersey Railway	,, 15	2,070	+ 258	24	44,223	+ 2,265
Merthyr	,, 7	188	- 98	22	4,568	+ 231
Metropolitan Dist. Railway	,, 16	8,516	+ 164	24	189,489	- 3,898
Metropolitan Elec. Trams.	,, 7	4,380	- 1,062	22	93,237	+ 20,775
Middleton	,, 7	303	- 290	22	7,493	+ 178
Nelson Corporation	,, 15	151	+ 8	12	1,730	+ 53
Newcastle-on-Tyne Corp.	,, 15	4,061	+ 271	11	44,389	+ 1,052
Newport (Mon.)	,, 15	816	+ 232	11	8,318	+ 1,416
Northampton Corporation	,, 14	432	- 6	‡11	4,673	- 166
Oldham, Ashton & Hyde	,, 7	548	- 176	22	13,159	+ 800
Oldham Corporation	,, 16	1,805	+ 77	12	23,010	+ 1,654
Perth (N.B.) Corporation	,, 12	158	- 3	4	647	- 15
Perth (W.A.) Elec. Trams.	,, 14	1,325	- 126	21	34,909	- 1,046
Peterborough	,, 7	105	- 116	22	2,530	- 40
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 15	1,917	- 329	11	20,723	- 768
Potteries	,, 7	1,983	- 172	22	41,257	+ 785
Preston Corporation	,, 12	735	- 1	11	8,242	+ 114
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 13	610	+ 127	†11	6,974	+ 870
Rothesay	,, 7	174	- 128	22	2,228	- 85
Salford Corporation	,, 17	4,561	+ 243	11	52,188	+ 1,058
Sheerness	,, 5	57	- 31	22	1,149	- 36
Sheffield Corporation	,, 16	5,538	+ 551	12	65,773	+ 2,737
Singapore Trams	,, 15	$9,514	+ $2,280	11	$107,337	+ $19,259

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	June 12	377	- 34	11	3,636	- 197
South Metropolitan	,, 7	805	+ 147	22	16,101	- 147
Southport Tramways	,, 7	287	- 375	22	5,789	- 277
South Staffs	,, 7	830	- 464	22	19,688	+ 1,378
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 9	1,384	- 596	11	15,078	- 147
	,, 16	1,445	+ 172			
Sunderland and District	,, 12	453	+ 20	21	10,105	+ 1,215
Swansea Trams	,, 7	827	- 391	22	18,293	+ 455
Swindon Corporation	,, 12	169	- 5	...	...	...
Taunton	,, 7	39	- 25	22	903	- 71
Tynemouth and District	,, 7	199	- 333	22	4,001	- 601
Tyneside Trams Co.	,, 12	445	- 15	24	9,805	+ 565
Victoria, Elec. Supply Co. of	May 12	780	+ 67	7	6,793	+ 691
Wallasey District Council	June 15	844	- 28	11	8,918	+ 148
Walsall Corporation	,, 16	526	+ 39	24	11,543	- 527
Warrington Corporation	,, 13	393	+ 23	11	4,187	+ 147
West Ham Corporation	,, 13	2,378	+ 99	11	26,088	+ 949
Weston-super-Mare	,, 5	98	- 250	22	1,456	- 30
Wolverhampton Co.	,, 7	418	- 400	22	9,730	+ 270
Wolverhampton Corpn.	,, 12	837	...	21	18,833	...
*Worcester	,, 7	273	- 192	22	5,711	- 141
Wrexham	,, 7	95	- 50	22	2,167	- 34
Yorkshire W.R. Trams	,, 16	1,093	+ 325	24	26,579	...
Yorkshire Woollen District	,, 7	903	- 441	22	20,789	+ 67

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., June 19.	Rate % Yielded.	Dividend Due.	Business Week to June 19. High-est.	Business Week to June 19. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	7⅞—8⅜	4 15 6	Ap, Oct	8 1/16	7 31/32
5	2/9	Do. 5½ per Cent. Cum Pref.	5 1/16—5 1/8	4 12 9	Ja, Jul	5⅛	5 1/16
St.	6⅔	Do. Permanent 6⅔ Deb. Stock	135 —136	4 8 8	Ju, Dec	134	..
St.	5⅔	Auckland Elec. Trams. 5⅔ Deb. (red.)	101 —107	4 13 6	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	2 15/16—3 3/16	3 2 6	May ..	3 1/16	3
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	My, Nv	4 15/16	4 13/16
St.	4¼	Do. 4¼ per Cent. Db. Prov. Certs.	98 —102	4 8 0	Ja, Jul	..	..
St.	7⅔	British Columbia El. Ry. Df. Ord.	123 —127	4 14 3	Mr, Spt	123	..
St.	6⅔	Do. Pref. Ord. Stock	103½—108½	4 12 0	My, Nv	..	..
St.	5⅔	Do. 5⅔ Cum. Perp. Pref. Stock	102 —1 6	4 14 3	Ja, Jul	..	..
40	4½⅔	Do. 4½ per Cent. 1st Mort. Debs.	99 —101⅔	4 8 0	Ap, Oct	..	..
100	4½⅔	Do. Vancouver Power Debs.	103 —1 5	4 5 6	Ja, Jul	3 31/32	3 31/32
5	3/0	Buenos Ayres & Belgrano Ord.	8 1/16—8 1/8	3 14 0	Ap, Oct	8 1/16	8 1/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4 1/16—5 1/16	5 11 6	Ap, Oct	..	..
5	3/0	Do. "B"	4 1/16—5 1/16	5 14 0	April ..	..	..
St.	5⅔	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5⅔	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	Ja, Jul	..	..
St.	5⅔	Buenos Ayres Elec. Trams. (1901) Ltd.	95 —100	5 0 0	Ja, Jul	..	..
10	5½⅔	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	100 —104	5 5 9	Ja, Jul	..	..
100	6⅔	Do. 6 per Cent. 1st Deb. Bonds.	100 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7 1/16—7 3/16	5 3 0	Mr, Spt	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5 1/16—5 3/16	4 7 0	Ja, Jul	5 1/16	..
1	4½⅔	Do. 4½⅔ 1st Deb. Stock (red.)	104 —107	4 4 0	Ja, Jul	104½	..
St.	..	Cape Electric Tram Shares	3/16—7/16	..	..	7/16	..
..	5⅔	Colombo Tr. & Ltg. 5⅔ 1st Mt. Db.	96 —100	5 0 0	My, Nv	..	..
1	6⅔	Havana Elec. Ry. Con. Mt. 5⅔ $1,000 50 year Coup. Bds.	85 —90⅔	5 11 0	Fb, Aug	..	..
10	5⅔	†Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
5	6⅔	† Do. 6 per Cent. "B" Ditto	78 —82	7 6 0	Ja, Jul	81½	..
5	1/0	Lisbon Elec. Trams. Ord.	1 1/16—1 1/8	3 12 9	July .	..	..
100	7⅛	Do. 6 per Cent. Cum. Pref.	1 7/8—1 15/16	5 1 0	Ja, Jul	..	..
St	5⅔	Do. 5 per Cent. Reg. Mort. Deb	98 —101	4 19 0	Ja, Jul	..	..
St.	5⅔	Madras Elec. Trams. 5⅔ Deb Stk.	98 —101	4 19 0	Ja, Jul	..	..
St.	4½⅔	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	..	..
St	6⅔	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	Ja, Jul	..	..
.	$5	Sao Paulo Tramway, Light & Power Co. $100 Stock	123 —128	3 2 6	..	..	..
..	5⅔	Do. 5 per Cent. 1st Mt. $500 Db	92⅔—94⅔	5 6 6	Ju, Dec	92¾	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6⅔ Cu. Pr.	4¾—5 1/16	5 14 0	Mr, Spt	..	..
10	3/1½	Bombay E. S. & T. 6⅔ Cm. Pf. £8 pd.	7⅞—8⅛	5 15 0	..	..	..
St.	4½⅔	Do. 4½ per Cent. Deb. Stk. (red.)	95 —98	4 11 9	Ja, Jul	..	..
5	5/3	Calcutta Elec. Supply Ord.	7½—8½	5 2 0	Ap, Oct	..	..
5	2/3	Do. £4 paid	6 —7	..	..	..	..
50	5⅔	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2¾	..	Fb, Aug	..	..
St.	5⅔	Do. 5 per Cent. Deb Stock	85 —92	5 8 6	Ja, Jul	..	..
St.	5⅔	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	97 - 99	5 1 0	Ja, Jul	..	..
St.	6⅔	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	196 —199	5 10 0	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	31/32—1 1/32	..	Ap, Oct	..	..
St.	5⅔	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½—97½	5 2 6	Ap, Oct	95¾	..
1	1/6	Raud Electric	1 1/16—1 1/8	..	..	..	..
1	0/6	River Plate Electricity Co. Ord.	3/4—7/8	..	April ..	..	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	7/8—1	6 0 0	May ..	31/32	..
St	6⅔	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	Ja, Jul	98½	..
5	3/0	Rosario Elec. Co. 6⅔ Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	..	..
..	5⅔	Shawinigan Water & Power 5 per Cent. Deb. Sts., Scrip	100 —102⅔	4 13 0	Ja, Jul	101	1 0

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption, † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., June 19.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 19. High- est.	Low- est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 – 11	6 6 0	Mar, Sept,	..	..
10	4/8	Do. 4½ per Cent. Cum. Pref.	9⅝–10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10 – 10⅛	5 14 0	Feb, Aug	10⅜	10⅜
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	101 – 104	4 6 6	Jan, July.	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜–5⅛	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 –100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅜–8⅜	5 14 6	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅛– ⅞	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4½ Guar. Db. Stock	19 – 1/2	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	2¼– 3⅜	6 13 8	Feb, Aug	..	..
5	2/3	Do 4⅜ per Cent. Pref.	4 – 4¼	5 0 0	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 2 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜– 4½	6 9 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3⅜– 4½	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	103 – 106	4 5 0	June, Dec	103	..
10	7/0	City of London Electric Lighting Ord...	9½ – 9⅞	6 3 0	Feb, Aug	9 15/16	9¼
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅞ – 12½	4 18 0	Jan, July	11 15/16	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 –124	4 0 9	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.	4⅛– 4⅜	3 0 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜– 5	4 10 0	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅞– 8⅛	5 17 6	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10⅜–11½	5 4 0	Mar, Sept	11 5/16	11 5/16
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)....	1 6 –119	4 2 6	Jan, July	106½	1 6
St.	4½%	Do. Second Deb. Stock Prov. Certs....	98 – 66	4 18 9	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord	4⅜–5⅜	5 2 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 11 0	Mar, Sept	5	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	99 –101	4 9 0	Feb, Aug	..	..
5	5 0	Hove Electric Lighting Ord.	7 –7⅛	6 0 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8½–9⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½– 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 – 100	4 0 0	..	..	..
St.	4%	Kensingtn. & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	101 – 103	3 17 9	April, Oct	..	..
3	2 4⅓	London Electric Supply Ord.	1⅞–2⅛	5 13 0	Mar, Sept	..	..
5	3 0	Do. 6 per Cent. Pref.	4⅜–5⅛	5 14 0	Mar, Sept	5	..
St.	4%	† Do. 4 per Cent. 1st Mort. Deb.	93 – 96	4 3 8	Jan, July	94½	94
5	4/0	Metropolitan Electric Sup. Ord.	6 – 6⅛	6 3 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	106 –109	4 2 9	June, Dec	..	..
St.	3½	Do. 3½ per Cent. Deb. Stock (red.)	90 – 93	3 15 8	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 – 98⅞	4 11 9	June, Dec	97	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9⅛–9⅜	4 17 1	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	101 –103	4 8 3	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7⅜–7¾	5 11 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛–5⅜	4 10 1	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	99 – 100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½	Do. 4½ per Cent. Deb.	100 –101	4 10 0	Jan, July	..	..
10	9 0	Notting Hill Electric Ord.	12 – 13	5 15 0	March ..	..	..
5	4 6	Oxford Electric Ord.	6 – 6⅛	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 – 98	4 1 6	Jan, July	..	..
5	5 0	St. James' & Pall Mall Elec. Ord.	7⅜–7⅝	6 1 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅞– 7⅛	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	88 –90⅜	3 15 8	Jan, July	..	..
5	.	Smithfield Markets Electric Sup. Ord...	1¼–2⅛	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 – 77	5 4 0	Feb, Aug	..	..
5	3 0	South London Electric Supply Ord.....	2 – 2⅛	6 12 0	April ...	2 1/16	2
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅞–1	3 6 9	..	..	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.....	1⅛–1⅜	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 –103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1¼–2⅛	8 18 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	2⅜– 3⅛	7 3 0	April, Oct	3 1/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
[illegible]	6 6	Westminster Elec. Sup. Ord.	9⅛ – 9⅜	6 8 0	Mar, Sept	9 1/16	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛–5⅜	8 13 8	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. Stk.	90 – 95	4 4 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜– ⅞	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜– 1	5 0 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	April, Oct	96½	96
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 – 99	4 11 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14½–14¾	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	9 –9½	4 5 0	..	..	..
St.	4%	Do. 4 per Cent. Debs.	100 – 102	3 18 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅛– 2⅜	..	June, Dec	3⅛	2 15/16
10	£/0	Do. 6 per Cent. Cum. Pref.....	6⅞– 7	8 11 6	Feb, Aug	7 1/16	6 15/16
St.	5%	Do. 5 per Cent. Perpetual Debs.	102 – 105	4 15 3	April, Oct	103	1 1/2
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 –81	5 11 0	May, Nov	..	..
St.	4%	Central London Ordinary Stock..	78 – 75	5 6 9	Feb, Aug	75	73
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	Feb, Aug	93⅜	92½
St.	4%	Do. Deferred Stock	53 – 56	7 2 8	Feb	54½	53½
100	4%	Do. 4 per Cent. Debs.	103 – 106	3 15 6	Jan, July	..	..
St.	4%	†Charing X. Euston & Hmpstd Per. Db. Stk.	80 – 83	4 16 6	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 – 101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	44 –46	4 7 0	Feb, Aug	44⅜	42½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ..	117 –121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1890)	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 –105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½– 14½	4 2 9	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Pref.	13 – 14	4 5 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2 – 2⅜	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock	83 – 85	4 14 6	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db. St	93 – 101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	11 –11½	5 6 6	Mar, Sept	..	..
St.	4%	‡ Do. 4½ per Cent. Debs.	99 – 101	4 9 0	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref	1 – 1⅛	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 – 73	5 9 6	Jan, July	..	..
St.	47/6	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 –98	..	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.....	1⅜–1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 –90	4 9 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜–7⅝	5 14 3	Jan, July	8 1/16	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 85	4 11 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 –4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅜– ⅝	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝– ⅞	5 3 0	Feb, Aug	⅞	⅝
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 – 99	4 11 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref	⅞– 1⅛	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	13/16– 1⅛	6 8 0	April, Oct	7/8	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 – 7/8	6 13 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock	95 – 98	4 11 9	May, Nov	..	..
1	3/6d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅜–1/16	5 16 6	Feb, Aug	..	..
St	36/3½	Do. 4 per Cent. Deb. Stock	82 – 86	4 13 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	86 –90	5 11 0	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London...	67 – 70	7 8 0	June, Dec	67½	65
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1¼ 1⅝	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛–3½	—	..	3⅜	3⅛
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 –93	4 16 9	Jan, July	..	..

SHARE	LAST DIVIDEND	NAME.	Price Wed., June 19.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 19. High- est.	Low- est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	5/16–⅜	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜–½	8 0 0	April, Oct	..	..
1	9/4⅓	Babcock & Wilcox Ord.....	3½–4	5 0 0	April, Oct	3 15/16	3 13/16
1	0/7⅛	Do. Pref.....	1 5/16–1⅜	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¼–6⅝	7 8 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅜– 6⅛	4 16 0	Jan, July	5⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 –1 5	4 5 9	Jan, July	..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	92 – 96	4 14 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	Feb, Aug	1⅛	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	63 – 67	5 19 3	Jan, July	..	..
2	..	Bruch Electrical Engineering	⅛–⅜	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜– 1½	4 16 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	84 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	75 –78	5 14 6	Jan, July	..	..
5	10 0	†Callender's Cable Con. Ord. xd & bonus	9⅛ – 10⅛	7 2 6	Jan, July	10	9⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛– 5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106⅛–108½	4 3 0	Nov, May	..	..
1	0/0⅔	Castner-Kellner Alkali Co.	1⅛–1½	6 0 0	May, Nov	1 3/32	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	Feb, Aug	98	..
1	1/2½	†Chadburn's (Ship) Telegraph Ord.	1⅛–1⅜	8 0 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1 5/16	5 4 0	April, Oct	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 64,000).....	1⅛– 2⅛	3 12 9	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96⅞–99⅞	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1 5/16–1⅝	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 5/16– 1⅜	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 – 105	4 5 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1 –1⅛	10 2 0	Feb, Aug	1⅛	..
5	3/2	Do. (£5 paid)	2⅛–2⅜	4 11 6	Feb, Aug	—	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	85 – 87	4 12 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 –92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅞–1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1⅛– 2⅛	..	May, Nov	1 1/16	1⅛
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	78 – 83	5 8 0	Jan, July	..	..
2	..	Electric Construction Co.....	⅜– ⅝	..	Jan, July	⅝	..
2	2/9⅓	Do. 7 per Cent. Cum. Pref.	1⅛– 1⅜	8 0 0	July	1⅜	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	79 – 83	4 16 3	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref....	8⅛ 8⅝	5 14 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11½ – 12⅛	6 0 0	Feb, Aug	11⅛	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5⅛	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 –107	4 4 0	Mar, Sept	106⅜	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15 –16	6 5 0	Feb, Aug	..	..
10	4%	Do. 4 per Cent. Debs. (red.).....	97 –99	4 1 0	April, Oct	..	..
1	1/2⅔	Richardsons, Westgarth & Co., Ltd. Ord.	⅜– ⅝	7 6 0	Nov	⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅝–1	6 0 0	May, Nov	..	..
St.	4½%	Jo. 4½ per Cent. Perp. Deb. Stock ...	97 –100	4 10 0	Jan, July	—	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	30½–31⅛	5 14 3	Mar, July	31⅛	30⅛
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	101 – 104	3 16 6	Jan, July	102	1 1/8
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛–2⅜	6 6 6	..	2⅜	2 3/32
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜–1 7/8	4 1 0	..	1 7/8	1 13/16
St.	5%	Do. 5 per Cent. non-Cum. Preferred	113 –116	4 6 0	..	114½	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 –104	3 17 0	June, Dec	102½	..
100	4½%	† Do. 4½ per Cent. 2nd Mort. Deb. (red.)	1 3 –105	4 5 6	June, Dec	104	103
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½–10	5 0 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	1⅛–1⅜	..	Apr, Oct	1⅜	1 1/16
5	..	Do. 6 per Cent. Cum. Pref.	1⅛–4	..	Apr, Oct	3/8	3⅛
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	77 – 81	4 18 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 –91	5 10 0	June, Dec	..	..
St.	15/0	Anglo-American	61 – 63	6 3 0	F, My, Ag, N	..	..
St.	30/0	Do. Preferred	107⅛–108	5 11 0	F, My, Ag, N	108⅛	107⅞
St.	13%	Do. Deferred	19⅜–19⅝	4 9 0	F, My, Ag, N	19⅝	19½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 – 94	4 5 0	Jn, Ap, Jy, O	95⅛	92½
10	5/0	Cuba Submarine Ord.....	7⅜– 8⅛	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent	15⅜–16⅛	5 19 8	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅛– 3⅜	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅜– 9⅛	5 8 0	April, Oct	..	..
5	4½%	Do. 4½ per Cent. Deb.....	100–103⅝	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	1⅝–1⅞	5 17 6	Ja, Ap, Jy, O	15/16	15/16
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	..	..
St	£5/0	Eastern Ordinary	138⅜–140½	4 19 6	Ja, Ap, Jy, O	140⅜	138
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 –91	3 17 0	Ja, Ap, Jy, O	91	8 ½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104⅛–106⅛	3 15 0	May, Nov	106	..
10	6/6	Eastern Extension	13⅜–13⅝	5 3 0	Ja, Ap, Jy, O	13 7/16	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock	101½–106⅛	3 15 0	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	98⅞–100⅞	4 0 0	May, Nov	..	..
10	3/0	G.N. (of Copenhagen), with Coupon 70..	24 –26	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 –102	4 8 0	June, Dec	..	..
25	1/2/6	Indo-European.....	56 – 58	5 12 0	May, Nov	..	..
100	4%	Mackay Companies Common	68 –70	5 14 0	Jan, July	..	..
100	4%	Do. Preference	67 –70	5 14 0	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅝–¾	..	April	23/32	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Db. (red.)	99⅛–100⅜	3 19 6	June, Dec	..	..
10	4/0	†West African Telegraph Shares	10 –10⅛	3 16 0	June, Dec	..	..
2½	1/8	West Coast of America	1⅛– 1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1 5/16–1⅜	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅞– 7⅞	7 12 0	May, Nov	7⅞	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅞– 7⅛	..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	100 – 103	4 17 0	Jan, July	..	..
10	3/0	Western Telegraph	14 –14½	4 16 6	Mr, Jn, O, D	14½	13⅞
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 –105	3 16 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 – 94	4 5 0	Jan. July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 – 101	4 19 0	Mar, Sept	..	..
5	3 0	Chili Telephone	6⅞– 7⅛	5 11 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	⅝– 1⅛	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅝–1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	108 –110	5 9 0	Feb, Aug	109	108¾
St.	4½%	Do. Def. Stock.....	105 –107	6 2 6	Feb, Aug	106½	106
10	£/0	Do. 6 per Cent. Cum. 1st Pref.	11½–13½	4 9 0	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛–6⅜	4 10 0	Feb, Aug	..	..
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	96½–97½	3 11 9	June, Dec	97	96⅞
St	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 0	Jan, July	102	101½
1	0/9⅜	Oriental	1⅛– 1⅜	4 17 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 16 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 – 98	4 2 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	99 – 102	4 7 0	Jan, July	..	..
[illegible]	3/0	United River Plate.....	6⅞–7⅛	5 9 6	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	4 11 0	June, Dec	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	108⅛–111⅛	4 9 9	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	4 – 5	6 0 0	Jan, July	..	..
10	2 0	Globe Telegraph & Trust.....	10⅝ – 11⅛	4 19 0	Ja, Ap, Jy, O	11⅛	11
10	3/0	Do. 6 per Cent. Pref.	13⅜–14⅛	4 6 0	Ja, Ap, Jy, O	14⅛	13⅞
10	6%	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

The Power Scheme of the L.C.C.

To many people it will come as a surprise that the Hybrid Committee, to which the Electric Supply Bill of the London County Council was referred, have found that the preamble of the Bill has not been proved; though to those who have some knowledge of politics it may appear a somewhat natural conclusion, even though the Committee did not trouble to hear the evidence in opposition to the Bill. It is the general opinion that this fiasco has been caused by those who consider that the Council should not seek to lease its powers, and who go so far as to prefer no scheme at all to one that would be worked by a company. Opinions may differ as to the desirability of establishing a large scheme for a general supply, and we confess we are inclined to the view that it is unnecessary, but it is to be regretted that a matter of this kind, which is supposed to be of urgent importance, should be made a question of politics. As it is, another year must pass before a similar Bill can be introduced, and the waste of money of ratepayers and others in promoting schemes for the consideration of Parliament continues. It is to be hoped that the London Electric Supply Bill, which has been introduced by the principal supply companies of London, will not share a similar fate.

The Incorporated Municipal Electrical Association.

ELSEWHERE we give an account of the Annual Convention of the Incorporated Municipal Electrical Association, which is now being held at Sheffield, and which terminates to-day. All the Papers that are being read at the Convention this year have been written by engineers, as distinct from members of electricity supply committees; but as the majority of the Papers are not of a highly technical nature the discussions have not been lacking in interest to the numerous municipal committee members present. The social side of the Convention was well provided for, but visits to works in the neighbourhood were given a less prominent position than usual. One of the great advantages of these Conventions is the opportunity which they provide for enabling engineers to talk over new schemes and to obtain new ideas on difficulties which they may have encountered during the previous twelve months. These private discussions, although not forming part of the official programme, are probably equally important in influencing the future policy of those taking part in them.

THE presidential address delivered by Mr. FEDDEN at the opening of the Convention was principally of interest to municipal engineers. Among the subjects dealt with was that of the present policy of the Local Government Board. It will be remembered that the Board for some time past has insisted on the municipal electricity departments allocating the wages of their permanent employés to revenue accounts in all cases, even when employed on extensions which are to be paid for out of capital. Local authorities have strongly objected to this regulation, and the Council of the I.M.E.A. have endeavoured to send a deputation to the President of the Local Government Board to put the case of the municipalities before him, but all to no purpose. A refusal to receive any such deputation has been the only result, and as a last resource the point is to be

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brought forward in Parliament when the Local Government Board estimates are presented. The carrying out of extensions by a municipal staff offers, in certain cases, advantages over the alternative of allowing the work to be done by contract, but the present policy of the Local Government Board will probably lead in many cases to the latter method. This is scarcely what was expected from the present head of the Department, but possibly he is of the opinion that any other course would lead to difficulties, and that while, in the case of small extensions, the question is unimportant, where large sums are involved it is preferable that such work should be done by contract.

Voltage Regulators.

THE use of the Tirrill voltage regulator, as suggested in Mr. ACLAND'S Paper before the I.M.E.A., given elsewhere in abstract, would appear to materially assist the solution of the supply problem to outlying districts, especially from small stations. The discussion of the Paper elicited a number of important comments upon the possible combination of the regulator with cheaper generators and separately excited continuous-current machines. These proposals, however, though perfectly feasible, could only be seriously acted upon with an absolutely reliable regulator, as failure would cause serious trouble with the maintenance of even a fairly constant voltage. Mr. FEDDEN, who was able to speak well of the regulator after three years' use, still regarded a man to watch it as a necessity. The principle and main details of the device are admirable, but the most vital parts are the relay contacts, and the question of the reliability of these occasioned the greatest comment. The behaviour of silver and platinum appears to vary considerably, and apparently no serious research has been made to acquire definite data giving the conditions under which the respective metals should be used. The general utility of such a device appears to be sufficiently well established to merit some investigation to be conducted, if not by the makers themselves, then by the National Physical Laboratory. The apparatus, judging by its use, does not appear to be one of those refinements which are frequently not worth paying for. Further, the question is hardly one of cost of contact renewals—in Mr. ACLAND'S case 8s. per annum is given—but of reliability under working conditions. This must take precedence of all other considerations, and, in the selection of the correct metal for the contacts, reliability should be kept well in view. No speaker suggested the operation of the contacts in vacuo. We have seen this done recently on a regulator in a cotton mill installation but were unable to ascertain any details of the operating life of the contacts. A representative of the makers of the Tirrill regulator informed us that no experiments had been made with this arrangement. The discussion of the subject has certainly produced some valuable information, and we shall hope that some of the particulars asked for regarding the contacts will be shortly forthcoming.

Electrolysis by Stray Currents.

IT is interesting to note that the Metropolitan Water Board has been successful in forcing the North Metropolitan Electric Power Supply Co. to include in their 1907 Bill, which confers additional powers upon the Company, including the right to supply electrical energy to the North-East London Railway, a clause by which the Company is liable for any electrolytic action proved to be due to currents from their network. Possibly the Committee to whom the Bill was referred took the view that such a clause, contrary to custom, should be included because the current in question will be generated as three-phase high-tension alternating current, though it is difficult to see what this fact has to do with the case, for such current would not be used without transformation. But this did not prevent the question of electrolytic trouble from three-phase high-tension current being discussed before the Committee. Hitherto the regulations of the Board of Trade have been found sufficient protection against possible effects of direct currents, and it is generally recognised that, although electrolysis may take place with alternating current, the effect produced is much less than with direct. Nevertheless, the clause has been inserted, presumably to be on the safe side.

The Hampstead Tube.

LONDON'S latest tube—that from Charing Cross to Golder's Green and Highgate—was opened last Saturday, when for seven hours the public were allowed the privilege of travelling over the line free of charge. We believe that this is the first railway in England to adopt such a method of advertising, but that it was fully taken advantage of by the public is evident from the fact that 127,000 passengers were carried in the few hours during which the line remained open. It will be remembered that the construction of this latest tube, which was described in *The Electrician* a few weeks ago, differs in no respect from its immediate predecessors. The traffic conditions will, however, be different, owing to the fact that the line runs from the centre of London to a point outside the suburbs, whilst the other tubes are more directly concerned with the internal traffic of the City. At the opening ceremony, which was performed by Mr. LLOYD-GEORGE, the suggestion was made by Sir EDGAR SPEYER that, as the London County Council were directly concerned in the solution of the traffic problem, that body should take over the control of the tube railways. Notwithstanding the readiness of a certain section of the Council to take over anything and everything, we doubt if such a scheme is likely to meet with any support from the ratepayers, who have no desire to add one more to their present municipal undertakings, especially as the financial prospects do not seem to be of the most rosy nature.

Personal.—It is announced that M. H. Armagnat has been appointed editor-in-chief of *L'Industrie Électrique*, a post left vacant a few weeks ago by the death of M. Hospitalier.

Wireless Telegraphy Notes.—H.M.S. "Euryalus" is shortly to be taken in hand at Portsmouth. During her refit a wireless telegraphy cabin is to be built on board, and the rigging altered to bring it up to date with the latest wireless telegraphy practice.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Tarifa—Tangier	Jan. 18, 1904 ..	—
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Panama—Buenaventura	Feb. 28, 1907 ..	—
Buenaventura—Santa Elena..	Feb. 28, 1907 ..	—
Trinidad—Demerara	June 18, 1907 ..	June 24, 1907

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Kryptol Resistances for Radiators.—*L'Industrie Electrique* gives an account of some kryptol resistances. Granular kryptol is placed in glass tubes about 18 in. long, whose ends are fitted with metallic pieces and spring contacts. Each tube absorbs 400 watts at 110 volts. They are placed in parallel or series according to the voltage, are easy to replace and can be used on all voltages between 63 and 600. Their temperature scarcely rises above 100 deg., so that the substance does not burn or fall into dust.

Engineering Standards Committee.—We are informed that the Standard Specification for "Material used in the Construction of Railway Rolling Stock" has been revised and will shortly be available. The price of the specification is 10s. 6d., and it may be obtained from the publishers, Messrs. Crosby, Lockwood & Son, or from the offices of the committee. The alterations are mainly in the test clauses, modifications having been introduced to bring the original tests more into line with existing practice.

Junior Institution of Engineers.—During the forthcoming meeting of the Junior Institution of Engineers in the Clyde district an extensive programme of visits to engineering works in the neighbourhood has been arranged. This will include, among others, the works of Barr & Stroud, of Sir William Arrol & Co. and of Babcock and Wilcox. Visits will also be paid to the Naval Construction Works of Wm. Beardmore & Co. and of the Fairfield Shipbuilding & Engineering Co., and to the engineering laboratory of Edinburgh University. On Monday, July 1st, the members are to be received and entertained by the Lord Provost and magistrates of Glasgow.

Royal Society.—Among the Papers read at the meeting of the Royal Society yesterday afternoon, were Papers on "The Annealing of Copper, with special Reference to Dilatation," by Prof. T. Turner and Mr. D. M. Levy; on "A Standard of Mutual Induction," by Mr. A. Campbell; on "A New Current Weigher and a Determination of the E.M.F. of the Normal Weston Cadmium Cell," by Prof. W. E. Ayrton, F.R.S., and Messrs. T. Mather, F.R.S., and F. E. Smith; on "The Force Required to Stop a Moving Electrified Sphere," by Mr. G. F. C. Searle, F.R.S.; and on "Some Notes on Carbon at High Temperatures and Pressures," by Hon. C. A. Parsons, F.R.S.

Electricity in Horticulture.—We appear to be approaching the time when information and statistics will be forthcoming concerning the value of the application of the electric current to the culture of fruits, &c. Experiments are now being conducted on a fairly considerable scale by gentlemen whose names give a guarantee for the accuracy and thoroughness of their conclusions, and these we hope to make public in due course. We may say at this stage that, in a season which is remarkable for low temperatures and other drawbacks to successful cultivation, results have been obtained which point to the great value of electrical treatment. But the results (according to *The Fruit-Grower*) are not sufficiently definite to admit of their publication at the present moment.

A New Method of Preparing Tantalum.—*L'Industrie Electrique* gives a new method of preparing tantalum by the use of cathode rays. The metal is connected to the anode and is placed at the focus of the cathode rays, which are concentrated on it by a mirror. It is noticed that the cathode rays cause rapid fusion of the metal; by means of a magnet their action and direction can be controlled in a simple manner and the adjustment of the rays on any part of the metallic mass obtained. Another advantage of this apparatus is that it will work with alternating currents, for it acts as a rectifier and always keeps the same pole as cathode. The metal may also be placed at the common focus of two cathodes and the emission of rays from these alternately concentrated on it.

Verband Deutscher Elektrotechniker.—The fifteenth annual meeting of the Verband Deutscher Electrotechniker was held at Hamburg from June 6th to 9th. The visitors were welcomed by Dr. A. Voller, the chairman of the Society's section in that town. The meetings were held under the presidency of Dr. W. Kohlrausch, and the first Paper read was by Herr D. Schulthes on "The Present Position of Electricity in Ship Work." The author complained of the slow progress that had been made in this matter, especially in the mercantile marine. The great drawback to the installation of electrical machinery was the first cost. In the navy, where this point was not of such importance as in private enterprises, electrical working was being quickly adopted. It was now used for such purposes as driving the boat hoists and capstans as well as for supplying the searchlights and the ordinary ship-lighting. The safety of the electrical system is so firmly established that its adoption in the mercantile marine is only a question of time. Other Papers were read by Dr. Sahulka on "Two New Methods of Driving Railways on the Single-phase System," and by Herr Wagmüller on "A New System of Automatic Short-Circuit Braking for Electric Motors." A number of excursions were made to places and works of interest in the neighbourhood.

Society of Arts.—The annual general meeting of the Society of Arts was held on Wednesday last, June 26th. H.R.H. the Prince of Wales was re-elected President of the Society, an office which His Royal Highness has filled since 1901. Amongst the prizes announced for next year is a gold medal under the Benjamin Shaw Trust for industrial hygiene, similar medals under the Stock and Mulready Trusts to students of schools of art, and one under the Fothergill Trust for the best portable apparatus for use in mines and other places where the air is noxious, enabling men to undertake rescue work. It was noted that there had been a slight increase in the number of candidates at the Society's examinations, the total number of Papers worked being 24,568. It was announced that a committee had been appointed to make further investigation into the subject of the deterioration of paper, on which subject a committee had reported in 1898.

High-Tension Direct-Current Railway.—An electric inter-urban railway is under construction in California, in which an interesting feature of the design is the proposal to operate the cars by an under-running third-rail carrying direct current at 1,200 volts. The *Railway and Engineering Review* states that the entire length of the road will be about 70·5 miles. The third rail will be of special section, having the form of the letter T inverted. The weight of this rail is to be 22·4 lb. per yard, and it will be of special low carbon steel. The rail will be supported by a wrought-iron stirrup keyed to the web of the inverted T section and suspended from porcelain insulators. These insulators will be carried by channel iron brackets spiked to the ties. To afford some protection from the high voltage, the rail will be fitted with a covering of wood made to rest upon it by its own weight. Considerable economy in the metal required for transmission will result from the high voltage used. Current for the operation of the road will be supplied from hydro-electric plants of the California Gas & Electric Corpn. which operate in the vicinity. The passenger cars will be similar to the common type and 52 ft. in length. The motive power will consist of quadruple motor equipments, each motor being of 75 H.P. These motors will be wound for 600 volts and connected two in series for operation on the 1,200 volt supply. To avoid possibility of disastrous effects from the slipping of one motor of a pair, potential relays will be shunted across the motor terminals. In addition to the under-running shoes, a pantagraph trolley will be used for operation on city streets with the usual trolley wire.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, June 28th (to-day).

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

10 a.m. Meeting at the Royal Victoria Hotel, Sheffield. Paper on "Alternating-current Distribution," by Mr. A. J. Cridge.

2:15 p.m. Visits to Kelham Island Tramway Power Station and to Neepsend Power House.

PHYSICAL SOCIETY.

5 p.m. Meeting at the Central Technical College, Exhibition-road, S.W. Papers on "A Cosine Flicker Photometer," and "Some Phenomena in Colour Vision," by Mr. J. S. Dow, and on "Design of Chokers," by Prof. W. E. Ayrton, F.R.S., and Mr. T. Mather, F.R.S. A Demonstration of his Hot-wire Oscillographs and Hot-wire Wattmeters will be given by Mr. J. T. Irwin, and a Description of Students' Apparatus for Measuring Permeability and Hysteresis, by Prof. W. E. Ayrton, F.R.S., and Mr. T. Mather, F.R.S.

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ON THE LOSS OF ENERGY IN THE DIELECTRIC OF CONDENSERS AND CABLES.

BY DR. BRUNO MONASCH.

Summary.—After dealing with the subject historically, the Author gives a method of measuring dielectric losses and discusses the sources of error to be avoided. He then considers the effect of different wave forms, frequency, change of temperature, &c., and gives measurements on various dielectrics and cables. Finally, the loss occurring in cables under working conditions is discussed, and quantitative figures are given.

The loss of energy that takes place in solid and liquid dielectrics situated in a periodically varying electric field at present arouses interest equally from the physical and technical points of view. The technologist's interest in the subject has increased during the last few years in proportion as continually higher voltages were brought into use in the various spheres of applied electricity.

The attention paid to this loss and the phenomena connected therewith in regard to their physical aspect dates back some years. Since Werner Siemens,* in 1864, pointed out the fact that the glass wall of a Leyden jar grows warm by the charging and discharging, the questions attending this phenomenon have been made the subject of very numerous experimental, and also several theoretical, investigations. It is not my intention to discuss, or even to refer to them all, but I shall try to give a brief outline of the present state of the views, and of the experimental results hitherto attained, relating to the phenomena in question. As to the cause of the loss, there are essentially two opinions opposed to one another, since Ch. P. Steinmetz,† in his first publication upon this subject, first spoke of "dielectric hysteresis." One of these views attributes the loss, or at least a portion of it, to a sort of molecular friction by which the electric displacement would be caused to lag behind the intensity of the given electric field; thus the loss would appear as a perfect analogue of that occurring in ferromagnetic materials by magnetic hysteresis. The other view seeks to explain the loss by the presence of some conduction phenomena, perhaps of an electrolytic kind, or of the kind of loss taking place in a resistance; this is feasible, for instance, by aid of Maxwell's view of a stratified dielectric, which has been repeatedly put forward for that purpose.‡ The experimental investigations concerned with the question of hysteresis were rendered very difficult by the viscous effects connected with the formation of residual charges; in so far as they attempted the proof of a true static hysteresis, in a sense of a phenomenon independent of the speed of alteration of the field, most of them gave negative results.§ One author, however, M. de Hoor,‖ describes experiments carried out with a specially prepared paper, by which he succeeded in obtaining a regular static hysteresis—viz., a constant loss per cycle, even at very low frequencies.

But without taking as a starting point a fixed view as to the loss, or of a part of it, one can nevertheless determine the laws followed by the loss in alternating or revolving electric fields on the whole; this, in fact, was the object of the greater part of the experimental investigations hitherto published. The question turns principally upon the dependence of the loss on the voltage or the intensity of the field and on the frequency. The results of these inquiries differ extremely and are contradictory to one another, especially as regards the influence of the intensity of the field. As to the way in which the loss depends on the voltage, or intensity of the field, several authors obtain the result that with a low field intensity the loss is approximately proportional to the square of the intensity of the field, as was first supposed by Borgmann¶ as early as 1886, whilst in strong fields it increases more rapidly than the square of the field intensity. The numbers 1·5* and 3† may be mentioned as extreme values of this exponent, but numerous figures between these limits are also found. Further, since during the last few years the opinion has been repeatedly stated that the loss cannot be expressed as proportional to a power of the strength of the field with a constant exponent at all,‡ we cannot at present form any conclusive opinion as to the sort of connection between the energy loss in dielectrics and the intensity of the electric field. In conclusion, we need only mention that all the views which seek to explain the loss as caused by some kind of conduction start from the necessary supposition of its exact proportionality to the square of the voltage or the strength of the field.

Now, as regards technical interest in the subject, this was confined till a few years ago to the fact that the heating of condensers subjected to an alternating pressure was felt as a drawback in itself as well as on account of the energy-loss accompanying it. For the most part these condensers were made of impregnated paper or other fibrous materials, and, owing to the comparatively high losses, they became hot so easily as to be ruined as soon as they were subjected for any length of time to an alternating pressure of more than a few hundred volts. It was only a few years ago that more suitable dielectrics as regards loss (for instance, glass of a better sort) began to be used for technical purposes, and that proper high-tension condensers were made. The need for the latter has increased, inasmuch as a use for condensers at very high voltages in various branches of the industry has arisen during the last few years, as, for instance, in the production of nitric acid from the atmosphere; and so the technical interest in condensers, and thus also in the losses taking place in them, may be said indeed to be more keen at present than it has been hitherto.

Setting aside the numerous less extended spheres of application of condensers, there are, nevertheless, two departments of applied electricity at present in which a knowledge of the dielectric loss and its laws possesses a special interest. One of these is the department of wireless telegraphy. The energy loss taking place in the dielectric of the condensers appears therein as an increase of the damping of the oscillations in the circuit in question. It is not intended here, however, to enter into the particulars of questions concerning high frequencies. The second department is that of the transmission of alternating currents through cables. In Europe also, during recent years, we have begun to follow the example of countries outside Europe, principally of the United States of America—viz., in establishing plants for the transmission of electric energy over great distances, and thus introducing very high working pressures for the line. But since we are not permitted altogether to follow American practice in these matters, we are compelled in the closely peopled countries of Europe to use underground lines for the sake of safety—*i.e.*, to use cables to a comparatively large extent. As the working pressure of the cable increases, so does the importance of the dielectric phenomena, and not the least among these is the loss of energy taking place.

The interest acquired by the latter is concerned with two points: First, the knowledge of the magnitude of the loss in such a cable is of importance merely from the economic aspect, because the loss takes place as soon as the cable network is energised, and continues even if no power at all is transmitted. In such a network energy is being wasted continually, and thus, even if small in itself, the loss might possibly influence materially the efficiency of the transmission. Secondly, the loss may become important in the propagation of current in the cable. In estimating the conditions in a cable in advance, such as pressure, current and phase, the loss can be taken into account by introducing it into the calculation as an increase of the leakage. This may be done without hesitation only if it takes place like a loss occurring through

* W. Siemens, *Monatsberichte d. Berliner Akad.*, October, 1864.

† Ch. P. Steinmetz, *Elektrotechn. Zeitschrift*, Berlin, Vol. XIII., p. 227, 1892.

‡ A. Hess, *Journal de Physique* (3), Vol I., p. 459, 1892. J. Hanauer, *Wiedemann's Annalen*, Vol. LXV., p. 789, 1898. H. A. Rowland and T. D. Penniman, "John Hopkins University Circulars," Baltimore, Vol. XVII., p. 52, 1898.

§ A. W. Porter and D. K. Morris, *Proceedings* of Royal Society, London, Vol. LVII., p. 469, 1895. F. Beaulard, *Journal de Physique* (3), Vol. IX., p. 422, 1900.

‖ M. de Hoor, *Elektrotech. Zeitschrift*, Vol. XXII., pp. 170, 187, 213, 716, 749, 781, 1901.

¶ J. Borgmann, *Journal* of the Russian Physico-Chemical Society (1), Vol. XVIII., p. 1, 1886.

* R. Threlfall, *Phys. Review*, Vol. IV., p. 457, Vol. V., pp. 21, 65, 1897. R. Arno, Rendic. della R. Accad. dei Lincei (5), Vol. I., 2nd Sem., p. 284, 1892; Vol. II, 1st Sem., p. 341, 2nd Sem., p. 260, 1893; Vol. III., 1st Sem., p. 272, 585, 2nd Sem., p. 294, 1894.

† P. Holitscher, *Elektrotechn. Zeitschrift*, Vol. XXIV., p. 635, 1903.

‡ J. Moscicki, *Elektrotechn. Zeitschrift*, Vol. XXV., p. 549, 1904.

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resistance—*i.e.*, if it is exactly proportional to the square of the voltage. Now, in the measurements hitherto available, made on cables, the loss was found to increase approximately proportionally to the square of the pressure, but more quickly at higher voltages,* a result quite similar to that obtained in a number of former experimental inquiries relating to condensers. In the case of cables, however, we are, as stated above, essentially interested in knowing if this proportionality of the loss to the square of the voltage is exactly true, or really only approximately. It may be mentioned that just the same effects come into consideration as regards the damping produced by the loss in oscillation circuits. This damping also can only be regarded as constant at different voltages if the loss is exactly proportional to the square of the pressure.

It appears, therefore, both from the physical and from the technical points of view, to be of some interest to inquire if the square law is exactly obeyed or not, and whether there is a method of measurement better suited than those hitherto used. Such a method, possessing several other advantages in addition, and its application, are here described.

The Method.

I. The Method and its Essential Qualities.

The method involves the producing of a balance in the bridge arrangement† shown in Fig. 1, hitherto used for capacity measurements. In our case the four arms of the bridge have the following meanings: Arm AD contains the condenser, the loss of which is to be determined. Without making any supposition as to the nature of the loss, we can always replace this condenser in the bridge by a perfect condenser (without any loss) of capacity

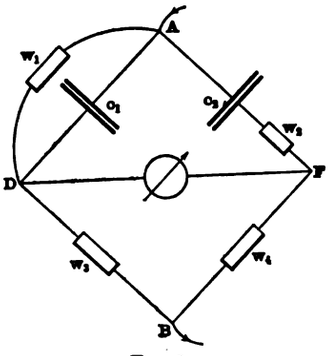

Fig. 1.

c_1 shunted by a pure resistance w_1 free from capacity and inductance. This substitution is admissible under all circumstances because the question turns only upon representing the phase-difference between the voltage on and current in the arm AD. In the arm A F there is a perfect condenser of capacity c_2 in series with a pure resistance w_2; in the arms BD and BF pure resistances w_3 and w_4 are inserted. The conditions necessary for the vanishing of current in the cross-connection and the results that may be deduced will be briefly considered. The points A and B of the bridge may be supposed first to be acted upon by a sine wave P.D. Then the conditions necessary for no current to flow in the cross-connection are obtained in the simplest way by carrying out the investigation by means of the complex resistance-operators first introduced by Oliver Heaviside. Denoting these quantities for the four arms A D, A F, B D, B F respectively by a_1, a_2, a_3, a_4, we have

$$a_1 = \frac{w_1}{1 + inc_1w_1},\quad a_2 = w_2 + \frac{1}{inc_2},\quad a_3 = w_3,\quad a_4 = w_4,$$

where $i = \sqrt{-1}$ and n is the number of complete periods in 2π seconds. There is no current flowing in the cross-connection if $a_1\,a_4 = a_2\,a_3$—*i.e.*, if

$$\frac{w_1w_4}{1 + inc_1w_1} = w_2w_3 + \frac{w_3}{inc};$$

hence we get
$$n^2c_1c_2w_1w_2 = 1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1a)$$

and
$$\frac{c_1}{c_2} = \frac{w_4}{w_3} - \frac{w_2}{w_1}. \quad . \quad . \quad . \quad . \quad . \quad (1b)$$

The vanishing of current in the cross-connection thus requires the fulfilment of two conditions, and therefore to carry out the measurement either c_2 and the ratio w_3/w_4, or w_2 and the ratio w_3/w_4, or c_2 and w_2 must be varied until the current in D F vanishes.

Several conclusions may now be deduced from the equations (1*a*) and (1*b*).

1. *Square-law.*—By eliminating c_1 we get for w_1

$$w_1 = \frac{1 + n^2c_2^2w_2^2}{n^2c_2^2w_2} \cdot \frac{w_3}{w_4}.$$

If E is the effective value (in volts) of the voltage on the arm A D, supposed in the first instance to be exactly sinusoidal, the power wasted in the condenser to be tested amounts to

$$A = \frac{E^2}{w_1} = \frac{n_2c_2^2w_2}{1 + n^2c_2^2w_2^2} \cdot \frac{w_4}{w_3} \cdot E^2 \text{ watts}, \quad . \quad . \quad (2)$$

if w_1 is expressed in ohms, c_2 and w_2 in farads and ohms respectively. The multiplier of E in equation (2) remains constant if E varies only if A, the loss in the condenser being tested, is exactly proportional to the square of the voltage E. But as the constancy of this multiplier, by the equations (1*a*) and (1*b*), requires that no current should flow in the cross-connection, this method affords a very suitable and ready means for determining whether a square law connects the loss with the voltage. If the law is exactly obeyed, the instrument in the cross connection will, after the bridge is once balanced, indicate no current also when the voltage is varied.

Table I.

E.	w_2	E.	w_2
1,000	100,000	6,000	119,580
2,000	107,140	8,000	123,070
4,000	114,830	..	..

From equation (2) it is not obvious how large a variation of the adjustment of the bridge would correspond with a given deviation from the square law. I have, therefore, calculated the figures given in Table I., starting from data agreeing with the measurements actually made—viz., a balance is supposed to have been obtained at 1,000 volts with $n = 538{\cdot}0$, $c_2 = 2{\cdot}3.10^{-4}$ mfd., and $w_2 = 100{,}000$ ohms. The table gives the values of w_2 (which, of course, remains constant as soon as the square law is strictly obeyed), that would have to be adopted if the loss were to increase proportionally to the 2·1th power of the voltage. E here denotes, as also in all the tables that follow, the effective value of the pressure in volts, whilst w_2 is expressed in ohms. When calculating this table the adjustment was supposed to be made by varying c_2 and w_2, and it was assumed that $w_3 = w_4$ unchanged. The increase shown by w_2 with rising voltage must be described as very considerable, having regard to the fact that the sensibility of adjustment in the measurements carried out was ordinarily such as to allow me to perceive with certainty variations in w_2 of 1,500–2,000 ohms at 2,000 volts, and of less than 1,000 ohms at 8,000 volts; c_2, on the contrary, scarcely varies at all in the case considered. This is because c_1, the capacity of the condenser under test, was assumed to be constant, and only the loss was supposed to increase more quickly than the square of the voltage.

2. *Proportionality of the Loss to the Capacity.*—Something more may be deduced from equation (2). From (1*a*) and (1*b*) it follows that $c_1 = \frac{c_2}{1 + n^2c_2^2w_2^2} \cdot \frac{w_4}{w_3}$. The quantity $1 + n^2c_2^2w_2^2$ in the denominator differs very little from unity in all the cases here in question. In the example just considered, for instance, it amounts to 1·000153. We may therefore write with very great approximation $c_1/c_2 = w_1/w_2$. This simplified relation is used throughout in what follows for calculating c_1 from the data of the bridge. Now, the exact expression found for c_1 may be introduced into the equation (2); this latter then takes the form:—

$$A = n^2c_2w_2.c_1E^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad (2^1)$$

* R. Apt and C. Mauritius, *Elektrotechn. Zeitschrift*, Vol. XXIV., p. 879, 1903. P. Humann, *Elektrotechn. Zeitschrift*, Vol. XXV., p. 359, 1904; Vol. XXVI., p. 300, 1905.

† M. Wien, *Wiedemann's Annalen*, Vol. XLIV., p. 689, 1891.

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Hence it follows that as soon as the product $c_2 w_2$ remains constant at the same voltage and frequency, but at different values of the capacity c_1, the loss A is proportional to the capacity c_1. This conclusion will also be made use of later.

3. *Wave-form of Voltage.*—The quantities c_2 and w_2 may now be computed from the equations (1*a*) and (1*b*). We get

$$c_2 = \frac{1 + n^2 c_1^2 w_1^2}{n^2 c_1 w_1^2} \cdot \frac{w_3}{w_4} \text{ and } w_2 = \frac{w_1}{1 + n^2 c_1^2 w_1^2} \cdot \frac{w_4}{w_3}.$$

As may be seen, each of these expressions contains the frequency n. Since a balance, as explained, can only be produced by altering either both the quantities c_2 and w_2, or one of them and w_3/w_4, an important conclusion results, namely, the adjustment of the bridge differs for each frequency. If, therefore, the bridge carries simultaneously a number of currents of different frequencies a balance is no longer possible, unless the instrument in the cross-connection is sensitive only to currents of one single frequency, thus in a way acting as a frequency filter. That means, however, that only in the case of a pure sine-wave tension acting between the points A and B is a balance feasible by means of a bridge instrument of the ordinary kind, for instance, a telephone; at the least departure of the tension from the sine-wave this cannot be effected any more. The bridge can be brought to a balance with other than sine-wave forms only if the instrument responds to but one of the sinusoidal voltages of which the applied voltage is composed, viz., in our case, to the fundamental component. If, however, such an instrument is used, the method presents an advantage especially valuable here. As only the fundamental component of the current actuates the instrument, it is of no consequence what upper harmonics exist. As regards the instrument and the adjustment of the bridge, the position is exactly the same as if only the fundamental component existed—*i.e.*, as if a pure sine-wave pressure were applied between the points A and B. Neither is the whole loss really taking place in the condenser under test measured here, but only that caused by the fundamental component of the voltage on the arm AD—*i.e.*, that which would take place if only the fundamental component of this voltage, a pure sine-wave voltage, acted upon the condenser. As an instrument possessing among other advantages that of being actuated only by currents of a fixed frequency, the optical telephone* devised by M. Wien was used in the observations here described.

In the case of the existence of hysteresis, upper harmonics in the current would have to be taken into account also if the voltage is exactly sinusoidal. As may be easily proved, however, the loss caused by the fundamental component of the voltage would be correctly measured also in this case.

The fulfilment of this condition of the exact sine-wave form of the voltage acting upon the condenser under test has certainly been attempted in the investigations hitherto published in different ways, but it has, as far as I know, never been really attained. In the investigation of the connection between the loss and voltage also the dependence of the loss upon the wave-form of the voltage involves a cause of error hitherto often not sufficiently taken into account. But this cause of error also, which is by no means unimportant, especially in measurements on condensers, is avoided in the method here discussed.

(To be continued.)

WORKMEN'S COMPENSATION AND INSURANCE.

BY JOS. J. H. STANSFIELD.

Summary.—The author deals with the effect of the new Employers' Liability Act upon the position of the manufacturer, and shows that in some ways the Act is obscure, besides adding materially to the employer's liability.

The time is rapidly approaching when it will become necessary to reconsider the question of insurance against liability in case of injury to any employé, and to none is the question of more importance than to those engaged in the electrical industry. In view of this it may be of value to shortly review the legislation leading to the present position and to consider what liability it is necessary to provide against.

Until the year 1846 the family of a person who was killed in the course of his or her employment had no legal remedy against the employer, either in England or Ireland, but in that year the Fatal Accidents Act (perhaps more generally known as Lord Campbell's Act) was passed, which entitled the husband, wife, parent or child who might have suffered pecuniary loss through the death of his or her relative to proceed against the employer for damages if the death were due to the wrongful act, neglect or default of the employer.

The liability for payment of compensation thus definitely became common law, and a master was thereafter bound to take all reasonable precautions to ensure the safety of his employés. The servant was still supposed to have undertaken to run the ordinary risks of "common employment," and the employer could not be held liable for injury to an employé through the negligence of another. But on the Employers' Liability Act, 1880, being passed the liability of employers was greatly extended and they then became answerable to their servants for negligence on the part of those to whom they had delegated their authority, and in certain cases of injury the same rights of reparation were given to workmen as had previously been enjoyed by others who were not workmen. This Act was, however, limited in its scope and did not apply to those who were not engaged in manual labour, neither was any provision made to prevent either master or workman from contracting himself out of the Act.

The Act of 1880 was in many respects badly drawn and led to much litigation, many accidents being held as not coming within its provisions, and still leaving open the common law defences of accepted risks and contributory negligence. In order to remedy this the Workmen's Compensation Act, 1897, was added to the statute roll, which, although not abrogating the Act of 1880, greatly extended its provisions and made the payment of compensation compulsory within certain limits and irrespective of any question of negligence, except in cases of serious and wilful misconduct on the part of the workman, allowing contracting out only where the scheme was certified by the registrar of friendly societies to be on the whole not less favourable to the employee than that of the Act, and preventing employers escaping liability even where work was carried out by means of sub-contracting. This Act was followed in 1900 by an extension of its provisions to agricultural labourers.

The Acts of 1897 and 1900 were designedly limited in scope. The accident had to take place on, in, or about the premises of the employer, and the application of the Act of 1897 to railways, mines, quarries and engineering works was confined to accidents occurring during building operations when the building was not less than 30 ft. high, and many actions have from time to time been brought to decide whether one or other accident came within the meaning of these words. The Acts were experimental in character, but the Act of 1906, whilst leaving open the option to the employé to sue under common law or under the Employers' Liability Act, 1880, repealed both the Acts of 1897 and 1900, and incidentally greatly increased the liability of employers, not only by altering the conditions under which compensation may be claimed by those who were previously protected, but, with few exceptions, by bringing all employers within its purview. The following comparison will more clearly show how seriously the position has been altered:—

Acts of 1897 and 1900.—In cases of temporary or permanent disablement or death compensation was limited to persons employed by way of manual labour in or about certain specified employments, or in or about the premises of the employer or sub-contractor.

In cases of death compensation was payable to dependants (except in cases of serious and wilful misconduct on the part of the workmen) of an amount equal to three years' wages, with a minimum of £150 and a maximum of £300.

In cases of temporary or partial disablement compensation was payable from the end of the first two weeks to employés (whether adults or minors) if the injury prevented the employé from earning full wages for more than two weeks after the accident, the amount payable being limited to 50 per cent. of the average weekly wages received during the previous 12 months or shorter period of employment, with a maximum of 20s. per week.

Act of 1906.—In cases of temporary or permanent disablement or death, arising out of or in the course of his employment, compensation is now payable to all persons employed by way of manual or clerical

* M. Wien, *Wiedemann's Annalen*, Vol. XLII., p. 593, Vol. XLIV., p. 681, 1891.

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labour or otherwise, whose remuneration from that labour is £250 or less than £250 per annum, except (1) persons whose employment is of a casual nature and who are employed otherwise than for the purposes of the employer's trade or business, (2) a member of the police force, (3) an outworker, (4) a member of the family dwelling in the house, and (5) persons in the naval or military service of the Crown.

In cases of death compensation is now payable to dependants in all cases of an amount similar to that provided in the Acts of 1897.

In cases of temporary or partial disablement compensation is now payable from the end of the first week where the incapacity lasts less than two weeks, and from the date of the accident if the incapacity lasts two weeks or more, the amounts payable to adults being as provided in the Act of 1897, but in case of injury to minors compensation is now payable at the rate of 100 per cent. where the average weekly wages are less than 20s., with a maximum of 10s., and the whole matter may be reconsidered 12 months or more after the accident, and the weekly payment increased to 50 per cent. of the weekly sum which the workman *would probably* have been earning at the date of the reconsideration if he had remained uninjured, with a maximum payment of 20s.

The liability of the employer has also been increased by the application of the Act to industrial diseases, compensation being now payable in case of illness or death caused through the contraction of lead, mercury, phosphorus or arsenic poisoning or their sequelæ, or by anthrax or ankylostomiasis (better known as miners' disease), and provision has also been made by which the Secretary of State may include other diseases within the provisions of the Act,* and further liability has been caused through an increase in the "dependants" who may make a claim, including within the meaning of that word even an illegitimate child or grandchild.

The draughtmanship of the Act has received much criticism, and a game of legal ping-pong seems to have become temporarily popular in the halfpenny press. Questions are asked somewhat like the following: "If the curate, when making a duty visit, trips over the front-door mat and hurts himself, will the bishop or the vicar be liable?" or "If the charwoman brings her next-door neighbour to carry the cleaning materials, will she be an employer or a workman within the meaning of the Act?" But beneath much legal verbiage it is clear that the intention of the Act is to prevent the employer, whoever he may be, evading liability, although on the other hand it may perhaps with truth be argued that a great amount of uncertainty has been created, as, for instance, in sec. 2, where it is enacted that the claim must be made within six months after the accident, but always provided that the failure to make a claim within that period shall not be a bar to the maintenance of any proceedings for recovery if it be found that the failure was occasioned by a mistake, absence from the United Kingdom, or other reasonable cause, somewhat altering the old principle of *ignorantia legis excusant neminem*, and making it almost seem that it may prove to have been quite unnecessary to have fixed a limiting period at all, and much doubt has also been raised as to the meaning of the provision in sec. 13, enacting that a workman is "a person whose employment is not of a casual nature, and who is not employed otherwise than for the purposes of the employer's trade or business," and until the Courts have decided what this exactly means a state of considerable uncertainty must remain.

In considering the question of insurance it is very important that the policy be taken out with a reputable insurance company having substantial reserves and both able and willing to meet any claim that may arise, for it must not be overlooked that insurance does not lessen the liability of the insured, but simply brings in a third party who, for a consideration, undertakes to refund any compensation that the insured may have become liable to pay; and should the insurance company become insolvent, the insured, or, if deceased, his executors or administrators, would still be liable to make the payments as they became due, but would have no possibility of a refund; and a further matter of importance is that the policy be one which fully protects the insured, covering to the full extent all claims under common law, under the Employers' Liability Act, 1880, and under the Workmen's Compensation Act, 1906, and must include not only those employés who are continuously or at more or less regular intervals employed at the date of the proposal or renewal of the policy, but provision must also be made to include all employés who may be afterwards engaged to be continuously or at more or less regular intervals employed during the currency of the policy, and the policy should also cover any liability which may arise out of the meaning that may be attached by the Courts to doubtful phraseology in the Act, and include the repayment of any expenses of any action that may have to be brought either to defend a claim for compensation or to compel other employers of the injured person to bear any portion of the liability in cases where, under the Act, there may be a joint liability.

Under the method of insurance arising out of liability under the acts prior to 1906, it is comparatively easy to deal with the proposal forms and arrange for the renewal of the policy, this method, as is well known, being simply to estimate the wages payable at the date of the proposal or renewal of the policy, paying thereon a premium based on each £100 of estimated wages and at the end of the year to make a statement of the amount of wages actually paid, and in case of an under-estimate pay the difference due, or where the wages have not been so much as anticipated, an allowance would be made by the insurance company when renewing the policy or an actual return of the overpayment made in cash, but the new Act has, whilst necessitating the retaining of the old method, brought about (especially in the case of domestic servants) insurance by means of counting heads and introduced some possibilities of error. The writer took the opportunity recently to write to one of the leading offices with regard to the difficulties arising out of the new method in properly applying for a policy which would give full protection in the circumstances already explained, and it may be of some interest to state the method suggested by them in order to attain this object. The proposal form should fully state the number of servants employed at the date of the proposal. Should any addition be made before the expiry of the current premium the insurance company should be informed without delay, and at the end of the year the insurer must pay any additional premium due under the altered circumstances. He will also be wise to pay an additional premium to cover any casual or additional labour so as to obtain protection against any doubtful liability and be relieved of expense in defending any action that may be brought against him by persons whose employment is not of a permanent character. The better class insurance offices are always prepared to deal generously with the policy holder where they are convinced that the claim is genuine, but it is only reasonable that a payment should be made for this additional protection and the matter treated so far as possible on a business footing.

The amount of compensation payable is based on the average earnings, but it must not be overlooked that the employer has a contingent liability in the case of pupils, apprentices and others (being minors) who are not at the date of the accident in receipt of any wage, for under sec. 16 of the first schedule to the new Act, if the compensation payable is reviewed 12 months or more after the date of the accident, the amount payable may be increased to an amount not exceeding 50 per cent. of the weekly sum which the employé *would probably have been* earning at the date of review if he had remained uninjured, with a maximum payment of £1. These employés should be specifically included in the proposal for insurance or renewal, the insurance company requiring a premium on employés of this character on a basis of an annual wage of £60.

It is, of course, too soon to dogmatise on the effects of the new Act, but from previous experience certain results may be anticipated, and, of one thing we may rest assured—the work of the Courts will be enormously increased, as whilst under the old acts the majority of the cases were settled by agreement, the Legislature has seen fit to increase the supervision of the Court, and has conferred upon it certain discretionary powers. The additional risks will also add to the trade expenses of working, as, whilst under the old acts a premium of 10s. per cent. upon the wages roll was considered high, premiums of 30s. per cent. will now be ordinary for the same risk, and indeed, in hazardous risks, premiums are already quoted at minimums of 50s., 75s. and even so high as 200s. per cent., and it must be remembered that these rates are

* Eighteen other industrial diseases have already been added under this provision.

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necessarily tentative in character until the extent of the liabilities become better understood.

The effects of this will be twofold, and (especially in hazardous trades) the liabilities will, firstly, either tend to lower the rate of wages or increase the selling price, and will, secondly, render it still more difficult for the infirm, partially disabled, or old to obtain employment. These are serious possibilities, and it cannot be considered that the Act of 1906 is final, in which opinion I am supported by the leading insurance offices. In this connection, it is significant to note that at the annual meeting of the Sun Life Assurance Society it was decided to transfer the accident and workmen's compensation department to the Sun Fire Office, so as to avoid any untoward effect upon the working of that department through further legislative shocks, a proceeding which will, perhaps, be followed by many other life offices with fire and workmen's compensation departments. Sec. 12 also points to further legislation, as it provides that the Secretary of State may require every employer in any industry to submit every year a return of the injuries in respect of which compensation has been paid, a return which, it would seem (as few dare fail to insure), might have been better provided by the various insurance companies. It has been suggested that a national scheme of insurance should be inaugurated, and, indeed, it would almost seem that this will eventually become necessary to protect the smaller trader whose business is of such a hazardous nature as to make insurance difficult or onerous, and whatever may be our opinion on the merits of the principle involved in giving a workman a greater claim against his employer than is enjoyed by strangers, it cannot be doubted that the Act has greatly increased the responsibilities of all employers, and its effects will be more far-reaching than was ever contemplated by those who were responsible for its framing and passing into law.

FOURTH ENGINEERING CONFERENCE, JUNE 19-21, 1907.

(*Concluded from page 399.*)

On Thursday, June 20, in Section I. (Railways) three Papers were read, of which we gave the first in our last issue. We now give the remaining two Papers and an account of the discussion upon them.

A SYSTEM OF AUDIBLE SIGNALLING ON RAILWAYS.

BY W. DAWSON.

The outdoor visible signals on our railways have been found satisfactory when the atmosphere is clear, either by day or by night, but on the descent of a fog they need to be supplemented or replaced by something which is audible.

It has been felt by railway officers and by the inspecting officers of the Board of Trade that no device would meet the requirements of the situation unless it would give the driver of a train a distinct audible "danger" signal and a distinct audible "all right" signal; further, that the device must not depend on electricity to give the "danger" signal, and that should there by chance be any failure in the mechanism the result must be the sounding of the audible "danger" signal.

Such an apparatus has now been designed, and has been in use on the Great Western Railway on a short branch double line for 15 months, supplementing the ordinary fixed outdoor visible signals as a first test; and as a more advanced experiment it has been in use for the past five months on a single line—22 miles long—in total substitution of the semaphore distant signals, which have been removed. During these experimental periods the apparatus has given great satisfaction, and the drivers and their officers have every confidence in it.

The inspecting officers of the Board of Trade have expressed their satisfaction with it, subject to the Great Western Railway Company reporting to the department at the end of six months' trial the result of the extended experiment.

The main features and advantages of the system are as under:—

The parts consist of a slightly arched piece of timber, 40 ft. to 60 ft. long, bolted to the sleepers midway between the two running-rails, on top of which is bolted a bar of T iron suitably mounted and insulated, the bar being electrically connected by means of a length of telegraph-wire to a switch at the signal-box. This bar is electrified by pulling a lever when it is desired to give the "all right" signal. There is no moving part in this ground apparatus.

This fixed non-movable sloping bar also serves the purpose of lifting a rod connected with a mechanical device fixed beneath the engine of a standardised design to fit any engine. The lifting of this rod opens a small steam-whistle fixed in the cab of the engine when it is desired to give the "danger" signal. To give the "all right" signal, the action set up by the electrified bar on the ground apparatus restrains the whistle from blowing, but rings a bell.

When the whistle or the bell sounds, either continues to do so until the driver shuts it off, and without any further action on his part it is ready to produce the same signal again at the next station.

Neither frost nor snow prevents the operation of the "danger" signal.

The system is applicable to both double and single lines, and works satisfactorily whichever end of the engine may be leading.

The "danger" signal will always be given should there by any chance be a failure of the electric action.

Each signal being audible does not reduce the constancy of the driver's "look out" ahead.

The arrangement will save all fogging expenses for those signalling posts at which it may be fixed.

It operates during daylight, darkness or foggy weather, and will bridge over the doubtful period between the time when a fog begins and the time when the fogman arrives at his post; and even then it is infinitely to be preferred to the fogman himself.

It will avoid the serious disorganisation to the train service which now occurs even with the most approved detonator system of signalling.

The detonator system of signalling, although the best hitherto devised, cannot claim for itself perfection, being subject to the possibilities of no explosion or of the detonator being skidded off the rail. Even the fogman himself, without the knowledge of the man in the signal box, may become disabled by accident, exposure or indisposition.

Seeing that the device is available at all times and in all states of the weather, it follows that fixed distant semaphores are not needed, and their cost and maintenance and lighting need not be incurred. The Great Western Railway Co. have removed them altogether on the single branch line already referred to.

The use of the system may be extended, with the slight additional cost of the ground apparatus un-electrified, to give a "danger" signal as a reminder to drivers to be prepared to run at the required speed over portions of the line where a reduced rate is ordered.

The ground apparatus can be fixed at any desired distance from the home signal, in tunnels, on viaducts and round curves in cuttings, and thus get rid of many difficulties which now beset railway officers in fixing a site suitable to ensure a driver getting a proper view of the signal.

No additional duty is required from the signalman, as the same lever which now works the distant signal will serve to electrify the ground apparatus.

Being audible, the signal cannot be obscured or overlooked during fog or snowstorm, as is the case with a visual signal.

To test the apparatus on any engine which has to pass any place where the distant visual signal has been removed, the Great Western Railway Co. have fitted alongside the signal post which controls the outlet from the locomotive yard a ground apparatus similar to that described.

It is not going too far to say that, if an audible signal, such as the one which forms the subject of this note, had been in use, it would have been a most important factor in at least rendering very improbable indeed several melancholy and destructive accidents which have unhappily taken place very recently, both in this country and elsewhere.

Mr. J. W. JACOMB-HOOD said that the system explained by Mr. Dawson was, of course, not the only system, but it was a system which had been successful in practice, and it was a question whether this would not enable the doing away with the original semaphore signals. The question had to be looked at from two points of view—the safety of the public, and its effect upon the finances of railway corporations. So far as the public were concerned it seemed obvious that automatic signalling was the better system. It relieved the anxiety of the driver and enabled him the better to perform his duties. As to finances, everything seemed in favour of automatic signalling, particularly if it was going to save the enormous expense of something like £30,000 a year on some lines in the maintenance of signals alone; the figure for maintenance of rods, wires, semaphores, &c., worked out at about £32 per route-mile per annum. With audible signalling connected with an automatic system it ought to be possible to reduce maintenance and working charges considerably.

Mr. ALEX. ROSS said it was true this was not the only system of the kind, in fact not a month passed but what railway engineers had some new system or other brought before them, and naturally they had to be very cautious in adopting any system. The objection against most of the ideas was the possibility of the impact being such as to shatter both sets of apparatus. Any system which necessitated a striking blow was unsuitable for fast-running trains. Then, again, automatic systems

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which stopped a train when a signal was at danger gave the driver no indication as to when he could proceed.

Mr. ALEX. SIEMENS said his experience covered a large number of systems of communicating with the engine driver. An essential point about the system they were discussing was that if anything went wrong with the apparatus the danger signal was given. As to Mr. Ross' point about the instructions for the driver to proceed, the system was to replace distant signals where trains did not stop whether the signal was at danger or not. It was merely a warning to the driver as to how the home signal stood. Therefore, the question of when the driver had to go on again did not come in. The making of an electrical circuit was not so certain in action as the breaking of a circuit, as had to be done in this case. This was the difference between the present system and its predecessors. He thought audible signals on the locomotives had a great advantage over visible signals inasmuch as the driver need not take his eyes off the track.

Col. H. A. YORKE said he thought they would all agree that this was a most important departure and one of the most important developments in signalling that had been attempted in this country for some years. Much credit was undoubtedly due to the Great Western Railway Co., for inaugurating and continuing experiments in the direction of the improvement of signalling. The experiment had been watched with the greatest interest by the officers of the Board of Trade, and he personally had been by the courtesy of the Great Western Railway Co. kept informed of all details in connection with the working of the apparatus. So far as the experiments had gone the Board of Trade officers had been able to express satisfaction at the results. As he understood it this apparatus had resulted from the endeavour of railway companies to discover some efficient substitute for the fog signalman. The Board of Trade for years past had been pressing the companies to endeavour to discover some apparatus of this nature, although there was no reason to doubt the reliability of the fog signalmen, in fact he could not call to mind any single accident due to the neglect of the fog signalman to do his duty. The danger from fog, however, was that it came on suddenly, and there was necessarily some interval between that moment and the arrival of the man at his post. The requirements of a fog signal were well known. It should be absolutely reliable and constantly available. It should be easily understood by a driver, and should be placed at such a distance from the stop signal that the train could be brought to a standstill before it reached the stop signal. The only way to ensure these requirements was that the signal should be in constant use. Unless in constant use it was liable to be neglected, and the apparatus would perhaps not be workable when wanted. The introduction of an apparatus for constant use seemed to be a duplication of the present signals, and such a duplication of signals might be disturbing to the driver, probably resulting in his ignoring one and observing the other. When that was the case the second signal became superfluous and might as well be taken away. If a signal was sufficiently reliable for the conducting of traffic in times of fog it was equally reliable for use in time of clear weather. He suggested that the feelings of the drivers should be ascertained as to systems of signalling.

Mr. W. J. BURTON said the subject of signalling was of the most serious importance to railway engineers. With regard to audible signalling, however, there were certain matters which would have to be carefully considered. Memory was an important factor, and doubts might arise in the mind of a driver as to his having heard a sound, whereas in the case of semaphore signals he could look again to confirm his first impression.

Mr. D. D. COATH said there were probably few subjects which had advanced so little as signalling. With the exception of interlocking the same methods were in use as 60 years ago. He considered the system put forward by Mr. Dawson as a great advance. He had seen the apparatus working, and it struck him as an excellent thing. He, himself, had brought out an apparatus which in some respects was an improvement on the one dealt with in the Paper. An advantage of his system was that it dispensed entirely with batteries on the engine, and what was perhaps more important, if the driver attempted to run past a danger signal his brakes were put on, and his conduct was bound to come before the notice of his superior. All previous systems had something on the permanent way and something on the engine to strike it, but his apparatus had been designed to give practically no blow at all. He utilised in his system the slack of an overhead wire, such as could be noticed with any telegraph wire. The driver could then see the apparatus was there, whereas in all other systems there was nothing to inform the driver of the fact.

Mr. L. M. G. FERREIRA said he had had a lot of inventions and apparatus brought to his notice. As a rule such systems had failed from one important and essential point. They did not give the danger signal in the event of any possible failure of the apparatus. The arrangement dealt with in Mr. Dawson's Paper appeared to get over this point. As to remembering the signal, the driver had no opportunity of forgetting it, as the bell ringing was continuous until the driver stopped it, and the whistle valve was kept open until he closed it. One great object of such a system was to do away with the maintenance of distant signals, which in most cases were a quarter of a mile away from the cabin and which were troublesome to keep in adjustment owing to the length of the pull. He thought the system described in the paper was the first to combine the necessary considerations.

Mr. J. BLACKALL said he had some experience of the apparatus in use on the Great Western Railway. They had had no failures at all, except such as they would expect to get. The apparatus had been in use on lines over which trains were running regularly at between 60 and 70 miles per hour, and no damage of any kind had resulted from impact. It had worked perfectly in all weathers. He thought an overhead wire system could not be relied upon for fast running trains.

Mr. J. EMILE MARCH said the chief factor in considering this question was the human element involved, and therefore it was most undesirable to have two systems of signalling on a line.

Mr. E. C. IRVING said he should like to see the rail take the place of the semaphore signal and if they could get a system that was operated electrically from the rails they would have something that would be as near perfection as possible.

LIGHT-RAILWAY POLICY.

BY W. BARRINGTON.

Probably there are not very many people who have clear ideas as to what a light railway really is, what reasons, if any, justify its existence, what special functions it is intended to perform, and how it performs them. As a nation we have been accused of "muddling through" our wars, and many other national enterprises; but there is another expression—"rule of thumb"—which probably conveys the idea more accurately. If this discussion has the effect of inducing some engineers (with a talent for reducing facts and figures into orderly and systematic formulæ) to undertake the labour of investigating this subject, much advantage will be derived by our profession and the public. The conversion of the "rule of thumb" (which at present too often guides the persons responsible for advising as to the initiation of light-railway projects) into systematised and logical principles would be found to be extremely useful.

I believe I am correct in saying that the first experiment with light railways on a fairly large scale which was tried in the United Kingdom was undertaken in Ireland. In 1883 the Government introduced a bill into Parliament entitled the Tramways (Ireland) Act. This act recognised the principle that it might be desirable in the interests of the country at large to subsidise from public funds railways which could not be expected to earn sufficient to pay any dividend on the cost of construction, and in some cases were unlikely even to earn their working expenses. Under this and subsequent acts, 600 miles of light railways have been constructed, which form upwards of 18 per cent. of the entire railway mileage of Ireland.

In the light of the 24 years' experience which has been gained since this policy was inaugurated, some broad facts, which many persons may regard as curious, have become apparent.

1. That, although the population of Ireland has largely decreased during this period—the actual decrease in the districts in which these lines are principally situated varies from 16 to 25 per cent.—the gross receipts of the light railways have shown a steady increase of from 10 to 119 per cent., the average being 51 per cent.

2. That, although the bulk of these light railways are worked as independent lines, thus violating (for reasons which are too long to give in detail here) the principles which have always been considered the soundest economically, the increases upon the lines which have remained independent average 40 per cent. more than those of the lines which are worked by other companies.

3. The increase in gross receipts of the standard main lines in Ireland in the same time has only averaged 43 per cent.; and it must be remembered that the light railways operate in the poorer parts of the country.

Within the compass of this brief note one cannot go fully or exhaustively into this question, and I only intend to direct the attention of those interested in the solution of traffic problems to some matters which will, I believe, repay fuller investigation.

Anyone who has been in a position to observe the developments which have been taking place in continental countries can scarcely have failed to note the growth of subsidiary or light railways even in those countries where the bulk of the main standard lines are the property of the State.

In Belgium an enormous system of local railways has sprung up, till, like a network, they cover most of the country. There are 3,622 km. (2,249 miles) of light railways of various gauges, while I believe the length of the main State railways is not quite as great. In Germany and Austria there are 4,221 km. of small railways (2,623 miles). In Italy, Switzerland and Holland a great growth of local subsidiary railways is also manifest. Perhaps our continental neighbours have recognised and formulated, more clearly than we have, the principles which should regulate such questions.

A consideration of the following facts may be helpful in enabling us to arrive at a conclusion. They are taken from the latest published statistics. But in tabulating them it has become necessary to make certain adjustments so as to reduce all to a common basis for comparison:—

Average capital cost per mile of constructing the principal independent light railways in Ireland	£3,999
Ditto Belgium	4,015
Ditto Germany	6,033

These figures include rolling stock and all equipment, purchase of lands, promotion, finance, legal and engineering fees, &c. The working costs on the same basis have been as follows:—

	Per mile per ann.	Per train-mile.
Irish light railways	£271	22d.
Belgian ,, ,, ...	205	10d.
German ,, ,, ...	398	34d.

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The average cost of working the standard-gauge main lines is as follows:—

	Per mile per ann.	Per train-mile.
In England	£3,645	..... 41d.
In Germany	1,384	..... 38d.
In Ireland	738	..... 34d.

I trust none of my hearers will misunderstand me, and think that because I make these comparisons I intend to advocate a general substitution of light for standard railways. This is far from my view; every case must be considered on its own merits, but it seems as sheer a waste of money and material to construct a heavy main standard line of railway to collect and distribute the small traffic of an isolated country district as it would be to erect and use a 500 ton crane to handle parcels averaging only 1 ton in weight.

One explanation of the relatively low cost of working light railways will no doubt be found in the fact of the lighter rolling stock employed and the relatively higher ratio of paying to non-paying load. I have frequently noticed instances (I do not give them as a true average, but they may be not far from it) in which the paying load in a light railway train was about 10 tons, the weight of the vehicles (empty) composing the train (excluding locomotive) was 27 tons, and the total weight of the train 37 tons, the ratio of paying to total load being 27 per cent. A standard-line train with the same vehicles (again excluding the locomotive) would be 54 tons, the total weight 64 tons, and ratio of paying to total load 15 per cent. These figures show a difference in favour of the light railway of 12 per cent.

We hear of countries whose railways are unable to handle their traffic, and of famines in waggons and rolling stock. Some means must be found of meeting these difficulties in an economic manner. It seems as absurd to expect a country to be economically drained of its traffic by means of standard main lines of railway alone as it would be to attempt to drain its waters economically by means of main rivers, unassisted by the streams and rivulets of which Nature has given us examples in abundance.

DISCUSSION.

Mr. A. BENN expressed great disappointment that subsidiary railways had not been taken up in this country as they had been on the Continent. One of the principal reasons for this was the excessive cost of land for railway purposes and the cumbersome system of acquisition of land. Passengers also expected as much luxury in travelling on small subsidiary lines as on the main lines. He was strongly in favour of light railways for handling much of the present heavy road traffic such as was now worked by traction engines.

Mr. C. P. BURGE said he had been concerned with the introduction of light railways into Australia, where they had been very successful. He found that, notwithstanding that they had to import all their rails and to carry all their sleepers between 400 and 500 miles, besides paying labourers 30s. per day, the cost came to less than the figure per mile given by Mr. Barrington.

Mr. R. LLOYD COOPER said he had taken part in discussions on this subject as far back as 1870. There was then, and always had been, a difficulty in defining what was or what was not a light railway. He thought the author was right in saying that there was not such a thing as a light railway, the only difference being in the process by which the necessary powers were obtained. He thought it unfortunate that the Light Railway Commissioners had no power to grant permission for a line against which competition was advanced by an existing interest. He thought there was a great future before light railways as feeders for junctions and termini. Landowners, he considered, ought to encourage light railways instead of demanding excessive values for any land which had to be acquired.

Sir GUILDFORD MOLESWORTH said it would have been an advantage if the author had given some idea of the cost per ton-mile instead of the cost per train-mile, as train-mile cost was of little use owing to the variation in the quantity of goods carried on different lines. As to the gauge of light railways, he thought it required very special conditions to justify any departure from the standard gauge owing to the loss of possibility of transmission over other railways.

Mr. J. BURTON said he had had experience of several broad and narrow-gauge light railways in Ireland, where they had proved distinctly advantageous and a commercial success.

Mr. M. N. RIDLEY said that unless the powers given to the Light Railway Commissioners could be extended the progress of light railways in this country would be practically nil. Their inability to deal with any application where competition was involved practically negatived any power they had, as in no case could a line be erected that did not come into some sort of competition with existing lines.

Mr. J. W. JACOMB-HOOD said the apparent absence of light railways in this country was due to so many having been absorbed by the great main lines.

The CHAIRMAN (Mr. W. R. Galbraith) said that, in regard to light railways in general, in his opinion light railways costing between £2,000 and £3,000 per mile in England were impossible. This cost was chiefly due to the heavy cost of land. As to gauges, he had hoped that light railways would be restricted to some gauge—say 3 ft.—such gauge to be standardised.

Mr. W. BARRINGTON, in reply, said his remark in the Paper that very few people really knew what a light railway was, had been amply confirmed by the discussion. The only difference between main lines and light railways was the restrictions put on light railways by the Act of 1866, which limited the speed of the trains and the weight on the axles. As to the cost per ton-mile, he thought Sir G. Molesworth had answered himself. This would be regulated by the traffic which the line could manage to capture, and on such traffic, of course, would depend whether or not the line could be worked profitably. The size and character of the rolling stock would naturally be regulated by the traffic.

On Friday a combined meeting of Sections IV. and VII. (Mining and Metallurgy, and Applications of Electricity) was held, and the following two Papers were read and discussed:—

ELECTRO-METALLURGY.

BY BERTRAM BLOUNT.

It may, I think, be rightly said that at the present there is more solid progress being made in electro-metallurgy than at any previous time. The older electro-metallurgical processes are being worked with economic and industrial success, and there is no lack of new ideas and improvements. There is a great difference between the mode of development of these new ideas as practised now, and the method which was formerly thought adequate. Then the subject of electro-metallurgy was so special that few were able to judge whether a process was likely to be successful or not. Now it has been studied like any other branch of chemical engineering, and its principles are well understood. The result is that processes which may be of considerable laboratory interest, but are plainly unworkable commercially, are put aside, and the energy and money formerly wasted on these are directed to those which can be made an industrial success.

The principal electro-metallurgical industries are the refining of copper, the manufacture of aluminum, of sodium and of steel. The greater part of the world's output of copper is refined electrolytically, with the result that good commercial copper, such as is used for locomotive fire-boxes, is often almost chemically pure. The advantage of this is that the users of copper as such, or the makers of alloys of copper, can now obtain the pure metal, and either use it pure or add to it a definite percentage of some other substance; their predecessors had to be content with copper containing any impurity which the manufacturer of those days found difficult to remove, and any accurate conclusion as to the cause of the behaviour of the metal or alloy under practical conditions was almost impossible. An incidental but very substantial advantage is that the recovery of the gold and silver in crude copper is effected completely and much more cheaply than is possible by any of the older metallurgical processes. It may be noted in passing that as the result of working up the anode sludge for its valuable contents, an element which 20 years ago was a chemical curiosity—I mean tellurium—is now procurable in quantity, and doubtless would be prepared commercially if an industrial use were found for it. The winning of copper electrolytically, as distinct from its refining, is in a very backward state; but I may perhaps be allowed to venture to express the opinion that in the future—and it may be in the near future—a method will be found which, for some ores at least, will displace ordinary smelting methods as completely as electrolytic refining has replaced the older dry processes.

The aluminium industry is in an exceptionally prosperous condition. The old trouble of finding an outlet for the metal has been replaced by the difficulty of manufacturing enough of it for modern needs with existing plants, and new works are rapidly being erected; at present, processes of the Héroult type are universally employed, but it is not likely that no improvement on these will be made. There are several directions in which experiments are being made, which, if successful, may lower the cost of manufacture substantially and allow of the use of aluminium at least as freely as that of zinc.

The use of sodium is not so large as to induce any great effort to improve or abolish the clever Castner process by which it is at present made, but even here there is some opening for invention in the way of electrolysing a sodium salt cheaper than caustic soda—*e.g.*, sodium chloride. Work is being done in this direction.

The largest of all electro-metallurgical industries will be the manufacture of steel. I say "will be" because suitable methods are only now being developed. Some are already at work, and in my view there is no doubt of their rapid and fruitful growth. Much delay in arriving at the present status has occurred because for years inventors tried to smelt iron instead of manufacturing steel from iron already smelted in the blast furnace. Now, however, attention is turned to steel making as a more easily attainable end, with the result that already steels of high grade can be successfully prepared in electric furnaces of various type—the Héroult and the Kjellin representing two of the most distinctive and promising. Probably, in the first instance, the electrical method will have its greatest measure of success in preparing steels of such high grade that any extra cost will be quite outweighed by the certainty that the metal will absorb no impurity in the course of manufacture. But as methods are cheapened, it may well be that every grade of steel now prepared in open-hearth furnaces will be prepared in corresponding furnaces electrically heated. The power necessary should

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be obtainable from blast-furnace gases, for, after a liberal allowance for heating the blast and for the blowing engines, hoists and subsidiary gear, there is certainly an ample surplus provided modern power-plant is installed.

Zinc is a metal not at present smelted electrically, but which for chemical and physical reasons is excellently fitted for production in that manner. There is much the same reason to replace the present furnaces with their numberless small and costly retorts by a furnace internally heated by current as there was to supersede the older mode of making phosphorus and carbon bisulphide by the electrical methods now in operation.

DISCUSSION.

Mr. T. PARKER said that as far back as 1885 at his works they were turning out about 160 tons of copper per week; subsequently they had taken up the manufacture of phosphorus, chlorite of soda, &c. Other works had also been running but he regretted to find that most of these industries had now gone out of the country. He had hopes, however, that electricity would provide cheap enough power to enable the industries to be reinstated in this country. They all recognised that electrolytic methods would be greatly used in the future. The question of getting current cheap enough in this country was the all important point to enable them to compete with the great waterfalls of the world.

Mr. McLAREN said that in order that they might arrive at a conclusion in the application of smelting of copper ore it was necessary that the conditions and difficulties should be recognised. A large amount of success had been attained in iron and steel making by electrical processes, and especially in the making of alloys. The conditions were, however, different in nearly every case. In the smelting of copper they had to produce a large proportion of slag which in specific gravity was not much less than the valuable product produced. It appeared to him that the usefulness of the electric process of smelting would be chiefly shown in districts where fuel was expensive, but where water power was available.

Mr. C. T. WEISS pointed out that electrolytic recovery of tin was now being carried on. In copper refining the additional cost of the electrical process was more than counterbalanced by the gold and silver obtained. In the development of the industry the supply of electricity in bulk would play an important part.

Mr. W. HARBORD said it had been found possible in Canada to work with very heavy sulphur ore and still produce pig iron free from sulphur. Also they could economically smelt iron sands and produce good pig iron. As these iron sands existed in boundless quantities in Canada and New Zealand this offered a special field for the electric furnace apart altogether from the use of the process for other purposes. The electric process was, he took it, not a competitor with the blast furnace where fuel was cheap and plentiful, but in out-of-the-way places where fuel was dear and water power to be obtained the electric furnace had a chance of success. The opening in England for the electric process was in preparation of high-grade steel, starting with ordinary steel and making it into a high-class product. The electric furnace was not a cheap smelter but a cheap refiner. He thought the economy of water power was greatly exaggerated

Mr. A. A. C. SWINTON said there was one aspect which would interest all electrical engineers and that was the possibility of utilising electro-metallurgical works for the purpose of improving their load factors. The Newcastle-on-Tyne Electric Supply Co. had recently made an arrangement with the Castner Kellner Co. and with the British Aluminium Co. for the supply of power to their works at a cheap rate. In such cases as these the cost of the current was really not the most important factor, the cost of labour and material, railway accommodation, &c., being more important. One process which had not been mentioned was working with cathode rays, with which it had been found possible to melt substances which were practically non-fusible in any other way. Messrs. Siemens & Halske were employing the cathode-ray system in the manufacture of metallic filaments for electric lamps. He thought that it was not realised that cathode rays would produce high temperatures on a large scale and that vacuum tubes could be provided which would absorb thousands of horse-power, enabling the production of chemical reactions without any interference from outside.

Mr. W. M. MORDEY said that however desirable it might be to improve the load factor of any electricity station he did not think they ought to look to the advance of metallurgical work for such improvement. Works which were going to have a continuous metallurgical process would find that they could produce their own current more cheaply than it could be supplied from outside. If a supply of current were obtained from a station, this would have to be a continuous supply and would be over and above the ordinary peak and would not much improve the position of the station.

Prof. TURNER said rather exaggerated views had been taken as to what could be done with blast furnace gases. About 10 million tons of fuel were used in blast furnaces in this country—about 2½ per cent. of the total output of coal—so that the utilisation of blast furnace gases was almost negligible, although locally it might be important.

Mr. T. H. BAILEY said he would be glad to know whether the author had considered the application of the electric process to repairs. One great difficulty with welding was the hardness of the material, which the ordinary welding processes would not touch.

Mr. T. H. WHINFIELD said he had not seen any reference to the application of the electric furnace to the production of tool steel, chain steel, &c. Were these furnaces adapted to the production of such material?

Dr. F. M. PERKIN said he noticed that Mr. Blount did not mention the production of graphite, which was now manufactured in large quantities in America, also the production of silicate used for furnace linings, metallic calcium, &c. He thought the chemists and the engineers did not work in conjunction with one another, or electrolytic processes might have made greater progress in this country. The manufacture of atmospheric nitrogen had gone abroad, also the manufacture of calcium carbide. This was doubtless more a question of cheap power.

The CHAIRMAN (Col. R. E. Crompton) said they were much indebted to Mr. Blount. Such discussions were distinctly interesting, and would be likely to do much good. One of the most important applications of the electric furnace was the treatment of steel after it had been prepared in the ordinary furnace. Another point of great interest was the treatment of metals at the lower temperatures. With the electric furnace it was possible to accurately control the heat so as to obtain any temperature required.

Mr. BERTRAM BLOUNT, in reply, said he was glad to have elucidated so much information as to the possibility of utilising the surplus power of blast furnace gases. It had been mentioned that only 10 million tons of coal per year were used for blast furnace purposes, but the surplus power even from this quantity of fuel would, he thought, if put into horse-power, represent many thousands of horse-power. As to Mr. McLaren's remarks, he was speaking of smelting, whereas the Paper dealt merely with electro-metallurgical winning. The electrolytic recovery of tin had been omitted because it was relatively a small industry, as was also the preparation of lead. As to the cathode-ray method of heating, he thought that method was a little in the air as yet. Because a thing was physically sound on a small scale it was extremely unwise to say it must be different on a large scale, but it had still to be tried.

MODERN APPLICATIONS OF ELECTRICITY TO MINES.

BY C. P. SPARKS.

The importance of increasing the application of power to reduce labour costs renders the use of electricity a matter of interest to all mine owners, as no other system has equal flexibility in distribution or is so well adapted to meet every form of drive above or below ground.

Economies.—The principal economies resulting from the use of electricity are through: (1) Reduced stand-by charges. (2) Small loss in transmission. (3) High efficiency of the electric motor for the lower capital cost of producing and transmitting energy. The saving is specially noticeable where the workings are spread over a large area, as the whole of the steam plant can be concentrated at one point.

The cost of electric power varies over wide limits and depends upon: (1) The size of the undertaking. (2) Capital outlay (influenced by locality). (3) Cost of fuel and circulating water (if water-power is not available). (4) Load factor.

Where electric driving has been adopted on an extensive scale, the load factor at the power house is between 30 and 40 per cent. This high load factor makes the fuel cost important. With the cheap fuel available at collieries, the cost of the coal only accounts for one-quarter of the total cost at the power house; whereas, when fuel is purchased, its cost may amount to more than one-half of the total; thus the advantage to be gained in applying electric driving in mines, where fuel has to be purchased, is much greater than the economy obtained in colliery working.

The following figures of the Powell Duffryn Company were recently quoted by me as representative costs at a discussion at the Institution:—

POWER HOUSE.

Low speed steam-driven generators = 3,000 kw.
(Largest unit, 1,500 kw.)

Average horse-power of motors at work during the last year:—	
Haulage	2,900 H.P.
Winders	180 ,,
Fans	380 ,,
Pumps	340 ,,
Screens	240 ,,
Auxiliary motors on surface	480 ,,
Total	4,520 H.P.
Output of power-house for 12 months	4,800,000 units.
Average cost of coal during the year	5s. per ton.
Coal consumption per unit	3·7 lb.
Running costs	0·18d.
Interest and depreciation charges 10 % on capital	0·17d.
Total cost per unit	0·35d.
Average load factor	36 per cent.

Advantages for Underground Work.—The difficulties of ventilation, even when no gases have to be dealt with as in collieries, render the application of steam difficult, and until electricity was applied compressed air was the only available agent for the inner workings. In consequence of the high capital and running costs of compressed air, the haulage gears were generally steam driven, being placed on the surface or at the bottom of the intake shaft.

Principal Applications.—While electric motors are now used for every form of colliery drive, the most important applications in England have been for haulage. Owing to the intermittent character of this work, the percentage saving by remodelling existing haulages is greater than that obtained in modifying any other part of a colliery equipment. Next in importance to haulage is the use of electricity for pumping, which has received great

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impetus through the development of the high-lift centrifugal pump. Owing to the comparatively large powers, the foregoing uses attract special attention, but the use of electricity for detailed purposes, while already of importance, will attract even greater attention in the future. Great progress has been made in electric coal-cutting, which not only reduces the cost of winning a ton of coal and increases the percentage of large coal won, but allows the thinner seams to be profitably worked, thus increasing the coal reserves. The possibilities of electric drilling are now coming to the front, and it is in the extension of the use of electricity in detail that the future reduction in mining costs are to be looked for.

Electric Winding.—While there is a substantial saving in the running costs, owing to the low cost of fuel available at collieries, this saving is at present counterbalanced by the interest charges due to high capital cost of electric winding plant. In consequence, this is the last part of a colliery plant to receive attention in conversion from steam to electric working. Where the hours of winding are long or the cost of fuel high, a substantial saving can now be made by adding electric winding, the whole power required being obtained from a single power house.

Haulage.—In addition to the lower power costs the first advantage gained with electrically driven haulage is the freedom in choice of position and speed; and second, the decreased wear and tear on the ropes and road through the steadier drive. In collieries it is seldom possible to consider the use of electric locomotives, owing to the diffi ulty of sparkless collection of current, but where mines are sufficiently dry and gradients not excessive, a considerable gain in efficiency and maintenance will result in operating by electric locomotives in place of main and tail haulage.

The 2,900 H.P. of haulage motors in use in the Aberdare collieries of the Powell Duffryn Company are divided between thirty two motors of 300, 150, 75 and 50 B.H.P.; these are all 3,000-volt motors, 50 periods. The 300 B.H.P. motor runs at 120 revs. per min., driving the haulage gear through single reduction-gear. The greater number of the haulages are driven by 150 B.H.P. motors of 290 revs. per min., driving through double reduction, while the smaller motors run at 365 revs. These motors are wound to give a maximum torque of 2½, and have an average efficiency from half to full load, of 89 per cent. and power-factor of 0·7.

Pumping.—The comparatively high speed at which it was necessary to run the motors in order to keep down the capi al c st was a disadvantage in the first pumping applications when three-throw pumps were dri en by ropes or gearing, but the combination of the electric motor with the high-lift centrifugal pump has resulted in a great advance on previous methods of pumping. The high speed and purely rotary motion has much reduced the capital cost and the space occupied compared with any previous system. The Powell Duffryn Company have several high-lift centrifugals at work. At Lower Duffryn a seven-stage Sulzer pump, delivering 800 gallons per minute against 1,150 ft. head, is driven by a 3,000 volt 50 cycle 1,450 revolution induction motor supplied by the Electrical Company, rated at 450 B.H.P. The motor is of the slip-ring type and is started by varying a liquid resistance in the rotor-circuit. It is generally run seven hours each night when the haulage machinery is shut down, and thus equalises the load on the power house. Tests show an over-all efficiency from motor terminals to output of water at surface of 65 per cent. when delivering 798 gallons per minute against a head of 1,115 feet, suction 20 feet, pump speed 1,480 revs. per min.

In the Brithdir seam at Bargoed a five-stage Simpson pump is at work, driven by a 3,000 volt, 50 period, Westinghouse squirrel-cage induction motor, running at 1,450 revs. per min., delivering 800 gallons per minute against 700 ft. head.

Two turbine pumps have just been completed for the East Elliot pit, each capable of delivering 1,300 gallons per minute against a head of 1,650 ft. These pumps are of the six-stage Simpson type, and are to be driven by Westinghouse 3,000-volt, 50-period, squirrel-cage induction motors, started by autostarters. The guaranteed efficiency from input at motor terminals to output at surface is 69 per cent. It is proposed to run these pumps at night, when the haulage-gears and other machinery are shut down, thus providing a steady load for the power-house, this being equipped with Nuernberg gas engines of 1,200 and 2,400 B.H.P. driven from th surplus gas of the by-product coke ovens.

DISCUSSION.

Mr. E. M. HANN said that he could only approach the subject from a mining point of view. The space required for the accommodation of pumping apparatus was a matter for consideration, and in some mines the engineers experienced considerable difficulty in providing space for large pumping installations. The small space occupied by centrifugal pumps as compared with the big pumps at present working in many mines was a distinct advantage.

Prof. REDMAYNE said compressed air had been found exceedingly useful in mining work and he thought there was a great future before it. The author in his reference to electrical winding stated that perhaps the high capital cost had prevented the introduction of electrical winding, but in his, the speaker's, opinion it was the absence of a good system of electrical winding rather than the capital cost which had prevented its adoption.

Mr. H. DAVEY said he quite agreed with Mr. Sparks as to the flexibility and other advantages in the application of electricity to mining work, but he altogether disagreed with the suggestion that because electricity had been found to be an advantage in one mine it was equally advantageous for all mines and that great economy would be effected by its application. Local conditions varied too much and the conditions of mining varied too much for a broad reasoning of that kind. The same remarks applied to pumping. Centrifugal pumps were being installed in Cornish mines, but the application was quite different to the application in collieries.

Mr. W. H. PATCHELL said he agreed that the economical application of electricity depended to a great extent upon the relative positions of the motors which had to be served. Ventilation of mines was a very important matter and could probably be carried out better by electrical means than by any other system. In spite of what had been said by Prof. Redmayne as to compressed air, the application ofelectricity to the driving of coal cutters and other mining apparatus was increasing rapidly.

Mr. J. S. PECK said an active interest was being taken throughout the country by mining engineers in the application of electricity to mine working. The working of coal cutters was a very large field. As to winding, he believed that electric winding would eventually supersede other systems. The question of alternating as against continuous current had been pretty well settled in favour of alternating current, three-phase. There was, however, still the question of frequency. In this country there were two standards—25 and 50 periods. There were certain advantages in both, but for mining work 25 periods had the greater advantage. Although the system for main winding was now by direct current motors, there would undoubtedly be a great many installations where alternating-current motors would be used. For haulage work a frequency of 25 was best.

Mr. H. MAVOR said it was rather premature to say that compressed air was excelling electricity in working coal cutters, inasmuch as electric coal cutting was proving to be the most favourable method. In certain cases there were advantages in compressed air working, but even then it was necessary to have the air compressors as close to the work as possible, and the driving of the compressors by electricity was adopted to some extent, but the working cost of this was high compared with the direct electric drive. As to centrifugal pumps, these had certainly a useful field, but there was evidently something wrong with the figures given in the Paper as to efficiency.

Dr. HERZFIELD described an instance where a mine had gone out of use owing to the heavy inflow of water but which it was decided to drain and work again. This necessitated a pumping installation capable of pumping 16,000 gallons of water per minute, which was the largest pumping installation that he knew of. Centrifugal pumps were found to offer the greatest facilities and these were worked electrically from a generating station about 2,000 yds. distant, the energy available from the station being 2,600 H.P. He thought such examples as this showed that electricity was not only revolutionising mining operations, but offered a means of doing things which could not otherwise be done.

Major A. H. MESEY THOMPSON said no one would deny that for a great many purposes electricity was the most suitable. The figures in the Paper showed that electrical power was costing £10 per actual horse power per year, but if all the losses were taken into account he thought the actual cost would be nearer £20 per actual horse-power per year. From a previous Paper they had had before them it appeared that the cost of a large steam plant came out at between £9 and £10 per actual horse-power per year, so that it appeared roughly that an electrical plant would cost just double this. In some cases this extra expenditure was, of course, justified by circumstances. The flexibility of the electrical system was its great factor.

Mr. C. P. SPARKS, in reply, said that as to Prof. Redmayne's remarks he agreed that there were certain classes of mines where the use of compressed air was desirable, and that was where he thought electricity and compressed air were better worked in conjunction than with the old system of compressing the air on the surface and conveying it long distances by a pipe line, entailing necessarily a reduction of efficiency. As to winding, he had carefully considered the matter and found that the only objection to electric winding was the capital cost and under special circumstances such capital cost was justified. As to Mr. Peck's remarks on frequency, where large high-speed motors were used it was a case for special application. There was, however, greater flexibility and choice of speed with the higher frequency. As to Major Thompson's and Mr. Davey's remarks on the cost per horse-power per annum, if the whole of the power available had been utilised, the cost would not have exceeded £10 per horse-power per annum.

In Section V. (Shipbuilding) the only Paper of electrical interest was on

THE WELDING OF STRUCTURAL MATERIALS IN PLACE.

BY H. A. RUCK-KEENE.

The ordinary method of welding wrought iron or steel, whereby the parts to be united are heated to a suitable temperature, at which they become plastic but not actually fused, and are then united by hammering, squeezing or rolling, is well known. Some engineers consider that a properly-made weld is as strong, or nearly so, as the iron itself; others will not sanction a welded joint in any important detail of structure if it is possible to avoid it, and when

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a weld is sanctioned it has to be arranged in a position in which the minimum of stress is likely to come upon it. But the fact that practically every link of every chain, every wrought-iron steam and water pipe, all iron boiler tubes, and the majority of steel boiler tubes and nearly all boiler furnaces are welded, shows that very considerable reliance is placed on welding

Many engineers consider that iron is more reliable for welding purposes than mild steel, and also that a better weld can be obtained from poor than from high quality iron. These opinions were, no doubt, the reason why, in welding up steel beam knees, steel boiler furnaces and other mild-steel sections, it was formerly common practice to unite the pieces by means of a "glut" of iron. They arose probably from the fact that wrought iron contains numerous small inclusions of slag, which is mainly silicate of iron, the poorer qualities of iron containing these in larger quantities. When raised to welding temperature the oxide formed, being mixed with this silicate, is slightly more fusible than the purer oxide formed on the purer metal. Tests made by the Superintendent of Lloyd's Proving House at Netherton, show that this prevalent idea is not correct, the better quality iron giving the best results throughout.*

A comparison of the extensions shows that the welded bars, as compared with the solid bars, lose far more in ductility than in tensile strength. This suggests the necessity of annealing the articles after welding, and this is always done in the case of furnaces, and is practically done in chain and tube making, as the pieces operated on are raised to a fairly uniform temperature throughout. In the Elihu Thomson process of electric welding, which is extensively used for welding pipes together in the manufacture of coils, &c., the union is made in the same way as in ordinary welding, but the necessary heat is generated by passing an electric current of low intensity through the pieces to be welded. When the proper temperature is reached, the pieces are squeezed together by mechanical means. In the case of pipes soundness of weld is of more importance than strength, and this process is eminently suitable for this work.

The tests given below, made by the Superintendent of Lloyd's Proving House at Glasgow on steel and iron bars welded by this system, are of interest. Here again the advisability of annealing is indicated.

No. of test.	Description.	Prepared dimensions of sample.		Breaking stress.		Elongation taken on 5 in.		Contraction of area.
		Diam	Area.	Tot'l	Per sq.in	Tot'l	Per cent.	
		In.	Sq.in	Tons	Tons	In.		%
1	½ in. round steel solid bar..	0·640	0·321	8·9	27·7	1·60	32·0	64·7
2†	11/16 in. round steel bar	0·645	0·326	9·21	28·2	1·24	24·8	63·5
3†	½ in. „ „	0·620	0·301	8·42	27·9	0·67	13·4	26·9
4†	½ in. „ „	0·610	0·292	8·42	28·8	1·25	25·0	64·3
5	11/16 in. round iron solid bar..	0·625	0·306	8·0	26·1	0·94	18·8	44·7
6†	11/16 in. round iron bar	0·635	0·316	8·1	25·6	1·23	24·6	40·5
7†	½ in. „ „	0·622	0·303	7·8	25·7	0·76	15·2	21·7
8†	½ in. „ „	0·630	0·311	7·57	24·3	0·51	10·2	16·0

In the Benardos or arc system of electric welding a different method is employed; the articles to be welded are placed in position and are connected by a cable to the positive pole of the dynamo, and the negative pole is connected to a carbon pencil. On the pencil being brought into contact with the article to be dealt with, and then withdrawn a short distance, an electric arc is formed which rapidly heats the part in close proximity to the arc. When the surface of this part is fused a small piece of metal is added, and this becomes fused and attaches itself to the fused surface; this process is continued until sufficient metal has been added and fused, to fill the space between the parts to be united. Great care must be taken to ensure that each and every one of the small pieces of the metal added becomes firmly attached before adding more metal to it. Many successful repairs have been carried out by this process, more especially to steel castings, &c., and it is generally considered necessary to anneal the parts dealt with, after the operation, to relieve the contraction strains set up by the intense local heat.

In another system, instead of the carbon pencil, a small rod of specially prepared iron is used; this itself becomes fused in the arc and forms the metal which builds up the so-called welded joint. Repairs to boilers have been satisfactorily carried out by this process, wasted portions of boiler plates being built up to their original thicknesses, and leaky riveted seams, both vertical and horizontal, being dealt with so as to weld the plates together, some of the rivets in these seams being so fused to the plates as to become integral parts of them. All three of these processes of electric welding have the advantage that the material to be dealt with need not necessarily be close to the generating plant, as the required electric current is carried through cables.

Somewhat similar processes are the oxy-acetylene and oxy-hydrogen systems. Here the required heat is generated by mixing acetylene or hydrogen gas with oxygen in a blow pipe; the flame resulting from ignition of the mixture at the nozzle gives out an intense heat, and the same process of fusing is carried out as in the case of the electric arc welding, the metal being added drop by drop until sufficient building up has been done either to join the pieces to be united, or to fill up the wasted portions. This system has been successfully employed in welding tram rails in position, welding branches and flanges on iron and steel pipes, and also in repairing boilers, in building up wasted portions of plates to the required thicknesses, filling up cracks, and in welding new pieces of plate in place. The repairs thus made give every appearance of being permanently satisfactory.

The oxy-hydrogen and oxy-acetylene flames have both been usefully employed in the reverse process to welding—namely, in cutting up structural work. The heads of rivets are easily so melted that the rivets themselves can be backed out, and where large plates have to be cut out they can be separated in much less time than by hammer and chisel. As an example, a furnace ⅝ in. thick has been cut round its circumference of 10 ft. in 40 min., the separation being quite as cleanly and accurately done as by the ordinary method of hand labour.

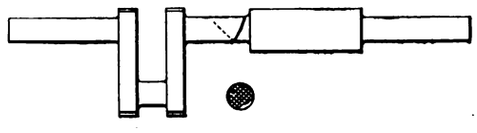

FIG. 1.—MOTOR SHAFT.

Since the shaft was repaired as shown, it broke in another place and was again repaired by electrical welding. It has since been in use several months without further accidents.

When large pieces have to be united, by either the electric or the oxy-acetylene methods, although they may be brought close together for a portion of the section, yet the opening between them has to be so much cut away, to admit of the carbon pencil or the blow-pipe flame being brought into any required spot, that the amount of metal requiring to be fused is larger than in proportion to the section of the piece to be united. It is evident that the nature of the metal added, in all these processes, is different from that of the pieces joined, and the desirability of subsequent annealing is manifest.

The results of two tests of test-pieces cut from a $\frac{9}{16}$-in. plate, which had been welded by the oxy-acetylene process, gave the tensile strength as 21·1 and 21·9 tons per square inch, with elongations of 15¼ and 6 per cent. in 8 in. The tensile strength of the original metal was 25·6 tons per square inch and the elongation 38·5 per cent. in 2 in.

Another method of uniting pieces of a structure is that of fusing the surfaces and filling up the spaces between them with molten

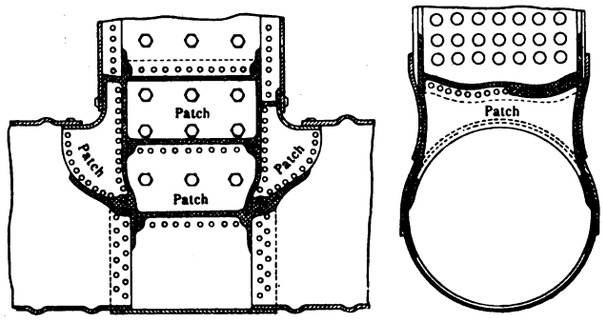

FIG. 2.—DOUBLE-ENDED BOILER, CENTRE COMBUSTION CHAMBER PREVIOUSLY PATCHED, REPAIRED BY ELECTRICAL WELDING.

Scale 1 : 10.

metal; but in this case the molten metal is added in one operation, instead of its being built up fragment by fragment. This system was employed some years ago in the manufacture of compound armour plates. A hard steel plate and one of highly ductile iron were placed parallel at a certain distance apart, raised to a welding temperature, and the space between them was then filled by pouring molten mild steel between them; perfect union of the hard to the mild steel and of the mild steel to the iron was thus obtained. This, of course, needed most extensive and costly plant, and improved methods of armour plate manufacture have rendered it obsolete.

A new method of joining comparatively large pieces together has, however, been introduced by the Thermit Company, and is called the "Alumino Thermic" process. The essential ingredients of thermit are finely divided aluminium and iron-oxide intimately mixed. This is placed in a crucible, and when ignited by a special ignition powder it becomes liquid in a few seconds, the resultant being aluminium oxide and molten iron at an exceedingly high

[* The table showing these results has been omitted.—ED. *E.*]
† Welded by electricity in middle.

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temperature; the iron is then run between the surfaces to be joined, and raises them to the necessary temperature to permit union between the surfaces and the thermit metal.

This process has been used successfully for welding tram-rails in place, &c., and abroad several stern-frames and other pieces of fairly

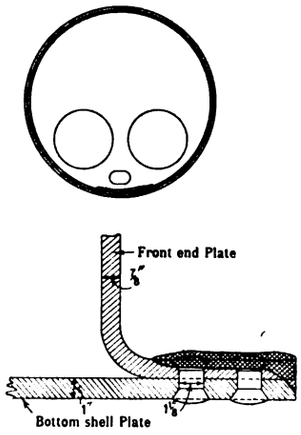

FIG. 3.—THE REPAIRED BOILER WAS EXAMINED AFTER BEING UNDER STEAM ABOUT 450 HOURS AND FOUND PERFECTLY TIGHT.

large section have been repaired. A large wrought-iron stern-frame, and two U-shaped steel castings of heavy section, representing the stern castings of a large twin-screw vessel, have recently been welded in London for the purpose of testing the efficiency of this

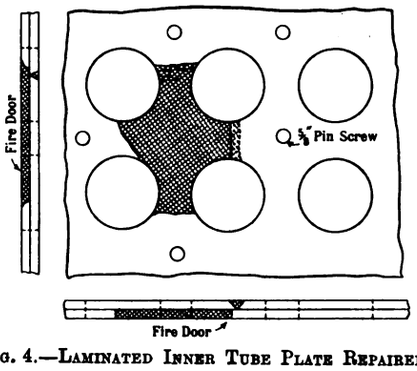

FIG. 4.—LAMINATED INNER TUBE PLATE REPAIRED.
Scale 1 : 8.

system, but unfortunately, owing to some delay, the suggested mechanical tests have not been completed at the time of writing this note.

DISCUSSION.

The author then submitted specimens and showed some diagrams of electric welding, some of which we give in Figs. 1, 2, 3 and 4. The following particulars of tests of steel plates welded by the oxy-acetylene and electric processes were also added to the Paper :—

Oxy-acetylene Welding.

—	Brdth.	Thickness.	Area.	Tons, total.	Tons p.sq.in	* Extension in 4 in. % † ,, ,, 8 in. %	
Not an'eal'd	1·5	0·62	0·93	22·85	24·5	*30	Solid plate.
Annealed..	1·5	0·62	0·93	22·35	24·0	*36	
Not an'eal'd	1·5	0·62	0·93	22·9	24·6	†28	Welded sample broke outside weld.
Annealed..	1·5	0·63	0·945	22·1	23·3	†29	

Cold Bend Tests, bent through Weld.

Not annealed..... 180 deg.
Annealed ..... 180 deg.

Electric Welding.

Not an'eal'd	1·0	0·56	0·56	15·35	27·4	*14	Broke in weld.
Annealed..	1·0	0·55	0·55	14·5	26·3	*12	

Cold Bend Tests, bent through Weld.

Not annealed ..... 58 deg. } Showed signs of fracture.
Annealed ..... 160 deg. }

Mr. E. W. DE RUSETT said those who had to do with the repair of ships knew that a broken stern frame was a very troublesome business. If a satisfactory process of making welds in plates were secured, it would prove of great benefit. He had witnessed the experiments referred to at the end of the Paper in connection with the thermit welding of a stern frame. It did not strike him that the result was altogether what one would like. There were defects in the stern frame close to the weld. The welding of tubes and small pieces was really a commercial process and might be satisfactory. He supposed they were not subject to any stress and there appeared to be no risk of corrosion. If work in combustion chambers could be done in a reasonable time it might be satisfactory, but the cost of the plant would be rather a drawback. The examples of the method of building up the material on the plates were also interesting, but he doubted the commercial value of the process. It seemed to him that if a boiler was in such a state as to require such treatment it would be better to get a new one or put a new plate in.

Mr. EDWARDS said he considered the Paper of immense value in connection with the repair of boilers. He had had many repairs where it had been exceedingly difficult to get the parts tight and close up, and he could see by the samples that this would be an easy matter compared to getting patches made and then getting them caulked up and made tight. He would like to know what means there were in this country of getting the necessary plant for the repair of boiler plates by this method.

Mr. RUCK-KEENE said he did not know of any electric process suitable for this work for which the plant could be obtained at present, but the oxy-acetylene could be easily got.

Mr. EDWARDS, continuing, said it would be a serious matter for ship repairers and boiler repairers if this process came into use. He would like to know whether anything had been done in the direction of renewing a whole furnace crown. If that could be done it would save disturbing the back end seam and the awkward corners at the side of the combustion chamber.

Mr. HOLGATE said that after long experience of ship repairing and engineering he could see there was a great future for this method. It might, however, take a little time to get the experience and the faith to enable the repairers to use the process.

Mr. C. H. WINGFIELD asked whether the elongations and contractions of area were inside or outside the welds. If outside they did not show the nature of the new materials, but from the appearance of the samples the metal which seemed to have been dropped on like sealing wax, appeared to have stretched the rest.

Mr. R. J. WALLIS-JONES said the author referred to the necessity for annealing after electric welding by the Thomson process. He might mention that it was quite the usual practice in factories where they used a high-class steel for armouring cables to anneal the wire by slightly heating it after the weld had been made and allow it to cool gradually in the air. The author also referred to the welding of tramway lines by the thermit process. The Thomson process of electric welding had, after a long period of experimental work, been very successfully carried out in that direction. He believed that during the last two years something like 300 miles of track had been electrically welded in the United States by that process, and that there were some 10,000 joints at work in this country. There was one point which was interesting because it was the one detail essential to success. In the joints now made in this country there were two long splice-bars which were put on each side of the web of the rail, and these were welded at each end and also in the middle. It cost a large amount of money to find out that the thing essential to success was to make the weld under considerable pressure, and to leave the welded portion while hot under pressure for some three minutes.

Mr. DE RUSETT asked whether the thermit burned away the stern frame above and below the boss, which seemed to form over the point of fracture, because it seemed that the frame was such a large mass that there must be a great deal of surface heat which, he thought, would have a tendency to burn into the stern frame and reduce its section about the weld.

Mr. RUCK-KEENE, in reply, said with regard to broken stern frames he did not think they had got far enough yet with the oxy-acetylene or thermit processes to say whether they would do such repairs satisfactorily. Both processes had given good results in boiler repairs, but he could not say whether they would give as good results in welding a big stern frame until more experience had been gained. He did not know the price of the electric process, but repairs to 18 furnaces on a steamer at Marseilles by the oxy-acetylene process cost £818. These furnaces were badly burned in the line of firebars, and they filled up the wasted portions with little steel bars. The work took a month. Annealing was always a good thing if it could be done. They did not apply the welding heat for that purpose but a lower temperature. In a good many other repairs instead of riveting and making another seam, the seam had been welded up and the wasted landing edges filled up. The back plates of the combustion chambers had also been filled up to their original thickness and had given satisfactory results. He did not know whether the electric plants could be got in England, but he supposed so. As regarded the oxy-acetylene the outfit was simple. A complete outfit with a cylinder of oxy-acetylene gas could be got for £79, and a blow-pipe, which might come to between £6 and £10. It was easier in the case of boilers to use dissolved acetylene than generated acetylene gas because it was easier to get about. It was cheaper in a shop to put down acetylene plant. The cylinder of oxygen should be started at 120 atmospheres and the oxygen used under pressure. Dissolved acetylene cost 2d. per cubic foot and the oxygen gas ½d. to 1d. per cubic foot. With regard to Mr. Edwards' question, whether it would be possible to renew an entire furnace crown without cutting it out, he did not see why it should not be done, but a little more experience would first be necessary. It would probably cost as much as taking out the furnace. For patches the system was good. In many furnaces at Marseilles cracks 9 in. long had been repaired and also boiler tubes ⅝ in. thick. With regard to Mr. Wingfield's question the contraction he had given in the Paper was the contraction in the way of the weld. In reference to the question as to the reduction of the section of the metal in the vicinity of the weld by the thermit process, he could not say much about it one way or the other until he had the results of tests that had been made. He understood the electric—and he knew the acetylene—had been used to a certain

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extent for repairing copper, but he had not had much experience of that yet. It had also been used to a limited extent for cast iron.

Sir FORTESCUE FLANNERY, who presided, said that a point against the new process was the statement by the author of the Paper that there was a necessity for annealing after welding. If that was so, could a rudder frame that had been thermitised in places be repaired? He did not say it was impossible, but it might be difficult to meet the case efficiently. The cost of the repairs was not of much importance compared with the loss occasioned by the detention of big ships while the repairs were being carried out.

ELECTRICAL TRANSMISSION-GEARS ON MOTOR VEHICLES.

In the discussion on this Paper, which we gave in our last issue, Mr. H. A. MAVOR said that he was inclined to think that in future development we were more likely to find alternating currents useful. One idea, which he had experimented with to a small extent without being able to put it into practice, was to change the frequency of the generator as follows:

The primary and secondary circuits of the alternator were wound in the usual way, but the secondary magnet, nominally the stator, was freely supported on bearings, and might be rotated in either direction. The windings F and G formed a motor, which drove C in either direction at a speed determined by the number of poles in B and D and by the speed of B. There were thus three possible changes in the frequency.

1. The normal frequency when there was no current in F, and C was prevented from rotating.
2. An increased frequency when C rotated oppositely to B.
3. A decreased frequency when C rotated with B.

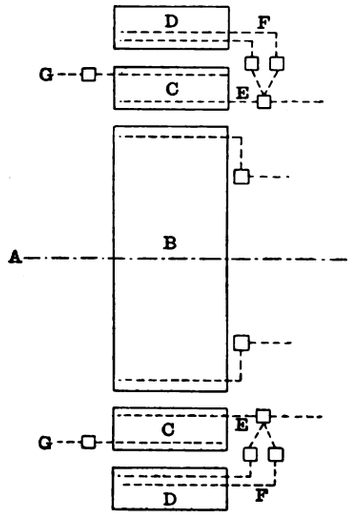

DIAGRAM OF FREQUENCY REGULATOR FOR OBTAINING A FREQUENCY GREATER OR LESS THAN THE NORMAL.

Explanation of Diagram—

A. Driving Shaft of Alternator.

B. Separately excited Primary Magnet of Alternator.

C. Secondary Magnet of Alternator and of Regulator.

D. Primary Magnet of Regulator.

E. Secondary Circuit of Alternator with Slipping Connection to the External Circuit Supplying Motors, &c., and to

F. The Primary Circuit of the Regulator with Reversible Connection to E.

G. Secondary Circuit of Regulator which may be short-circuited or wound and supplied with resistances for starting.

The power of the motor was directly proportional to the change of frequency. The torque between B and C being assumed, this was the torque to be overcome by the motor when the frequency was increased, or conversely this torque would return power to the circuit when the frequency was reduced, in each case the power was = torque × speed.

By connecting C mechanically to the work, and closing circuit E through circuit F, a speed reduction or increase was obtained with reversibility in direction of rotation, but there was then a fixed ratio of speed for each direction of rotation, and change of speed must be obtained by change of speed in the generator, or by resistances in the circuit G. The arrangement had been worked out in detail for dealing with road or marine propulsion, and offered no difficulties in its application to either purpose.

AN EFFICIENCY METER FOR ELECTRIC INCANDESCENT LAMPS.*

BY EDWARD P. HYDE AND H. B. BROOKS.

The life of a normal incandescent lamp depends primarily on the temperature at which the lamp is operated, and the temperature of the filament is a function of the watts per candle; that is, of the "efficiency" at which the lamp is operated. For lamps of the same type, the higher the efficiency the shorter the life, and vice versa; and since uniformity in life is one of the first qualifications in a good lot of lamps, uniformity of efficiency is of great importance.

In order to meet the need for an efficiency meter in the photometric work of the Bureau of Standards, the writers have recently designed and constructed such an instrument.

* Abstract from the *Bulletin of the Bureau of Standards*, Washington, Vol. II., No. 1.

The problem to be solved consisted in devising some method by which the readings of a wattmeter would be made to vary inversely as the candle-power. Two general methods suggested themselves—a mechanical method and an electrical one. According to the former either the scale of the wattmeter would be moved by the motion of the photometer carriage, or the motion of the latter would vary the counterforce opposed to the moving coil, as, for example, by increasing or decreasing the effective length of the spring. Either of these methods would require the wattmeter to be specially constructed and to be fixed in position relative to the photometer, and would present other serious practical difficulties, so that the mechanical method was abandoned for the more promising electrical method.

According to the latter there are three possible ways of decreasing the wattmeter reading in the ratio of $\frac{\text{constant}}{\text{candle-power}}$: (*a*) by placing a variable resistance in parallel with the current coil of the wattmeter; (*b*) by placing a variable resistance in parallel with the moving coil; and (*c*) by placing a variable resistance in series with the pressure circuit in the wattmeter.

Case (*a*) is objectionable because of the low resistance of the series coil in a wattmeter of the required range. It would necessitate a low resistance in the shunt circuit controlled by the moving screen, and hence would be liable to error due to variations in the contact resistance. In case (*b*) this objection will not arise, since the resistance of the moving coil will be about 50 ohms, and hence the shunt controlled by the movement of the screen will not, in general, be less than 50 ohms, in comparison with which variations in the resistance of well-made sliding contacts will be negligible. This method requires that an extra lead be brought out to an extra binding post on the wattmeter, as both terminals of the moving coil are not directly accessible.

In both the shunt methods the range of the efficiency meter, in case the instrument is to read ten times the efficiency, will have as its lower limit 10 c.p., for at 10 c.p. the resistance of the external shunt must be infinite, or, in other words, the shunt circuit must be

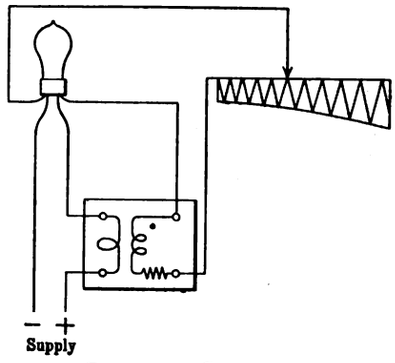

DIAGRAM OF CONNECTIONS.

open. Moreover, in case (*b*), if the instrument is to be used for candle-power values above 20 c.p. the shunt resistance would become smaller than 50 ohms, and hence care must be exercised to have the contact resistance sufficiently constant to produce no appreciable error. In general practice, however, in reading 16 c.p. lamps the range is seldom greater than from 10 to 20 c.p., so that these difficulties are not serious.

Method (*c*) is more nearly free from errors and limitations than either of the other two methods. According to this method a variable resistance is placed in series with the pressure circuit in the wattmeter, and since the latter will have a resistance of several thousand ohms the contact resistance is of much less importance than in the other cases. Moreover, there are practically no limits to the range of the instrument if we take out of the wattmeter part of the resistance in series with the moving coil. This becomes necessary only in case we desire to use the efficiency meter below 10 c.p.; otherwise the wattmeter can be used without any modification. Method (*c*) therefore seemed more promising than either of the other two methods, and was hence adopted.

Assuming that the wattmeter to be used reads correctly as a wattmeter, the resistance in series with it should be zero at 10 c.p., since the reading at 10 c.p. should be total watts. At 20 c.p. the reading should be one-half the total watts; that is, the added resistance for the position of the photometer corresponding to 20 c.p. should equal the resistance of the wattmeter. It only remains, therefore, to determine the relation between the candle-power reading and the resistance for other points on the bar, and to find some convenient, practical way of introducing the additional resistance. The authors prove that if this is denoted by r, and r_1 is the resistance of the wattmeter pressure winding, while I_1 is the intensity of the comparison lamp, $2a$ the constant distance between the two lamps, x the distance from the test lamp to the photometer

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screen at balance, and K the factor of proportionality between the scale reading and the efficiency, then

$$r = r_1\left[\frac{I_1}{K}\left(\frac{x}{2a-x}\right)^2 - 1\right]. \quad . \quad . \quad . \quad . \quad (1)$$

The method which seemed most desirable for the construction of a rheostat to follow this law consisted in winding closely a fine silk-covered resistance wire on a block of insulating material. After coating with shellac varnish and drying, the insulation was removed along a strip over which travels a contact brush attached to the photometer carriage. The variable rheostat thus formed is connected in the pressure circuit of the wattmeter, so that the resistance of this circuit varies with the position of the photometer. The electrical connections are shown diagrammatically in Fig. 1. The top of the block, along which the contact is made, is straight, and the bottom of the block must have whatever form is necessary to give the proper increments dr to the resistance as the contact moves over successive small distances dx.

The equation governing the curvature of the bottom is

$$y = \frac{2ar_1I_1}{Kn\rho_1}\frac{x}{(2a-x)^3} - h, \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where h is the thickness of the block, y the downward height of the block, n the turns per unit length, and ρ_1 resistance per unit length.

Some particulars are given as to the limits of the efficiency meter in practice. If K = 10 there will be no resistance in series with the wattmeter when the photometer is at 10 c.p. Hence the coil begins at this point unless it is desired to read efficiencies for points below 10 c.p., in which case some of the resistance in series with the moving coil can be taken out of the wattmeter and placed in the external coil. This can be accomplished without unfitting the wattmeter for other uses, by bringing to an extra binding post on the instrument a tap from some point in the resistance depending on how far below 10 c.p. the meter is to be used. While there is no difficulty in doing this, there is also no need generally of having the meter to read below 10 c.p. on a 16 c.p. bench. The upper limit can be as high as desired, although the ordinates of the block increase very rapidly as we reach higher candle-power positions, so that unless there is some particular reason to the contrary it will be found desirable to take as the upper limit 20 c.p. or 25 c.p. The meter at the Bureau reads watts per candle for a range of from 10 c.p. to 20 c.p.

Besides the ordinary use of the instrument in reading watts per candle when lamps are tested for candle-power at some constant voltage, or for voltage at some fixed candle-power, it is very convenient for determining directly the voltage at which a lamp has a definite efficiency.

[In connection with this article we may mention that an efficiency meter on these lines was patented some years ago by Messrs. Wilson and Hardingham, and is now manufactured by Messrs. Everett, Edgcumbe & Co. This instrument was described in *The Electrician*, Vol. LV., p. 993.—ED. *E.*]

PARLIAMENTARY INTELLIGENCE.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

At the sitting, on the 18th inst., of the Hybrid Committee of the House of Commons appointed to consider this bill, Mr. Wedderburn, who appeared for Shoreditch and Woolwich, commenced the cross-examination of Mr. Rider, and said that his clients' case rested more upon policy than anything else.

Mr. WEDDERBURN: You have told the committee that in your view the scheme is a sound one. Now, the complaint against the existing state of things is that the generating stations are too small and too numerous, and the areas to be supplied are also too small and too numerous. You have referred in your evidence on several occasions to the question as to the use to which, should this scheme pass, the existing generating stations can be put. You said you would show that these need not be entirely shut down. Take the case of Shoreditch. If this bill is passed, what, the day after the establishment of your undertaking, would be the position of the Shoreditch generating station—I mean when your scheme is working?—It could deal with the peak loads in the district.

I suggest that it would be at the option of the transferee to do what he pleased with Shoreditch?—I do not think so. Shoreditch would utilise its plant to deal with the peaks, and if the total demand were 4,600 kw., then I suggest a good arrangement would be for Shoreditch to supply 2,300 kw., and the Council under this scheme to supply 2,300 kw.

But is there anything in this bill to guarantee or provide for such an arrangement?—I do not think it is required to be stated, as it is a business proposition.

Is there any objection, if it can be done, to protect Shoreditch in the way suggested?—I cannot say.

Then you speak of the gradual closing down of the existing undertakings. What do you mean by the word gradual?—That as the time is drawing to an end when the borrowed money will have been paid off the stations should be gradually shut down. I think by that time the stations would be ready to be shut down by obsolescence of the plant.

I do not quite follow? Surely you cannot let an electrical undertaking gradually decay. You must either keep it or not keep it up?—There are many cases where plant in stations is not used at the present time. It is put on one side for more modern plant, and that is what I suggest will happen in the case of some of the stations.

Mr. Peel in his evidence suggested that they should be used as stand-bys. What did he mean?—I cannot answer that question, but it is obvious that the generating stations of the local authorities cannot be used as stand-bys beyond their capacity. In the case of Shoreditch we suggest that it could be used up to 2,300 kw., and it could be used at times of the day when the County Council's supply would otherwise be used.

You cannot really use an electric station as a stand-by. It must be kept in complete working order. You could not stop it for a year and then suddenly, when a breakdown occurs, bring it into use?—No, but you can keep it in condition, as is proposed in this scheme, and use it every day for a certain number of hours during the peak load.

Then you suggest Shoreditch should not take all its electricity from the County Council or from the transferee, but should generate some itself. But if so, we should come within clause 20 of the bill, and I ask you why we should pay that penalty?—That is merely a provision which could be enforced if necessary.

I suggest that the transferee would never be foolish enough not to enforce it?—The object of the clause is to prevent any authorised undertaker obtaining a supply of energy from the Council, and using it merely as a stand-by supply.

Then the position is that the County Council or their transferee will not consent to be stand-bys, but, as I understand Mr. Peel, they will compel the existing undertakings to occupy that position?—I do not suggest this. There is no intention of utilising the existing plant as a stand-by.

I am endeavouring to find out where anybody else is in this bill except the County Council, and I am afraid I am failing. Now, when you speak of using a station as a stand-by you could not use it for half an hour or an hour. You must use it, must not you, for a shift of eight hours?—You may have to pay the men for eight hours, but you need not use it for eight hours.

You do not suggest that the authorised undertakers should pay their men and not use them?—No, my suggestion is that they should utilise their plant for two shifts, and our estimates provide for the labour for so doing.

You spoke of some stations being put up on the premises of the existing undertakings. Do you mean that the transferee, when he has bought your bill, or hired it, or whatever it is to be, should have the right, although he is our competitor, to come upon our premises and put up his works there?—No. Suppose you are at Shoreditch and require a supply of direct current at 400 volts, this supply would be given from our Shoreditch control station, and would be brought to your works at 15,000 volts. The suggestion is that you have found accommodation in your building for the transforming plant necessary to bring the current down to the required lower voltage.

And who would do the transforming, Shoreditch or its competitor?—The person who is giving you the bulk supply, Shoreditch giving all the facilities, and the estimates provide for simple modifications to the buildings and foundations, &c., as are necessary for the transforming plant.

Passing to another matter. Take, for instance, Shoreditch and Hackney, and three or four other stations in the vicinity, might not these stations be linked up with great advantage to them?—I think not, because the linking up could only be done by the running of trunk mains from one station to another, and the erection in the stations of much bigger plant than they now have.

But you propose to link up all your sub-stations?—Yes.

Assuming the works are suitable, you would be getting over the difficulty of too small a generating station and too small an area by linking up three or four or more of the existing stations?—I cannot assume that existing generating stations are suitable for extending.

Take the case of Poplar, Stepney, Islington and Shoreditch. I suggest that these stations might very well be linked up?—I do not think they are fitted. Linking up per se is right, and if we built two stations at Barking and Erith we should link and we should also link up the control stations. You can link up things which are suitable, that is my point.

But assuming it could be done in the cases I have mentioned, would it not be to some extent a remedy for the present condition of things, and a precaution against competition?—I cannot agree with your premises. Taking the case of the four stations you have named, Islington is single-phase, alternating current, 50 cycles, generating at 2,000 volts. How can that be linked up with Shoreditch, which generates direct current at 1,100 volts? I say that is impracticable, although not impossible, to an engineer.

Looking at Table 32, are you prepared to limit this bill to bulk supply?—No.

Learned counsel then dealt with the financial tables put in, and asked whether witness was prepared to put before the Committee the financial conditions of working the Erith station. Mr. Rider answered that the financial conditions of the work at Erith would be the same as those of working at Barking; but that the financial results in the enlarged scheme would be better than those shown in the tables for the Barking operations. Therefore he contended the extension of the scheme would go to improve it. He would prepare the figures for Erith if the Committee desired it, but all he could say was that the estimate for Erith would be based upon their present knowledge as to the Barking Station.

Mr. Rider was cross-examined by Sir Ralph Littler on behalf of the City of London authorities mainly on the question whether it would be necessary to run trunk mains through the City, and, also, as to the probable power requirements for industrial purposes.

This was followed by the cross-examination of the witness by Mr. Reader Harris (for Ealing), it being desired to prove that Ealing was essentially a residential quarter and offered no opening for power supply for industrial purposes.

On Wednesday last week Mr. Rider was cross-examined by Mr. Moon, representing, with Mr. Balfour Browne, the London companies.

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Mr. MOON: The whole of the County of London is, I think, now supplied either by local authorities or companies who are authorised distributors?—No, not the whole of the County. Bethnal Green has no supply, and I believe a small part of Westminster also has no supply. Bethnal Green has obtained powers but they have not been used.

I think we may take it that the companies are now supplying two-thirds of the area and two-thirds of the energy, or thereabouts?—To answer I should have to refer to the outputs, but I will take it from you that this is the case.

The prices charged for current by the companies are subject to revision at certain periods, and also on the application of the County Council, which, therefore, has already that amount of control over the companies?—Yes, the Council have the right of appeal to the Board of Trade every seven years.

And in other matters also the County Council are the controlling authority?—I believe so.

I do not know whether you or the Committee know that the provisions which prevented the acquisition of one company's concern by another company, and prevented the working of agreements between the different companies, were provisions inserted at the request of the London County Council in June, 1889, which provisions provide that, in order to ensure healthy competition between the companies, no amalgamation or working agreement should be permitted without the consent of the Council. So that the provision which has prevented the companies from associating themselves for the purpose of reducing the cost of the electricity is a provision which the County Council were instrumental in obtaining?—Yes, but I am not sure whether the amalgamation of the companies was not prevented in the original Electric Lighting Acts.

In any case the Council have obtained a very important control over the operations of the companies?—The Council can appeal to the Board of Trade for a revision of price, and can appoint inspectors to look after the pressure of supply, &c.

Did you give evidence last year in favour of the County Council's then scheme?—Yes.

What was the volt pressure then proposed?—6,600 volts, and we are now proposing 15,000 volts. This results from the alteration of the positions of the generating stations. The periodicity was last year 25 cycles per second, it is now 50. This latter change was not due to the alteration in the position of the generating stations, but is an improvement upon our then scheme.

You have given us the probable demand of electrical energy for power as 370,000 H.P. How do you arrive at that potential demand?—From a return of the number of places in London and the outside area at the present time using power of one kind and another.

But when the Administrative County propounded their scheme the estimated horse-power which existed in the area was put at 592,000 H.P., which you cut down, after investigation, to 370,000, and your area is larger?—The difference between us and Mr. Merz may depend upon how far the future extends. Mr. Merz's figures, I believe, do not include the demand for power for railways or tramways, and my figures do.

Perhaps you can give us details as to how that 370,000 H.P. is made up, because it is an important figure as it is the basis of the whole scheme?—I can give you the data, but it will take me some time. I have taken separate years.

Mr. BALFOUR BROWNE: We do not wish to go into individual cases, but I am bound to say that we have made a census of the power used in London, and we make it entirely different from Mr. Rider. It is, therefore, absolutely essential that we should have the means of judging whether his or our estimate is accurate. We shall put in our estimate. I propose that the information submitted by Mr. Rider should compare with that which we have prepared, as we shall then see where the discrepancy arises.

Mr. FREEMAN: I suggest that Mr. Rider should give a list of the separate areas with the horse-power in each.

Mr. MOON: According to our census, the whole of the horse-power available for being supplied with electricity in the company areas is 103,000 H.P., of which about 45 per cent. is already supplied by the companies. But there is something more in the area of the local authorities.

Mr. FREEMAN: I have now a figure, the inside area according to Mr. Rider being 293,887 H.P., the outside area 77,108.

Mr. MOON: You do not arrive at these figures by census taken except in two districts. In the other districts it is an assumed figure?—Yes.

Then as to the factories shown in the Table*; you first get a return of the factories in each district from the Home Office, and this is the information contained in the first four columns of the table?—Yes.

Where do you get the figures for the last column, showing the horse-power which you presume is employed in these particular trades?—I arrive at that first from our general experience, and, secondly, on the data obtained from a canvass in Shoreditch and Battersea. We took a separate constant for the character of the factory, and we applied this to the persons employed.

What was the constant you took in the chemical trade?—¾ H.P. per head.

And in the engineering, metal and builders' material trades?—1½ H.P.

The printing and stationery trades?—About ¼ H.P.

The total number of hands employed in Battersea and Shoreditch amounted to upwards of 26,000. What is the total number of factories?—702 in the two districts.

Do you know that in Shoreditch the local authority is supplying two-thirds of the electrical horse-power now installed?—That does not agree with my canvass, which shows that 2,200 E.H.P. is used in Shoreditch, and that the total horse-power is about 12,800.

Now, inasmuch as your figures of revenue are based upon evidence which you gave as to the existence of a certain field for power, if that field does not exist your figures for revenue showing profit are, of course, inapplicable?—I do not think so, because our estimates of revenue are based upon a very large supply being given to authorised distributors quite irrespective of the general power load of London and are based also upon a certain demand for railways and purposes of that kind.

But if you rely upon your authorised distributor to take your supply and he has not the field to supply electricity which you imagine he has, you will not, of course, supply so much power to him. That is to say, supposing he is supplying all that is required and will increase his supply as the demand for power arises, if you can make no further demand you cannot increase your supply to the extent you have suggested?—I am not prepared to say you cannot increase the power demand if you reduce the price.

But if there is no possibility of demand—that is, if there is no machinery for which to use the power?—If it should turn out that we do not get the demand for electrical power such as we anticipate, we should not build our stations so rapidly.

I am looking at the matter from the point of view of your hypothetical lessee. If he finds that he has not got this demand to deal with, he will hardly be likely to take up your scheme?—My information is quite against you, as it is to the effect that there is this potential demand in the area.

That I will deal with presently. How will you proceed? Will you, in the first instance, lay cables to all the stations which you expect to supply, or will you leave part of your district out of the operations in the first and second sections?—By the time the first two sections are built we shall have made arrangements for the utilization of the greater part of the power which will be given from that station. But we should not put transmission mains or control stations in any part of the area where we had not secured custom. We should only put cables in as the demand to the stations warranted it.

Council then cross-examined Mr. Rider at some length on the financial aspect of the undertaking and an interesting discussion arose on the question of depreciation and sinking fund.

Mr. MOON: Looking at your tables, I wish to ask you what the transferee has to look forward to as the most tempting result of his operations. Assuming that all your expectations were realised he would evidently get something like 10 per cent. gross, out of which he would have to provide working capital?—Yes.

From which you have to take 2¾ per cent. for depreciation, leaving 7¼ per cent. as the utmost he could expect?—Yes, based upon a load on the station of 165,000 kw.

How do you get at this figure? Where is the load coming from? Have you split it up into the various fields, such as the supply to tramways and railways?—Yes, partly. I have based my figure upon an assumed division of the output into three classes of load—untransformed supply about 15,000 kw., transformed alternating supply about 112,000 kw., and low-tension direct-current supply about 36,000 kw. The first would be supplied to authorised distributors, who would do their own transforming, or to railway companies; the second would be supplied to authorised distributors, and for power purposes; and the third to authorised distributors who are now using direct current and who might wish to continue that supply. This is a scheme of distribution based upon my experience and the experience of my colleagues as to the likely demand for these classes of energy.

Then in your tables there is a figure 0·6331d.; where do you get that figure?—The revenue has been assumed to be obtained from the diversified load as just explained. We can charge different rates for these different supplies and the losses in transmission are different in the three cases. I have assumed a different load factor for each of these classes of supply and the resultant income based upon the charges per unit resulting from the respective load factors give us an average of 0·6331d. per unit—that is, on a mixed supply.

What do you regard as the proper proportion to allow for spares?—25 per cent.

You have, I suppose, no means of knowing how much plant capacity there is in the existing station buildings in your area not utilised, or what plant capacity there is on existing sites not utilised?—I cannot say.

I suggest that there is at present in the works of the existing companies 25,000 kw. of plant installed and available for use, 50,000 kw. capacity in the buildings for additional plant, and 356,000 additional kilowatt capacity in existing sets not at present utilised?—I do not dispute that the capacities of the existing sites in London are very great; my argument is that they are in the wrong places, and that local stations in London should not be extended. You would have to put a great deal of plant into the existing stations to bring the cost per kilowatt down to anything like that to which it can be brought at a site like that at Barking. Although you might possibly be able to get plant on to the existing sites you would have great difficulty in obtaining the necessary supplies of coal, and, especially, the required supplies of condensing water (in some cases it will be impossible to get the water) and you would become a nuisance.

But the question is that you are proposing to supply us with a cheaper supply in bulk, and the point becomes whether we, having the premises and the buildings, and being able to buy plant as cheaply as the County Council, cannot supply ourselves as cheaply?—I would rather put the point that the majority of the sites are physically incapable of handling a greatly increased load because of the faulty coaling and condensing water facilities.

But are not many of the existing sites favourable in both those respects? What about Deptford and Bankside, and the South Metropolitan Co.'s station and the Metropolitan Co.'s station at Wimbledon?—The answer is that these sites are all right for the present capacity of the stations, but my point is that if you increase the station to anything like the size of Barking the site becomes an impossible one. In regard to cost of generation, I have already shown that we can actually provide energy at the stations of the existing distributors at a less capital cost, including transmission, than they are doing.

* See Table at end of PARLIAMENTARY INTELLIGENCE.

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To what extent do you anticipate the existing companies will substitute bulk supply from the County Council for their own supply?—Where we can supply the companies more cheaply than their present working costs it would, of course, pay them to take the whole of their supply from us, but our suggestion is that the local plant should be used up to its maximum capacity, less a certain reserve for spares and for peak purposes, and that the remainder should come from the Council, and this remainder, of course, depends upon the total outputs from the stations. Table 38 suggests that the company should generate with their own plant 74,000 kw., leaving 27,000 kw. to be supplied by the Council. And this does not take into account the Kensington & Knightsbridge, the Notting Hill, the St. James's or the Westminster Cos., who have already their own bulk stations. In this way the companies would give up but little of their existing supply; not more than 25 per cent. Referring to the tables, we compare the costs of the Council supply with the existing cost of the companies' supply, and in many cases we show that it would pay to stop the works entirely.

You will agree that when the authorised distributor has to determine whether he will take energy from the Council or not he would have to add to the charge which the County Council propose to make for their supply a sum representing capital charges which would remain unproductive if he did not provide his own supply?—Yes, certainly, and we have provided for that.

At this stage of the proceedings Mr. Freeman introduced the new clause 66A and the heads of agreement set out in *The Electrician* for June 21, p. 402, with the remark that he did not suppose any of the conditions would pass without criticism, but their endeavour had been to meet the wishes of the Committee that full information of what it was proposed to insert in the bill in connection with these matters should be presented.

The cross-examination of Mr. Rider by Mr. Moon was then resumed.

Mr. MOON: In another table you have shown the growth of the demand in the areas of the local authorities and the companies, and have pointed out that this growth has been more rapid in the former than in the matter. You suggested that this more rapid increase was due to the fact that the local authorities were charging a less price?—I would rather that were taken as showing the total increase rather than the comparative increase between the two kinds of undertakers.

Mr. RIDER was then cross-examined by Mr. Balfour Browne on behalf of Middlesex County Council and Croydon County Borough.

Mr. BALFOUR BROWNE: We can understand a local authority being content to supply electricity if it can do so, without laying a burden upon the ratepayers; it need not necessarily make a profit, as, if it makes both ends meet, it is doing good to the ratepayers by supplying an important commodity?—If it does so at a cheap price.

But the lessee whom you propose to substitute must have a profit—a return upon his capital?—Yes, but this does not affect the maximum price which either the Council or its lessee would be entitled to charge.

Do you mean if I become lessee and wanted a profit I can only charge the same price that the County Council would have charged when they did not want a profit?—You can only charge the price the Council would be empowered to charge under the bill.

But if I am the lessee and have to make a profit I must charge more than the County Council, and that alters the relations between this governing body, the Council and the consumers?—If the other conditions were alike, certainly.

Now as to Croydon. The Council's bill of last year did not seek power to supply traders in Croydon, while this year it does?—Yes, under the Kitson clause. We are able under this bill to offer Croydon electrical energy in bulk cheaper than Croydon can produce it. Therefore it is beneficial to Croydon to be included.

You have explained to the Committee your scheme, but that will not be your scheme, but the scheme of the transferee, who is not bound to carry out the work in the way you suggest?—If he is a wise man he will.

I see that in your schedule you provide that the generating station or stations shall be constructed on the site or sites described, "or on such other site or sites as shall be provided by the Council." Last year your site was in Battersea, and you have told us that you had to alter your voltage from 6,500 to 15,000 because of the position of the two stations at Erith and Barking?—Yes.

Therefore the whole scheme depends upon where your power station is to be?—Entirely.

And we do not know where it is to be, so that you are asking the Committee to give the County Council the power to legislate as to where the station is to be?—Any site upon which a generating station is to be built will have to come to Parliament for approval.

Now you have spoken of the power load—the 370,000 H.P. which you think is within your district. Will you tell me what, in your opinion, would be necessary in the way of a station to supply that load?—I gave that in my evidence in chief, and my estimate was that that load would be sufficient to utilise about 180,000 kw. in a generating station, because of the circumstances which I mentioned, namely, the diversity of the individual factory and the diversity between the different classes of factories.

I suggest that a very much smaller station than that could deal with a load of 370,000 H.P., but I will leave that point. What is the distance from Barking to the first control station—Tottenham?—7¼ miles.

Cross-examined by Mr. VESEY KNOX (for Hornsey): I want to see whether your estimate of what will happen in the future as to the cost of energy is correct. In the first place you take the price at which you say we shall be able to get energy from the transferee?—Yes.

What security have we that we can get it at this price from the transferee? In the case of Hornsey one security would be that the transferee would be in competition with the North Metropolitan Co.

But we cannot obtain a supply from the transferee at all unless we are able to show him that there will be a reasonable return upon his capital?—Quite so.

So that we are not sure of getting any supply, and if we get it the price would be the maximum and not your estimated price of one-fourth less than the maximum?—Not if the transferee were a wise business man, as he would not do much business at the maximum price.

Then why do you leave this in the bill?—Merely as a safeguard. As a matter of actual practice maximum prices are seldom reached. Take the case of the Administrative Company, which, in 1905, had certain maximum prices in their bill, but they entered into a large number of agreements with authorised distributors at prices considerably under the maximum.

But the administrative company come now and get what is equivalent to a bill without being bound?—If they had obtained their bill they would have been entitled to charge anyone, other than those with whom they had supply agreements, up to their maximum price.

The object of the remainder of Mr. Vesey Knox's cross-examination of the witness was to show that the possible demand for energy for power in Beckenham, Hornsey and Finchley would be very small.

Mr. RIDER was next cross-examined by Mr. H. Lloyd (on behalf of Messrs. Curtis's and Harvey).

In reply to questions, witness said that the existence of this firm's powder magazine in the vicinity of the site for the station only became known to him when the firm's petition was presented.

Are you aware that this firm is licensed to store 607 tons of gunpowder, that they have a continuing licence, and further that, under the regulations of the Home Office, for every engine or machine or for any manufacturing purpose you must have a danger zone, even for 50 tons, of 850 yds.?—But there are other works within the danger distance already.

Do you think the coming of your works into this zone will be a danger?—I do not see in what way we can be a source of danger to the magazine.

Cross-examined by Mr. C. MUNROE (for Wimbledon and St. Pancras): Can you tell me why you included St. Pancras in your area?—Because it is within the County of London, and because we think St. Pancras would be glad to get a cheap supply of power.

Do you know that when the Administrative Companies' Bill of 1905 was brought in St. Pancras was put into the industrial area, but that, at the end of the inquiry, it was taken out of that area and put in the non-industrial area?—Yes.

Then why should St. Pancras be now handed over to your transferee for power supply?—Because I do not think that any distinction should be made. I think a common supply should be given all over the area.

What benefits are the consumers in St. Pancras going to get if you are allowed to come in?—By taking a supply in bulk from the County Council and so avoiding competition.

You want to come in here where they have got practically all the power consumers on their load at a low rate, at a better rate practically than you are proposing to offer?—Therefore we cannot hurt you. By taking a supply under this scheme you will be enabled to reduce the price for lighting, which is now higher than it should be because you are charging lower than you should do for energy for power.

What is to happen to the half million of money invested in St. Pancras?—We do not propose to harm this half million. We propose to supplement your present supply, which will have the effect of lowering your total costs.

But if you are going to supply do you suppose we shall keep our stations going just to meet cases like fog and accident?—When this bulk scheme is ready you are going to increase your demand from 8,000,000 to 13,000,000 units.

When do you think this period will be reached?—I cannot say, but certainly, not until this bulk scheme is ready.

Mr. Munroe then cross-examined witness as to the prices to be charged for bulk supply, and suggested that having to pay not only the price for current set out in the bill but 20 per cent. upon the cost of the mains connecting St. Pancras or Wimbledon with the control station would prove a heavy burden.

WITNESS said that this additional 20 per cent. would not be incurred if the ordinary supply was taken from the Council's station. With regard to Wimbledon he said the inclusion of Wimbledon was a benefit to that borough, who would do nothing but gain from the County Council coming there with their supply.

You think so much of this benefit that it ought to be forced upon us without our consent?—We cannot give you a supply unless you wish to have it.

But you can come in and compete?—But you say there is no power load to compete for and we cannot compete for lighting.

We shall see. Do you suggest that your 20 per cent. for lighting does not give you power of competition. Suppose you obtained power to supply energy, you will be able to give everybody who is taking energy for power 20 per cent. for lighting. Now, suppose a person has a 1 H.P. motor, used 53 hours a week, would not he be entitled under your bill to have 20 lights in his house burning 2½ hours a day for every day of the year at the power rate, and would not that give you the power to compete for lighting for people occupying an ordinary 10-roomed house?—I must work that out, but it would certainly allow us to supply 20 per cent. for lighting out of the total amount for power.

Therefore, if you can supply a person having a 10-roomed house with 20 lights burning for 2½ hours a day for every day in the year, and he can obtain this supply for 1d. per unit, he would rather obtain it from you than pay the local authority 4d. per unit. And if that is so, it will be competition and strong competition will not it?—If your figures are right

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it would, but I must say as a general reply to this question that the Council's scheme, neither in the estimates nor in its intentions is devised for the purpose of giving a supply to individual consumers of the nature mentioned.

There again I must, of course, take the bill as it stands. You have the power to do it, or rather, your transferee would have the power?—Our transferee would be very unwise to attempt to carry out a distribution system in St. Pancras or in any other part of London, as he could not do it at the price.

I should like to see something in the bill to prevent him doing so, and I would ask you whether you would be content to do what the Administrative Company did with regard to St. Pancras and say, "We will give you a supply in bulk"?—I am not prepared to alter the bill at all.

Mr. JOSEPH SHAW then cross-examined Mr. Rider on behalf of the Maldens, and asked why this district was included in the Council's bill this year. Mr. Rider replied that it was considered it would be an advantage to the neighbourhood. He was unaware that the Maldens was entirely residential, but this left all the more room for development.

Mr. SHAW: Do you know that two or three days ago a provisional order was passed giving powers to the County of London to supply electricity in Coombe and Malden with the consent of the local authority, giving the latter power to purchase the undertaking in 21 years?—Yes, purchase the mains.

You know, of course, that your new clause 49 may alter such an arrangement?—Yes, it will give us or our transferee powers to buy. I do not consider Malden and Coombe will be hurt by our coming in, but benefited.

I notice that you omitted Surbiton from your scheme. Why do you leave out Surbiton and take in Coombe and Malden?—Because I do not consider Surbiton is of such benefit to us as some of the other districts.

On the Committee assembling on Thursday last week Mr. RIDER was recalled and cross-examined by Mr. G. J. Talbot (on behalf of the South Essex Waterworks Co.), the object of Mr. Talbot's cross-examination being to ascertain Mr. Rider's views in regard to the clauses in the Council's bill relating to water supply.

Mr. TALBOT: Under clause 27 you seek powers to acquire by agreement up to 50 acres for the purpose of the Council's undertaking. Do you intend to use the land so acquired for the purpose of obtaining water?—No, only for use of the control stations and sub-stations.

Are you prepared to give an undertaking not to take water in or under any of the lands acquired?—No.

Then I understand your answer to mean that you intend to take water if you want it?—Yes, it might pay us to sink a well rather than to take water from a company.

If the bill passes in its present form you would have ordinary landowners' powers to sink a well in any land you acquire, drawing underground water to any extent from these wells?—I believe so.

Seeing that the South Essex Waterworks Co. depend for their entire supply for the district upon wells, do you not think it a serious matter for Parliament to give unlimited power to you to draw water in this way?—The only water we should take from the wells would be what we call make-up water.

Under clause 46 of your bill you seek powers under the Waterworks Clauses Act with respect to breaking up the streets for laying pipes for conveying water to or from any generating station of the Council, and under that clause, combined with clause 27, you could sink a well at any part of your area of supply and draw water to any quantity and convey it to your generating station. Do you consider that a reasonable power to be given without the control of Parliament in an area where all the available water is wanted for the purposes of domestic and public supply?—It may be necessary for us to lay a pipe to connect with your mains.

Are you prepared to confine it to that?—No. I consider the power sought is reasonable, because the use to which it would be put is very limited.

Very well. Clause 44 purports to authorise you and the Metropolitan Water Board to make arrangements for the supply of water to the Council or your transferees. Is the power under that clause to be exercised within the area of supply of another water undertaking? Obviously the power would include the right of the Metropolitan Water Board to make an agreement for supplying water to the Council within the area of supply, for instance, of my company. Is that the intention of the Council?—Speaking as an engineer, I should go to the water company that is nearest.

Then it is not intended to interfere with the existing demarcations of water supply?—Not so far as I know.

Cross-examined by Mr. JEEVES (for Kingston): Under the provisions of this bill you propose, I think, to compete with existing authorised distributors and to have the power to supply to the consumer for power direct?—Yes, and we also propose the consumer should have the power to demand a supply from us, which he could not under the bill of last year. This bill is a distinct improvement upon the bill of 1906, and we have inserted the Kitson clause, which will give us power to go direct to a consumer on the direct advice of the Board of Trade.

Certain figures are given in large type in your Table 34, and included in these are capital charges, interest, depreciation, &c. These charges will continue even if the distributors were to take their supply wholly from the County Council?—Yes. But I have explained that Table 34 is merely a comparision between the present cost of generation by the local authorities outside the county, with the cost at which the Council's scheme would provide energy.

Kingston does not adjoin the County of London at all, the nearest boundary being something like 1½ miles away?—That is so.

I understand it is proposed to supply Kingston from the trunk main ending at Richmond?—Yes, from the Richmond control station.

Kingston had a hard struggle for some years, only during the last three or four years have they been able to make the concern pay. Competition under these circumstances would land them in a bad way again, and take away their customers?—We want co-operation with you, not competition. We want to give you a supply which will help you to supply a good deal cheaper.

Then why do you ask for powers to supply to power consumers?—Because we think that if you do not see your way to take a supply from us which will enable you to give a cheap supply to your few power users, these power users ought not to be deprived of a cheap supply.

You think it fair to come and take away our customers?—But we give you the means of supplying them yourself.

What exactly do you expect to get from Kingston?—We expect to get a share of the lighting and power load of the neighbourhood given through the authorised distributor, which will help us in getting a diversified load. In return we shall give you cheap supply.

Cross-examined by Mr. BLENNERHASSET: Clause 42 provides for the purchase of undertakings by agreement by the Council or by the transferees of the Council?—In the County Council Bill of last year there was no provision of that sort?—You have been the adviser of the Council all through these electrical bills. May I take it therefore, that, in your opinion, a provision of this kind is not essential to a successful undertaking in the hands of the County Council?—I do not agree. The whole scheme this year is much larger and on entirely different lines from last year's scheme. You must not compare one with the other.

I suggest to you that the new clause 49 in this bill is practically included in clause 71 of the Administrative bill?—It is very like it.

Do you know, when the Administrative bill was before Parliament, counsel on behalf of the County Council proposed to strike out clause 71?—I will take it from you that it was so.

The Committee refused to strike out the provision that such a purchase of the undertaking should be subject to the consent of the local authority?—I cannot say.

If it was reasonable to impose this condition on the Administrative Co., why is it not equally reasonable to impose it on the transferee, which might be the Administrative Co.?—In one case it would be outside the County Council, and in the other they would be under the control of the County Council.

Supposing the County Council, or the transferees of the County Council, purchase some of these undertakings, and supply partly from the County Council's generating stations and partly from their own central generating station, will not the works under the new bill and the old works of the authorised distributors be mixed up? If you get a district in London partly supplied by works non-purchasable under the present bill and partly supplied by the purchasable works under the local undertakers, you would have a state of confusion?—Very likely, as things stand at present.

The City of Westminster would have the power in 1931 to purchase all the electrical undertakings in the city, and also the generating station in Marylebone?—I think that is so.

That is, when the Westminster County Council wish to start an electrical undertaking of their own, they would be able to start a successful undertaking on a large scale?—I do not think so. The position of the power station is not a good one for cheap generation. It is not practicable, judging from present knowledge, to work successfully any local supply in London when you compare it with what can be done under our large scheme. The time has gone by for dealing with the supply of London in small areas.

You consider that, in the general interests of London, the rights of the local authorities should be set aside?—If necessary.

Cross-examined by Mr. E. MORTON (for West Ham):—The whole of your mains from Barking except one will go through the borough of West Ham?—Yes.

You know that we have a large building and plenty of room for additional plant, and also ample land for extensions if necessary?—I take it from you it is so.

We have a lighting load, traction load and a very large power load?—I believe you have.

All the elements of diversity necessary for a good load factor?—On a small scale.

So far as generation goes, we are in a good position?—You are in a better position than many London stations, but you are not in a perfect position.

In addition to being in a good position in regard to generating, are we not in a good position as regards distribution also?—You are entirely at one corner of the borough, and from the point of view of distribution only it would be better in the middle.

So far as generation and distribution goes we are in a good position?—Therefore, if you take energy from us under this scheme it would not cost you much to give it to your consumer.

How do you get at West Ham's position five years hence?—I know what West Ham has done and is doing.

In your Table No. 16 you give our total supply for all purposes as 6,000,616 units. For the year ended March 31, 1907, the total units delivered was 8,013,343?—In taking this from you I am bound to refer to some figures given for West Ham for 1906 which, when the accounts came out, were proved to be inaccurate. Therefore your present figures may prove inaccurate.

Assuming 8,000,000 instead of 6,000,000, this shows an increase of 33 per cent. on the previous year. We estimate the contracts we have at present will give the total for the coming year as 12,000,000?—If you turn to our Table No. 38 you will see we have allowed you in the near future up to 15,000,000.

That is the County Council giving a bulk supply?—No, it is the output partly by you and partly by us.

(PARLIAMENTARY INTELLIGENCE *continued on page 44*.*)

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With the number of THE ELECTRICIAN for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with THE ELECTRICIAN. The eleventh issue of the Supplement is published (Gratis) with THE ELECTRICIAN this week.

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CHEAP POWER SUPPLY BY MUNICIPALITIES.

At the Convention of the Incorporated Municipal Electrical Association Mr. C. E. C. SHAWFIELD read a Paper yesterday upon the question of cheap power supply by municipalities, in which he took up the view that the "heretical" people who believe that the maximum demand system is not the most suitable system to use are in the right, and that electricity supply would be more happy without such a system. He then proceeded to consider, as will be seen elsewhere in the present issue, what sort of a charge should be made for power supplied from a municipal station which is already supplying current for lighting purposes.

There are, no doubt, two ways in which a new commodity may be pushed. One of these is to put the price at as low a figure as is consistent with the immediate output, or with the output that is likely to come in the near future, and to lower this price as the demand increases. The second is to lower the price to a figure that will not be remunera-

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tive until the demand is very considerable, and then to wait in faith and hope for prosperity. Naturally, there is a greater chance of risk in the latter policy, and it is not always justified by subsequent events, as has been seen quite recently in the case of the Metropolitan District Railway, on which the fares have had to be raised owing to expectations not being fulfilled. It is this sort of policy which Mr. SHAWFIELD advocates, and as a maxim he says, "Adjust the tariff to suit the competition, and the cost of production will adjust itself to the tariff." This undoubtedly sounds a very simple method of obtaining a tariff, but it is quite obvious that in some cases a tariff of this kind would certainly lead to ruin. Mr. SHAWFIELD considers, however, that such a tariff could always be adopted provided that the proposed rate is not hampered with costs that do not properly belong to it. Here we come into the difficulty of the proper allocation of costs. What, in fact, Mr. SHAWFIELD proposes to do is to put in plant for power purposes in a station which is already supplying light, and to consider the costs purely on that part of the plant, the contention being that if this were done electrical energy for power purposes could be supplied at 0·8d. per unit. For this purpose he considers the putting down of a plant of 2,000 kw., giving an annual output of 3,500,000 units. The cost of this plant, including buildings, is given as £13 per kilowatt, and the cost of mains is estimated at £10 per kilowatt, making a total of £23 per kilowatt. This, of course, is a very low capital cost, and if it can be realised for general power supply the capital charges will necessarily be small. We think, however, that in most average-sized towns the conditions would not be so favourable. Although the load factor is not very high, the running costs—namely, fuel, oil, water and stores—are put as low as 0·21d., which seems to be an optimistic figure, the fuel being based on a consumption of 3·75 lb. per unit, a figure which is scarcely likely to be reached without depending on the lighting plant for bearing some of the stand-by losses. The capital charges, rates, taxes, wages and repairs amount to 0·425d., giving a total figure of 0·635d.; but management and office expenses are neglected.

If it is so very simple to supply at this low rate, we can only feel surprised that such a rate is not more general, and we think that Mr. SHAWFIELD'S case must be taken rather as an exception to the rule than what is generally possible. His argument really reduces not to one against the maximum demand system, but to one against an average of capital costs. It is difficult, however, to allocate capital costs logically in the way proposed. As far as the plant is concerned, if it can be put down for £13 per kilowatt for power the same is true of plant for lighting. Presumably this has not been done in any given case, because small, and therefore more expensive, plant has been used to develop the station from the start, chiefly on a lighting load. If this plant is to be allocated entirely to lighting, then the rate for light must remain practically constant and will not benefit by any power load. A similar argument to that given by Mr. SHAWFIELD might be used to justify the putting down of new plant at £13 per kilowatt for supplying *new* consumers for light at much reduced rates. When it comes to the question of mains the position is really still more difficult. Frequently, separate mains would not be laid, because the power consumers would be largely scattered about the lighting network as well as in a power area, and it would not pay to run special mains. Unless the positions of consumers are very favourable it is doubtful if mains could be laid for £10 per kilowatt. If the lighting mains are used, then the lighting consumers ought to benefit.

Passing to the question of load factor, it is doubtful whether anything is gained by disregarding this important point by putting the maximum demand system on one side. If a consumer happens to have a very much better load factor than the one assumed there is really no reason why such a consumer should not have even better terms than the tariff suggested. Perhaps the most important question, however, is the one of policy to be adopted by a local authority. The idea of putting down a plant of 2,000 kw. in order to supply a power load which it is hoped will in due time develop is one to which ratepayers would strongly object. It involves a risk which is more than most Councils would care to contemplate, and the certainty of a considerable loss for a time. We think, therefore, that the more cautious policy adopted by most municipalities, some of which nevertheless are supplying power at very cheap rates, is really to be preferred.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Alternating-current Motors. By A. S. MCALLISTER. (New York: McGraw Publishing Co.) $3 net.

The author of this book discusses the theory of alternating-current motors, and shows, by the way of test examples, how to find theoretically the performance of the machines. As a student's text-book it is generally very well written, and gives exhaustive information on the algebraical and graphical treatment of these motors. It is to be regretted, however, that—as in so many other books of this class—the practicability of different methods to obtain a certain result has often not been investigated sufficiently, and advantages and disadvantages of one or the other ought to have been made clearer. More than one-half has been devoted to induction motors, rather too much in our opinion, as the different chapters overlap to a large extent, and "simple methods" are very elaborately dealt with, besides the "complete methods," which latter are not much more complicated. Even the headings of the different chapters indicate this. For instance: Chapter II., "Outline of Induction Motor Phenomena"; Chapter IV., "Induction Motors as Frequency Converters"; Chapter VII., "Graphical Treatment of Induction Motor Phenomena"; Chapter VIII., "Induction Motors as Synchronous Generators"; Chapter IX., "Transformer Features of the Induction Motor." It would have been to the advantage of the book if all these chapters had been melted together into one. Synchronous motors and converters have been treated far more briefly, filling about one-eighth of the book. The commutator type of motor occupies the rest of the book; it has been far more uniformly dealt with than the induction motor and gives the reader a clear idea on the subject, though one would wish to see less analytical treatment (the formulæ of this part number up to 263). However, this is a matter of taste. A somewhat general question may be mentioned. This is the American way of using the "total current" with polyphase systems. With three-phase machinery this is 1·73 × current per phase, with two-phase twice the current per phase. Generally it is the current by which the terminal voltage is to be multiplied to obtain the kilovolt-amperes. There is no doubt that the current per phase is the only measurable one, and, therefore, cannot be altogether replaced. Is it worth while to introduce two expressions where one will really do? We do not think that the "total current" will find many friends in England.

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Projektierung von Elektrizitätswerken. By Fritz Hoppe. (Hanover: Dr. Max Jänecke.) 3.80m.

In the opening chapter the author enumerates the commercial and technical principles on which a sound project of an electricity works ought to be based, and emphasises the importance of adjusting the capital expenditure from the very beginning, so as to ensure an appropriate monetary return, in contradistinction to the method, not infrequently employed, of drawing up the specification without regard to this ultimate object, and afterwards juggling with the figures until a satisfactory yield is obtained—on paper. In the following chapters preliminary work is gone into at length; the matters discussed include the number and nature of the connections to the electricity works which may be expected for places of various sizes, the probable maximum output which the station will have to deal with, the choice of voltage and kind of supply, the most advantageous number and sizes of the generating sets, accumulator batteries and prime movers, and so on. A number of tables, containing actual figures from German practice, are given to elucidate the points discussed and to fix ideas, but they would be more useful if brought up to date. In the succeeding part of the book the author shows how to estimate the probable working costs of an electricity works and the profits to be expected, and includes many valuable data in tabular form. The next chapters contain technical descriptions, interspersed with numerous numerical data, culled from practice, of modern boiler plant, steam and gas engines, steam and water turbines, dynamos for continuous current and alternating current, transformers, motor-generators, batteries, switchboards, &c.; in fact, all the principal machinery which goes to make a complete electric generating station. A few pages are also devoted to the buildings, and the author warns the reader against wasting money on too elaborate and out-of-place ornamentation. The last part of the book treats of the calculation and general lay-out of feeder and distributing networks, but it is too short to do justice to this comprehensive subject. There are two appendixes. The first contains practical information on the approximate capital costs of all kinds of generating machinery and auxiliaries, while the second appendix is an instructive discourse, replete with actual figures, on the financial position of a large number of German electricity works.

As will be gathered from the above, Herr Hoppe has approached his subject in a thoroughly practical spirit. The matter is treated on broad lines, and for detailed information the student is referred to more specialised works, the names of some of which are given in footnotes.

The book, which forms the tenth volume of the "Repetitorien der Elektrotechnik," may be recommended to those who desire information on modern German practice in the equipment of electric generating stations.

The Schultz Steam Turbine for Land and Marine Purposes. By Max Dietrich. (London: A. Owen & Co.) 5s.

This is one of a series of books on the steam turbine which it is proposed to issue from time to time under the editorship of Mr. R. Liddell. The peculiarity of the Schultz turbine is the way the axial pressure is balanced by dividing the turbine into two groups of vanes and causing the steam to flow in opposite directions through each group. For marine purposes the turbine is constructed so that the thrust of the propeller is balanced by the axial thrust of the steam. The various devices and arrangements proposed by Schultz are shown in this volume, though the scientific basis of turbine design, both as regards the flow of steam and the mechanical construction of the parts, is not considered, so that the book is one which will not be very useful to students. Notwithstanding the disclaimer of any partisanship in the preface, the claims of Schultz seem to be urged in a somewhat partisan spirit where they conflict with those of Parsons. There are 73 pages in the book illustrated with 43 diagrams and 6 tables.

"Vorlesungen über die Vektorenrechnung." By Dr. E. Jahnke. (Leipzig: B. G. Teubner.) 5.60m.

The author has here reproduced his lectures on "Quaternions," delivered at the Technische Hochschule at Charlottenburg between 1902 and 1905. This calculus, invented independently by Sir William Rowan Hamilton in this country and by Hermann Grassmann in Germany, in the early forties of last century, was at first little appreciated, but its peculiar power, transparency and wide range of application are now fully recognised, and in electrical science, more particularly, it is replacing in many cases the more cumbersome and opaque analytical methods. The book is based in the main on Grassmann's "Ausdehnungslehre," and, although Hamilton's merits are recognised in a fashion, we do not think that he has been given all the credit he deserves; it is to be regretted, for instance, that his original work has found no place in the author's list of publications on the subject. Considerable skill has been exercised by the author in concentrating the vast subject matter into less than 250 pages, but the treatment is still more or less sketchy. For this reason the book would be of little value to beginners, although the numerous examples which are given should be of great benefit to those who have mastered the rudiments of this unique calculus.

The Engineering Index. By H. H. Suplee, J. H. Cuntz and C. B. Going. (London: "The Engineering Magazine.") 30s. net.

The fourth volume of this publication contains a record of the principal articles which have been published, during the years 1901 to 1905 inclusive in the 250 leading technical and engineering journals of the world, and is compiled from the monthly index in the *Engineering Magazine*. It offers a ready means for obtaining the necessary references when it is desired to refer to the most recent information published on any particular subject. Each article is placed under a "catch-word" which best indicates the subject dealt with, and it is necessary to first think of the "catch-word" under which the required articles will be found. In addition to the full title of the article, the author, the journal and date of publication, there is given a résumé of the article dealt with; thus the necessity of referring to the actual articles for such information is obviated. As mentioned above, the present volume deals with a period of five years, but in future the volumes are to be issued annually.

Fowler's Mechanical Engineer's Pocket Book, 1907. Edited by W. H. Fowler. (Manchester: Scientific Publishing Co.) 1s. 6d.

This well-known work again makes its appearance. All the old features have been retained, while their details have been brought up to date. The section relating to steam turbines has been thoroughly revised, and that relating to gas and oil engines has been brought into line with current practice. The book should be very useful for reference purposes, as its range is large. Many well-arranged tables of costs and test figures greatly increase its value.

Hilfsbuch fur die Elektrotechnik. By Dr. Karl Strecker. (Berlin Julius Springer.) 14m.

The value of this book, which has for some time held an acknowledged position in Germany as a work of reference, can best be judged from the fact that it is now appearing in its seventh edition and it would be difficult to name any other single book that covers such a large field in so comprehensive a manner. It contains no original material, and its character, which is so well denoted by the word "Hilfsbuch," may be said to lie between that of the engineer's pocket-book and of the text-book, inasmuch as the method of treatment is considerably fuller than that adopted in the average pocket-book, especially in the theoretical portions, but more condensed than one would look for in a text-book.

The writer has a happy gift of giving the pith of the subject he is treating in a short and yet intelligible manner, and references are nearly always given stating the source whence the matter is drawn and from which more detailed information can be found if desired. The book forms a guide to the general literature of electrical engineering, including text-books and technical papers, and is provided with extensive indexes to facilitate reference; it contains about 1,000 pages of matter and over 600 diagrams and figures.

After giving a number of tables of a general nature the book opens with a section on electrical instruments and the methods of carrying out tests of all descriptions. An interesting feature of this section is an enumeration in a tabular form of the instruments built by all the important German firms, comparing their particular constructive features and the results obtained,

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such as sensitiveness and power consumption. A similar comparison of electrical machinery of various makers occupies about 60 pages of the next part of the book, but as it contains only overall dimensions and guaranteed efficiencies and power factors, that are to be found in trade lists, it seems doubtful whether the information given is important enough to devote so much space to it.

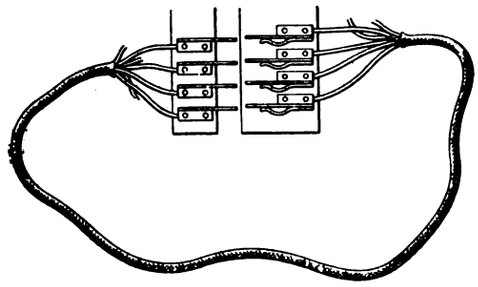
The principal subjects treated in the subsequent portions of the book comprise the theory and construction of electrical machinery, the laying out of generating stations, systems of transmission, lighting, heating and traction, electrochemistry, telegraphy and telephony, and an appendix is added including reprints of the regulations of the Association of German Electrical Engineers and of the principal laws of the State relating to electrical matters.

CORRESPONDENCE.

SIMPLE ZERO METHODS FOR DETERMINATION OF LEAKAGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest the article of Dr. R. Pohl on above subject (No. 1,514, p. 215) and think that his development of my method is excellent. Will you allow me, however, to remark that it is not so very difficult to wind a high number of turns and to adjust them, if the arrangement is used as described in the *Elektrotechnische Zeitschrift*, 1902, p. 314. The ends of 10, 20 or more "open turns" are connected to contacts, the latter ones being mounted on two little boards (*see* sketch). The "open turns" are placed once or twice round the pole and closed through one movement by means of



little springs, or possibly by connecting the turns in series by means of short ends of wire. Hardly a minute is required to wind 50 or 100 turns, the contact board affording an easy means for cutting as many out of the circuit as necessary. No resistance or galvanometer would be required, a millivoltmeter, so easy for transport, being the only instrument used. If the deflections on the millivoltmeter are—as near as possible—read off and used for interpolation, only about 10 turns are required for obtaining an accuracy of 2 or 3 per cent.—I am, &c.,

R. GOLDSCHMIDT.

Manchester, June 23.

WILLANS DICK-KERR TURBO-ALTERNATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your edition of June 7 on p. 301 it is stated with regard to the Dick-Kerr three-phase alternator that "the rotor is of the radial pole pattern as distinguished from the cylindrical construction common to Continental machines." To this I have to say that the cylindrical construction is not "common to Continental machines," because I know of numerous Continental machines with salient pole type rotors.

Further, you say the makers claim a lower magnetic leakage and better regulation for the design. This does not seem to coincide with the real facts, because one can easily prove by calculation that the magnetic leakage of the field system, as given in your illustration, is of the order of about 10 per cent. or more, whilst the magnetic leakage of the cylindrical type rotor is only of the order of from 3 to 5 per cent., so that, if anything, this point should be put forward in favour of the cylindrical type.

As regards regulation, there is no reason to believe that the cylindrical type rotor should necessarily involve a bad inherent regulation, inasmuch as this point depends merely on the ratio of the short-circuit current to the normal current, and on the leakage of the armature. On the other hand, it might easily happen that a salient type pole machine has actually a very poor regulation, if it is not properly designed or if a machine is put forward which is rated too high.

Further, the makers of the alternator seem to make a strong point of the ventilation being obtained "without having recourse to forced draught." By that I take it they mean that the rotor itself acts as a ventilator, so that there is no need to provide a special fan. However, I do not feel inclined to regard this argument as a very strong one, inasmuch as I think that a smooth rotor is likely to produce less windage, and a special fan is likely to give a much better and a more effective action than a "field magnet" which is called upon to serve as a "ventilator." Anyhow, one would expect that such a "ventilator" would produce rather a big noise. This seems to be silently admitted by the sentence on p. 302, where it says "to reduce noise and prevent the entrance of an undue amount of dust, the alternator is provided with end shields similar to those shown in Fig. 7." I am afraid there was a virtue made out of a necessity, or else I should not think that the makers would have committed themselves to adopt solid end shields, which, as far as I am aware, are "common to Continental machines," at least to the same extent as is the cylindrical rotor construction.

In taking up this design the makers only prove that there is a distinct tendency to abandon the open type design altogether for turbo machines.

This development is quite justified not only from the point of noise, but also from the ventilation point of view. If one considers that the sizes of the units put down in large power stations are becoming larger and larger, it is evident that with such large units the question of taking away the heat produced by the losses becomes more and more important.

If one keeps in mind that a modern power station might have a capacity of 100,000 H.P. in only a few units, one can easily realise that there are several thousands of horse-power dissipated in the form of heat. Under the circumstances I feel sure that the time is not far distant when not only will the cooling air be drawn into the machine through special ducts in the foundation from the outside, but also the hot air will be taken away and not allowed to go into the power house.

In conclusion I should like to say that it is not the object of this letter to condemn the salient pole construction. I only wish to prevent readers of your article from being misled by an unjustified prejudice against the cylindrical type of rotor.—I am, &c.,

M. KLOSS.

Stafford, June 25.

INTERPOLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your note on the above subject in the last issue, I should like to point out that "intersection" is of a different form to the "faked-up" word interpole.

Intersection is the place where there is a mutual cutting, just as interregnum is the indefinite space between two reigns.

On these lines interpole should mean the space between two poles, and should not refer in particular to an auxiliary pole itself!

In other words, while you can legitimately understand the words, "the place where," or, "that which," you cannot leave unexpressed the definition of place or motion or state which inter involves.

I really do not see that the term auxiliary pole, which I always use, is much more of a mouthful than the less elegant "Interpole," while it has the advantage of defining your meaning.—I am, &c.,

S. E. G.

June 25.

[We regret that we have found it necessary to hold over some correspondence.—ED. *E.*]

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TWELFTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

On Tuesday the opening meeting of the Twelfth Annual Convention of the Incorporated Municipal Electrical Association was held in the Council Chamber of the Town Hall, Sheffield, about 250 members being present. The Right Hon. the Lord Mayor (Ald. R. Styring), on behalf of the Corporation, extended a hearty welcome to the association. In the course of his remarks he said that, though in Sheffield they were handicapped by the low price of gas, they had nevertheless made great progress with the electrical undertaking. The motors installed in local manufacturing works represented some 7,000 H.P. at the present time, and they had at Neepsend an up-to-date station erected, not so much with a view to present necessities as to needs in the immediate future.

Mr. S. E. Fedden thanked the Lord Mayor for his kindness in welcoming the Convention to Sheffield, and referred to the fact that the Lord Mayor had, with the exception of one year, always been chairman of the Electric Lighting committee, and took a very keen interest in electrical matters.

He also proposed a vote of thanks to the Lord Mayor and the Lady Mayoress for their kind invitation to the members to the reception at the Town Hall on Tuesday evening.

Mr. Fedden then read his presidential address, of which the following is an abstract:—

Mr. Fedden referred to the important work which had been undertaken by the Association during the past 12 months in connection with Parliamentary and Local Government Board questions. He did not think the present and future importance of this Association, and the good work which it had in the past accomplished, and was now carrying out, were sufficiently appreciated either by the engineers or committees of Corporation departments. Of late years the status of the municipal engineer had considerably improved, which was very satisfactory, and it was realised that the successful public supply of electrical energy was an undertaking to which the best class of technical and business men might entirely devote themselves. He referred to statements which had appeared in the press to the effect that it was not well for the control of so many public utilities to fall into the hands of officials. To say that the officials of a Corporation were the real powers might be flattering to those officials, but was certainly not true. The continuity of the chairman and principal members of committees was essential to the successful development and well-being of the electricity departments, and he was pleased to see the change which had taken place in recent years, whereby the chief engineers were now not continually changing office. He did not, however, recommend too great a devotion to any particular berth on the part of the younger men.

A question which had been the subject of some discussion was the division of the management of an electric supply business into two departments—an engineering and a commercial—and although the circumstances varied to some extent with local conditions and the relative proportion which the engineering side bore to the commercial in different undertakings, yet he was of the opinion that generally such a business as theirs should be under the control of an engineer who was qualified by temperament, education and experience to watch and foster its commercial development whilst well able to carry forward the engineering work and deal with the various problems of supply. Such a man would realise that no engineering success could be considered complete until time had testified to its thorough public utility and the financial soundness of its results. It had been stated that few, if any, could be found to possess those qualifications, but he did not think that was so. They were sufficiently numerous in the other great branches of the engineering profession, and he had no doubt that time would add to the number of those who had been so conspicuously successful with their own larger undertakings.

He would urge that the whole business of the supply department should be carried out by the engineer manager. There had been some attempts to combine certain duties, such as account collecting, with the rates and other demands made from the borough treasurer's office. This, at first sight, possessed certain advantages, but very little experience went to prove it a dangerous policy, because the electricity department held no real monopoly and had all to gain by keeping in close touch with its consumers, meeting their complaints promptly and taking care to give them the feeling that it was ever ready to assist them to get actual value for the moneys paid, and not force them to pay whether pleased or not in the automatic and impersonal manner which is associated with rate collecting.

During the year a good deal of attention had been drawn to the action of the Local Government Board with regard to loans for extension work. The inspectors of the Board who conducted the local inquiries which followed an application for permission to borrow appeared to be vested with very comprehensive powers, and in certain cases had employed them with so much zeal as to suggest a desire to restrict the expenditure of public money in such undertakings, and had also shown a disposition to criticise the manner in which the undertakings were being developed and the cost of works done, questions, in his opinion, solely for the local authorities themselves.

It was not an easy matter to prepare close estimates for work to be carried out over a number of years, because of the fluctuations in cost of material and labour, and because it became frequently sound policy to change details of a scheme as it progressed. It was, therefore, necessary to be somewhat liberal in estimating for some work, with the result that when the inquiry took place the engineer might be subjected to a searching cross-examination on almost every detail of his past and future estimates, many items in which should be looked upon as provisional sums for use at his discretion.

Recently it had been the practice of the Board to sanction loans for specific purposes only, which was very unsatisfactory from the engineer's standpoint and unfavourable to the electric supply department. For example, a firm might decide to build new works and apply to the Corporation for a supply of power, probably at some distance from the nearest mains. This extension would involve an unlooked-for expenditure on cables, and most likely plant to meet the demand. Under existing conditions money could not be spent in this way; in fact, nothing could be done until a loan had been specially sanctioned by the Local Government Board, which would entail a long delay. Naturally the firm would not wait indefinitely and would probably either put in another form of power or instal their own electrical plant. Consequently, a valuable customer might be lost to the electric supply department, whereas if municipal authorities were empowered to proceed with such extensions as and when called upon, and to pay for the additional plant out of a floating or provisional loan to be accounted for afterwards, it was conceivable that in many cases valuable business could be secured.

Again, the Local Government Board had an unfair condition, which insisted on charging to revenue account the wages paid to permanent workmen and officials engaged on work rightly chargeable to capital. It was contended by them that if employés were engaged specially to carry out extension work and were discharged on the completion of such work, their wages might be charged to capital, but if after the completion of such work they continued to be employed, the whole of their wages must be charged against revenue.

The effect of this was to discourage the direct employment of labour and to force municipalities to place work in the hands of private contractors which could frequently be done better and more cheaply by themselves, although it did not appear that this result was realised or desired by the Local Government Board. All municipal departments of any size were obliged to keep a staff of jointers and labourers for cable work. It would not, however, be practicable to employ distinct gangs of men on capital and revenue works.

He contended that engineers should be allowed to analyse the wages paid to their staffs and debit the proper proportions to capital and revenue accounts in accordance with the nature of the work carried out. By doing this the cost of capital works was often less than it would be if a private contractor were employed, and the cost of maintenance work was also benefited by the greater continuity of employment which could be given to workmen through carrying out everything with directly-employed labour.

They had endeavoured to obtain an interview with the President of the Local Government Board, with a view to ventilating their grievances, and he (the speaker) believed that if the complaints were clearly put before him he would see that they had just cause for dissatisfaction, and that a friendly discussion would lead to a more reasonable mode of procedure in dealing with applications for loans by municipal electrical undertakings. Also the removal of some of the more objectionable regulations now in force or, at any rate, an undertaking that they would be interpreted with less rigour than at present.

Mr. Fedden concluded his address with some remarks on advertising and the creation of a demand for electrical energy. He did not think that they would be well advised to take too seriously the exponents of the new publicity who were arising, each with his own particular method for stunning the unsuspecting public. After all, the object in view was simply to ensure that every likely consumer should become acquainted with the possibilities of electricity supply in relation to his business, pleasure or home life, and that such information should certainly reach him without any effort on his part. The safest and most efficient means of securing this result was by demonstration in the form of press records of work done, showroom displays, exhibitions, and the loan of apparatus on approval, and although this method might involve considerable outlay, he thought the return would be immeasurably greater than upon any extensive scheme of general advertising alone.

Ald. G. Pearson (Bristol), in proposing a vote of thanks to the president, said he was in entire accord with all Mr. Fedden had said. Ald. Bruce (Sunderland) seconded, and Mr. R. L. Acland then read his Paper on

EXTENSION OF ELECTRICITY SUPPLY TO OUTLYING DISTRICTS.*

BY R. L. ACLAND.

(Borough Electrical Engineer, Chesterfield.)

This Paper gives the author's method of overcoming a supply problem, and the result of over 12 months' operation of the installation. The lighting network of a small town of which the growth

* Slightly abbreviated.

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was somewhat slow was naturally cut pretty fine on the outskirts, and when a demand arose for a considerable supply in a small compact area some 1½ miles beyond the edge of the existing network and 2½ miles from the power house, the question was how to deal with same in the most all-round economical manner—that is, combining a small capital expenditure with low working costs when installed.

It was considered that the requirements of the district would be supplied for the present by 50 kw., and, taking this figure as a basis, a comparison of the various systems was made, in order to arrive at the one which seemed to conform most to the above requirements. High-tension transmission from the power-house 2½ miles distant would have involved rotary converters, static transformers and special switch gear at either end, with an enlargement of the main power-house at one end and special buildings at the other, to accommodate the necessary plant, whether the supply given was alternating or direct, in addition to 2½ miles of high-tension cable, half of which would have been drawn into the existing ducts, and the remainder laid solid. An extension of the existing low-tension system was out of the question, as the nearest feeding point could not accommodate the load, and it would have been necessary to go right back to the power-house.

An ample area of copper had fortunately been laid with the tramways, which extended to the district requiring the supply, and the full length of line provided for was not ultimately constructed. It was, therefore, considered that the best method would be to utilise a portion of this surplus copper, but as the lighting would have to run in parallel with the tramway supply, the question of taking up the variation in voltage at the far end of the traction feeders was the most important one that had to be settled. This could be done in one of two ways, either by putting down a battery of accumulators and charging same by a motor-generator during the day and discharging at night time, or by running direct in conjunction with some form of automatic voltage regulator. The last-mentioned was the scheme ultimately adopted, as a guarantee was received from the makers of the regulator used to give an automatic regulation within 1 per cent., with a 10 per cent. variation of the voltage on the tramway supply above and below normal, namely, from 450 to 550 volts.

The capital cost of the various schemes was taken to be approximately as follows :—

High-tension transmission with direct current supply.....	£1,770
" " " alternating current supply	1,560
Low " " from lighting supply	3,500
" " " " traction supply (with accumulators).....	1,720
Low-tension transmission from traction supply direct with voltage regulator	600

The cost of the local mains network required is not included in any of the above figures, as this would be practically the same in each case.

A general description of the apparatus† is as follows :—

A 0·4 feeder is taken from the panel on the traction board in the power house (the circuit breaker controlling same being wedged up) and carried to a point on the route two miles distant and terminating in a feeder pillar containing four 200 ampere circuit breakers and isolating feeder switches; for the remaining half-mile, a 0·2 cable is taken, terminating in a second feeder pillar, in which the negative connection is also made to the rails and provision made for connecting to the trolley line in the event of a breakdown on the feeder supplying the sub-station. From here connection is made by underground cable, both poles insulated, to the motor starting panel on the sub-station switchboard.

The sub-station is a plain brick building situated on land behind some cottages adjacent to the largest consumer, and contains one 75 H.P. motor, direct coupled to a 50 kw. compound wound generator, space being provided for a second set if required in future.

The switchboard consists of three panels; they are (1) controlling the motor and containing circuit breaker, ammeter single pole switch, starting rheostat and wattmeter; (2) is the generator panel mounted with ammeter, double pole switch and fuse, automatic voltage regulator and shunt rheostat for dynamo, and also shunt rheostat for motor; (3) controls the out-going feeder and contains ammeter, double pole switch and fuse, wattmeter and recording voltmeter connected across the generator. The diagram shows the general arrangement of connections.

An all-night supply is not at present required, so that the sub-station is started up at 6 a.m. in the winter, and later in summer, by a man going down, whose duty is to go carefully round the brushes, oiling apparatus and voltage regulator, and see that all is in order for an eighteen-hour run, log the previous day's output, and take out the recording charts. The plant is shut down at 12 p.m. from the traction switchboard by opening the switch controlling the feeder supplying the sub-station. A remote control apparatus was considered for starting up from the power-house, but this would probably have led to the daily inspection being sometimes neglected, and was in consequence abandoned.

From the above remarks it will be seen that the running labour costs are small, amounting to about 6s. per week. The current taken by the motor being a kind of steadying load on the traction generator, which is run without a battery in parallel, the cost of power can be put at a very small figure, as the fuel costs at the power house are 0·20d. per unit generated. The only other costs are voltmeter records, carbon brushes and renewal contacts for the exciter, which latter amount works out about 8s. per annum.

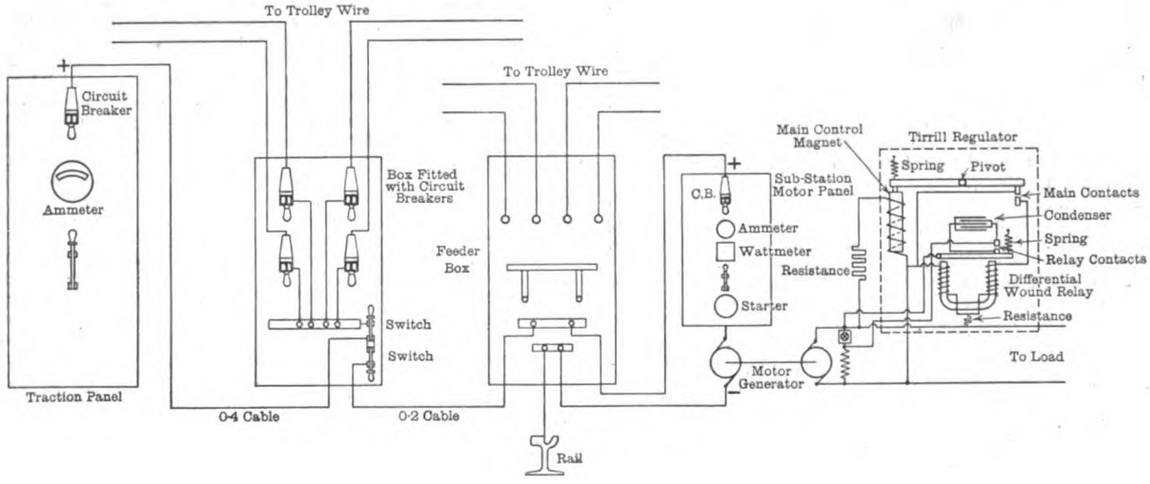

Diagram of Connections.

The Tirrill regulator, operating on direct current, requires somewhat more careful attention (as one has to deal with larger currents by working on the main shunt) than it does with alternating current, when the regulation is done on the shunt of the exciter, as in the Neepsend Power House, Sheffield.

The operation of the regulator can be traced by reference to the diagram. When starting up, the voltage of the generator is raised by hand rheostat to about 210 volts (the supply being at 240), and the regulator is then switched in, when it immediately short circuits all the shunt resistance that has been left in, by the spring pulling against the solenoid and closing the contacts, and the voltage commences to rise to the maximum of 300 with the machine being described, but on reaching the pressure for which the main control coil has been set the solenoid overcomes the spring tension and the resistance is again inserted as the contacts open and the voltage tends to fall to 210. This operation is repeated at high frequency, and the resultant on the recording chart of a voltmeter with the dashpot taken off is practically a straight line at any predetermined pressure for which the spring tension on the main coil has been set.

The only things that require attention are the contacts, and neglect of these will cause trouble, and gradual burning of the silver tips must be made up for by adjustment to keep them the proper distance apart, about $\frac{1}{16}$ in.; the silver must must not be burnt completely off, and dirt or dust must be kept off the contacts. The

[† See *The Electrician*, Sept. 21, 1906, for further details.—Ed. *E.*]

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sparking in the relay contacts is taken up largely by condensers placed in multiple across them, but these must be assisted by cutting out with the hand rheostat as much of the shunt as possible consistent with the regulator having control of the maximum rise in voltage, for by this means the burning of the contacts will be reduced, also any chance of a flicker on the lamps with a small load on the generator.

In Chesterfield the tramways are supplied with current at the switchboard for 1¼d. per unit, which price, somewhat lower than the average, is taken to counterbalance any use that is made by the lighting department of the tramway cables, for running the sub-station and any other motors that may be connected.

DISCUSSION.

Mr. G. WILKINSON (Harrogate), who opened the discussion, said the time had gone by when those in villages and outlying parts would be content with the older forms of illumination whilst their friends in the big towns enjoyed the more healthful and cleanly forms furnished by electric supply. Recent extension of tramways, light railways and power lines into scattered neighbourhoods had made it possible for engineers to give a lighting supply. The chief difficulty, however, was with the voltage variation with a power load. In Norway recently, in a small hotel, he found electric lamps run from the feeders of an adjoining railway, and the fluctuations were very painful. The Tirrill regulator was first introduced on public supply lines in Harrogate, but he did not at first recognise all its advantages. He was induced to take it because by doing so he could employ a cheaper generator with greater armature reaction and a larger voltage drop. The experience had proved very satisfactory. When the Council of the Association was at Harrogate two years ago, it was suggested that a ruler had been used to produce the charts. He noticed that the capital cost for the Tirrill regulator system was put at £600, but there was no amount included in that £600 for the trunk mains from the station. He asked Mr. Acland to give a portion of the cost of these mains as part of the outlay. Taking 30 amperes as the current for tramway purposes and 10 amperes for the lighting, he thought that three-quarters of the interest and sinking fund on these mains should be put against the tramways undertaking and one-quarter against the lighting undertaking. He strongly recommended the use of platinum contacts for the relay contacts of the Tirrill regulator. He asked for pressure charts of the tramway feeders and of the lighting feeders to compare them with the pressure record of the regulator.

Mr. S. L. PEARCE (Manchester) said the Paper opened up the possibility of giving cheap lighting supply to outlying networks by utilising existing traction mains. On paper the scheme appeared to be economical, but he asked, Did it give a reliable supply for the lighting? To ensure reliability he thought the main traction circuit-breaker must be fastened up, in addition to that on the traction feeder panel. If not, on a heavy traction short-circuit, both the traction and the lighting supply would fail. But if neither of the station circuit-breakers opened, the sectional breakers in the tramway feeder pillar would open and interrupt the tramway supply, and there would be no means of replacing these circuit-breakers from the station. There would be delay either in the lighting or in the traction supply.

Mr. C. O. MILTON (Maidenhead) said Mr. Acland had hit upon a smart solution of his particular problem. The question was very important for small towns. At Maidenhead the demand had developed in areas 1½ to 2 miles from the station, and, later, districts 3 to 5 miles away had been taken in. He would like to hear the experience of other engineers faced with the problem of supplying these outlying places from a station put down for a compact area. Running at different voltages on the station 'bus bars seemed impracticable and inefficient.

Mr. H. RICHARDSON (Dundee) referred to the sanguine way in which Mr. Acland spoke of no all-night supply in view of the keen competition of gas. He thought high-tension supply would be a better way out of the difficulty. The amount of capital (£600) was so small that if it were even doubled there would be a good deal to be said for the high-tension supply system for outlying districts.

Mr. F. AYTON (Ipswich) asked if Mr. Acland found any difficulty in regulation in the winter, when there was sometimes heavy tramway traffic, with a lighting peak load. He did not think many of them could utilise the system. Tramway feeders were usually equal to the normal traffic, and with heavy traffic it was sometimes difficult to see on a car at all. They could not afford to lay down a large amount of copper not immediately required.

Mr. A. C. CRAMB (Croydon), referring to his experience with the Tirrill regulator, said that in controlling a direct-current generator the regulation was not equal to that of a regulator he used in the exciter circuit of a motor-driven alternator. The value of the regulator lay largely in the fact that in small stations it enabled a small set to be run on the day load.

Mr. C. TURNBULL (Tynemouth) remarked on the use of the Tirrill regulator with compound-wound machines. He asked what would be the effect of the regulator with several compound machines with equalisers. He had found that compound-wound machines for lighting purposes were generally less desirable than plain shunt machines. As to the protection of the dynamo, circuit-breakers were needed because the modern engine was usually capable of running a generator to destruction. If a few more shillings per kilowatt were spent on the dynamo, in preference to automatic protective appliances, the only safety device needed at the generator switchboard would be a powerful fuse with magnetic blow-out. For large direct-current generators he thought that separate excitation of the field would get over any difficulty which might arise with the relay contacts dealing with heavy currents.

Mr. V. A. H. McCOWEN (Salford) said that at Salford a number of 800 kw. machines were controlled by a Tirrill regulator which was placed in circuit with one machine, and the rest were run in parallel with this machine.

Mr. E. GARTON (British Thomson-Houston Co.) said they could not generally recommend platinum contacts, as in some cases these gave trouble, but silver gave good results at Sheffield. In another case, however, it was impossible to use silver, but platinum contacts got over the trouble. Another regulator was working on the Liverpool & Southport Railway where they had as wide a pressure variation as from 420 to 680 volts. The regulator had been able to keep this within 1¾ per cent. It was worth the trouble of keeping the contacts clean to maintain the voltage well within the limits, say 1 per cent.

Mr. F. M. LONG (Norwich) asked for particulars of the efficiency of the Chesterfield plant.

Mr. W. M. ROGERSON (Halifax) asked for figures as to the partition of the costs between the tramway and lighting departments with this particular extension.

Mr. C. D. BURNET (Carlisle) inquired whether any pressure was brought to bear on the Lighting committee by the Tramways committee on account of the joint use of cables. The charge for traction appeared low (1¼d.), and he asked what the figure was before it was reduced in respect of the use of the traction cables.

Mr. R. L. ACLAND, in reply, emphasised that he had not attempted to give more than a solution of the supply problem of a district just beyond the Chesterfield boundary. In the estimate given for the scheme adopted, a sum should have been added for the use of the tramway cables, but he would give this in his printed reply. In regard to the relay contacts, they used platinum in the first case, but had since used silver, which proved equally suitable but did not wear quite so long. The difference in the cost of the two metals compensated for this shorter life. He promised to include a voltage curve of the above tramway feeder in the *Proceedings*. The pressure varied between 460 and 540 volts. The regulator he used in conjunction with the motor-generator was relieved of a certain amount of the regulation by the flywheel effect of the revolving armatures, this tending to smooth out a great deal of the irregularities. As to the reliability of the supply, this had been considered and allowed for as far as possible. The circuit-breaker on the generator was controlled by a time-limit relay, allowing the breaker to remain in for 1½ to 2 seconds for ordinary overloads. He had omitted to mention that in the feeder pillar was a bell circuit closed by the circuit-breakers when they came out. When the next motorman came to the standard and found the bell ringing he was instructed to replace the circuit-breakers. They had not found this cause any delay. Regarding any faults on the motor-generator, the use of one machine entailed certain risks, but spare armature coils, &c., were available in case of need. An all-night supply was not given as it was not called for, but if it were required it could be easily given, as the tramway generator was only shut down from 12:30 till 4:30 a.m., and for three nights per week was running all night. Figures of the actual efficiency of the machine used would be inserted in his printed reply. If the load was continually heavy during snowy weather a man was kept standing against the feeder pillar during the lighting hours. The charge for tramway supply had always been 1¼d., as generating costs were very low. The figure was arrived at between the two committees.

Mr. S. E. FEDDEN, in proposing a vote of thanks to Mr. Acland for his Paper, said that in Sheffield he had used Tirrill regulators for some three years, and it was quite impossible to keep the pressure steady without them. He had put them into both stations, with very satisfactory results. He found, however, that they required a man to watch the regulator. He did not quite understand how Mr. Acland got his to work for from 14 to 18 hours without inspection. It would be very interesting to hear if data could be given as to which were the best contacts to use. They had tried both silver and platinum, and were in favour of silver, but there must be some underlying condition, which he thought, perhaps, the experts of the B.T.-H. Co. could investigate and give fuller details of.

In the afternoon the party was permitted by the courtesy of Messrs. Vickers, Sons & Maxim (Ltd.) to inspect a considerable portion of their River Don Works. Special cars, provided by the Sheffield Corporation, conveyed the visitors to the works and a most interesting time was spent in the inspection of the various processes in use. The rolling and cutting of large steel plates, the turning, boring and rifling of guns, the building of dynamo electric machinery, the forging and rolling of wheel tyres and the grinding of armour plates were among the principal sections of the work carried out which were brought to the notice of the party. The use of electric power throughout the works is very extensive and many interesting and unique applications of motors have been made to the many different types of machine tools employed. Lathes were particularly in evidence and most of them were driven by individual motors either by chain, belt or gear. Considerable interest was taken in a large steam-driven rolling mill, an ingot for a belt-plate for H.M.S. "Bellerophon" being passed several times through the rolls. This was afterwards cut under a large hydraulic press. The duty of a reversing rolling mill appears particularly severe, and after witnessing its actual operation, electrical engineers must be at once struck with the arduous character

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of the load which would be imposed upon any electrical system adopted for the purpose. In the electrical department, which occupies a large bay in one of the main shops, direct-current and alternating-current dynamos and motors were in course of construction, amongst the former being a 1,000 kw. generator for the Sheffield tramways power house. The extensive use of electric power was noticeable throughout the works and appeared to impress the visitors considerably. Particularly was this the case at the steel furnace platform, where an electrically-operated charging machine was shown in operation. Under the guidance of a party of officials, headed by Mr. A. D. Williamson, a most enjoyable afternoon was spent.

The day's proceedings concluded with a reception and dance given by the Lord Mayor at the Town Hall. Invitations were issued to members of the Association, delegates of municipalities and visitors. Altogether about 300 guests were present, and a very pleasant evening was spent. The music for the dances was provided by the Hallamshires band, which also played a number of selections during the reception.

Wednesday, June 26, 1907.

Fortunately the weather was very favourable for the day's excursion to the Dukeries. A party numbering about 220 left by train at 9:15 a.m. for Worksop, from whence they drove to Welbeck Abbey and through Budby Forest to Ollerton, where lunch was served. The return route to Worksop was via Clumber. Tea was taken in the Town Hall at Worksop, and the party returned by a special train to Sheffield at 7:45, after paying a visit to the District Council's electricity works.

An impromtu smoking concert was held at the Royal Victoria Hotel in the evening.

Thursday, June 27, 1907.

The annual general meeting was held in the morning at the Royal Victoria Hotel, when the twelfth annual report of the council was presented :

In their report the Council mention that the membership of the Association now stands at 388, made up as follows: Committees (members) 152, chief electrical engineers (members) 166, honorary members 2, assistants (associate members) 13, assistants (associates) 55—the total showing a decrease of ten on last year's figure, principally in the associates class.

Articles of Association.—Since the last convention the alterations then made in the articles of association have been confirmed. These, it will be remembered, relate chiefly to the constitution of the council, the number of committee representatives being increased and equal terms of tenure of office being given to representatives of committees and engineer members of the council, viz., two years. The association's financial year has been altered and now terminates on March 31.

Carbon Filament Lamp Specification.—The council having withheld their own specification at the request of the Engineering Standards Committee, approached the committee with a view of arranging that members of the association be able to purchase copies at a considerable reduction. The only concession at present obtained, however, was an offer to supply in bulk, which would have involved the council in considerable initial outlay with some doubt as to recoupment and they did not deem it advisable to run this risk.

Information Bureau.—The Council, while desirous of extending the usefulness of the Association, felt that the proposals of Mr. J. E. Edgcome in his last year's presidential address were outside its scope, and that a great deal of the information which it was assumed the members would require could be obtained by other means; and that the formation of a publicity department was rather a question for local effort than for centralisation.

Travelling Studentship.—The Council regret that the response of the associates has been limited to one candidate, but the Paper submitted was of such a high standard that its author, Mr. McCourt, of Harrogate, has been awarded the studentship, and the Paper is being read during the Convention. The subject is "The Value of Photometry in Central Station Practice."

Local Government Board Loans.—In response to a circular letter, the members have expressed a unanimous opinion that the wages of permanent employés engaged on capital work should be paid for out of capital, such employés being of the order of workmen. There was some divergence of opinion as to whether the wages of other officials should be borne by capital or revenue account, some few expressing the opinion that an official's remuneration should be wholly charged to revenue, unless exclusively engaged for capital work. The members were also unanimous in their opinion that delegates' subscriptions and expenses in connection with the Incorporated Municipal Electrical Association meetings should be payable out of the expenses of their undertakings. The Council endeavoured to obtain an interview with the President of the Local Government Board on these matters; but although that gentleman was approached by several Members of Parliament individually, he declined to receive a deputation. A meeting of the Council and nearly 40 Members of Parliament was then held, and a resolution on this matter, which was unanimously carried, was presented to the President of the Local Government Board, and that gentleman has since been approached on more than one occasion, but he still declines to receive a deputation. Having regard to the failure to obtain an interview upon the above-mentioned matters, the Council have felt that the next step was to move the House on the matter, on the occasion of the presenting of the Local Government Board estimates, and arrangements have been made for that to be done.

Board of Trade Electricity Bill.—Members of the Association, in reply to the circular of October 16, 1906, were unanimously in favour of the Board of Trade Electricity Bill becoming law as soon as possible. At a private interview the Parliamentary Secretary to the Local Government Board stated that the bill had been put forward at the present time with a view to obtaining criticism and the opinions of all persons concerned, and that after these had been obtained, the bill would be taken forward next session with the full intention of its becoming law and (it was hoped) as an unopposed bill.

Street Lighting.—In order to provide data to controvert the statement, so often brought forward by those interested in the supply of gas for public lighting, to the effect that electric lamps are not suitable for this purpose, the Council issued a schedule of questions to every municipal electrical engineer with a view to publishing periodically a progress sheet showing the number of gas lamps displaced by electric lamps. As the returns are not yet complete, the final result of the Council's action will be subsequently published in the *Proceedings*.

Honorary Treasurer's Report.—The balance sheet shows a credit balance of £16. 4s. 4d., making a surplus of £309. 19s. 3d. to be carried forward.

Before the report, given above, was discussed, the election of officers and council for 1908 took place. Mr. H. Talbot, of Nottingham, was elected president for 1908, and the place of meeting was left to the new president and council.

The nomination and ballot for vice-presidents resulted in the election of Mr. S. L. Pearce and Mr. W. W. Lackie.

As a result of the new regulations governing the constitution of the council, all members of that body retired, and the following were elected on the new council :—

Ald. G. Pearson (hon. solicitor), Mr. J. E. Edgcome (hon. treasurer) and Mr. Faraday Proctor (hon, secretary). Eleven chairmen of committees and 21 engineers were nominated to serve on the council, and the following (given in the order of votes received) were elected :—Six chairmen of committees: Ald. Sir John Turney (Nottingham), Councillor J. P. Smith (Barrow-in-Furness), Ald Bruce (Sunderland), Councillor Sinclair (Swansea), Ald. Dowson (Doncaster), Ald. Wilkinson (Luton). Eight engineers: J. Christie (Brighton), T. P. Wilmshurst (Derby), C. E. C. Shawfield (Wolverhampton), G. Wilkinson (Harrogate), A. A. Day (Bolton), J. K. Brydges (Eastbourne), H. Richardson (Dundee), V. A. H. McCowen (Salford).

The annual report and balance sheet were taken as read, and adopted.

After other formal business, a vote of thanks was accorded to Mr. Fedden, who responded briefly, alluding to the hard work attached to the position of president, which he now left to his successor. The thanks of the meeting were also accorded to the honorary officers and to the council.

In the afternoon three Papers were read and discussed, the first one was as follows :—

CHEAP POWER SUPPLY BY MUNICIPALITIES.*

BY C. E. C. SHAWFIELD.

(Borough Electrical Engineer, Wolverhampton.)

At various times and before various associations papers upon this same subject have been read and discussed until it would almost appear that the question was worn so threadbare that nothing further of interest could be written in connection therewith. Nevertheless, the author has ventured to re-open the subject once again, believing that there is an aspect of the case which hitherto has not received the attention that it deserves, and in the light of which it is possible that conclusions previously arrived at may be considerably modified.

For many years past the Maximum Demand System, in one form or another, has formed the basis upon which electrical energy is sold to consumers in the great majority of electricity undertakings in the United Kingdom, and it may perhaps be argued that its almost universal adoption for a lengthy period is primâ facie evidence of the soundness of its principles, and it may also be claimed that the enormous developments in electricity supply during the last decade are in themselves proof of the excellence of the system of charging which has been principally in vogue during this period. There are, however, certain heretical persons who have expressed a doubt as to whether the progress that has been made is not in spite of, rather than because of, the Maximum Demand System, and it is to this sect of apostates that the author now confesses his adherence.

* Paper slightly abbreviated.

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The fundamental basis of practically all existing tariffs which have their parentage in the Maximum Demand System is the equal allocation of all charges among all consumers on a load factor basis. This would appear at first sight an equitable arrangement, and indeed would be such if electrical energy were produced to be sold to one class of consumer for one purpose only; for example, illuminating purposes. Such, however, is not, and should not be, the case.

In the author's opinion one of the largest and most important uses for electricity is to be found in power supply. In any fairly large industrial town in the United Kingdom it will be found that, out of the total amount of motive power of all descriptions which is in use in the various works, only a relatively small proportion is provided by electric motors. After making every allowance for the inherent conservatism of the British manufacturer, the author is of opinion that this unfortunate state of affairs is chiefly attributable to the existing methods of determining the charges made for electricity supply.

If any of the commonly accepted systems of cost allocation is applied to any existing electricity undertaking for the purpose of deducing a rate of charge which shall be applicable to motive power supply, it will be found that in almost every case the price thus arrived at is an amount considerably in excess of 1d. per unit.

The author presented a tabulated statement showing the rates charged for power supply in the case of 35 municipalities in the United Kingdom, from which it was seen that the average price received was in nearly every instance well over 1d. per unit, and that in only two cases was it below that figure. Further, it was observed that the average rate for power supply for the whole of the undertakings scheduled was 1·33d. per unit.

The fact remains, therefore, that, even after due allowance is made for the special advantages of electrical driving, and the incidental savings accruing therefrom, the present power rates are in the great majority of cases too high to enable electricity to replace other existing forms of motive power, except in the case of small consumers. Therefore one is forced to the conclusion that either the principle upon which existing power tariffs are based is wrong, or that electricity cannot be produced cheaply enough to enter into commercial competition with other forms of motive power in the case of large works and factories. That the latter is the case the author is not prepared to admit, but rather believes that the fault lies in the existing system of cost allocation, and he will endeavour to indicate as briefly as possible the direction in which a remedy may be found.

It would appear to be almost a settled principle that new tariffs should be based on existing cost sheets, with the result that the possibilities of the future are largely discounted by the accidents of the past. The author believes this principle to be fundamentally wrong, and would substitute therefor a maxim which may be briefly expressed as follows:—"Adjust the tariff to suit the competition and the cost of production will adjust itself to the tariff."

Acting on this assumption, the first thing to be done is to determine what the selling price per unit must be, to enable electricity to compete with the other forms of motive power at present available, due allowance being made for the inherent advantages possessed by electric motors over other types of prime mover.

It is impossible to lay down any scale of charges which is of general application, but it will be found that in the majority of industrial centres the maximum price per unit for electricity for motive-power purposes must not exceed 1d. to any but the quite small consumers. Further than this, it would be necessary in the case of large works using over 1,000,000 units per annum to offer a rate of ½d. per unit, or less, and in the case of still larger manufacturers the rates to be quoted may fall as low as ¼d. per unit.

Having arrived at a scale of charges which will enable any given electricity undertaking to secure the bulk of the power load within its area, the question then arises, can such undertaking produce electrical energy at a cost sufficiently low to enable it to meet all its capital and other standing charges, inclusive of reserve fund, and leave a margin for profit? The author firmly believes that it can be done, provided always that the proposed rate is not debited with costs that do not properly belong to it.

Owing to the overlapping of the lighting and power loads in winter, the power consumer is debited with a considerable proportion of those standing charges which properly belong to the lighting consumer, and thus a certain advantage of a combined lighting and power supply from one station is negatived.

The author believes that a solution of the difficulty is to be found by regarding lighting and motive power as two separate and distinct classes of supply, each of which should bear only those charges directly incurred by its production, and if this principle be adopted it will be found that in practice it will often pay to instal different types of plant for their respective requirements.

Let there be assumed the case of a central station, equipped with condensing plant and situated in a medium-size industrial town, the existing plant capacity of the station being taken at, say, 2,000 kw. Under present conditions it may safely be taken that at least 1,500 kw. of this plant is required to meet the lighting demand, and that not more than the remaining 500 kw. is required for power supply purposes. On a canvass of the area being taken, it is found that there is a possible power load to be obtained which would represent a demand at the generating station of a further 2,000 kw. and a corresponding annual output of 3,500,000 units.

After taking into consideration local conditions as regards the price of coal, gas and water, which determine the cost per horse-power-year of the competitive forms of motive power, it is found that the rate of charge which it would be necessary to make in order to secure this load, when averaged over the total output per annum, represents an average selling price per unit of 0·8d.

The total capital cost involved in the installation of the necessary generating plant to deal with the proposed power load would be approximately as follows:—

Capital expenditure—	
Buildings and foundations, chimney and flues	£6,000
Boilers, stokers, economisers, superheaters and feed pumps	4,700
Turbo-generating sets, with condensers and switch gear	14,300
Steam, exhaust and water piping and valves	500
Contingencies	500
Total cost of generating plant	£26,000

The amount of the expenditure on mains will depend on the system adopted—that is, whether continuous or alternating—and the choice of the system will again be affected by the size of the area to be served.

In the absence of direct information as to the size of the area to be covered or as to the system of transmission adopted, it is impossible to state definitely what capital expenditure would be incurred in transmitting the assumed output to the consumer, but the author believes that a mean cost of £10 per kilowatt demanded at the station would be amply sufficient to meet the average case. Hence, for 2,000 kw. station demand the capital expenditure on mains would amount to £20,000.

Then the total capital expenditure to be incurred in generating and transmitting 3,500,000 units per annum for power supply only would be £46,000.

Annual Standing Charges.—If the standing charges are taken as consisting of the following items—interest, sinking fund and reserve fund, rates, taxes and insurance, wages and repairs—the total annual expenditure under the heading of standing charges will be as follows:—

	Per annum.	Per unit.
Additional interest, sinking fund and reserve fund, at 9 per cent.	£4,150	0·285d.
Additional rates, taxes and insurance	600	0·041d.
Additional wages	500	0·034d.
Additional repairs	950	0·065d.
Total standing charges	£6,200	0·425d.
Running costs:—		
Assuming fuel having a calorific value equivalent to 12,000 B.T.U. per lb. the coal consumption per unit sold should not exceed 3·75 lb., and on this basis the cost would be, at 10s. per ton		0·20d.
Oil, water and stores		0·01d.
		0·21d.

Total cost of production = 0·425d. + 0·21d. = 0·635d.

On the basis of an average price received of 0·8d. per unit the net annual profit to be derived from the power supply side of the undertaking would be:—

(0·8d. − 0·635d.) × 3,500,000 = £2,400 approximately,

which is equivalent to over 5 per cent. on the capital expenditure.

It may be urged that no allowance is made for additional costs of supervision and management, but these, unfortunately, are not always incurred, and, when incurred, are usually small in amount. In any event, there is ample margin for a considerable expansion of the expenditure side of the account without seriously affecting the financial result.

It should be noted that the whole of the foregoing particulars with reference to capital expenditure on generating plant are not estimated, but are based on tenders actually received, and that the figures relating to coal consumption per unit are based upon guaranteed results with a sufficient allowance for contingent losses.

As regards the coal consumption per unit metered the author is acquainted with two undertakings in which the actual results obtained are considerably better than those herein assumed for the purpose of this paper. In the case of very large consumers whose individual demand would be 1,000 kw. and over, the supply would probably be given on the extra high-tension 3-phase system, in which case the total capital expenditure per kilowatt for both plant and mains would be considerably reduced.

It will be observed that the power production costs previously given as being attainable in the case of a medium size station in an industrial town are only possible on the assumption that the power

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supply is only debited with those additional items of expenditure actually incurred in respect of it, and that it is not made to bear the burden of any portion of those previously existing standing charges in respect of the lighting supply which would still have had to have been paid whether the additional power supply existed or not.

It may be argued, however, that difficulties would arise with regard to the correct determination of certain of the charges debitable to the power consumer, as, for example, where motive power supply is taken from previously existing mains, as it would then appear that the power supply was getting the benefit of the capital originally expended on behalf of the lighting consumers. This objection, however, cannot arise if, when the power tariffs are first determined, the principle is adhered to that this class of supply is to be regarded as separate and distinct from lighting, and that allowance must be made for the cost of transmission of the energy to be consumed to any point within a given radius from the station, it being virtually assumed that special mains are laid for power purposes.

(BY TELEGRAPH.)

From our own Correspondents.

SHEFFIELD, June 27 (Evening).

At the conclusion of the annual meeting a resolution was submitted, "That this Convention requests the Council of the Association to continue their efforts to secure an amendment of the Local Government Board regulations as to the granting of loans upon the lines of the report of the Council on the subject, and that a copy of this resolution be forwarded to the various municipal councils and also to the President of the Local Government Board."

This was proposed by Councillor LLOYD, seconded by Ald. PEARSON, and adopted.

Mr. J. A. CROWTHER, electrical engineer to Wallasey District Council, suggested that they should co-operate with municipal gas and water engineers, as giving greater support to the movement; and he also proposed that a copy of the resolution be sent to the Non-County and County Borough Associations for discussion at their meetings.

Mr. CHAS. TURNBULL, of Tynemouth, proposed a resolution, "That suggested Papers for the next Convention be invited during the present Convention, and that these should be given to the Secretary during the Convention for consideration by the Council."

Ald. ROBINSON (Stoke-on-Trent) lamented the lack of Papers giving information useful to municipal committeemen. Most of the Papers dealt with technical subjects on which the committeemen were ignorant. More Papers from members of committees might be considered by the Council.

Mr. S. E. FEDDEN said it was almost impossible to get Papers from chairmen of committees, though great efforts had been made. He would be pleased to enter Ald. Robinson's name for a Paper.

Mr. A. B. MOUNTAIN (Huddersfield) proposed a vote of thanks to the retiring members of the Council in recognition of their past arduous services.

This was seconded by Ald. WEST and carried unanimously.

This concluded the business of the annual meeting.

At the afternoon session Mr. S. E. FEDDEN invited Mr. J. F. C. Snell to open discussion. He referred to Mr. Snell's past association with the Convention, and he expressed his pleasure at Mr. Snell's presence at the Sheffield meeting.

Mr. J. F. C. SNELL referred to the importance of the subject now that competition was more keen, particularly in connection with power supply, and he suggested the apportioning of costs and profits to every consumer. It was presupposed that the tariff was in consonance with the maximum demand system, but Mr. Shawfield did not any longer adhere to this, though it was, in his opinion, the fundamental basis of a proper system of charge. Cheaper power plant, now obtainable, materially caused the decrease of production costs. A tariff based on capital charges for fresh plant to meet power demand left the lighting consumer to pay for capital invested in the original undertaking, though the power supply might improve the load factor to the extent of ultimately reducing the lighting tariff. All consumers should bear a just proportion of costs. Mr. Shawfield appeared to have under-estimated the stand-by plant. He should increase his figures to 5,000 kw. for 3,500 kw. maximum demand, increasing total plant cost to £36,000. With substation plant, this increased total standing charges to £7,090, or 0·486d. per unit on output given. As to running costs 3·75 lbs. coal per unit appeared too low. The diversity factor must also be reckoned with. He preferred 4 lbs. coal and 25 per cent. load factor, which would give 0·746d. as total cost per unit for 4,025,000 units generated to supply 3,500,000. This reduced the profit to £788 or 1½ per cent. on capital expenditure. Power tariffs should make provision for rise in price of coal by a sliding scale based on coal rates.

Mr. S. L. PEARCE (Manchester) agreed with the equal allocation of all charges upon all consumers on a load factor basis, and said Mr. Shawfield had not disproved this principle. By it electric power could successfully compete with other agents. With isolated plants where load factor was not 40 to 50 per cent. public supply might be introduced, and his Manchester tender confirmed this, Mr. Shawfield's maxim would involve most present undertakings in disaster. Undue stress was laid on profit. Power load reduced production costs, so that prices need not be based on, say, 5 to 15 per cent. profit. It also would enable lighting charges to be decreased at an early date. Power rates might advantageously be framed on prospective costs in two or three quarters. They had a coal clause in Manchester by which for every 10s. increase above first 10s., 0·15d. was added and *pro rata*.

Messrs. A. M. Taylor (Birmingham), S. Clegg (Lincoln), W. W. Lackie (Glasgow), E. E. Hoadley (Maidstone) and Alderman West (Coventry) continued the discussion, but we must defer their remarks and Mr. Shawfield's reply, together with the remaining Papers, to our next issue.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Distribution of Electrical Energy." By John F. C. Snell. (Sunderland: Thomas Reed & Co.) 18s. net.

"Le Pérou d'Aujourd'hui et le Pérou de Demain." By Emile Guarini. (Paris: H. Dunod & E. Pinat.) 1fr.

"Impianti Elettrici a Correnti Alternate." By Ing. A. Marro. 2nd edition. (Milano: Ulrico Hoepli.) 8.50 lire.

LEGAL INTELLIGENCE.

Electromobile Co. (Ltd.) v. British Electromobile Co. (Ltd.)

On Wednesday last week, before Mr. Justice Warrington, plaintiffs sought an injunction to restrain defendants from carrying on business in a name so like the plaintiffs' as to be calculated to deceive.

Mr. C. A. RUSSELL, K.C., for plaintiffs, said that in 1900 a company called the British & Foreign Vehicle Co. was formed, the principal promoter being Mr. Chambers, who was now managing director of plaintiff company. In January, 1902, it changed its name to the British Electromotor Co. (Ltd.). In October, 1902, the business was sold to plaintiff company. At that time there was in existence the London Electromobile Synd. But the word "electromobile" was written in two words, and as that company did business in a cheaper kind of car than plaintiff it did not matter much to plaintiffs, and, moreover, that company had now practically ceased to exist. Defendant company was formed on April 8 last, and they proceeded to do business in cars suitable for the town and in the West End of London, where plaintiffs carried on business. He contended that the similarity of name was calculated to do plaintiffs a great deal of harm.

Lord MONTAGUE gave evidence, and said that he knew of no other firm manufacturing electric cars which described their cars as electromobiles. Parts of the cars made by plaintiff company were of British manufacture. Plaintiffs' cars had a good reputation. They were widely known in this country. In cross-examination he said he had not heard of the word "electromobile" being used before 1902, but it might have been used in America. Electromobile was descriptive of an electric car. Up to 1902 the word "electromobile" was used in the generic sense, but since then it had acquired a special meaning, and was applied to one particular kind of car.

Mr. T. G. CHAMBERS, managing director of plaintiff company, also gave evidence.

In the result, Mr. Justice WARRINGTON said that the word "electromobile," like other equally barbarous words, had a limited meaning. It was not part of the English language, but it was part of the language used in this country to describe a vehicle driven by electricity. He considered that plaintiffs had not made out their case, and gave judgment for defendants, with costs.

Harper & Bros. v. Biggs & Sons.

On Wednesday Mr. Justice Swinfen Eady heard this action, in which plaintiffs claimed damages for the infringement of their copyright in a book entitled "Elements of Electric Traction," registered on March 22, 1907, and also an injunction to restrain the infringement of their copyright. Plaintiffs case was that under an agreement between them and Mr. L. W. Gant they became proprietors of the copyright in "Elements of Motor Traction for Motor Men," and defendants had infringed the copyright by printing and publishing in their newspaper called the "Electrical Engineer" long extracts from the book. The defence was that the extracts were published by way of review.

Mr. Scrutton, K.C., and Mr. Hart appeared for plaintiffs; Mr. Eve, K.C., and Mr. Meyer appeared for defendants.

Mr. SCRUTTON said the review not merely told the public the nature of the book, but printed one chapter wholly verbatim without reference to the book. He submitted that to take important chapters in that way for the purpose of getting good copy for nothing was unjustifiable from the legal point of view.

Mr. JOHN MURRAY, the well-known publisher, and others, gave evidence to the effect that the publication of such extracts as those complained of would interfere with the sale of a technical book.

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Mr. SLATER, manager of plaintiffs, said that neither for payment nor by request would they have given permission to defendants to print 10 pages straight off. He estimated the damage at over £25. As soon as plaintiffs complained, defendants undertook that nothing else should appear. His estimate of damage was based on the sale of a book on "Alternating Currents."

Mr. EVE, K.C., said the question of damages seemed to be reduced to the difference between £5 and £25. It was the extravagant demand made by plaintiffs that necessitated the bringing of the action. The review was intended to help the book, but owing to the exigencies of space it had appeared in an unfortunate form.

Mr. C. H. W. BIGGS said he wrote the review and marked the portion of the book to be extracted, not knowing the review would appear in instalments. He had a high opinion of the book and extracted the portion about "Brakes" in consequence of accidents to tramcars.

In cross-examination, Witness said he did not know how many copies of the paper were printed per week. He might have taken as much from other books for review purposes.

Mr. W. W. BEAUMONT expressed the opinion that the extracts published by defendants would not interfere with the sale of the book, because they only gave an idea of the method of treatment, in which there was nothing new. The quotation was an unusually long one.

Mr. Justice SWINFEN EADY, in giving judgment, said it was admitted that the first article and extracts were fair, but complaint was made of subsequent extracts without any acknowledgment of their source. That far exceeded the fair and reasonable limits of review. In his opinion defendants had made a mistake and had infringed plaintiffs' copyright in four numbers of their paper. Defendants had paid £5 into Court, and he assessed the damages sustained by plaintiffs at £15, or £10 in excess of that sum. Defendants must pay plaintiffs' costs on the High Court scale.

Hiscock v. Irwin.

At Wandsworth (London) County Court on Monday Judge Russell reheard this case, which had been sent back for re-trial by a Divisional Court. The original action was brought by plaintiff (the contractor for electric lighting work) against Mr. Wm. Irwin (as contractor) and Mr. Edward Neal (as building owner of a block of flats) for the recovery of £70 odd, balance of account. The case was originally heard in January and the facts were reported in our issue for Feb. 1. On that occasion his Honour gave judgment against Neal and ordered plaintiff to pay Irwin's costs, Neal to repay them to plaintiff. Neal appealed and a new trial was ordered as between plaintiff and Irwin. It was stated that in the contract between Neal and Irwin £150 was provided for electric lighting and bells. A dispute had arisen between Neal and Irwin and an action was pending. It was contended on behalf of plaintiff that he was entitled to recover what the architect had certified to be due to him and that he ought not to be prejudiced by any dispute between Irwin and Neal.

Mr. NEAL said he had paid Irwin £6,000, including the amount due to plaintiff.

Mr. A. HISCOCK (plaintiff's manager) and Mr. PERCY E. RYCROFT also gave evidence.

Mr. MORTON, for defendant, said he did not propose to call any evidence. The point he wanted to take to the Court of Appeal was that there was no authority for saying that a contractor was liable where an order was given by an architect and not by the builder himself. He suggested that Neal was liable.

His HONOUR, in giving judgment, said the logical result of the decision of the Divisional Court was that Irwin must be liable. There was ample evidence of the authority of the architect (Mr. Davis), and he found for plaintiff for the full amount claimed. He refused to allow plaintiff the costs of the appeal, but he gave him the costs of the action and of that day's trial.

Westminster Electrical Supply Corpn. v. London County Council.

In the Westminster County Court on Monday, before Judge Woodfall, plaintiffs claimed to be entitled to compensation for damages to an underground electric cable in consequence of work carried out for defendants. The L.C.C. erected a new fire station at Westminster, and in connection with a "run out" that was being constructed concrete got into an inspection chamber in the pavement and caused a short-circuit, which was the damage complained of. The L.C.C. pleaded the Public Authorities Protection Act, under which proceedings had to be taken within six months of the happening or discovery or continuancy of the matter complained of. The damage was caused in February, 1906, but it could not be discovered until the short-circuit occurred and that was not till October. It was not possible to take proceedings, therefore, "within six months of the happening." When the damage was discovered in October it was remedied, and the L.C.C. was asked to pay. Plaintiffs were asked to wait until the Fire Brigade committee considered the matter and plaintiffs waited. Then the L.C.C. denied liability and pleaded that the proceedings were not taken within the time prescribed by the act. Mr. Shaw (for plaintiffs) contended that that was a defence not available in this case because plaintiffs gave notice within the specified time, and defendants waived their protection under the act for the consideration that plaintiffs deferred taking action until the committee had considered the matter.

His HONOUR held that there was no contract to that effect by defendants, and if there had been they had no right to enter into such a contract, because, as a public body, they could not waive the rights of the great body of ratepayers, for whom they were trustees. The L.C.C. had no power to waive the rights of the public under the act. He entered judgment for defendants, with costs, granting a stay of execution to give an opportunity for appeal.

PARLIAMENTARY INTELLIGENCE.

LONDON COUNTY COUNCIL (ELECTRIC SUPPLY) BILL.

(Continued from page 431 of the present issue.)

With this increase in the lighting, power and traction, we shall get, as time goes on, a much better load factor?—You should.

The load factor for the present year will, it is estimated, be 29. Supposing it is 29, and we supply 12,000,000 units to our consumers, we shall be able to supply as well without the County Council as with it?—That I could not say.

What benefit will West Ham get for the nuisance and inconvenience of running these extra cables through the borough?—The benefit of cheap supply which we offer you.

If we generate electricity at less than you are likely to supply it to us, there is no benefit?—I cannot accept without proof that you will be able to do so. If you could generate cheaper than we could supply to you, the benefit would naturally be nil.

If there is any profit on this scheme, would West Ham get any benefit from this?—Mr. Peel said he proposed to consider a proper division of the profits. It is provided in the new clause 66A handed in to the Committee* that "A proportion of the surplus profits beyond a fixed dividend to be specified in the deed to be paid to the Council for the benefit of the ratepayers in the area of supply." That includes West Ham.

West Ham Corporation would have no part in settling the terms of that deed?—It will be under the control of the Board of Trade, I think, but I cannot deal with that point.

You propose your transferee will be in a position to supply to the railway companies and dock companies within the area?—Yes.

We have 13 railway stations, and we have the works of the Great Eastern Railway Co., which employ 5,000 men, the carriage works of the Tilbury and Southend Company, the Victoria Dock, and part of the Royal Albert Dock within our area. Your transferee would be entitled to supply energy to all these?—Yes, but you do not think they would come direct to us, if you are able to give the supply cheaper than we are.

In the Bill as it stands, if these people did come to you for direct supply they might use it for all purposes. The Great Eastern Company and the Tilbury Company might use it for power in their works, and the Dock Companies might use it for power in their shops and docks?—Certainly.

Do you know we are negotiating at present for supplying these people?—I do not know, but I should suspect you were.

Why should the County Council have the right to bring in someone else to compete with us?—For the benefit of the people in the borough who want power.

Then it is to benefit the railway companies, &c., that you propose to compete with the local authority?—No, for the general benefit of the power user.

Mr. HUTCHINSON (for Barnes Urban District Council): Looking at this scheme from a technical and engineering point of view, the object of the bill is to give cheap supply of electricity?—Yes.

Is it desirable in operations of this kind to include the interposition of a middleman?—That is a matter of policy.

The middleman does not make in the direction of cheap supply, I think?—Speaking broadly, the middleman would increase the cost slightly.

The correct principle in electricity is direct supply in one hand?—If possible, yes.

You conceived it to be possible last year, and you desired to have that possibility made certain?—Yes.

This bill only differs from the bill of last year, as I understand, from an engineering point of view, in so far as you interpose the undesirable middleman?—The undesirable middleman, as you call him, has nothing whatever to do with the engineering part of the scheme.

He works it, does he not?—After it is designed.

Will he design it?—He will be consulted.

If you tied his hands it would not lead to economy?—If you tied his hands probably it would not.

It has been urged to Parliament many times that the advantage of a supply in one hand is the diversity of purpose and the high load factor that you obtain?—No, I do not think that has anything to do with the powers being in one hand, but with the area covered and the kind of load you get.

Suppose you had an area in which there are three purposes of supply, lighting, power and, say, x, two purposes in one hand and the other purpose, the unknown purpose, in the other. Surely you do not get as high a load factor and as economical a supply as if the three were in one hand?—Not knowing x I cannot follow your argument.

Call it tramways, a very important element, I believe, in obtaining a load factor?—It depends entirely upon the ultimate size of the scheme whether tramways is an important factor or not.

The bigger the scheme the more important it is?—No, the bigger the scheme the less important is the fixed output for tramways.

Are you going to give your middleman the benefit of your tramway load?—We are not.

In that respect your bill falls short of that you proposed last year?—In last year's bill we included the tramways, but in this bill we are excluding the tramways because we are going to hand over the powers under this bill to another person. Therefore, it is to our advantage to maintain and keep the tramways supply in our own hands.

Although that is to your advantage, it is not to the advantage of the consumer with the middleman supplying him, because you deprive the middleman of the opportunity of giving a cheaper supply by reason of

* See *The Electrician* for June 21, p. 402.

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the higher load factor on the tramways?—The basis of charge is such that whatever the load factor the supply can be given cheaply.

In regard to your Table XVI., the units delivered have increased from the 529,000 given in the table to 757,000, and the average price, instead of being as stated in your table, is now 2·68d.?—That is so, for 1907.

Your deductions are based upon figures that are not correct, then?—The figures were perfectly correct for the dates given, and had I been able to get the figures to March 31, 1907, I should have put them in.

Why should you come and imperil our capital without due protection, and induce a middleman to disturb our harmony?—We are not attempting either ourselves directly, or indirectly through our transferee, to disturb your harmony, your capital or your station. We are attempting to come to you with a cheap supply, and if you do not like to take it you need not have it.

Cross-examined by Mr. W. L. WILLIAMS (for Stepney): You are doubtless aware that Stepney stands at the head of the list of the London boroughs with regard to its management and its low charges?—I see that for the year 1906 Stepney made a net profit of £1,988.

Perhaps you will accept from me that since that time we have made up our accounts to March, 1907, and show much better results than up to March, 1906?—I have heard of accounts made up in that way.

We shall prove these accounts before the Committee, and if our position is better now than in 1906, so our position is also stronger here to-day?—That is for you to prove.

For the purposes of this inquiry we may discard Erith and take your total capital as applying to the Barking station, and the supply to the area is estimated to cost £4,500,000?—Yes.

Last year your scheme for supply to almost the same district was estimated at £3,500,000?—About that.

The prices which you propose to charge for energy to large or small consumers must, of course, in the main, depend upon a reasonable return upon the capital invested?—Yes.

Under your last year's bill you had two generating stations, a large one at Battersea, capacity 80,000 kw., and a smaller one at Greenwich, capacity 34,000 kw., and your Barking station now proposed will have, when completed, a capacity of 120,000 kw.?—Yes.

And so far as the cost of construction at Barking is concerned, it is much lower than the total estimate of cost last year for both stations, so that, as far as generating is concerned, you ought to be able to generate energy at a less price at Barking than you could have done with last year's combined stations?—If you include capital charges, yes.

Then the great distinction between your estimates of last year and the present is that of transmission?—Yes.

In your estimates this year you have the sum of £2,712,000 against £1,065,187 last year. How do you make up all this extra, considerably more than double?—We are dealing with a much larger output, and the area we are covering is larger.

From an engineering point of view you can generate more cheaply at one large station than at two smaller ones?—Yes.

Are there no risks in having the whole supply of London obtained from one generating station?—I think not.

Supposing there were a serious fire at Barking, do you consider it advisable, considering the large population within this area, that there should be only one generating station?—I consider that is quite sufficient for the present.

Last year in your costs you put down a sum per unit to meet interest and sinking charges on the capital raised by the Council. Without going into details your total cost per unit was 0·46d.?—Including transmission and capital charges.

This year it is 0·2929d. without any allowance for capital charges?—Yes.

Adding that to the 0·2929 makes 0·4782d. How do you account for the increase over the figure of last year, which was 0·4618d.?—There are various reasons; coal is up for one thing.

The CHAIRMAN: You base your estimates on the present price of coal?—Yes, 12s. a ton; last year it was 9s. 3d.

Mr. WILLIAMS: You assume a revenue from a sale of 333,000,000 units of £808,000 gross. Your figures last year were very much less. With a sale of 249,000,000 units you only expected £573,000 gross?—Yes, the units were very much less.

About one-third less than under your present estimate?—Yes.

If you add one-third on to £573,000 it brings the total up to £764,000, not £808,000?—Last year the sale was estimated to be at a 35 per cent. load factor, while the load factor is now taken at 23·3 per cent. Both figures are estimates.

Now as to the system of charging set out in the schedule. It is to be a fixed sum of £5. 12s. 6d. per annum per kilowatt of the maximum power required to be supplied plus ·027d. for every unit actually consumed?—Yes.

"Required to be supplied" means, I presume, that supposing we require you to furnish us with, say, 1,000 kw., for argument sake, we should have to pay 1,000 times £5. 12s. 6d.?—Assuming that you did take 1,000 kw. from us, that is so.

Or if we required you to supply us with that quantity?—If you called upon us to enter into an obligation to supply you with 1,000 kw. you would, I presume, take 1,000 kw., or be prepared to pay for it.

I suggest to you that if we give you notice requiring 1,000 kw. per annum we shall have to pay for that whether we take it or not?—It is entirely a matter of arrangement, and depends entirely upon the meaning of the words "required to be supplied." If you say you are likely to use it, then the Council or its transferee must hold plant and mains in readiness for you to use it.

If we only consume 80 per cent. of what we "required to be supplied," and assuming the charge to be £5. 12s. 6d. per kilowatt, the actual charge for energy supplied to us would be £7. 6s. 8d. per kilowatt?—It is entirely a matter of arrangement.

Are you prepared to substitute in the schedule the words "actually required"?—No, the words already in the schedule are a common form of words in all power bills, and have apparently so far done no harm.

Do you know that the Administrative Co. in their bill of 1905 were prepared to supply Stepney with all the power they required at £3 per kilowatt, plus 0·3d. per unit?—Yes.

Do you know that the cost of generating electricity at our own works at Stepney comes to £3. 12s. per kilowatt, plus 0·3d. per unit?—I know what it costs you as a result per unit.

Do you not think it grossly unfair to put into your schedule, having regard to what we were offered by a company, or by a set of promoters who may be your lessees, £5 12s. 6d. per kw. compared with £3 per kw.?—Is there any reason why the Council or their transferees should not be able to do the same?

We want them to be bound, and if you will put that into the bill we shall be content?—Not likely! If you are prepared to enter into an agreement we will give you a price.

We are prepared to accept the Stepney clause in the bill of 1905?—If your borough is prepared to enter into an agreemnt to take bulk supply from the transferee at a price, we are prepared to give it you on terms to be discussed.

Our load factor is practically 23 for the district load, and I am told that our charge for power under our present scale is under 1d. per unit (0·976d.) We sell 1,250,000 units for power?—If you refer to my Table XVIII. I show that for the year ended March 31, 1906, you were selling under cost. I see from your published statistics that it cost you for every unit you sent out for power 1½d.

I deny the accuracy of your table. Our present scale for power is either a flat rate of 1d. or 5s. per horse-power, and ½d. for every unit consumed.—In fairness to myself I ask you to put in figures that will show your actual working costs, so that I may judge whether it is costing you more or less than that figure.

You know, as a matter of fact, that we pay our interest and sinking fund, we are putting a large sum to reserve, we depreciate for working costs, and we have another reserve fund.—You borrow a great deal of your money in Stepney for 42 years, practically all of it, therefore, the figures which I give as being the correct charge are based upon the assumption that a 25 years' life is allowed, and if you are getting it for 42 years you ought to have put by a reserve or a depreciation fund equivalent to the difference between the two periods. I do not think you have done that.

Counsel for the promoters of this bill will have an opportunity of examining our engineer on this point. I suggest to you that 0·976d. is the charge we make to our power consumers. If we are bound to take power from you we shall be bound to increase the charge, as it will cost us 1·134d. per unit?—How do you calculate that?

I am working it out on the load factor of 23 per cent. That load factor of 23 per cent. for direct current would come to about 0·75d. delivered.

The basis of this bill is controlled by the London County Council?—Yes.

There is no company having statutory powers in existence which may become your lessee?—Why not.

A private syndicate, unless very wealthy, could not raise a capital of £4,500,000?—Quite so.

Therefore we must assume that it will either be a statutory company under the control of Parliament, or a company formed under the Limited Liability Acts?—Yes.

Have you advised the County Council as to what should be the standard dividend of your lessee in order that the sliding scale in the fourth schedule to the bill may apply?—Not yet.

Cross-examined by Mr. G. SANDERS (for Islington Borough Council): You know that Islington has very large capital commitments. We have spent nearly half a milion, I think?—About £428,000.

I wish to know what you are going to do with us. I see that our nearest control station is Holloway?—Yes.

As I understand you will not bring a main up to Islington until there is a demand?—Not before there is a demand.

I understand you to say that under this bill you could insist upon our paying you something for bringing the main to us, and that you could decline to give a supply until we had contributed to the cost?—We should decline on the terms of the second schedule if you declined to pay something towards the cost of the main.

Those are your powers under the bill, or the powers of your transferee?—Yes.

Why am I not to be allowed to extend my stations? Do you know that without putting up a single extra building I could develop 40,000 kw. at my station?—I know that Islington has more buildings than it requires and thereby its capital cost is considerably increased.

They have been put up with a view to the future?—No doubt. I say it would pay you if this supply were available to scrap your plant in Islington and incur your capital charges still, and yet you would pay a less price per unit than you are now paying.

This closed Mr. Rider's cross-examination, and he was then shortly re-examined by Mr. Clode.

Mr. CLODE: The object of this scheme is to assist in supplying cheap electricity in London, by supplementing the supply of the present authorised distribution?—Yes.

You are convinced, and I believe all electrical experts are, that there is a large load coming on in the future?—Yes.

Under this scheme all talk about scrapping the stations and shutting up the stations as a result of its operations is, you consider, nonsense?—Yes, you might employ a stronger term.

You say that no extension of the existing stations could produce the same economical results as is produced by this scheme?—That is so.

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Now, a point was raised as to running your mains through the City of London and through West Ham. The new clause 43 provides an alternative route or deviation where objection is raised on this head?—Yes, the clause has been put in specially to provide for this contingency.

Taking the question broadly, I think the case for the supply companies must be that there is not likely to be so great a demand in the future as we have anticipated, and that they are in a position to deal with the demand either by themselves or by linking up their stations. What do you say as to that?—I do not agree. In many cases their sites are inadequate, and with their available buildings and provision for spares I do not consider they could deal with the future load economically. My chief point, however, is that the positions of most of the stations are such that their extension is not warranted.

Then it is objected that by interposing the transferee the price to the consumer for electrical energy will be increased, and it has been contended that the bill places no obligation on the transferee to carry out the scheme?—I say the obligation will be put upon him in the fourth schedule under the deed, in addition to the cessor of powers in clause 66.

Have you any point you wish to make with regard to the Erith site?—No, except to say that this site is put into the bill either as an alternative site to Barking or as a site in the future, when the power demand shall require it.

This concluded Mr. Clode's re-examination of Mr. Rider.

Mr. NOLAN (a member of the Committee): Allow me, Mr. Rider, to say I think you have come through your ordeal with very great credit to yourself. I wish to clearly understand this question of Erith. You do not propose under this scheme to set up any installation at Erith?—The estimates submitted do not provide for a power house there.

I understand you to say that the present supply of electricity to London is 50 units per head?—Yes, that is my latest information, and includes all energy supplied to the Council tramways, the tube railways, the underground railways and for lighting and power. Our scheme provides for about doubling the supply.

The amount of money already invested in London is roughly £20,000,000, and your proposed scheme will double the present supply for about another £2,000,000?—The £20,000,000, I think, includes the capital which has been expended on distribution, and that we do not propose to touch. You can only compare our expenditure with the past expenditure on generation, and not as dealing with distribution mains. It, however, includes the trunk mains between our power-house and the consumers' stations. We consider our capital of £4,500,000 would be ample to deal with this and to supply 163,000 kw. in bulk to consumers over the entire area.

What is the estimated consumption of coal at Barking?—When the station is complete about 460,000 tons per annum. I estimated that we shall be able to generate at Barking on a very large scale at something like one-half the weight of coal which would be required for local stations.

Sir ALBERT SPICER (a member of the Committee): With regard to the consumption in cities like Glasgow, Manchester, Leeds, Birmingham and Bristol?—Yes. These particulars are given in the following tables:—

Table of Principal Towns in the United Kingdom with a Population of 250,000 or upwards, with the Average Consumption of Electric Energy for all Purposes.

Town.	Population in thousands	No. of units used.	No. of units per head.
Belfast	358·7	4,502,049	12·6
Birmingham	522·2	5,383,904	10·3
Bradford	288·5	13,984,000	48·25
Bristol	358·5	14,511,000	40·25
Dublin	289·1	12,033,500	41·6
Edinburgh	336·6	12,914,000	38·4
Glasgow	800·0	43,886,000	55·00
Leeds	456·8	21,947,000	47·75
Liverpool	704·1	33,234,000	47·20
Manchester	698·3	40,617,000	57·20
Newcastle and District	614·9	35,562,000	58·00
Sheffield	413·0	5,188,000	40·20

Table of European Cities with the Average Consumption of Electric Energy for all Purposes.

Town.	Population in Thousands.	No. of units used.	No. of units per head.
Berlin, 1905	2,335	141,100,000	49·8
Breslau, 1905	446	8,100,000	18·1
Cologne, 1904	373	13,100,000	35·10
Copenhagen, 1904	400·5	13,300,000	33·00
Dresden, 1904	405·6	18,000,000	44·25
Frankfort, 1904	289	18,500,000	64·00
Hamburg, 1904	830	27,200,000	32·8
Munich, 1904	509	12,900,000	25·5
Paris, 1904 (lighting)	2,660	33,000,000	12·40
Stockholm, 1905	301	10,900,000	36·2
Strasburg, 1905	151	10,600,000	70·00
Vienna, 1904	1,726	45,900,000	26·5

The figures you have given us and the whole of your evidence takes for granted that the London County Council is to have complete control, but the bill proposes that they should hand over their powers to a transferee. How do these figures apply to a transfer company?—Speaking entirely as an engineer, I see no reason why a transfer company should not carry out the scheme exactly on engineering lines, and on the price of my estimates.

But if the transfer company provides the whole of the capital they will want to utilise that capital to the best advantage of their shareholders?—My figures are engineering figures, and whether a company buys plant or a municipality buys plant it costs the same money.

But do you consider your figures will give them sufficient margin, first to raise the capital and then to make an adequate return on the capital?—I am not familiar with the operation of raising capital in a company. What I do know is that the figures I have put in as estimates on capital expenditure are entirely on safe lines and, in my opinion, contain quite sufficient margin to allow a company to do so.

But directly you have transferred your powers how can you control the capital expenditure, or questions relating to the generating station or the character of the machinery?—We can see that the machinery is put in to an agreed specification, and to that extent we have control. The price which the transferee would have to pay for the plant would depend upon the market value at the time, naturally.

What has occurred to me all through your evidence is that the scheme is simply splendid if the London County Council were carrying it out, seeing that they are not looking so much for profit as for supplying the consumer at as low a price as possible; but when you transfer your powers the Council have another set of interests to look after. Do you think a company will be prepared to carry out the scheme in harmony with your figures?—I cannot say, but, as an engineer, I should answer yes.

The CHAIRMAN: For what interest on capital would your figures provide after allowing for sinking fund?—Our table, No. VII., shows a gross surplus of about £431,000, or sufficient to pay not only the sinking fund on a 25 years' life, and interest, say, 3½ per cent. on the loan, and to allow 2 per cent. on machinery and plant to be put to reserve, but it gives, in addition, a net surplus of £114,000—that would give the transferee his dividend over and above 3½ per cent.

Sir ALBERT SPICER: What percentage do you consider a local authority should put aside for depreciation and sinking fund?—If plant is maintained out of revenue, and the sinking fund is based on an average of 25 years' life, I do not consider that any depreciation in addition is required. I consider that 25 years is the average useful life of electric plant.

Mr. DUNN (a member of the Committee): Of course, if a company were applying for this bill it would be necessary for us to go into the question whether or not they could raise their capital. Taking your Table VI., that is the estimate a company would look at and the investing public would look at in deciding whether or not they would put their money into the undertaking. Your profits are based mainly upon 35 per cent. load factor on the station. Is not this a high load factor?—Not for a supply of this nature.

In Table VI. you show interest on capital. What do you provide for interest on capital while it is non-earning?—3½ per cent.

At the bottom of the table you have gross surplus available for depreciation, interest, &c. What is *&c.*?—Any renewals which may be required or anything of that kind.

Does it include rent for London County Council for this undertaking or interest on any capital estimated to be paid for the privilege of the lease?—No, it merely includes the sum which the lessee or the transferee company use for payment of any charges upon his capital or for other purposes.

Having regard to these matters, you would not show more than 5 per cent. interest?—£140,000 on a capital expenditure of £2,108,000. This is a gross profit and comes out at 7 per cent., I think.

If you take off depreciation, sent for the privileges of this lease, or interest on premium paid, and some other matters which you must take into consideration, can a prospective investor expect to get more than 5 per cent. for his risk?—Speaking without going into figures closely, I think not.

The CHAIRMAN: If you do not retain the power of supplying consumers direct, one of the advantages of this bill will be lost?—Yes, there is no protection to the consumer unless we have that power.

Mr. WARD (a member of the Committee): You do not take any powers in the present bill to lease the tramways to the proposed lessee?—No, we do not contemplate doing this in any shape or form. We have powers to sell to a transferee any surplus electric power which we may have at any time from our Greenwich power house, and we can, in like manner, take from the transferee any extra power we require over and above that which Greenwich can generate.

Somewhere in the bill a reference is made to the power of the Council for renting or leasing their ducts, which are constructed for the tramways, to this proposed transferee company? The object of the clause is this. We have a great many tramway cables made in London, and wherever we lay cables we lay a certain proportion of spare ducts or pipes. In order to obviate the breaking up of the streets as far as possible we considered it wise to put into this bill an order which allowed the council to lease to the transferee the use of these ducts. It would save him capital expenditure, and would ensure a rent to us for the use of the ducts, and avoid breaking up the public streets in certain districts where these spares are laid.

What is the mileage of these ducts?—That is a difficult question to answer.

The CHAIRMAN: There is one question I wish to ask, you said the power possessed by the local authorities of acquiring undertakings within their areas was largely nominal, and could not practically be operative?—Yes. In practically every case, not wholly so, the local authority would have the power to purchase the portion of the undertaking within its own area. This would result in some cases in the local authority being able

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to purchase only a portion of the mains, the power house being outside the area, or to purchase the power house and no mains. The local authorities' boundaries are not the boundaries of the distribution area.

This concluded Mr. Rider's evidence, and brought the proceedings up to Thursday, June 20, when the Committee adjourned till Tuesday, June 25. The first witness called on that day was Mr. HORACE FIELD PARSHALL, who was examined by Mr. Lewis Coward.

Mr. COWARD: You are a consulting engineer, Mr. Parshall, of wide experience, not only in this country, but in the United States and Canada?—Yes.

Have you investigated the conditions under which electricity is at present generated in London?—Yes.

What are your conclusions?—Under the present system it is impossible to obtain the best results, there are too many stations, they are not favourably situated and I should describe the system as entirely obsolete.

What, in your opinion, is the remedy?—Such an installation as has been described by Mr. Rider, to provide a large station down the river, to provide coaling and watering facilities, and to slowly but steadily abandon the present stations. I think there can be no difference of opinion between engineers that the scheme described by Mr. Rider is a good and proper one from the engineering standpoint. The site is good, the type of machinery it is proposed to employ for generation of energy is the best known as regards efficiency, the periodicity selected is best for a general supply, and means a minimum cost of the transforming apparatus, a minimum cost in regard to small motors, and includes the greater number of installations now in the area, which are all in the neighbourhood of 50 cycles. The selection of 15,000 volts pressure would mean a minimum cost of conductor and of the ducts, a minimum cost of distribution and transmission, and would be, I consider, practically the highest voltage at which we can transmit direct. The diameter of the cable selected is the best suitable for what is known as the drawn-in system, and the installation generally has been designed with due regard to giving a supply of power to every part of the area, either continuous or alternating current, to meet the requirements of all classes of consumers. The estimates are based largely on actual quotations for similar plant and apparatus, and are ample. Contingencies are amply provided for, and the estimates as to cost of generation, &c., are based on actual results obtained from similar installations.

Mr. PARSHALL was then cross-examined by Mr. Blennerhassett, Mr. Wedderburn, Mr. Rigg (for the City of London), Mr. C. C. Hutchinson, Mr. W. L. Williams and Mr. Tyldesley Jones (for the London companies).

Mr. RIGG: You are aware, Mr. Parshall, that a satisfactory arrangement has been made between the gas companies and gas consumers by Parliament putting into all acts of the gas companies a sliding scale which provides that a standard dividend is fixed and an authorised price. If the price of gas goes up the dividend goes down, and if the price goes down the dividend goes up. Therefore both producer and consumer are interested in cheap gas. Do you not think Parliament could devise a sliding scale in connection with electricity supply which would give a fair dividend to the producing company and ensure a fair price to the consumer?—I think this quite possible.

In the heads of agreement for the deed under the bill this matter is left to the Board of Trade. Do I understand you to prefer the Board of Trade to Parliament?—As an electrical engineer, I should prefer something cheaper and more flexible than coming to Parliament for the purpose of changing the selling price of my commodity.

Mr. HUTCHINSON: You have told the Committee that you consider 50 cycles the most advantageous rate of periodicity?—For this class of installation.

What is the periodicity on the Central London Railway, with which you were intimately associated?—I designed the Central London Railway installation before we had good converting machinery at 50 cycles. If I had to do it now I do not know that I should make any distinction between 25 and 50.

Mr. WILLIAMS: We have heard this morning that the Erith scheme has been abandoned. Are you responsible for that advice?—Not in particular. We did not propose to go to Erith for many years to come.

It is now proposed definitely that the Barking site shall be the only site where electric energy shall be generated for the whole of London. Do you consider it a wise provision to restrict the generation of electric energy for such a large population as London on one particular site?—Yes, the proposal is a sound engineering one.

Mr. TYLDESLEY JONES: Are you acquainted with the circumstances of Newcastle with regard to electricity supply?—I have no particular knowledge, but I am acquainted with the conditions at Newcastle as they are published from time to time.

You know that there is an energetic company there, and that they are pushing the supply of electric energy for power?—I have heard so.

Do you agree that the Newcastle district is one where you would expect to find the largest demand for electric energy per head of the population?—Not necessarily so. It is a large manufacturing centre, but it does not follow that it is a large electrical centre. I agree that it is one of the best examples we have of the use of electric energy for power.

Mr. Rider gave the Committee the figure of 50 units per head of the population as the amount of electric energy used in London. Do you consider that low?—For all purposes, yes.

But in this most favourable district of Newcastle the number of units is only 58?—That does not change my opinion, because electric energy is there only applied to one purpose. In London you have traction and numerous small power users. Industrial districts generally do not consume so much electricity per head of population as large cities like Berlin and New York.

Re-examined by Mr. LEWIS COWARD: It has been put to you that the supply in Newcastle-on-Tyne represents 58 units per head of the population?—I find that if you take the Newcastle-on-Tyne company it works out to 76 units, not 58.

This concluded Mr. Coward's re-examination, and the witness withdrew.

Mr. COWARD intimated that Mr. Robert Hammond and Mr. J. F. C. Snell were present to give confirmatory evidence.

The CHAIRMAN: If there is no new ground to be taken I do not think it is necessary for these gentlemen to be called. The Committee desire to curtail these proceedings as much as possible.

Mr. FREEMAN intimated that he did not propose to call any further evidence for the bill.

Mr. DUNN (a member of the Committee): There are one or two points which I should like cleared up. In manuscript clause 49, sub-sec. 2, occur the words, "Where the undertakers are a local authority the said undertaking shall be deemed within the provisions of sec. 2 of the Electric Lighting Act, 1888." That is the section that gives the local authority power to purchase undertakings within a certain specified time?

Mr. LEWIS COWARD: Yes.

Mr. DUNN: Therefore the undertaking referred to here would be the undertaking referred to in sec. 2 of the act, and it is in some way anticipated that the transferees will be in a position to purchase the undertakings of local authorities.

Mr. LEWIS COWARD: Yes.

The CHAIRMAN: That seems hardly consistent with the purely voluntary arrangement outlined in the first paragraph of the bill, "The Council may by agreement (but not otherwise) acquire."

Mr. DUNN: It would appear from the clause as drawn that the transferees may secure the property of one of these companies under terms, and when they have so secured the undertaking belonging to a company by arrangement they can compulsorily acquire, under sec. 2, the competing undertaking of a local authority.

Mr. LEWIS COWARD: This was not intended, and the point shall be considered.

Mr. DUNN: One other question. Mr. Rider was asked if the Council have the legal right to hand over to the transferees their tramway undertaking. Mr. Rider answered, No. Are you quite sure of that? I think all your local tramway acts incorporate Part III. of the Tramways Act, 1870, and it seems to me that sec. 44 of that act gives you ample and full powers to take your tramways and to make with them your bargain with the local authority. I am only suggesting that your bill, as it stands, gives you the right to do that, and I wish to know if that is your intention?

Mr. LEWIS COWARD: Certainly, there is no such intention.

At this stage the proceedings were adjourned, as the Chairman intimated that the Committee desired to deliberate.

On resuming on Wednesday, the CHAIRMAN (Mr. D. A. Thomas) announced that the Committee had deliberated, and found that the preamble of the bill was not proved. They would report to the House accordingly.

Following is the table of estimated power requirements of certain industries within the City of London referred to in Mr. Rider's evidence on page 429:—

Table of Power Requirements in the City of London.

Industry.	No. of factories.	No. of males employed	No. of females and young persons employed.	Total number of persons employed.	Power requirements (estimated) in H.P.
Chemical trades	34	566	197	763	534
Mills, &c.	11	169	12	181	713
Brewing	2	89	2	91	108
Engineering, metals and builders' materials ..	157	2,029	333	2,362	3,493
Printing and stationery	743	18,600	10,138	28,738	7,471
Textiles.....	9	18	116	134	67
Laundries	4	21	100	121	31
Miscellaneous	197	4,171	6,216	10,387	5,194
	1,157	25,663	17,114	42,777	17,611 (13,138kw.)

NORTH METROPOLITAN ELECTRIC POWER SUPPLY BILL.

This bill, which confers additional powers upon the North Metropolitan Electric Power Supply Co., was before a Select Committee of the House of Commons last week. The opponents were Walthamstow Council, the Harrow Electric Supply Co. and the Metropolitan Water Board.

For the promoters, Sir RALPH LITTLER said they were willing to meet the Harrow Co., but not the demand of the Water Board for the insertion of a protective clause against electrolysis.

After Mr. James Devonshire had given evidence for the promoters, Prof. S. P. THOMPSON was called, and gave it as his opinion that there was no danger of electrolytic action on the Board's mains by the three-phase high-tension current of the Power Co. He thought the existing regulations of the Board of Trade afforded ample protection and all that was required by the Board.

Mr. E. T. RUTHVEN MURRAY gave evidence in general support of the bill and of the need for a cheap supply of power for the numerous factories, &c., that were springing up in the district. Three stations had been erected (Brimsdown, Hertford and Willesden), and a fourth would be erected. The company's area of supply was 324 square miles. Power to supply the North-East London Railway with energy is also taken.

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Mr. C. H. WORDINGHAM (for the Water Board) said that, though he agreed with Prof. S. P. Thompson that with the three-phase current used by the company damage to water pipes was not likely to be caused by electrolytic action, it was possible, and the Board was justified in asking for a protective clause.

Mr. J. W. RESTLER, deputy engineer to the Water Board, produced a section of a pipe used for telephone purposes which had been subjected to electrolytic action near the line of a London County Council tramway. The pipe had a cast-iron casing and the electrolytic action caused by the return current had pierced both casing and pipe.

Mr. Fitzgerald, K.C., addressed the Committee on behalf of the Board, and Mr. Balfour Browne, K.C., for the promoters.

The CHAIRMAN (Sir J. Leese) said the Committee had come to the conclusion that the preamble of the bill was proved, subject to the insertion of certain clauses. The Committee had decided to insert a clause for the protection of the Water Board, of which the following is the text:—

"For the protection of the Metropolitan Water Board (in this section hereinafter referred to as 'the Board') the following provisions shall have effect unless otherwise agreed between the Board and the company (that is to say): 'If it be proved that any injury or damage to any water pipes or other metallic pipes, structures or substances of the Board shall have resulted from fusion or electrolytic action caused by any currents generated or used by the company for the purpose of electric energy under this act nothing in this act shall relieve the company from any liability to make compensation for any such injury or damage which would have existed but for the passing of this act.'"

As to the Walthamstow petition, the Committee struck out clause 8 from the bill, the effect being to leave the law unchanged in regard to the supply of electric energy in Walthamstow. In regard to Harrow, the committee decided that the clause suggested by the promotors prohibiting the supply to any trader within the area of the Harrow Company without the consent of the Harrow Company was sufficient.

The bill, as amended, was ordered to be reported.

TELEGRAPH (MONEY) BILL.

In the House of Commons on Friday, the Postmaster-General (Mr. S. Buxton) moved the second reading of this bill and explained that it had nothing to do with the telegraph service. It referred solely to the telephone service and its object was to enable the Post Office to carry on and extend that service until the purchase of the National Telephone Co.'s system in 1911. The bill was merely a continuation of previous Telegraph Acts for the purpose of raising capital for the telephone service. The total amount so far raised for telephones was £7,300,000; out of that £3,400,000 had been spent on trunk lines, £2,600,000 on the London exchange system, and about £500,000 on the provincial exchanges, the balance being in regard to stores and the purchase of municipal systems. Since the first line was purchased from the National Co. the mileage of trunk lines had increased from 29,000 to 145,0000, and the total mileage (London and provincial) was 328,000 miles. The £6,000,000 which he now asked for would, it was hoped, carry on the extension of the telephone system till the end of 1911, when the system of the National Co. would be acquired by the State. Though by agreement they might possibly purchase the system before, he did not think that would be satisfactory. The chief items of the six millions were £2,800,000 for the trunk system, £1,800,000 for the London exchange system, and £1,000,050 for provincial exchanges. While the telegraph system of the country was unfortunately being carried on at a considerable loss, there was a satisfactory and substantial profit on the telephone system. After providing for 3 per cent. interest on the capital expended, and allowing sufficient for depreciation of plant, the profit left during the last financial year was £37,200, representing an interest of 1 per cent. on capital, in addition to the 3 per cent. for which provision had already been made. In regard to the telegraphs the original capital was largely inflated, and they were carrying on at a loss, quite irrespective of any interest on the original capital.

Mr, HAROLD COX moved: "That it is undesirable to authorise a further capital expenditure on telegraphs or telephones until a full statement has been presented to Parliament showing the financial results of the Post Office telegraphs and telephones, judged from the standpoint of ordinary commercial undertakings." He said that it was difficult to verify the statement that the telephones were profitable, because the same office and the same servants were often used for both the postal or telegraph service and the telephones, and it was difficult to be certain that they had an accurate statement of accounts as between telegraphs and telephones. The Post Office had a motive to show a profit on the telephones and not on the telegraphs, because they were competing with a private company which was doing a very good business. The estimate of the life of the plant at the London exchange (33 years) was obviously an extravagant estimate, with new apparatus being constantly invented. The National Co. had to borrow money at 4 per cent. and to pay in royalties an equivalent of 2½ per cent. interest on their capital; the company had also to pay rates, which the Post Office escaped, and yet the company paid a dividend of 6 per cent. The Government ought to be making £540,000 a year on its capital expenditure on the telegraph system, whereas they were losing £580,000.

Other members took part in the discussion and the debate was adjourned.

RATING OF TELEGRAPH AND TELEPHONE WIRES.

In the House of Commons last week, Mr. J. S. HARMOOD BANNER asked the Postmaster-General why he declined to act on the Treasury Minute (Feb. 7, 1896) in reference to telegraph and trunk telephone wires and parochial and municipal rates, which directed that, in cases where higher contributions would otherwise be payable, the contributions should be increased accordingly, and whether he was aware that all telegraph and trunk telephone wires erected since 1868 escaped entirely from the payment of municipal and parochial rates.

Mr. BUXTON, in reply, said telegraph and telephone wires had always been regarded as on a different footing from other Government property in respect of contributions in lieu of rates, and he understood the Treasury were not prepared to sanction any departure from that practice. As regarded the second part of the question, the facts were not quite as represented, inasmuch as contributions in lieu of rates are paid on the trunk telephone wires acquired from the National Telephone Co. in 1896.

RADIO-TELEGRAPH CONVENTION.

The Select Committee of the House of Commons appointed to consider the Berlin Convention of 1906 met again on Monday to further consider their report.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The governing body of Battersea Polytechnic, London, S.W., require a head of the department of mechanical engineering and building trades, to commence in September. Particulars can be obtained up to July 8 from the secretary, Battersea Polytechnic, S.W. See an advertisement.

A superior man is wanted as inspector of work in progress and finished in a modern brass finishing shop manufacturing electrical apparatus. See an advertisement.

Whitby Borough Electrical Engineer (Mr. L. H. King) has a vacancy for a pupil. See an advertisement.

Oldham Corporation Electricity Committee invite applications for the position of junior assistant electrical engineer. Salary £80, advancing to £100 by annual increments of £10. Applications to borough electrical engineer (Mr. S. Wilmott Newington) by July 1.

The Council of University College, Bristol, invite applications for the position of lecturer in electrical technology. Particulars from the registrar, Mr. James Rafter.

Stirling Council require a burgh electrical engineer. Applications to the Town Clerk by July 16.

The committee of the Scottish National Exhibition require an engineer. Applications by July 8 to the Manager, 45, York-place, Edinburgh.

London County Council have appointed Mr. E. W. L. Nicol as a charge engineer at Greenwich Electricity Station at a salary of £250 a year.

Mr. F. J. Masters has resigned his position as station superintendent at the Canning Town station, West Ham, and Mr. G. Lloyd-Jones (late of the South London Electric Supply Corpn.) has been appointed his successor at a salary of £260 per annum.

Mr. W. G. Pickvance, chief assistant electrical engineer at Malvern, has been appointed borough electrical engineer at Wrexham, at £200, rising by annual increments of £10, to £250 per annum.

Mr. Harold Hale, manager and secretary of the North of Scotland Electric Light & Power Co., has been appointed resident engineer at the Savoy Hotel, London.

Mr. F. B. Hills, assistant engineer of the electricity works, Grantham, has been appointed to succeed Mr. Hale at Montrose

Mr. A. Nicols Moore, station superintendent at Belfast, has been appointed chief assistant engineer at a salary of £275 per annum, in succession to Mr. T. W. Bloxam, who was recently appointed city electrical engineer.

Ashton-under-Lyne.—An unopposed inquiry was held here last week into the Council's application for sanction to a loan of £17,000 for extensions of the electricity works.

Barnstaple.—The Council have decided to obtain an audit of the accounts of the electricity undertaking from its inception.

Belfast.—An inquiry was held here last week into the application of the Corporation for sanction to borrow £75,000 for extensions of the electricity works.

The town clerk (Sir Samuel Black), the city accountant (Mr. C. E. Dyer), Mr. Victor A. H. M'Cowen and the city electrical engineer (Mr. T. W. Bloxam) gave evidence in support of the application.

Mr. M'Cowen said that he was at present borough electrical engineer of Salford, but when at Belfast he advised the Corporation to extend their electricity undertaking owing to the increasing demand for energy for both lighting and power. He thought the undertaking was in a thoroughly sound financial position. The amount set aside for depreciation and renewals was 9·3 per cent. of the capital. That was above the average of municipal undertakings, and was (he thought) only exceeded by Edinburgh. The gross profit last year was £25,551 or 9·7 on the capital. The net profit (after paying interest and sinking fund) amounted to £11,478. The cost of production was extremely low, and the published returns showed that at present the Belfast costs for last year (0·634d. per unit)

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were the fifth lowest in the kingdom, and were only excelled by Salford and Bolton. That was due to the higher price of coal in Belfast. The increase in the demand for lighting and power had been very rapid for the last few years, and it was absolutely necessary that further plant should be available for next winter's load; otherwise the Corporation would be unable to carry out their obligations as a supply authority. Witness advised the Corporation in November last that it would be necessary to expend £75,000 in providing additional plant and mains, and prepared specifications for the principal plant proposed—steam dynamos, condensing plant, boilers, superheaters, mechanical stokers, economisers, pumps and pipework. The department paid its proper proportion of all standing charges. The tramways were charged 0·595d. per unit, but were not charged with the maintenance of the lighting mains. No call had been made for current for lighting from the tramway plant, but the combined station was a great advantage in that the different plants were able to assist each other. No preference was being was being shown, the matter lying between two departments of the Corporation.

Mr. T. W. Bloxam gave corroborative evidence.

An inquiry was also held into the application of the council to borrow £8,000 for various works at the Purdysburn Lunatic Asylum, including an electric lighting installation.

Bexley.—Sanction has been received to a loan of £6,293 for electricity supply extensions.

Bridgend.—The Council have applied for sanction to a loan of £6,500 for the purchase of the local station of the South Wales Electrical Power Distribution Co.

Brighton.—Arrangements have been made for intercommunication between the Post Office and the National Telephone Co.'s systems as from July 1.

Burton-on-Trent.—The salary of the borough electrical engineer and tramways manager (Mr. P. J. Pringle) has been increased by £50 per annum.

Bury (Lancs.)—An inquiry was held last week into the Council's application for sanction to a further loan of £22,500 for the extension of the electricity undertaking. During the progress of the inquiry the loan was reduced to £17,500, £5,000 for mains extensions being cut out.

Electric current is to be supplied at 1d. per unit for heating and cooking.

Canada.—The Canadian Electricity and Fluid Exportation Act, 1907, which became law on April 27 last, provides that a licence permitting the exportation from Canada of a certain quantity must be obtained by persons wishing to export electrical power or energy, petroleum, natural gas, water or other fluid, whether liquid or gaseous, by means of lines of wire, pipe lines or other like contrivances. The Governor-in-Council is empowered to make regulations for giving effect to the Act, and to impose fees to be paid for licences, and, by proclamation, to impose certain export duties upon power or fluid exported from Canada.

Croydon.—On Monday the tramcars of the South Metropolitan Tramways Co. commenced running from the Crystal Palace, Penge and Anerley through South Norwood to West Croydon, and the Corporation's cars from West Croydon to Anerley, Penge and the Crystal Palace.

Derby.—An inquiry was held here on Wednesday into the application of the Council for permission to borrow £51,850 for the erection of new electricity works, for extension of mains, &c.

The town clerk (Mr. G. Trevelyan Lee) and the borough accountant (Mr. W. Cooper) gave particulars of existing loans and of the prospects of the electricity undertaking. The borough electrical engineer (Mr. T. P. Wilmshurst) supplied technical details, and said the question of the erection of a new station had been repeatedly put off in order to save capital as long as possible. They saw that unless they took the matter in hand promptly they would not be ready for next winter.

Dublin.—The Corporation have decided to apply for a provisional order to enable them to supply electrical energy to the Viceregal Lodge and other buildings in Phœnix Park.

East Ham.—Acting on the suggestion of the Board of Trade, the Electric Lighting and Tramways committee have adopted a bye-law providing that on cars run especially for artisans, mechanics and daily labourers, no person shall be prevented from entering or remaining in or upon the car because of the condition of his dress or clothing if such is solely due to the nature of his employment.

Electric Driving in Joinery Works.—The Fulham Electric Joinery Works (Ltd.) have installed two 35 H.P. motors for driving their wood-working machinery. The motors, which are connected to the local municipal two-phase supply, are by T. Harding Churton & Co.

Exhibitions.—An exhibition of engineering models, optical, electrical and scientific instruments, is to be held from Oct. 22 to 26, at the Royal Horticultural Hall, Vincent Square, Westminster. In addition to instruments, &c., exhibited by their makers, there will be a loan collection of models and apparatus. Demonstrations in the various branches of applied science are to be given.

Gillingham Council are making arrangements for holding an exhibition of electric motors, electric light fittings, cooking and heating apparatus, &c., in the last week in September.

Finchley.—Mr. A. H. Preece (of Messrs. Preece & Cardew) has been retained at an inclusive fee of 75 guineas to report upon the present position of the electricity undertaking.

Gillingham.—The Council are applying for sanction to a loan of £5,000 for extensions of the electric lighting mains already carried out. Of the amount asked for £2,632. 18s. 1d. has already been expended.

Gravesend.—The Electric Lighting Committee have decided to reconsider the question of giving a supply of electricity in the Northfleet Council's area.

Hackney (London).—Messrs. Lewis Berger & Sons, who are already supplied with electrical energy by the Council, have made application for a supply up to the capacity of the present mains (250 kw. at 480 volts), and will take during three years all electrical energy required in their factory from the Council at present power rates (½d. per unit and £1 per quarter per kilowatt of demand).

Halifax.—The Tramways Committee have decided to allow their powers to construct tramway extensions to Elland, Stainland, Ripponden, Rishworth, Cragg Vale and Wainstalls to lapse. The extensions would have involved a capital expenditure of about £190,000.

Hipperholme (Yorks.)—*Correction.*—In our last issue (p. 405) we announced that the Council had sealed an agreement for the supply of electricity with the Yorkshire Electric Power Co. This is, we are informed, incorrect, as the agreement in question was with the Electrical Distribution of Yorkshire (Ltd.), which has already acquired provisional orders for Gomersal and Horsforth and is this year promoting orders for Liversedge and Castleford.

Hull.—The Electric Lighting committee have made an arrangement with Messrs. Reckitt & Sons for the supply of 150,000 units of electric current annually for their Stoneferry works at the same rate as that charged for their Kingston works—viz., a sliding scale varying from 1⅛d. per unit. The contract is for five years, and the supply is to be available by the end of September. The mains will cost £746. Negotiations are in progress with the Union Cold Storage Co. for the supply of 160,000 units anually for their cold store at the Alexandra Dock.

Inquest.—An inquest was held at Birmingham last week into the death of a machine riveter named Fisher, who was alleged to have been killed by receiving an electric shock at the works of the Metropolitan Amalgamated Railway Carriage & Wagon Co. on the 18th inst.

Evidence was given that the electric light cables were placed overhead in the waggon shops, the principals being of iron. Deceased was standing on an iron carriage frame, supported on wood trestles. He was coupling up some pneumatic pipes to carry the compressed air to his pneumatic hammer, and in his hand at the time was an iron hook. Near him was a lamp, which was alight.

A fellow workman said he saw deceased suddenly fall from the carriage frame. He went to him, but Fisher only gave a groan, and, although artificial respiration was resorted to and other attempts made to revive him, it was found on the arrival of a doctor that he was dead.

Medical evidence was to the effect that all appearances pointed to death from electric shock.

Mr. W. H. Thornberry, consulting engineer, said each lamp required 50 volts, but the lamps were in series. The dynamo gave current at about 2,100 volts. The lamp in question and the generating apparatus appeared to be in perfect order. He considered that deceased would get a shock equal to about 1,000 volts. If the carriage frame on which the man had been standing had been perfectly insulated from the earth he could not have received a shock, but he had been told that probably deceased had one of his feet in contact with the compressed air-pipe. If so, the pipe, being in metallic contact with the earth, would provide a pathway for the electric current. Mr. Thornbery thought accidents might be averted by wrapping the live parts of the lamp with indiarubber and insulated tape, but even that would leave the carbons exposed and would not be a perfect protection. If, however, the whole of the lamp was enclosed with strong wire framing or network, the chances of accident would be reduced to practically nil.

The Coroner (Mr. I. Bradley) said that, considering the remarkable growth of the applications of electricity, it was a singular fact that that was the first death from electric shock he had investigated during the last 10 years.

The jury returned a verdict of accidental death.

Islington (London).—The district auditor has reported upon the accounts of the electricity undertaking for the year ended March 31, 1906.

He states that there has been considerable delay in loan sanctions and this has given rise to two defects: (*a*) A portion of the capital outlay (£3,025) is not covered by loan sanction, and will have to be transferred to reserve, unless the sanction, which has at present been refused on account of the delay and lack of definitive information, is shortly obtained. (*b*) The incidence of the loan repayment charges has been deferred by the delay, and somewhat larger balances have been shown on net revenue account by reason thereof.

2. The charge made for current for street lighting, apart from the cost of providing or maintaining the lamps, &c., is 3·31d. per unit. This is greatly in excess of the fair and reasonable charge for this supply and it is almost as high as the charge for private lighting, and 0·5d. in excess of

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the average charge for all private supplies. It is also about twice as high as the average amount charged in other metropolitan boroughs. The electrical engineer (Mr. A. Gay) agrees that 1·75d. would be about a reasonable charge. The charges for public and street lighting represent a full third of the gross income from sale of current, and the overcharge is, therefore, a matter which greatly affects the statement of the financial position. It means in effect that rate contributions in aid of the undertaking to the extent of about £7,000 per annum is now being treated in the accounts as payment for street lighting.

3. No charge is made to the electricity revenues in respect of the services of the town clerk, borough treasurer or cashier, or in respect of some other expenditure, the benefit of which is common to the several departments. It would appear that a transfer of about £200 per annum would be reasonable in this connection.

4. The accounts show £13,306 as reserve for replacements, &c. This is the total of the accumulated balances shown by the accounts as profit. But it is to be remembered that these revenue balances are, in fact, in use as working capital and are not a proper invested reserve available for replacements, &c.

There is another important point to bear in mind in judging as to the sufficiency of the reserve which has been accumulated by the close of 11th year of working—viz., the fact that the loan redemption is in this case not only spread over the full equated period of 42 years, but is also based upon the "annuity" and not upon the "equal instalment" system. This means that the loan service burden in respect of the original capital outlay will remain unchanged throughout the 42 years, and that this Council cannot count on that great reduction in the burden which applies to the later years of the loan period in cases of "instalment" repayment and enables those later years to contribute much more freely than the early years towards the cost of renewals and the provision of reserve funds generally.

The electrical engineer (Mr. Gay) appears to be of opinion that the poor results shown by the accounts, after allowing for the defects which are herein reported, were largely due to premature reduction in the scale of charge for private lighting. Mr. Gay also calls attention to one circumstance which has in this case operated to increase the working expenses charged to the revenue account—viz., the fact that for a number of years no consulting engineer's fees have been charged to capital account, the whole of his salary being debited against revenue.

In conclusion, the District Auditor says: "The accounts have, as in former years, been presented for audit very promptly after the close of the financial year, and have been found to attain to the high standard of accuracy and of careful vouching which has characterised them in the past."

Kingston-on-Thames.—The Council have adopted the recommendation of the Lighting committee to give a supply of electric current to Kelly's Directories (Ltd.) for power at 1½d. per unit up to £150 per annum, or at 1¼d. if the account is between £150 and £250 or 1d. if in excess of £250.

Lees (Lancs.)—Before revoking the Council's provisional electric lighting order, the Board of Trade have asked if there is any prospect of the provisions of the order being put into force.

Leyton.—A recommendation of the electrical engineer (Mr F. Harman Lewis) which was endorsed by the Electric Lighting committee, to obtain a third generating set for the tramway load, has been referred back by the Council. It was proposed that the set should be 20 per cent. larger than the existing ones and would cost, with auxiliaries, about £4,000.

In regard to the proposal to rent a showroom, it was reported that Messrs. Headland & Headland had offered to show fittings, radiators, motors, &c., if the Council would supply electric current free of charge. Councillor Hannah had previously offered to let to the Council one of his shops in Lea Bridge-road for two or three years free of charge. The matter was referred to a sub-committee for consideration.

Tenders are to be invited for a large lathe, double-ended emery grinder and a screwing machine, with motor and shafting.

Four street gas lamps are to be replaced by electric lamps.

Light Railways.—The Board of Trade have confirmed the Wolverhampton and Cannock Chase Railway (Light Railway) Order, 1907, authorising the Wolverhampton and Cannock Chase Railway Co. to construct and work their authorised railways as a light railway.

L.C.C. Testing Fees.—A conference of representatives of London Borough Councils will be held on July 1 to consider the scale of fees proposed to be charged by the London County Council for meter testing, &c.

London United Tramways.—The Wimbledon extensions of the tramway system of the London United Tramways (1901) (Ltd.) were opened for traffic yesterday (Thursday). A through service is now provided between Wimbledon, Merton, Tooting, Summers Town and Hampton Court via Raynes Park, the Maldens, Kingston and Hampton Wick. Passengers by the London County Council cars from Westminster, Waterloo, Blackfriars and Southwark can change on to the new lines at Tooting.

Mansfield.—The Council have decided to apply for a provisional electric lighting order for Sutton-in-Ashfield.

Newbottle (Co. Durham.)—The Parish Council have asked the County of Durham Electrical Power Distribution Co. to give a supply of electricity for public lighting in the district.

Manchester.—On and after Dec. 25 it is proposed to reduce the charges to consumers of electricity on the flat rate from 4½d. to 3¾d. per unit. To long-hour consumers there is to be a reduction from £7 per kilowatt of maximum demand and 1¾d. per unit to 1½d. per unit.

Obituary.—The death occurred on June 20 of Mr. John Herbert Bower, of Alvey & Bower, electrical engineers, Chesterfield. Deceased, while engaged in wiring work, fell 16 ft.

We regret to have record the death of Mr. P. F. Nursey on Thursday, 20th inst. Mr. Nursey was closely associated with the Society of Engineers for many years, having filled the offices of president and secretary. He was also well known as a contributor to the technical Press.

The death is announced of Mr. John Arthur Croxson, manager since its formation of the Electric Landaulette Co. (Ltd.), and formerly for many years of Niagara, York-street, Westminster. Deceased, who was in his 40th year, was well-known and respected in the industry.

Personal.—Mr. A. Murray Coombs, A.M.I.E.E., has resigned his appointment with the D.P. Battery Co., and is now a director of Frank Suter & Co. (Ltd.), 66, Berners-street, Oxford-street, W.

Plymouth.—The West Hoe section of the Corporation tramways was opened on Saturday.

Presentations.—On his wedding, Mr. Robert Anderson, inspector at Blackburn for the National Telephone Co., has been presented by the electrical staff with a case of carvers, silver spoons, &c, and by the telephone staff with a dinner service.

The employés of the Barnsley & District Electric Traction Co. have presented an oak roll-top desk to the manager (Mr. W. H. Moorhouse) on his departure to become resident manager to the Llandudno & Colwyn Bay Light Railway & Construction Co. Mrs. Moorhouse received an oak bookcase.

Mr. Harold Hale, manager and secretary of the North of Scotland Electric Light and Power Co., was on Tuesday presented on behalf of the directors and employés, with a silver rose bowl and silver cigarette case, on his departure to take up the position of resident engineer of the Savoy Hotel, London. Mr. Hale has been for over five years in Montrose.

Mr. Charles Lamb, distribution engineer at Dundee, has been presented with a marble timepiece on his marriage, together with a gold brooch for his future wife. The presentation was made by the City electrical engineer, Mr. Harry Richardson.

Press Rates for Telegrams between Great Britain and Persia.—The Indo-European Telegraph Co. announce that a press tariff of 9d. per word has been introduced between Great Britain and Persia via the route of this company, the new tariff coming into operation on July 1. The rate is not applicable to Bushire. A press rate of 11d. per word is already in force over the company's route between Great Britain and the following places in the Persian Gulf: Ormara, Gwadur, Charbar, Jask and Muscat.

Provisional Order Revocation.—The Board of Trade have informed Kirkintilloch Town Council that their provisional electric lighting order (1903) has been revoked The Council have asked the Board to postpone the revocation for another year.

Provisional Order Transfers.—Whitefield District Council intend to transfer their powers, duties, &c., under their 1900 order to the Lancashire Electric Power Co. for £315. The Council have power to re-purchase at the end of seven or any multiple of seven years.

Worsley Council are also about to transfer to the same company their powers, &c., under their 1901 order for £442, and the conditions are the same as for Whitefield.

Notice is given by Ramsbottom Council of a similar intention with regard to their 1897 order. In this case £430 is payable.

St. Pancras (London).—The Finance committee report that they have had under consideration the resolutions passed by the Electric Lighting committee in respect of that portion of the district auditor's report which related to the electricity accounts.

The Committee agree that the increase from £100 to £200 per annum in the share of central establishment charges to be borne by the electricity revenue account should be provided for in the accounts for the year ended March 31, 1907; that £75 be charged as provision for bad debts in respect of the March quarter accounts outstanding; that with reference to the items £142. 11s. 11d. (electrical exhibitions at Olympia) and £72. 5s. 4d. (pamphlet "Useful Hints on Electricity") the Council be informed that the Electricity committee do not contemplate any further expenditure similar to that of the first item; but that in regard to the second, they are of opinion that the right to incur similar cost should be reserved for the discretion of the Council. The committee express general approval of Mr. Carson Roberts' remarks as to provision for depreciation.

About ten years ago the Council laid mains at a cost of £3,000 to give a supply of electricity to the L. & N. W. Railway Co.'s Euston hotels and the revenue is about £1,000 a year. The Company now wishes to supply its own current and the Council have been asked to grant wayleaves, but the Electricity committee do not feel justified in voluntarily surrendering this source of income, and therefore they have decided to take no action in the matter until the company have proved that they have the right to supply current to the Euston Hotel.

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Society of Chemical Industry.—A charter of incorporation has been granted to this society, which was founded in 1881 to promote the application of chemical science to arts and manufactures.

Stepney (London).—The Council have adopted the recommendation of the Finance Committee to expend £120 in altering the wiring and fittings on a consumer's premises.

The recommendation to increase the salary of the borough electrical engineer (Mr. W. C. P. Tapper) to £650 a year, with a further increase to £750 if the Blyth's wharf station be erected, has been referred back to enable the Council to again consider the question of engaging a consulting engineer.

Stirling.—Mr. A. C. Hanson has tendered his resignation as burgh electrical engineer owing to ill-health.

Wrexham.—The Council have abandoned the proposal to call in an electrical expert to report upon the financial position of the electricity undertaking.

Sports.—The fourth annual sports of Manchester Corporation Tramway employés Social and Athletic Society took place at Fallowfield on Wednesday and Thursday evenings this week. Mr. Ald. Wainwright (Chairman of the Tramways committee) was present on Wednesday and stated that the society began with only 200 members, but 2,000 of the 3,000 tramway employés were now members. The entries for the events numbered 565, compared with 411 last year. Ald. Wainwright said he would present a silver shield for competition by the swimming club which, as well as the cricket and football clubs, is affiliated to this society.

"Simplex" Outing.—On Saturday last, the annual outing of the employés of Simplex Conduits, Ltd., took place at Bewdley. There was a good muster (about 200), including a number of the Company's district representatives and agents. The unavoidable absence of the managing director (Mr. L. M. Waterhouse) was much regretted. The earlier part of the day was taken up by various sports, which were contested with keenness and good feeling. Luncheon followed, at which prizes were presented by Mrs. Brooks, wife of the secretary of the company. The party subsequently spent the remainder of the day in boating trips, &c., on the river Severn.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Brighton.—The accounts of the electricity department for the year ended March 31 have been submitted to the Lighting committee and disclose a deficit of over £10,000, due to interest and sinking fund charges on capital expenditure on the Southwick power station.

Burnley.—The total income of the electricity department for the year ended March 31 was £21,280. 3s. 3d.

The total costs were £10,297. 3s. 6d., leaving a gross profit of £10,982. 19s. 9d. to meet interest (£2,466. 8s. 6d.), sinking fund (£3,120) and depreciation (£2,369. 7s. 1d.), &c. The net profit was £5,584. 12s. 8d., against £5,189. 13s. 7d. in 1906; £3,015 has been devoted to relief of rates; 2,954,608 units were sold (551,559 to private consumers, 2,232,957 to tramways department, 162,436 for power and 7,656 units for public lighting). The works costs were 0·595d. per unit (against 8·547d.), the total costs 0·759d. (against 0·727d.) and the gross costs (including interest and sinking fund) 1·291d., against 1·263d. There are 657 consumers, representing 51,759 8 c.p. connected, and there are 142 motors of 4,11½ B.H.P. (against 100 and 246 B.H.P.). The maximum load on the feeders was 1,592 kw. (against 1,475 kw.) and the load factor 21·19 per cent. (against 20·85 per cent.). The total capital expended is £92,839 against, £91,300 in 1906.

Coventry.—The profit on the past year's working of the electricity department was over £5,000.

Darlington.—A profit of £1,409 has resulted from the past year's working of the electricity undertaking and has been placed to reserve.

Devonport (Tasmania).—The report of the borough electrical engineer (Mr. Geo. H. Lofts) on the working of the municipal electricity department for the past year states that the gross profit was £695, or slightly over 6½ per cent. on the capital invested.

The charges for current are said to be amongst the lowest in Australasia—for lighting 7d. per unit. The average net cost per unit for the year was 5·7724d., against 6·2062d. The charge for power and heating was 2½d. and the cost was 1·5280d., against 1·4485d. It is suggested that auxiliary steam plant should be put down to meet any irregularity of the water-power plant arising from drought or flood.

Eastbourne.—The accounts of the electricity department for the year ended March show capital expenditure £164,741, an increase of £3,333.

Revenue was £22,405, leaving gross profit £12,304. Sinking fund required £4,738, and payment of loans not yet sanctioned £1,039, and with other charges the net profit was £1,568 (against £1,301 in previous year). This has been placed to depreciation. There are 1,175 (1,071) consumers, an increase of 104. 1,513,154 (1,280,895) units were generated, 904,029 (807,702) sold to private consumers for lighting and 72,172 (47,758) for power, and 170,164 units (166,379) were supplied for public lighting. The maximum load was 972 kw. (900 kw.) and the load factor 13·43 (12·96). There is the equivalent of 83,436 (76,758) 30 watt lamps for private lighting, with 72 (56) motors of an aggregate capacity of 198 H.P. (152¾ H.P.), and the total connections are equal to 90,306 (82,476) 30 watt lamps. Total works costs were 1·45d. (1·54d.), total costs 1·98d. (2·05d.), redemption of capital required 1d. (1·18d.) and interest 1·25d. (1·12d.), and net profit was 0·33d. (0·30d.). Revenue from sale of current to private consumers was 4·74d. (4·87d.) and for public lighting 2·39d. (2·63d.) per unit sold.

Gillingham.—The annual report of the electrical engineer (Mr. A. D. Chalmers) states that the equivalent of 25,917 8 c.p. lamps was connected at the end of the year, the number of customers having increased from 264 to 286; 1,174,220 units of electrical energy were generated and 899,332 sold.

Hornsey.—The chairman of the Finance committee (Mr. Barrenger) stated at the last meeting of the Council that the gross profit on the half-year's working of the electricity undertaking was £5,400. 18s. 2d., an increase over the corresponding six months of 1905-6 of £854. 1s. 2d., the income having increased by £1,055.18s.9d. and the expenditure by £201. 17s. 7d.

After paying interest and instalments of loans (£4,175. 3s. 5d.), the net profit for the half-year was £1,242. 2s. 1d. The deficiency for the first half of the year was £2,395. 8s. 9d., making the deficiency for the year £1,153. 6s. 8d. Adding the balance overdrawn 1905-6 of £267. 16s. 5d., there was a total to be provided out of district fund of £1,421. 3s. 1d.

Newport (Mon.).—The total receipts of the tramways department for the past year were £33,358. 11s. 9d.

The total expenditure was £22,118. 17s. 11d., and the gross profit was £11,269. 11s. 9d. Interest was £6,179. 8s. 2d., and sinking fund £2,847. 5s. 1d., giving a net profit of £2,243.

The electricity accounts showed receipts £27,244. 14s. 2d., expenditure £14,119. 9s. 7d., gross profit £13,125. 4s. 7d., interest and sinking fund £15,411. 1s., leaving a deficit of £2,285. 16s. 5d., against £372. 4s. 9d. last year. The increased cost of coal (£4,891. 18s. 8d., compared with an estimate of £3,700) and the lower charges for lighting (introduced about a year ago) are responsible for the deficit.

Plymouth.—On the past year's working of the electricity department there was a net profit of £1,883, of which £300 has been applied in relief of rates and the balance (£1,583) placed to reserve.

Warrington.—The total income of the electricity department for the year ended March 31 was £16,238. 16s.

The total expenses were £8,528 18s. 5d., leaving £7,709. 17s. 7d. (against £7,968. 12s. 10d. in 1906) to meet interest (£2,634. 1s. 1d.) and sinking fund (£2,558. 17s. 2d.), leaving a nett profit of £2,516. 19s. 4d., against £2,762. 19s. 7d. The total capital expended is £86,522. 8s. 5d., an increase of £5,104. 0s. 7d. during the year. 2,450,027 units were sold (1,768,283 to private consumers, 71,629 for public lighting and 610,115 to tramways department). The maximum load reached was 1,239 kw., and the equivalent of 64,711 8 c.p. lamps (320 consumers) is connected to the mains. The works costs were 0·540d. per unit sold, and the total costs (excluding interest and sinking fund) 0·749d. per unit.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

London County Council invite tenders for (*a*) supply and erection of 78 tramway feeder pillars for the Council's tramways and (*b*) supply, delivery and erection of overhead electrical equipment for 2,400 yds. of double track for the Council's tramways in the borough of Woolwich. Tenders, on official forms, from the Clerk of the Council, County Hall, Spring-gardens, S.W., to be sent in by 11 a.m. July 16. See also an advertisement.

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London County Council also invite tenders for the manufacture of two 5,000 kw. three-phase turbo-alternators, with surface condensers, &c., to be delivered and erected at the tramways generating station, East Greenwich. Tenders, on official forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., to be sent in by 11 a.m. July 2.

Handsworth District Council invite tenders for traction and lighting feeders, fibre ducts and roadwork. Specifications from the clerk (Mr. H. Ward), Council House, Handsworth. Specifications, &c., can be seen at (but not obtained from) the offices of the consulting engineers (Messrs. Kennedy & Jenkin), 17, Victoria-street, Westminster, S.W. Tenders to the Council House, Handsworth, by noon July 10. See also an advertisement.

Schemes and tenders are invited for the electric lighting of *Uffculme*, Devon, by overhead or underground mains. Current is supplied at 200 volts d.c. Tenders to Mr. S. B. Sparkes, Coldharbour, Uffculme, Devon, by July 12. See an advertisement.

Tenders are invited for the lighting by gas, oil, electricity or other illuminant of the streets, thoroughfares, &c., of the city of *Calcutta*. The city comprises approximately an area of 20 square miles, containing about 170 miles of main thoroughfares and 130 miles of smaller streets, besides several squares, markets, latrines, slaughter houses, &c., which are now lighted by gas and oil lamps. The new contract is timed to commence on May 1, 1911, and the successful tenderer will be required to have all arrangements completed and ready to begin and continue the lighting with effect from that date. Tenders should be for 10, 15 or 20 years. Further particulars are given in an advertisement, and tenders will be received by the Vice-Chairman of the Corporation up to 3 p.m. Jan. 2, 1908. See also an advertisement.

Clacton District Council are prepared to receive tenders for supply of two 25 kw. 500 volt dynamos, two existing 100 volt Taunton machines (which can be viewed on application to the resident engineer) to be taken in part payment; also for additions to switchboard. Tenders to the clerk (Mr. G. T. Lewis), Town Hall, Clacton-on-Sea, by noon July 3.

The Electricity committee of *Stepney* (London) Borough Council invite tenders for supply during the year ending June 30, 1908, of (1) ampere-hour meters and demand indicators, and (2) arc lamp carbons. Tenders to the engineer and manager (Mr. Wm. C. P. Tapper), 27, Osborn-street, Whitechapel, E., by July 1.

Newport (Mon.) Electricity and Tramways committee invite tenders for low-tension switchboard, two motor alternators (d.c. to a.c., single-phase), one battery, extensions to switchboard gallery, cooling tower (steel) and battery reversing booster. Tenders to the Town Clerk, Town Hall, Newport (Mon.), by first post July 1.

Hackney (London) Council require tenders by 7 p.m. July 11 for bituminous nutty slack steam coal for the electricity department. Specifications from the Electrical Engineer, Millfields-road, Clapton, N.E.

Pontypridd Council invite tenders for supply and laying of about 3,000 yds. of triple concentric feeder and distributing cables, paper-insulated. Tenders to Town Clerk by July 8.

Warrington Electricity and Tramways committee want tenders by noon July 16 for the erection of buildings for boiler-plant extension. Forms from the Borough Electrical Engineer.

Rotherham Corporation require tenders by July 12 for supply of single vulcanised bitumen (covered) cable and 2 amp. to 50 amp. meters. Particulars from Borough Electrical Engineer.

Plymouth Guardians want tenders by noon July 2 for electric lighting of new workhouse infirmary buildings. Specifications, &c., from Thornely & Rooke, 11, The Crescent, Plymouth.

Tenders will be received by the Deputy Postmaster-General, *Sydney*, up to Aug. 21, for the supply and delivery at Sydney of 180 quantity and intensity detectors, wound with two circuits of about 105 ohms and 0·22 ohm respectively, and the quantity coil fitted with a fifth shunt. Patterns may be seen and conditions and forms of tender obtained at the Departments Stores, Sydney, Melbourne, Brisbane and Adelaide. Specifications, &c., can also be obtained at the Commonwealth Office in London, 72, Victoria-street, S.W.

Tenders will be received until noon Sept. 3 by the Chairman of the Board of Control, *Winnipeg*, Canada, for supply and erection of the equipment for the hydro-electric works and station at Point du Bois, for a transmission line thence to Winnipeg and for a transformer station at the latter place. Specifications, &c., from the Power Engineer's office, Carnegie Library Buildings, Winnipeg.

The *Danish Royal Telegraph Department* want tenders for supply of 25,000 kg. of 4·5 mm. iron wire and 25,000 kg. of 3 mm. steel wire. Tenders marked "Tilbud paa Jaern-og Staaltraad" should reach the Telegrafdirektoratets tekniske Afdeling, Frederiksholms Kanal, 28, Copenhagen, by mid-day July 1. Conditions and specifications may be inspected at the Board of Trade, 73, Basinghall-street London, E.C.

TENDERS RECEIVED AND ACCEPTED.

St. Pancras (London) Council have accepted the tender of Spencer Santo & Co. (at £3,825) for extending the King's-road station buildings, that of E. C. & J. Keay for the constructional steel work for the buildings at £1,623. 17s. 4d., and that of Adamson, Ramsbottom & Co. for an overhead travelling crane at £640.

Twenty-two tenders were received for the supply of coal to the Regent's Park and King's-road power stations of St. Pancras Council for 12 months, and the following were accepted: Brentnall & Cleland (Barber Walker's nutty slack, about 5,600 tons), Warwickshire small nuts, about 5,000 tons, and Watnall seconds hard steam, about 6,616 tons, at 13s. 7d., 15s. 6d. and 16s. 7d. per ton respectively, delivered at King's-road works, and Watnall seconds at Regent's Park at 16s. 9d. per ton. The tender of G. Hinchliffe & Co. for Welsh (Bwllfa) coal, to be delivered at the Regent's Park and King's-road electricity works (at 28s. 11d. per ton), was also accepted.

The following tenders were received by London County Council for cable ducts for tramway work:—

Stanley Bros. (*accepted*), 400,000, at £11, **£4,500**; Gibbs & Canning, 100,000, £11. 15s., £1,275; George Skey & Co., 160,000, £11. 17s. 6d., £2,000; James Woodward (Ltd.), 400,000, £12, £4,900; Hosea, Tugby & Co., 400,000, £12. 9s. 6d., £5,090; H. R. Mansfield, 400,000, £12. 9s. 6d., £5,090; Robinson & Dowler, 200,000, £12. 10s., £2,600; Sutton & Co., 200,000, £12. 10s., £2,600; Donington Sanitary Pipe and Fire Brick Co., 100,000, £13. 15s., £1,475; Doulton & Co., 200,000, £14, £2,900; Ensor & Co., 100,000, £15, £1,600; Thomas Wragg & Son, 400,000 £15, £6,100; George Jennings, 100,000, £15, £1,600; Leeds Fire Clay Co., 200,000, £16. 17s. 6d., £3,475. The amount of the tender includes in each case £100 for contingencies.

London County Council received the following tenders for low-tension electric cables:—

Western Electric Co. (*accepted*)	**£55,200**	**11**	**10**	Callender's Co.	£56,666	10	0
W. T. Henley's Co.	56,356	13	4	British Insulated & Helsby Cables ..	57,267	11	5
Union Cable Co. ..	56,397	9	9	W. T. Glover & Co.	59,468	16	5
Johnson & Phillips	56,573	15	4	St. Helen's Cable Co.	60,750	10	0
Siemens Bros. & Co.	56,645	10	0				

Hammersmith (London) Council have placed an order with the British Electric Transformer Co. for a 300 kw. transformer. The Council have also accepted the tender of the Crynant Colliery Co. for 1,000 tons of coal under the terms of their previous contract (12s. 10d. per ton delivered alongside), and have agreed to purchase a further 1,000 tons of coal at the current price (16s. 10d. per ton).

Belfast Corporation recently received 16 tenders for a lighting switchboard, and that of Siemens Bros. & Co., at £710, was accepted. The same firm's tender for a motor balancer, at £396, and the tender of Whipp & Bourne for a 1,000 kw. traction panel, at £514, were also accepted.

The Bombay Electric Co. have supplied 300 cells to the Rajputana-Malwa State Railway for electric train lighting. Electric is the only system of lighting on the trains of this line, but only about 25 per cent. of the coaches are at present fitted.

Peterborough Council have accepted the tender of the G.P.O. for water-level indicator and telephone between Peterborough, Etton and Braceborough, at £84. 5s. per annum. The Great Northern Railway Co. tendered at £89. 12s.

East Ham Council have accepted the tender of the Klein Engineering Co. (at £896) for two additional cooling towers, that of Callender's Co. for feeder cables at £396. 9s. 6d., and that of Docker Bros. for annual supply of paints and painters' materials.

The Metropolitan Asylums Board has placed an order with Callender's Co. at £30. 10s. for the cleaning of the electric switch boxes in the subways at Tooting Bec Asylum and refilling same with compound.

Merthyr Tydfil Council have accepted the tender of the local electric traction and lighting company for public lighting at Dowlais at £3. 6s. per annum per pair of Osram lamps.

Hull Tramways committee have accepted the tender of Brecknell, Munro & Rogers for a Tierney & Malone patent point controller at £80. 15s.

West Ham Council have made arrangements on special terms with the General Electric Co. for supply of 800 Osram lamps per month for 12 months.

Mansfield Council have accepted the tender of the Western Electric Co. for a tramway feeder and that of Frank Wardle for electric bell fitting at the police buildings.

Messrs. Bruce Peebles & Co., Edinburgh and London, have received an order from Wolverhampton Corporation for a 500 kw. 50 cycle motor converter.

Harrington Council have accepted the tender of J. Bain & Co. for public electric lighting at Lowca at 30s. per 16 c.p. lamp from Sept. 1 to April 30.

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Croydon Corporation have accepted the tender of T. Harding Churton & Co. for a single-phase motor-driven pump capable of delivering 50,000 gallons per hour.

West Ham Corporation have placed an order with the Fuller Electrical Co. for a rotary converter for supplying Messrs. J. Knight (Ltd.) with electrical energy to the extent of 150 kw.

T. Harding Churton & Co. have received (per Ferranti Limited) an order for two motor-generators for Leeds Council.

An order for electrical clocks for the Rangoon station of the Burma railways has been placed with Remfry, Davies & Co.

Portsmouth Council have accepted the tender of Baker & Co. for 200 tramway tyres at 31s. 6d. each.

The tender of Heaney & Co. has been accepted for wiring the new post office, &c., at Wrexham.

Barnes Council have accepted the tender of Spencer Santo & Co. at £1,300 for extension of the electricity station buildings.

City of London Guardians have placed an order with Baxter & Caunter for 16 c.p. Premier lamps at 9s. 6d. per dozen.

Belfast Corporation have accepted the tender of Gregg, Sons & Phenix for cast-iron frames and covers for the electricity supply department.

BUSINESS NOTICES.

Mr. Horace L. P. Boot, M.I.E.E., A.M.I.Mech. E., recently resigned his appointment as resident engineer at Tunbridge Wells (but has been retained by the Corporation as their permanent consulting electrical engineer and superviser) in order to engage in practice as a consulting engineer. Mr. Boot, whose London address will be 4, Great George-street, Westminster, S.W., is prepared to advise corporations and companies upon financial, rating and all technical questions regarding the erection of new or the extension of existing electricity works.

The British Thomson-Houston Co. have opened a new branch office at Maritime-buildings, Albert-road, Middlesbrough. Telephone No. 814; telegraphic address, "Asteroidal Middlesbrough."

Wright & Wood, Halifax, have appointed Fletcher & Eaton, 79, West Regent-street, Glasgow, as their sole agents for that city, and Norrie & Co., 7, Ward-road, Dundee, as sole agents for the East Coast of Scotland.

Mr. Charles Bright, F.R.S.E., M.I.E.E., has removed his office from 21, Old Queen-street, to Parliament-chambers, Westminster, S.W.

Messrs. Harris, Lea & Co. (Ltd.), electrical and mechanical engineers, of Johanesburg, have removed their London address to 55, Berners-street, Oxford-street, W. Telephone No.: 10014 Central.

F. Pooley and F. Clifford Austin have commenced business at 25, Victoria-street as suppliers of general electrical and mechanical requirements. Mr. Pooley has had 15 years' experience in the electrical profession, and Mr. Austin has been engaged in business in the City for a like period.

Morris-Hawkins (Ltd.), 9½, Union-court, Old Broad-street, E.C., and Dagenham, Essex, have purchased the business of the Morris-Hawkins Electrical Co. (Ltd.), including plant, stock-in-trade, &c., and is now in a position to supply standard Morris-Hawkins motors and dynamos and all spare parts.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the failure of James Clifford Brown (trading as Rowland Carr & Co.) the summary of bankrupt's affairs shows 64 unsecured creditors for £5,115. 10s. 10d., two creditors partly secured, £2,316. 6s. 9d. (£1,141. 6s. 9d. shortage on realisation). Other liabilities bring the amount expected to rank for dividend to £6,294. 7s. 7d. Assets are estimated to realise £561. 17s. 8d., making the deficiency £5,732. 9s. 11d.

Bankrupt failed on a previous occasion, the creditors being paid in full shortly afterwards. In 1896 he commenced with a partner as commission agent and general merchant, and with a third partner traded together until Feb., 1905, when the partnership was broken up, and bankrupt traded alone until Oct., 1905, when he was joined by the petitioning creditor, who introduced £3,000 capital into the business. He withdrew in Sept., 1906, on bankrupt agreeing to pay him by deferred instalments £2,512. 3s. 6d. None of these instalments have been paid. On Feb. 18 last bankrupt executed a deed of assignment for the benefit of his creditors generally. He attributes his insolvency to loss in trading, non-developments of contracts and decline in the business consequent upon the "shutting down of some of his best customers and the falling off of electrical business in London through outside corporations being afraid of the London County Council's electrical schemes being passed, and through the Local Government Board stopping to a large extent the borrowing powers of corporations for extensions, &c."

A receiving order has been made against Charles W. Stafford, electrical engineer, 59, Toll End-road, Ocker Hill, Tipton. The first meeting of creditors will take place on July 4, at 199, Wolverhampton-street, Dudley, and the public examination on July 12 at the Court House, Priory-street, Dudley.

Claims against John Fell, engineer and contractor, 25, Victoria-street, London, S.W., by July 4 to Mr. Thos. Ford, 11 and 12, Finsbury-square, London, E.C.

Ernest Rosenberg, patent broker, 465 and 466, Birkbeck Bank-chambers, London, W.C., has been allowed to withdraw the application for discharge made by him in November last.

A meeting will be held on July 22 at 1, Oxford-street, London, E.C., to receive an account of the winding up of the South-Western Electrical Co. (Ltd.)

A meeting to receive an account of the winding up of the Scottish House-to-House Electricity Co. (Ltd.) will be held on July 26 at Moorgate-court, Moorgate-place, London, E.C.

Winding-up Petition.—A petition by the Electrical Power Storage Co. for the winding up of Patent Exploitation (Ltd.) will be heard at the Court House, Liverpool, on July 12.

Sale by Tender.—Messrs. John R. Woodley & Co. will sell by tender in 10 lots the stock-in-trade of Hale Bros., wholesale electricians, on the premises at 156, Upper Thames-street, London, E.C., consisting of brackets, fittings, shades, cords and accessories. These are not on view until July 1. Tenders will be opened at noon, July 1, at the offices of Messrs. Woodley & Co., from whom full particulars can be obtained. See an advertisement.

Agent Wanted.—A firm of American electric lamp manufacturers require an agent for Great Britain. See an advertisement.

Electric Light Baths.—There have been considerable developments in the application of suitable electric lamps for the special treatment of the skin and for certain diseases. When arranged in a properly-shaped cabinet, electric lamps furnish a source of heat which can be conveniently controlled and are also more readily used than cabinets based upon the vapour method of heating. Mr. C. M. Holmquist, 52, Regent-street, London, W., is making a speciality of the Sunbeam electric light bath, combining thermal and electric ray effects for the treatment of certain ailments and diseases. He has opened an establishment at which it is possible to obtain a course of these baths with a minimum of inconvenience and at a moderate cost. The baths themselves are also purchasable at a comparatively low figure. Amongst the various designs of cabinets is one known as the self-reclining bath, the position of the patient in this case being the best that can be adopted for invalids or persons in a weak condition. Central station engineers will probably welcome the introduction of baths of this class into their consumers' houses, as they should prove a useful source of income. In the designs of these baths portability has been kept in view, so that the device can be stowed away compactly when not in use. The treatment is recommended in preference to Turkish baths, and has the further advantage of being always ready where the electric service is available.

National Telephone Directory.—The National Telephone Co. are about to make a useful improvement in the issue of their directories for various parts of the country. Hitherto the "Directory" has been issued annually, with an annual supplement containing new names and changes in the list of telephone subscribers. But new telephone subscribers come on in such large numbers that a more frequent issue is desirable, and, beginning with the current year, a complete directory will be published twice annually. The new directory will be published early in July.

CATALOGUES, &c.

Silvertown Instruments.—List No. 33 has just been issued by the India Rubber, Gutta Percha & Telegraph Works Co. and deals with a large range of electrical instruments manufactured by the company. Some fine views of these instruments are shown in the list, which is lavishly illustrated and is provided with good indexes, including one of pattern numbers. Many of the instruments listed are of Silvertown standard patterns in use in all parts of the world.

Motors.—Messrs. Wright & Wood, Halifax, are turning out largely increasing numbers of continuous, single and polyphase motors. These machines have recently been re-designed on the most up-to-date principles with liberal rating and large overload capacity. Inquiries in Glasgow and East Coast of Scotland should be addressed to the firm's agents as above.

Electric Motor Control.—Messrs. E. P. Allam & Co., 11, Red Lion-street, London, E.C., are issuing a new edition of their catalogue dealing with "Premier" electric motor control.

Sherardizing.—Messrs. E. A. Brandon & Co., 33, Devonshire Chambers, Bishopsgate, E.C., sole selling agents for the London Sherardizing Co., are issuing a sheet giving particulars of "Sherardizing." This is a new process by which steel or wrought and cast iron are protected from rust. Besides retaining the rust-resisting properties of the ordinary hot-dipped galvanised goods, other advantages are claimed for the process, including (1) that the zinc covering is not merely superficial but is alloyed into the surface and will not peel or break off; (2) the coating is even throughout, however complicated the shape of the article; (3) owing to the low temperature employed the most fragile articles can be sherardized

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without appreciably altering the temper; and (4) the sherardized articles take a lasting and brilliant polish.

Dynamos and Motors.—Messrs. Newtons (Ltd.), of Taunton, are issuing a new catalogue in convenient size for the pocket. The catalogue contains prices and particulars of the company's machines compactly arranged, so that a customer can ascertain the price of a dynamo or motor of any output and at various standard speeds in a few moments. A dimensioned sketch of the machines giving the overall sizes, and a table giving the gross and net weights and dimensions of packing cases, are included, and there are numerous illustrations of various types of machines, so that clients can obtain full information of the machines required before ordering. All machines are of the company's "Zone" patent type, capable of running at all loads with fixed brushes and sparkless commutation. Copies of the booklet will be sent on application.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from June 19 to 25, with the ports of destination:—

Africa—Alexandria, £378 (including £209 telegraph material); Berbice, £20; Cape Town, £130 (including £118 telegraph material); Delagoa Bay, £82; Durban, £879: East London, £260; Mombassa, £7; Port Sudan, £462; Suakim, £983 (telegraph material); Taltal, £1,521. *Argentina*—Buenos Ayres, £299 (including £78 telegraph material). *Australasia*—Adelaide, £220; Auckland, £958; Bluff, £521; Brisbane, £27; Melbourne, £237; Napier, £22; Perth, £175 (including £50 telegraph material); Sydney, £416; Wellington, £483. *Belgium*—Antwerp, £37; Brussels, £754. *British Guiana*—Demerara, £8. *Burma*—Rangoon, £23 (including £10 telegraph material). *Canada*—Toronto, £367. *Ceylon*—Colombo, £198. *Chili*—Punta Arenas, £2,558. *China*—Shanghai, £410. *Denmark*—Copenhagen, £548. *Germany*—Bremen, £34. *Gibraltar*, £613. *Holland*—Amsterdam, £363. *Hong Kong*, £98. *India*—Bombay, £1,990 (including £60 telegraph material); Calcutta, £2,001; Madras, £35. *Japan*—Nagasaki, 79 cwt. vulcanised wire. *Mexico*—Coatzacoalcos, £59. *North Atlantic*, £2700 (telegraph cable). *Norway*—Christiania, £28. *Russia*—Kurch, £2,351; St. Petersburg, £209 (telegraph material). *Spain*—Vigo, £42 (telegraph material). *Straits Settlements*—Singapore, £242 (including £43 telegraph material). *Sweden*—Gothenburg, £477; Malmo, £400 (telegraph material); Stockholm, £1,456. *Uruguay*—Monte Video, £114. *West Indies*—St. Lucia, £10. Total £26,205, against £18,472 in the corresponding week last year (June 20 to 26).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

April 11, 1907.

8,433 LATOUR. Alternating-current commutating electric machines. (Date applied for, 12/4/06.)*†

8,445 GRÖNDALL KJELLIN CO. & HÄRDÉN. Electric furnaces.

8,462 & 8,463 MARCONI & MARCONI'S WIRELESS TELEGRAPH CO. Wireless telegraphy.

8,471 KESSLER & JELICH. Electric signalling apparatus.

8,492 WATSON. Voltmeters.

April 12, 1907.

8,504 BROOK & HIRST. Multiple switch controlling apparatus.

8,520 BROWN, BOVERI & CIE., AKT.-GES. Shrouding blades of turbines. (Date applied for, 10/12/06.)*†

8,547 COCKERILL. Mechanically-operable tramway points.*

8,549 HERBERTS. Electric fuses.

8,555 SOCIÉTÉ DES GARAGES KRIÉGER ET BRASIER. Regulating the supply of electric currents. (Date applied for, 26/4/06.)*†

8,556 SOCIÉTÉ DES GARAGES KRIEGÉR ET BRASIER. High-tension ignition apparatus. (Date applied for, 27/4/06.)*†

8,562 PAWECK. Electro-deposition of zinc.

8,563 DEUTSCHE GASGLÜHLICHT A.-G. (AUERGES.). Manufacture of metallic illuminating bodies adapted for electric incandescence lamps. (Date applied for, 30/8/06).*†

8,574 FLORENCE. Electrical contacts or connections.

8,577 ATELIERS THOMSON-HOUSTON (ANCIENS ETABLISSEMENTS POSTEL-VINAY). Rheostats. (Date applied for, 13/4/06.)*†

8,578 HOLZWORTH & JUNGHANS. Gas turbines. (Date applied for, 12/4/06.)*†

April 13, 1907.

8,583 BOWELL. Electric lift controller.

8,593 KLEINSTEUBER. Insulators for high-tension currents.

8,611 BRUNNSCHWEILER. Device for connecting wires to telephone receivers.*

8,612 SIMS & STEVENSON. Arc lamps.

8,617 MILES. Switches.

8,623 STONE & MIGOTTI. Propulsion of electric trains.

8,629 HUMAN. Utilisation of electrical energy in intermittent or suddenly changing loads.

8,641 B.T.-H. Co. (G.E. Co., U.S.) Joints between incandescent lamp filaments and leading-in wires.

8,642 B.T.-H. Co. (G.E. Co., U.S.) Mounting incandescent lamp filaments.

April 15, 1907.

8,660 SZEK. Electric batteries.

8,677 FARRANTS. Holder or support for telephone receivers.

8,706 SCHMIDT. Commutators for electric circuits.*

8,742 OPPERMANN. Electrical controllers or switches.

8,761 GLOGAU. Filament of a high voltage electric lamp of small energy consumption.*

8,762 DUGUID. Trolley wheels or collectors for electric traction.

8,764 B.T.-H. Co. (G. E. Co.,U.S.) Controlling devices for electric motors.

6,765 B.T.-H. Co. (G. E. Co., U.S.) Apparatus for measuring electricity.

COMPANIES' MEETINGS AND REPORTS.

Globe Telegraph & Trust Co. (Ltd.)

The thirty-fourth ordinary general meeting was held on Tuesday, the Marquis of TWEEDDALE, K.T., presiding.

The SECRETARY (Mr. Sidney Collett) read the notice calling the meeting and the auditors' report.

The CHAIRMAN said: The accounts you have before you deal with a period of 13 months, and the receipts, after deducting expenses, amount to £244,096. It is impossible to compare these with last year's figures, as we are including an extra month this time, but had there been no change in the periods our receipts would have compared favourably with those of the preceding year. We have paid three interim dividends at the usual rate of 2s. per share on the ordinary shares, in addition to the fixed dividends at the rate of 6 per cent. on the preference shares, and your Directors now recommend the payment of the following final dividends, which on this occasion cover a period of four months to May 31—namely, 4s. per share, less income tax, on the preference shares, making, with previous distributions, a total dividend on those shares at the rate of 6 per cent. per annum, less income tax, for a period of 13 months, and 6s. 2d. per share net on the ordinary shares, making, with previous distributions, a dividend on these shares at the rate of 5¾ per cent. net for the year, which formerly ended April 30 (against 5½ per cent. last year) —this being the largest dividend this Company has paid during the 34 years of its existence—plus 8d. per share in respect of the month of May, representing one-third of the interim dividend of 2s. usually paid in the first quarter of the new financial year. In other words, the ordinary shareholders are this time getting 12s. 2d. for the 13 months as against 11s. last year for 12 months. These dividends will absorb £90,261. 12s. 4d., and leave a balance of £26,565. 12s. 6d. to be carried forward. This carry-over is principally accounted for by the fact that we have received during the 13 months covered by the report dividends which in the ordinary course belong to the year upon which we have now entered. For example, we have received five quarterly dividends from the Anglo-American Co. and two bonus dividends both from the Eastern and from the Indo-European Companies, all of which obviously do not properly belong to the accounts with which we are now dealing. There have been no changes during the year in the capital investments of the Company, but in three or four cases we have received increased dividends, while in one case there has been a slight decrease. The slight decrease is from the Great Northern Telegraph Co., which have paid a reduced dividend this year, but as our holding in that company is small, the reduction amounts to less than £100. Moreover, this investment is a very good one, and pays us even now at the rate of 8 per cent. The Direct United States Cable Co. have paid us 4⅝ per cent., as against 3⅝ per cent. in the preceding year, or a cash increase of £1,989. This, although their traffics have shown a steady increase, is mainly due to the fact that their Directors consider it unnecessary—for the present, at any rate—to add to their reserve fund out of revenue, thus allowing of a larger distribution to their shareholders. The West Coast of America Telegraph Co. have now entered the ranks of dividend-paying concerns, declaring a dividend at the rate of 2½ per cent., yielding £231. The amount, of course, is small, but it is so much to the good, and is, no doubt, due to a general revival of trade in those parts of the world served by their lines. We have also received larger dividends from the Mackay Companies. Last year I mentioned that they had increased the dividend on their common shares from 1 to 2 per cent. This year it is further increased from 2 to 4 per cent., showing an increase over last year's receipts of £393. The prosperous Central & South American Telegraph Co. have decided to distribute some of their surplus funds in the form of bonus shares. The amount which will be allotted to us, according to our present holding, is 911 shares of $100 (£20) each, or a nominal value of £18,220, while the present market value of these shares represents over £21,000; and although they do not affect the accounts we are now considering, they will in future years bring in an additional dividend of over £1,000 a year. Both this and our holding in the Mackay Companies, which also show an increase, were investments we made with part of the proceeds of the sale of Anglo-American deferred stock some years ago, affording the best evidence of the wisdom of getting rid of that unproductive and rather speculative stock, and re-investing the money in more suitable and profitable securities. I now move the adoption of the report and accounts and the declaration of the dividends therein set out.

Sir JAMES PENDER, Bart., seconded the motion, which was carried unanimously.

The retiring Director, the Marquis of Tweeddale, was then re-elected, as were the retiring auditors, and a cordial vote of thanks to the chairman and directors terminated the proceedings.

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Electric & General Investment Co. (Ltd.)

The eighteenth ordinary general meeting was held on Wednesday, under the presidency of Mr. J. B. BRAITHWAITE.

The SECRETARY (Mr. S. R. Shaw) having read the notice calling the meeting and the auditor's certificate,

The CHAIRMAN referred with feeling to the lamented death of Mr. George Herring, who had been so long chairman of the Company. Continuing, he said: With regard to the transactions of the past year, taking the profit and loss account, the profit that we have made was £38,621. 12s. 3d., compared with £15,924 last year, showing a very considerable increase. On the other hand, general charges remain about the same. The amount transferred to contingencies fund this year is £20,273. 17s. 10d. Naturally, you will ask why we have transferred such a large amount to the contingencies fund, which already stood at £46,714, but I need hardly remind you that during the past year there has been a continuous depreciation in all classes of securities, from Consols downwards, from which decrease in prices electrical securities have not been altogether exempt, although they have not, perhaps, suffered quite so much as what are commonly called "gilt-edged securities." I do not think you will be dissatisfied with a dividend of 27½ per cent. for the year and of £35 per share on the founders' shares; and while we do that we are still able, as I have said, to act prudently, and to raise our contingencies fund to the sum of £67,000. There is little change in the balance-sheet figures compared with last year. Our investments now stand at £246,888, against £232,494 last year, showing a small increase of £14,000. Our sundry debtors are £18,967, against £25,526, showing a reduction of about £7,000. Our cash at bankers' and in hand has increased from £717 to £9,815. On the other side of the balance-sheet the capital remains the same. Provision for contingencies, as I have already intimated, will be raised, if you pass this report, by the sum of £20,273. 17s. 10d., giving a total figure of £66,988. 1s. 9d. The loan account is very much the same as it was last year—£67,000 against £64,000. Sundry creditors are £15,668 against £26,993, being a reduction of about £11,000. The balance of profit and loss account is £6,000. That is the amount we propose to distribute. Reviewing the history of the Company since its inception, it may be interesting and convenient to you to know a little of what we have done since the Company was first established in 1891. In the first place, with respect to profits after paying general charges, we have realised during these 17 years a sum of £280,000. After paying the preference dividend, that left a surplus of £241,235. The amount we have distributed in dividends on the preference shares has been £38,827 and the amount we have distributed on the ordinary and founders' shares has been £141,250. The total amount we have distributed out of the profits of the Company on all classes of shares has been £180,077, in addition to which the trustees of the ordinary and the founders' reserve funds have distributed a further £20,580, making the total amount distributed in dividends over the 17 years £200,657. The average dividend the ordinary shareholders have received has been 5s. 7d. per share £1 paid—call it 5s. 6d. per share in both cases inclusive of the distributions by the trustees. That is an average dividend, curiously enough, of 27 per cent., as we propose to pay you this year. The founders have received an average dividend of £41. 0s. 1d. against the £35 we propose to pay them this year. That gives you very briefly the financial results of the Company's operations. With regard to the utility of the Company to the electrical industry in negotiating issues of capital for various electrical enterprises, there, I think, our record is one on which we have no cause to be ashamed. During those 17 years we have negotiated the issue of securities to the amount of about £12,463,000. We hear this morning that the Electric Supply Bill which the London County Council has been promoting in Parliament this year has been thrown out by the Committee to which it was referred, so that the London Electric Supply Companies will be left in peace, I suppose, for a further period; and I cannot help thinking that as the public realises that the policy of harassing capitalists who undertake great public services, whether in the way of tramways, lighting, or tube railways, is a bad policy, we may look forward to better conditions and less harassing attacks on British electrical companies. That must be distinctly to their advantage. The recent realisation of the fact that our London tube railways have been carrying people at a loss, and that that is not a good policy either, has resulted in an announcement that an arrangement has been made to make a moderate advance in the fares which will enable those concerned to make a reasonable profit. I think I am right in saying that the outlook for the electrical industry is improving as compared with the last few years, and I cannot help thinking also that it is likely to improve still further. I now move that the report and accounts be adopted.

Mr. EMILE GARCKE: I have much pleasure in seconding the resolution. The Chairman has asked me to say a few words, if I can do so, in confirmation of the statements which he has made with respect to the favourable outlook of the electrical industry. No one probably has experienced in a keener way than I have during the last 10 or 15 years the extraordinary troubles and the unnecessary troubles that have been placed in the way of electrical companies endeavouring to do good public service; but all I can say is that, notwithstanding all this discouragement, we are still full of hope and determination that the various companies for which we are responsible shall produce successful results.

The resolution was then carried unanimously.

Resolutions approving the dividends set out in the report were then carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. GARCKE, Mr. J. Cecil Bull was re-elected a Director of the Company. The CHAIRMAN said: We appointed during the year Mr. Bull, who has been associated with the Company ever since its institution. We are sure that you will confirm that appointment.

The retiring auditor, Mr. G. T. Rait, having been re-appointed, an extraordinary general meeting was held at which the question of the reconstruction of the Company was considered.

The CHAIRMAN said it was probable that in reconstructing the Company it would be able to acquire on advantageous terms a large amount of the electrical securities held by the late Mr. George Herring. The Directors had gone carefully into the matter and had prepared a scheme which they now submitted to the shareholders. They had received a large amount of support for the scheme. Since the meeting had been called a certain number of large and influential shareholders had made representations to the Directors that in their opinion the present was not an opportune time for reconstruction, and in view of that representation the Directors had decided to ask the shareholders present to agree to the meeting being adjourned sine die. If, however, any shareholder thought it better to substitute a definite date it was quite open for them to do so.

Mr. CROFT proposed an amendment to adjourn the meeting for three months.

The amendment was approved by the meeting, and was afterwards agreed to by the preference, ordinary and founders' shareholders.

British Electric Traction Co. (Ltd.)

The eleventh ordinary general meeting was held yesterday under the presidency of Sir CHAS. RIVERS WILSON, G.C.M.G., C.B.

The SECRETARY (Mr. Chas. H. Dade) read the notice convening the meeting and the report of the auditors.

The CHAIRMAN then said: I do not propose to analyse the accounts in detail, but will confine myself to mentioning a few of the more salient facts. The gross profits of all the associated companies, after deducting expenses but before charging interest on capital or rental of lines, have increased from £464,000 to £539,000. The increased amount which the British Electric Traction Co. has received in respect of dividends is £9,273. In addition to paying increased dividends the various associated companies have applied over £40,000 more than in the preceding year to depreciation and reserve—£176,000 against £132,000. The list of investments upon which revenue has been earned has been increased by £169,000. Of this amount £135,720 was included in the unremunerative list last year. On the other hand, the unremunerative investments have been increased by shares to the cost value of £405,000, which includes the Brush Co. £220,000. Our various undertakings carried during the past year over 300,000,000 passengers and the gross earnings were only about 1½ millions sterling or 1¼d. per passenger. Electric tramway facilities and services are infinitely superior in comfort and other respects to the horse and steam tramways which preceded them. On our Metropolitan system we are carrying ordinary passengers 2½ miles for 1d. and working people 5 miles for 1d. I have never myself been able to understand the difference which philanthropists have chosen to establish between workmen and other classes. Owing to a large number of the tramway undertakings in the country being in the hands of local authorities (two-thirds of the whole tramway mileage) there has been a never-ceasing agitation for the reduction of fares. Even now our fares are not as low as those charged by some of the local authorities in big cities, but they are too low having regard to the character of the districts we serve and the large capital outlay which has been necessary in adopting electric traction. If we had received the same fares per passenger which we received six years ago our companies would have made over £200,000 more profit, which would have been mainly available for increased dividends, and would have represented a very satisfactory return on the ordinary shares of this company. A stand must be made against the perpetual clamour for reduced fares and increased concessions, and this is a view which is now entertained by the large municipal corporations. It must always be remembered that the shareholders in the British Electric Traction Co. and other similar companies are many of them persons of moderate means, and their livelihood in great measure depends upon their investments in these undertakings, which they naturally conclude will be conducted on ordinary business lines without the intrusion of unfair interference from outside, and surely the time has come when it must be recognised that this tramway industry has to be worked upon a commercial basis. It was refreshing to read the remarks of the President of the Board of Trade when opening the latest of the London tube railways. He suggested that it was in the public interest that investors should be able to look for a reasonable return to encourage them to lend money to such enterprises. I trust that Mr. Lloyd-George will see his way to translate his words into acts, for, to speak frankly, we have received but scant support from the department over which Mr. Lloyd-George presides. It will be in the recollection of the shareholders that Birmingham Corporation a few years ago decided to municipalise the tramways because the Council were of opinion that an offer made by the British Electric Traction Co. was not good enough. Recent accounts of Birmingham Corporation show an available surplus of about £12,000, but the fact is overlooked that if the Corporation had left the tramways in the hands of the British Electric Traction Co., the Corporation would by this time have received a nett profit of between three to four times the amount of £12,000. Another case is Wolverhampton Corporation who decided to work the tramways themselves and up to 1906 there is still a deficit of over £3,000. Such cases might be multiplied. I am glad to say that there is growing up to-day a distinctly more tolerant spirit among the municipalities.

I have made the above remarks with the view of explaining to you how it is that we find ourselves for the first time unable to recommend a dividend on the ordinary shares. I will now summarise the points upon which we rely to show probably better results in the future. In the foreground I must put an increase of fares, which we are already commencing to carry into effect. In the next place, the prospects of some of the companies in which we have large holdings are particu-

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larly encouraging. We have £220,000 in the Auckland Tramways, and these pay 7 per cent. Extensions are being made to these lines. In the Bombay Tramways we hold £270,000, and this promises to be one of the most successful of our undertakings. In the Metropolitan Electric Tramways Co. we hold £300,000 and the prospects of this undertaking are most gratifying. 36,000,000 passengers were carried on this company's lines last year, compared with 29,000,000 in 1905. The rates per car-mile and per passenger are increasing. The Metropolitan Electric Tramways (Ltd.) holds a very large interest in the North Metropolitan Power Supply Co., the prospects of which are very encouraging. We hold £239,000 in the South Metropolitan Electric Tramway& Lighting Co. and this company will shortly emerge into the catagory of remunerative investments. Our management and general expenses show a big reduction on the preceding three years, and we are making certain re-arrangements which will tend to decrease these expenses.

In conclusion, I would say that the remarks of some of our critics that, because we have been reducing dividends on our ordinary shares and are not this year paying any ordinary dividend, there is cause for anxiety are not in accordance with our view. I say there is no real cause for anxiety, for we are bringing forward £13,115 and also about £42,000 of Bombay profits. There is every reason to hope that the dividends on our investments will continue to increase and generally the outlook is satisfactory. We are adding two new directors to our board. Mr. Arnold-Forster's career is well known to the shareholders, and Mr. Tuckett has taken a prominent part in our proceedings as a shareholder and has had great financial experience. The board deeply regret the death of Mr. George Herring, who was not only one of the very largest shareholders in this company, but was one of its promotors also, and gave his advice and assistance whenever he was asked to do so. We shall feel his loss very much. I now move the adoption of the report and accounts.

Mr. EMILE GARCKE seconded the resolution.

A general discussion followed, to which the Chairman replied, and the resolution was then put to the meeting and carried unanimously.

Mr. J. S. Raworth (the retiring director) and the retiring auditors having been re-elected, a cordial vote of thanks to and confidence in the Board was proposed by Mr. LIGHTON and seconded by Mr. CLOWES BAYLEY, and carried unanimously.

The CHAIRMAN having briefly replied, the proceedings terminated.

ELECTRICITY SUPPLY CO. FOR SPAIN (LTD.)—The marked improvement in the exchange was maintained throughout 1906. The rate on Dec. 31, 1906 (when the accounts were closed), was 27.44 pesestas = £1, compared with 31.70 at the end of 1905, and 33.80 in 1904. The average for the year was 28.42, against 32.92 for 1905, and 34.65 for 1904. The company's revenue of 1,100,000 pesetas has this year produced £37,829. 12s. 3d., an improvement of £4,922. 1s. 9d. over 1905, and of £5,776. 14s. 1d. over the average of the five previous years. Including interest the gross revenue was £38,533. 5s. 9d. Deducting debenture and other interest, and other charges (£18,730. 19s. 8d.) there remains £19,802. 6s. 1d. £15,247 has been applied to redemption of debentures, leaving £4,555. 6s. 1d., which, with £7,478. 12s. 4d. brought forward, makes £12,033. 18s. 5d., which the directors propose to carry forward.

The directors have appointed Mr. Oskar Oliven, managing director of the Gesellschaft für Elektrische Unternehmugen, of Berlin, to fill the vacancy created by the death of Mr. S. Kocherthaler.

GREENWOOD & BATLEY (LTD.)—After providing for debenture interest and management expenses and making provision for doubtful debts, the profit for year ended March 31 was £12,428. 6s. 5d., added to £6,123. 18s. 7d. from previous year. The directors have written off £4,000 for depreciation and recommend that dividends for the year be declared at the rates of 7 per cent. on the cumulative preference shares and 4 per cent. on the ordinary shares (absorbing £13,898).

INDIAN ELECTRIC SUPPLY & TRACTION CO. (LTD.)—At the meeting on Tuesday it was reported that contrary to expectations it was not until April 25 last that the buildings and the greater part of the plant, tramways, &c., were taken over by the company from the contractors. The supply of current for lighting and fans was commenced on a small scale on Jan. 1, 1907, and the equivalent of about 2,000 8 c.p. lamps are connected to the mains. The municipal authorities have arranged to take a supply for lighting the roads through which the tramway is laid at 3d. per unit under the terms provided in the licence. The greater portion of the tramway system was opened on March 11, and is working satisfactorily, and a very fair traffic has already been secured. It may be found desirable to extend the system, which at present is only 3½ miles in length.

LISBON ELECTRIC TRAMWAYS (LTD.)—Col. Sir C. Euan-Smith stated at the meeting last week that they had made considerable additions to the rolling stock and to their power equipment during 1906; but this year, again, they had had to add still further to the number of their cars, while they had now completed the erection of a turbo-generator at the power station. The net profit for the year was £96,117. 18s. 11d., which, with £16,096. 0s. 3d. brought forward, made £112,213. 19s. 2d. £35,000 had been placed to depreciation, and after providing preference dividend (£25,533. 3s. 8d.) the directors recommended a dividend of 5 per cent. for 1906 (£29,709. 8s.) on the ordinary shares, leaving £16,971. 7s. 6d. to be carried forward.

NEW GENERAL TRACTION CO. (LTD.)—For the year ended March 31 the revenue received and accrued from the various sub-companies was £14,767. The loss on the year amounted to £20,816, which was reduced to £17,241 by the transfer of £3,574 from the special reserve fund. The lease of the company's Philadelphia undertakings to the Philadelphia Rapid Transit Co. has been duly carried out. The Coventry company is showing substantial progress, but further capital expenditure became necessary and the requisite advances have been made by this company.

UNITED ELECTRIC TRAMWAYS OF MONTEVIDEO (LTD.)—The report for the year ended March states that the traffic receipts were $364,892, an increase of $14,939, but expenses were $27,730 higher, due to abnormal causes. When the electrification of the systems is completed large increases in the receipts are anticipated. The directors recommend a dividend on the ordinary shares of 2 per cent.

WESTERN UNION TELEGRAPH CO.—This company have issued their report for the quarter ending June 30, 1907. The following statement, dated June 12, shows the condition of the company at the close of the quarter ended March 31, 1907: There was a surplus on Jan. 1, 1907, as per last quarterly report, of $17,026,616.12, and the net revenues for the quarter ended March 31, 1907, were $1,509,699.70, making $18,536,315.82. After deducting for dividend of 1¼ per cent. paid on April 15, $1,217,023.75, and interest on bonded debt, $366,187.50, there was a surplus on March 31 of $16,953,104.57. The net revenues of the quarter ending June 30, based upon nearly completed returns for April, partial returns for May and estimating the business for June, will be about $1,650,000, and, after adding that amount and appropriating for interest on bonded debt, $366,187.50, and $1,217,023.75 for a dividend of 1¼ per cent., which the committee propose to declare on capital stock, a surplus of $17,019,893.32 will remain.

J. G. WHITE & CO. (LTD.)—The directors' report for the period to Feb. 28 states that the profit for the year is £38,378. 4s. 3d., showing a steady improvement on previous years' results. The business has continued to show considerable development in the foreign field, and the company is now actively carrying out works in Buenos Aires, Montevideo, Para (Brazil), Caracas (Venezuela) and Bombay. Very little business is offering in Great Britain, but the directors hope with the present outlook for foreign business and the continued development and widening of the scope of the company's legitimate fields of operation to offset any diminution in the volume of British contracting business. The total contract value of work (exclusive of work on which profits have been taken at Feb. 28 last) is in excess of £1,500,000. The operating and finance departments have been further developed during the year, and the directors see no reason to change their opinion that considerable profits can be obtained from these branches of the business. The company's investments are valued on what is believed to be a conservative basis, and it is anticipated that a considerable [profit will be made in realisation. The securities have been obtained in the ordinary course of the company's contracting and financial business, and as in a good many instances the properties have yet to develop, the valuations are considerably under par, but the yield in interest and dividends received and accrued during the year is in excess of 5 per cent. on valuation. The available balance after bringing in £16,357. 9s. from previous account, deducting interim preference dividend, and making provision for the percentages due to directors and staff is £47,811. 12s. 5d. The directors recommend payment of the dividend (tax free) on the 6 per cent. cumulative preference shares for the half-year to Feb. 28 (£4,500), a dividend (tax free) at the rate of 6 per cent. on the ordinary shares for the year (£3,000), and a bonus of 1 per cent. on the full amount of the preference and ordinary share capital (£2,000), placing £20,000 to reserve, leaving £18,311. 12s. 5d. to be carried forward.

CITY NOTES.

MEMORANDA (June 27).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 30⅞d.—31d. per oz. Consols $84\frac{7}{16}$—$84\frac{7}{16}$ for money, $84\frac{1}{2}$—$84\frac{5}{8}$ for account; 2½ per cent. annuities $82\frac{3}{4}$—$83\frac{1}{4}$. Consols Pay Day, July 3; Stocks and Shares Continuation Days, July 10 and 29; Ticket Days, July 11 and 30; Pay Days, July 11; Mining Share Carry-over Day, July 9.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—In a circular to the share holders the secretary states that an offer has been received from the Cie. Générale de Tramways de Buenos Ayres to transfer to this company the undertaking of the Buenos Ayres & Belgrano Electric Tramways Co.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The transfer books and register of members will be closed from July 2 to 16 inclusive.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The directors have appointed Mr. H. B. Renwick (at present secretary), general manager and secretary, and Mr. C. P. Sparks (at present chief engineer), engineer-in-chief to the company.

EASTERN TELEGRAPH CO. (LTD.)—This company announces payment on 15th prox. of a dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending 30th inst., and a first quarterly interim dividend of 1½ per cent. on the ordinary stock (tax free) in respect of profits for the year ending Dec. 31, 1907. The transfer books will be closed from July 6 to 13 inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH CO. (LTD.)—The directors have declared an interim dividend for the quarter ended March 31, of 2s. 6d. per share (tax-free), payable on 15th prox. The share register will be closed from July 6 to 13 inclusive.

PROVINCIAL TRAMWAYS CO.—The directors have resolved to pay a dividend of 3s. per share on the ordinary shares on account of the profit which may be made in the year ending Sept. 30, 1907.

SOUTH METROPOLITAN ELECTRIC LIGHT & POWER CO. (LTD.)—In order to provide for payment for the new power house at Blackwall Point and to meet the continuous expansion of the company's business, the directors are offering to the share and debenture stockholders £30,000 further 4½ per cent. first mortgage debenture stock (at £102) and 30,000 7 per cent. cumulative preference shares of £1 each (at 22s. 6d.).

STOCK EXCHANGE NOTICE.—The Stock Exchange Committee have been asked to grant a quotation to 28,381 £5, fully-paid ordinary shares of *Bruce Peebles & Co. (Ltd.)*.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 19	1,514	+ 53	13	3,938	+ 269
Airdrie	,, 14	233	- 6	23	5,177	...
Anglo-Argentine	,, 24	15,703	+ 1,947	25	412,232	+ 39,207
Ashton-under-Lyne Corp	,, 22	371	+ 23	13	5,051	+ 527
Ayr Corporation	,, 22	351	- 11	6	1,623	- 131
Baker St. & Waterloo Ry.	,, 22	2,530	+ 1,172	15	35,800	+ 14,106
Barnsley	,, 14	173	+ 18	23	3,752	- 64
Barrow	,, 14	273	- 29	23	92	- 85
Bath Electric Trams, Ltd.	,, 19	852	+ 18	25	18,363	- 36
Birkenhead Corporation	,, 23	1,034	- 16	...	...	...
Birmingham Corporation	,, 15	6,075	...	11	65,093	...
Birmingham & Mid.	,, 7	769	...	22	17,332	...
Blackburn Corporation	,, 19	996	- 44	§12	13,716	+ 663
Blackpool Corporation	,, 20	835	- 183	11	10,028	- 1,580
Blackpool and Fleetwood	...	...	...	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 23	2,286	+ 100	12	27,038	+ 796
Bournemouth Corporation	,, 19	1,533	- 26	¶11	19,013	- 66
Bradford Corporation	,, 22	4,644	- 70	12	55,451	- 230
Brighton Corporation	,, 23	891	- 162	12	10,571	- 1,018
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 21	5,007	- 31	19	93,114	- 4,001
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 22	1,218	+ 45	12	13,341	- 57
Burton Corporation	,, 23	297	- 11	11	3,415	+ 234
Bury Corporation	,, 16	1,065	...	11	11,724	...
Calcutta Tramways Co.	,, 23	R15,332	+ R2,990	24	R1,226,797	+ R25,058
Camborne-Redruth	,, 22	116	+ 5	25	2,891	- 27
Cardiff Corporation	,, 22	2,090	- 50	12	24,772	- 54
Cavehill	,, 14	82	- 56	23	1,711	- 41
Central London Railway	,, 22	5,466	- 493	25	151,618	- 15,717
Chatham & Dist. Lt. Rys.	,, 22	796	+ 124	¶24	16,680	+ 1,293
City & South London Rly.	,, 23	3,225	+ 249	25	74,450	+ 4,382
City of Birmingham	,, 14	2,931	...	23	64,013	...
Colchester Corporation	,, 19	207	- 9	...	...	...
Cork Electric Trams Co.	,, 20	521	- 3	25	10,788	- 351
Croydon Corporation	,, 21	1,474	- 113	‡12	16,880	- 39,127
Devonport & Dist. Trams	,, 14	431	- 25	23	10,279	+ 41
Dover Corporation	,, 22	230	- 62	12	2,630	- 313
Dublin & Lucan Railway	,, 21	138	+ 7	25	2,623	- 6
Dublin United	,, 21	6,507	+ 1,027	†25	127,152	+ 8,301
Dudley Stourbridge	,, 14	850	+ 61	23	19,173	- 327
Dundee Corporation	...	...	...	...	...	...
East Ham Council	,, 22	959	- 18	12	10,923	- 352
Exeter Corporation	,, 21	319	+ 24	12	3,730	+ 308
Falkirk and District	,, 19	274	...	...	...	...
Gateshead & Dist. Trams	,, 14	1,004	+ 43	23	22,908	+ 766
Glasgow Corporation	,, 22	17,676	+ 489	3	56,625	- 4,238
Glossop	,, 22	131	- 5	25	3,367	+ 60
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	,, 14	250	- 2	23	5,316	+ 59
Great Northern & City Rly.	,, 22	1,755	+ 103	25	45,347	+ 326
Gt. Northern, Piccadilly, &c.	,, 22	4,210	...	25	98,239	...
Greenock & Port Glasgow	,, 14	698	- 109	23	14,836	- 21
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 14	314	+ 14	23	6,103	- 372
Hastings Elec. Trams Co.	,, 20	1,010	+ 235	25	21,608	...
Hong Kong	,, 22	$7,339	+ $383	12	$192,160	...
Huddersfield	,, 22	1,606	+ 76	12	19,002	+ 650
Hull Corporation	,, 22	2,383	+ 108	12	28,373	+ 1,558
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 19	141	+ 15	12	1,692	+ 155
Ipswich Corporation	,, 22	419	- 77	12	4,655	- 427
Isle of Thanet Co.	,, 22	761	- 88	38	12,993	+ 80
Jarrow	,, 14	126	...	23	2,689	...
Keighley Corporation	,, 20	169	+ 6	51	7,745	+ 552
Kidderminster & District	,, 14	118	+ 5	23	2,409	- 124
Kilmarnock Corporation	,, 22	149	- 9	5	893	+ 15
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 20	1,185	+ 308	25	27,147	+ 5,819
Lancashire United	,, 19	1,243	+ 391	25	29,429	+ 8,065
Leamington	,, 14	158	- 28	23	3,415	- 242
Leeds Corporation	,, 22	6,719	+ 519	12	77,655	+ 3,164
Leicester Corporation	,, 22	2,301	- 36	25	51,914	- 31
Leith Corporation	,, 22	519	- 1	†6	2,896	- 76
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 24	1,526	+ 17	25	35,939	+ 478
Liverpool Corporation	,, 15	11,131	+ 199	24	253,726	+ 3,427
*London County Council	,, 15	32,159	+ 6,177	11	336,829	+ 47,965
London United	,, 21	7,092	- 194	†25	147,049	+ 2,703
Lowestoft	,, 23	201	+ 22	38	5,992	+ 809
Maidstone Corporation	,, 22	111	- 9	12	1,261	- 79
Manchester Corporation	,, 22	14,770	+ 955	12	174,063	+ 13,981
Mersey Railway	,, 22	1,946	+ 309	25	46,169	+ 2,574
Merthyr	,, 14	204	+ 1	23	4,772	+ 232
Metropolitan Dist. Railway	,, 23	7,886	- 173	25	197,375	- 4,071
Metropolitan Elec. Trams	,, 14	5,134	+ 1,405	23	98,371	+ 22,189
Middleton	,, 11	388	- 237	23	7,881	- 59
Nelson Corporation	,, 22	146	- 7	13	1,877	+ 46
Newcastle-on-Tyne Corp.	,, 22	4,048	+ 107	12	48,437	+ 1,159
Newport (Mon.)	,, 22	629	- 30	12	8,978	+ 1,386
Northampton Corporation	,, 21	425	- 15	‡12	5,097	- 181
Oldham, Ashton & Hyde	,, 14	625	- 88	23	13,781	+ 712
Oldham Corporation	,, 23	1,873	+ 54	13	24,913	+ 1,708
Perth (N.B.) Corporation	,, 19	152	+ 3	5	799	- 12
Perth (W.A.) Elec. Trams	,, 21	1,351	- 32	25	36,260	- 1,091
Peterborough	,, 14	123	- 2	23	2,653	- 42
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 22	1,993	- 101	12	22,716	- 867
Potteries	,, 14	1,913	+ 175	23	53,170	+ 958
Preston Corporation	,, 19	760	+ 36	12	9,602	+ 150
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 20	608	+ 139	†12	6,883	+ 1,610
Rothesay	,, 14	220	- 130	23	2,418	- 215
Salford Corporation	,, 24	4,580	- 1	12	57,769	+ 2,055
Sheerness	,, 12	60	- 1	23	1,209	- 10
Sheffield Corporation	,, 23	5,823	+ 115	13	71,596	+ 3,152
Singapore Trams	,, 22	$9,655	+ $2,562	12	$116,592	+ $21,821

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	June 19	384	- 25	12	4,020	- 223
South Metropolitan	,, 14	832	+ 446	23	16,933	+ 891
Southport Tramways	,, 14	313	- 139	23	6,102	- 416
South Staffs	,, 14	882	+ 124	23	20,570	+ 1,502
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 23	1,473	- 29	12	16,551	- 177
Sunderland and District	,, 19	445	+ 124	25	10,550	+ 1,339
Swansea Trams	,, 14	900	+ 9	23	19,193	+ 464
Swindon Corporation	,, 19	159	+ 7	...	...	...
Taunton	,, 14	43	- 1	23	946	- 72
Tynemouth and District	,, 14	266	- 58	23	4,267	- 659
Tyneside Trams Co.	,, 19	429	+ 46	25	10,235	+ 612
Victoria, Elec. Supply Co. of	May 19	805	+ 100	8	7,598	+ 791
Wallasey District Council	June 22	886	+ 36	12	9,804	+ 185
Walsall Corporation	,, 22	510	+ 5	25	12,053	- 529
Warrington Corporation	,, 20	402	+ 42	12	4,358	+ 125
West Ham Corporation	,, 20	2,329	+ 28	12	28,398	+ 977
Weston-super-Mare	,, 12	126	- 100	23	1,581	- 130
Wolverhampton Co.	,, 14	455	+ 76	23	10,185	+ 346
Wolverhampton Corpn.	,, 19	833	+ 12	22	9,666	...
*Worcester	,, 14	299	- 5	23	6,010	- 146
Wrexham	,, 14	107	- 2	23	2,274	- 36
Yorkshire W.R. Trams	,, 23	1,169	+ 318	25	27,748	...
Yorkshire Woollen District	,, 14	1,045	+ 141	23	21,834	+ 208

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., June 26.	Rate % Yielded.	Dividend Due.	Business Week to June 26. High-est.	Business Week to June 26. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8 —8½	4 14 0	Ap, Oct	8⅛	7⅞
5	2/9	Do. 5½ per Cent. Cum Pref.	5¾—6	4 11 9	Ja, Jul	5¹⁵/₁₆	5¹³/₁₆
St.	6%	Do. Permanent 6% Deb. Stock	134 —137	4 7 6	Ju, Dec	137	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	104 —107	4 13 6	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	2¹⁵/₁₆—3¹/₁₆	3 2 6	May ..	3⅛	3
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	My, Nv	4⅞	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	98 —102	4 8 0	Ja, Jul	99½	..
St.	7%	British Columbia El. Ry. Df. Ord.	130 —125	5 4 0	Mr, Spt	123¾	..
St.	5%	Do. Pref. Ord. Stock	103½—108½	4 12 0	My, Nv	107⅜	107
St.	5%	Do. 5% Cum. Perp. Pref. Stock	102 —106	4 14 3	Ja, Jul	105½	104¼
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	99 —101⅞	4 8 0	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	103 —105	4 5 6	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4¹/₁₆—4⅛	8 9 6	Ap, Oct	4¹/₁₆	8¹³/₁₆
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4¾—5⅛	5 11 6	Ap, Oct	..	..
5	3/0	Do. "B"	4¾—5¼	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	101 —104	4 16 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	95 —100	5 0 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	100 —104	5 5 9	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7¼—7⅜	5 3 0	Mr, Spt	7½	7⅜
100	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5⅜	4 7 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	104 —107	4 4 0	Ja, Jul	104½	..
St.		Cape Electric Tram Shares	..—⁵/₁₆	..—⁷/₁₆	..	⁷/₁₆	—
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	96 —100	5 0 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 —90%	5 11 0	Fb, Aug	87	..
100	5%	†Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
5	6%	† Do. 6 per Cent. "B" Ditto	78 - 82	7 6 0	Ja, Jul	80½	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅜	3 12 9	July ..	1⁵/₁₆	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1¹/₁₆—1¹/₁₆	5 1 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	98 —1 1	4 19 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	98 —101	4 19 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	..	..
St.	5%	Perth E. Trams. 1st Mt. Db. Stock	102 —106	4 14 3	Ja, Jul	..	..
..	5%	Sao Paulo Tramway, Light & Power Co. $100 Stock	123 - 128	3 2 6	..	127	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92%—94%	5 6 6	Ju, Dec	93½	93
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¾—5¼	5 14 0	Mr, Spt	..	..
10	3/1⅛	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8⅜	5 15 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 —98	4 11 9	Ja, Jul	97	..
5	5/3	Calcutta Elec. Supply Ord.	7¼ - 7¾	5 3 0	Ap, Oct	8	7⅛
5	7/3	Do. £4 paid	6½—6¾	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	43 —51	4 13 0	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2⅜	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	88 —92	5 8 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	97 - 99	5 1 0	Ja, Jul	98	97⅞
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	106 —109	5 10 0	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	3⅛ - 3⅜	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94½—97½	5 2 6	Ap, Oct	..	..
1	1/6	Rand Electric	¼ - 1	..	..	..	..
1	0/6	River Plate Electricity Co. Ord.	⅜—¾	..	April ..	..	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	⅛—1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	97 —100	5 0 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	..	..
..	5%	Shawmigan Water & Power 5 per Cent. Bds., Scrip	100 —102%	4 13 0	Ja, Jul	101	100⅜

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SERIES	LAST DIVIDEND	NAME.	Price Wed., June 26.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 26. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 —11	6 6 0	Mar, Sept,	..	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝—10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10 — 10½	5 14 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	101 —104	4 6 6	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅞—5⅛	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 —100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞—8⅛	5 14 6	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅛—7⅜	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	£9 - 1 2	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W.End & City)El.Sup.Co.	2⅛—3⅛	6 13 3	Feb, Aug	3⅛	..
5	2/3	Do 4½ per Cent. Pref.	4 —4¼	5 0 0	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 2 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ - 4⅛	5 9 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3⅛—4⅛	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	108 - 106	4 5 0	June, Dec	103⅛	..
10	7/0	City of London Electric Lighting Ord...	9⅛ - 9⅜	6 3 0	Feb, Aug	9⅜	9⅜
10	6/0	Do. 6 per Cent. Cum. Pref.	11⅛—12⅛	4 18 0	Jan, July	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.).....	121 —124	4 0 9	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 —100	4 10 0	Jan, July	100	..
5	5%	County of Durham Elec. P.D. Ord.....	3⅞—4⅛	5 0 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4⅝	5 4 11	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7⅛—8⅛	5 17 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10⅛—11⅛	5 4 0	Mar, Sept	11⅛	11⅛
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 —109	4 2 6	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	98 - 96	4 13 9	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅛—5⅛	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	98 —101	4 9 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜—7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8⅛—9⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜- 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 - 100	4 0 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	101 - 103	3 17 9	April, Oct	..	..
3	2/4⅔	London Electric Supply Ord.	1⅞—2⅛	5 13 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅞—5⅛	5 14 0	Mar, Sept	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Deb.	£8 - 96	4 3 8	Jan, July	94	..
5	4/0	Metropolitan Electric Sup. Ord.	6 - 6⅜	6 3 0	April, Oct	6⅛	6
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 - 5⅛	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1'6 —109	4 2 9	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	91 - 93	3 15 8	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D.1st Mort. Db.	95 - 9⅝%	4 11 9	June, Dec	97½	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9¼—9½	4 16 2	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	101 — 103	4 8 3	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7⅛—7⅜	5 11 1	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛—4⅜	4 10 1	Feb, Aug	..	..
100	4%	Do. 4 per Cent, Mort. Deb. red. 1907.	99 — 100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	99 —101	4 10 0	Jan, July	..	..
10	9/0	Notting Hill Electric Ord.....	12 - 13	5 15 0	March ..	..	..
5	4/6	Oxford Electric Ord.	6 — 6⅛	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 - 98	4 1 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7⅜—7⅝	6 1 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅞—7⅛	4 18 0	Feb, Aug	..	..
St.	3⅜%	Do. 3⅜ per Cent. Deb. Stock (red.) ...	£8 -98	3 15 8	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	1¼—2¼	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 - 77	5 4 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	2 - 2⅛	6 12 0	April ...	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅞—1	3 6 9	..	..	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 —103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1¼—2¼	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2¼—3⅛	7 3 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 - 97	4 12 9	April, Oct	..	..
5	6/6	Westminster Elec. Sup. Ord.	9⅛ - 9⅜	6 3 0	Mar, Sept	9⅝	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5⅛—5⅜	3 13 3	Jan, July	5⅛	5⅛
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 —95	4 4 0	Jan, July	92	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜—⅞	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅞—1	5 0 0	Jan, July	15/16	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 —99	4 11 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	96 - 99	4 11 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14¼—14⅜	6 8 0	Feb, Aug	..	..
10	4%	† Do. Cum. Pref. (fully paid).....	8¼—9	4 8 11	..	..	..
St.	4%	† Do. 4 per Cent. Debs.	95 — 100	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2¼—2⅜	..	June, Dec	2⅛	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6⅜ - 7	8 11 6	Feb, Aug	7⅜	6⅞
St.	5%	Do. 5 per Cent. Perpetual Debs.	103 —106	4 14 3	April, Oct	104	103
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 —81	5 11 0	May, Nov	80	..
St.	4%	Central London Ordinary Stock.....	72 —74	5 8 0	Feb, Aug	73½	73
St.	4%	Do. 4 per Cent. Pref. Stock	92 - 94	4 5 0	Feb, Aug	..	..
St.	4%	Do. Deferred Stock	53 — 56	7 2 8	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	103 - 106	3 15 6	Jan, July	..	..
St.	4%	†Charing X.Euston&Hmpstd Per.Db.Stk.	80 —83	4 16 6	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm.Pref.	4½ - 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 - 101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	45 —47	4 5 0	Feb, Aug	46⅞	42⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 —121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 — 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 — 118	4 4 9	Feb, Aug	117	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 - 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½ - 14½	4 2 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	13 - 14	4 5 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2 — 2¼	..	Feb, Aug	2⅛	2¼
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 —7	5 14 0	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock	82 — 85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db.St.	98 — 101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	12 - 13	6 18 6	Mar, Sept	..	..
10	6%	‡†Do. 6 per Cent. Pref.	10½ -11	5 9 1	Mar, Sept	..	..
St.	4½%	‡†Do. 4½ per Cent. Debs.	97 - 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 —1⅛	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	63 — 73	5 9 6	Jan, July	..	..
St.	47/6	Lancs. Utd. Trams 5% Prior Lien Db. St.	95 —98	..	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.....	1⅞—1⅞	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 — 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	83 —90	4 9 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜—8⅜	5 14 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	85 - 89	4 10 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 — 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 — 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	3/16 — 5/16	..	April....	5/16	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3⅞ - 4⅛	5 3 0	Feb, Aug	4⅛	4
St.	4½%	Do. 4½ per Cent. Deb. Stock	96 - 99	4 11 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜—1⅝	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	3⅞ - 6⅛	6 8 0	April, Oct	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	5 —7⅜	6 18 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 —98	4 11 9	May, Nov	..	..
1	3/56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	1⅝—1 13/16	5 16 6	Feb, Aug	..	..
St.	38/3½	Do. 4 per Cent. Deb. Stock	82 —86	4 13 0	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	86 —90	5 11 0	Jan, July	86⅞	..
..	5%	Underground Elec. Rys. Co. of London ...	61 —64	7 16 0	June, Dec	62½	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 —1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛—3⅝	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	90 —93	4 16 9	Jan, July	90½	..

SERIES	LAST DIVIDEND	NAME.	Price Wed., June 26.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JUNE 26. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	15/16 — 1	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	15/16 — 1	8 0 0	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.....	3⅜—3½	5 3 0	April, Oct	3½	3¼
1	0/7½	Do. Pref.....	1⅛—1 3/16	3 17 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¼—6⅝	7 8 0	July, Feb	6⅝	..
5	3/0	Do. 6 per Cent. Pref.	5⅞ - 6⅛	4 16 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	102 —1 5	4 5 9	Jan, July	..	..
St.	4%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	92 - 96	4 14 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 —1⅛	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£0 —65	6 3 0	Jan, July	..	..
2	..	Brush Electrical Engineering	⅛ - ⅜	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜—1½	4 16 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	85 - 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	74 —77	5 17 0	Jan, July	..	..
10	0	†Callender's Cable Con. Ord. xd & bonus	9½ - 10½	7 2 6	Jan, July	10	9½
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜ - 5⅝	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	106⅜—108½	4 3 0	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅛—1⅜	6 0 0	May, Nov	1⅜	1⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 —102	4 8 0	Feb, Aug	..	..
1	1/2⅞	†Chadburn's (Ship) Telegraph Ord.	1⅛—1⅜	8 0 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16 — 1⅛	5 4 0	April, Oct	..	..
3	1/6	†Crompton & Co. (Nos. 1 to 54,000).....	1⅛—2⅛	3 12 9	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	98⅝—99⅝	5 1 0	Jan, July	93	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16 — 1 1/16	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	4 16 0	Sept	1⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	102 — 105	4 5 6	Jan, July	..	..
5	4/2	Edison & Swan United ("A" sh.) (£3 pd.)	1 —1⅛	10 2 0	Feb, Aug	..	..
St.	4%	Do. (£5 paid)	2¼—2⅜	4 11 6	Feb, Aug	..	..
St.	5%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	85 — 87	4 12 0	June, Dec	..	..
5	4%	Do. 5 per Cent. 2nd Deb. Stock	89 —92	5 8 6	Mar, Sept	..	..
5	3/0	Edmundson's Elec. Corp. Ord.	½—1	10 0 0	Jan, July	..	..
5	4½%	Do. 6 per Cent. Cum. Pref.	1⅛—2¼	..	May, Nov	..	..
St.	4%	Do. 4½ per cent. 1st Mort. Deb. (red.)	78 —83	5 8 0	Jan, July	..	..
2	..	Electric Construction Co.....	⅜—⅝	..	Jan, July	1/16	..
2	2/9	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	8 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	79 —83	4 16 3	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8¼—8⅜	5 14 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 — 96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅝—12⅝	6 0 0	Feb, Aug	11 9/16	11½
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105 —107	4 4 0	Mar, Sept	106⅜	..
10	15/0	India Rubber, Gutta Percha, &c., Wrks.	15 —16	6 5 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 —99	4 1 0	April, Oct	..	..
1	1/2⅔	Richardsons, Westgarth & Co., Ltd. Ord.	¾—1⅛	7 6 0	Nov	¾	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1	6 0 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	97 —100	4 10 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	30½—31½	5 14 3	Mar, July	30	29⅜
100	4%	Do. 4 per Cent. Deb. Bonds (1900) ...	101 —104	3 16 6	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛—2⅜	6 6 6	..	2 13/32	2 3/32
1	0/6	Do. 5 per Cent. non-Cum. Preference	1 3/32 — 1 7/32	4 1 0	..	1 3/16	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	113 —116	4 6 0	..	1 11/32	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	103 —105	4 5 6	June, Dec	105	..
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9¼—10	5 0 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1¼—1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛—4	..	Apr, Oct	3⅞	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	77 —81	4 18 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 —3½	..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	88 —91	5 10 0	June, Dec	..	..
St.	15/0	Anglo-American	61 —63	6 3 0	F,My,Ag,N	61	..
St.	30/0	Do. Preferred	107 —108	5 11 0	F,My,Ag,N	108	107
St.	12½%	Do. Deferred	19⅜—19⅝	4 9 0	F,My,Ag,N	19⅜	18⅜
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 —94	4 5 0	Jn,Ap,Jy,O	93⅜	92⅞
10	5/0	Cuba Submarine Ord.....	7⅜—8⅛	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞—16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜—3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅝—9⅛	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝—103⅞	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	16⅜—15⅝	5 17 0	Ja,Ap,Jy,O	15⅞	15⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	..	..
St.	£5/0	Eastern Ordinary	185 —140	5 0 0	Ja,Ap,Jy,O	135½	134
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 —91	3 17 0	Ja,Ap,Jy,O	89⅛	89
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	104⅛—106⅛	3 15 0	May, Nov	..	..
10	6/6	Eastern Extension	13 - 13⅛	5 6 0	Ja,Ap,Jy,O	13 1/16	12 11/16
St.	4%	Do. 4 per Cent. Deb. Stock	104 —106	3 15 6	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 —101	3 19 0	Feb, Aug	99	98⅜
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	98⅜—100⅜	4 0 0	May, Nov	..	..
10	30/0	G.N. (of Copenhagen), with Coupon 70	84 —86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
25	52/6	Indo-European	56 — 58	5 12 0	May, Nov	..	..
100	4%	Mackay Companies Common	68 — 70	5 14 0	Jan, July	..	..
100	4%	Do. Preference	67 —70	5 14 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	1/16 — 1/8	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Debs.(red.)	99⅛—100½	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 —10⅛	N 16 0	June, Dec	..	..
2	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	1⅜	1⅜
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1/16 — 1/8	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ - 7⅝	7 12 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6¾ - 7½	..	May, Nov	..	..
100	5%	* Do. 5 per Cent. Debs.	10 —14	4 16 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅜—14½	4 19 0	Mr,Jn,O,D	14⅜	13⅞
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	102 —105	3 16 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	92 —94	4 5 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 —101	4 19 0	Mar, Sept	..	..
5	3/0	Chili Telephone	6⅞—7½	5 11 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1⅛—1⅜	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾—1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	108 —110	5 9 0	Feb, Aug	108⅛	108
St.	5½%	Do. Def. Stock.....	104 —106	5 4 0	Feb, Aug	105⅝	104⅝
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11⅜—13⅜	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5 3/16 — 6 5/16	4 10 0	Feb, Aug	6 5/16	..
St.	3½%	* Do. Deb. Stock 3½ per Cent. (red.) ...	95⅜—97½	3 11 9	June, Dec	97½	96⅝
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101½ - 102½	3 17 6	Jan, July	101½	101
1	0/9⅜	Oriental	1⅛ - 1⅜	5 2 0	April, Oct	1⅛	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	4 16 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	95 —98	4 2 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	99 — 102	4 7 0	Jan, July	..	..
5	3/0	United River Plate.....	6⅞—7⅛	5 9 6	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	June, Dec	..	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	108⅛—110⅛	4 9 9	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	4 —5	6 0 0	Jan, July	..	..
10	2 0	Globe Telegraph & Trust.....	10⅞—11⅛	4 19 0	Ja,Ap,Jy,O	11⅛	10⅞
10	3/0	Do. 6 per Cent. Pref.....	13½—14	4 5 9	Ja,Ap,Jy,O	14⅛	13⅜
10	6%	Submarine Cables Trust (Cert.).....	127 - 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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Power in Bulk and Coal Transport.

IT appears to be one of the laws of things that changes which benefit one section of the community or a branch of industry are detrimental to the interests of some other section. It seems but the inevitable consequence of change and at some time or other must be faced by the parties concerned. Electric power transmission is a case in point. In countries where water power is obtainable and coal expensive, and power is needed for industrial purposes the erection of a hydro-electric station and transmission line is the most convenient means whereby this power may be applied. If coal or oil are available for power production the idea of transmission naturally suggests itself. The coal or oil fields would be made the centres around which great neighbouring industries would turn.

But there is an important difference between the interests affected by electric power transmission from waterfalls and that from coal and oil fields. In the case of water the power available could not be economically transmitted by other than electrical means. In other words, if there were no dynamo electric machinery the many waterfalls in the world now harnessed would be running to waste. In this instance, however, the utilisation of the falls does not displace any previous section of industry at the particular spot. With coal and oil, however, very important businesses have been built up and are being successfully conducted in the traffic of these commodities. The actually mining of these products is not affected, but transport concerns relying on the business done between producer and buyer regard the freight charges as important items of their yearly accounts.

If now we are to have countries, with such natural resources as coal and oil at hand, emulating the example of hydro-electric transmission schemes, those engaged in the transport of these products are liable to be seriously affected. The freight revenue of a railway or steamship company for coal, for instance, must amount to a large annual sum in countries where coal is widely used for industrial purposes. A manufacturing concern may own its own colliery, but it cannot own the railway lines for the transport of the coal. The carrying company must be depended on entirely for that. With a pit's mouth steam-electric plant and a transmission line, the factory would, however, be independent of the railway company, and the latter would be the loser to the extent of the custom in coal hauled.

In this country there are few opportunities of utilizing the energy from waterfalls, but steam-electric transmission lines are quite feasible, and a number has been put into operation. But it is noticeable that very few of these are at the pit's mouth. Coal must be hauled to the site of the power station, and the railway companies are entrusted with the business of transporting it. The same applies to the many other electricity works in the country which depend upon rail or sea-borne coal. The establishment of these stations in every corner of the kingdom will have opened up accounts for transport between the railways and collieries which in the aggregate will represent a considerable annual sum. Similarly in crowded industrial areas, where the distances are shorter and there are more factories on the ground, the revenue from coal freight charges will be even greater. It is in such areas, however, that power transmission lines are likely to flourish as the consumers are nearer together, and the coal mines are in close proximity to the factories themselves. Pit head power plants taking coal direct from the ground would be independent of railway transport, and in transmitting energy to the surrounding works all coal haulage would also be dispensed with. It would therefore appear that railway companies are likely to suffer by the concentration of generating plants at coal pits and other sources of power.

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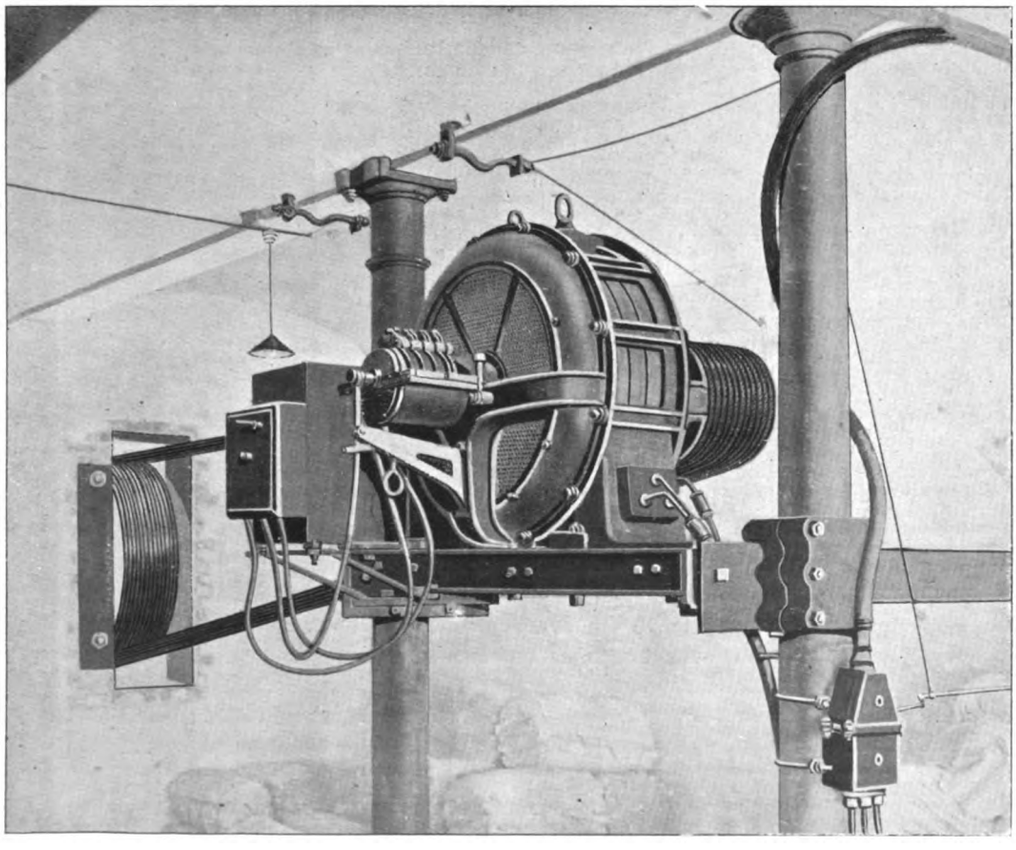
VARIABLE SPEED
INDUCTION MOTORS
WITHOUT SLIP-RINGS
THE SANDYCROFT FOUNDRY CO., Ltd.,
CHESTER.

Electric Power in Cotton Mills.

THE discussion of this subject, to which we referred at length in our last issue, has been continued with considerable energy in the columns of the *Manchester Guardian*. We are pleased to notice that the number of signed contributions to the discussion has increased.

The question of the cost of individual motors, which we criticised, was taken up and contradicted by a firm of motor makers, who lowered the price from the £35 quoted to £10 each. For the size of motor in question and for the equipment of a complete mill we should regard this price as approximately correct, and the figure for a good machine at that. The controversy has also brought a rope maker into the field with a long eulogy of rope as opposed to belt and motor driving of textile machinery. This contributor (E. Kenyon) endeavours to condemn electric power at the outset of his remarks by referring to some nameless installation put down four years ago and since replaced with a rope-driven equipment. Breakdowns and heavy repairs are quoted against this installation, but the only index to its whereabouts is the vague statement that "a firm in this country installed an electrical power plant to meet the requirements of one of their tenants." The figures given for maintenance and cost of the plant are also not acceptable without the means of verification.

Again, as is pointed out in a vigorous reply to this communication, "the figures regarding capital cost of the two systems of drive given are obviously of no value whatever to-day." The same writer makes an important statement regarding friction losses, and says: "I have not yet come across anyone who is prepared to give the exact figures representing losses due to friction when operating under full load, the usual practice being to take a friction diagram of engine, shafting and belts on loose pulleys, and assume this to represent losses which will, on a well-designed plant, figure out to anything from 25 to 50 per cent. of the total power required. But how often do we find, on starting up in the morning, particularly during the winter, that this figure may be considerably increased. I have known instances of diagrams being registered quite 20 per cent. in excess of the ordinary running load when taken during the first hour of operation." The same writer adds, in regard to the so-called unreliability of electric driving: "My experience, covering a period of 12 years, has proved to me that, given the same amount of attention as is usually devoted to the rope- or belt-driven plant, there



Large Induction Motor driving Weaving Shed by Ropes.
(Drake & Gorham.)

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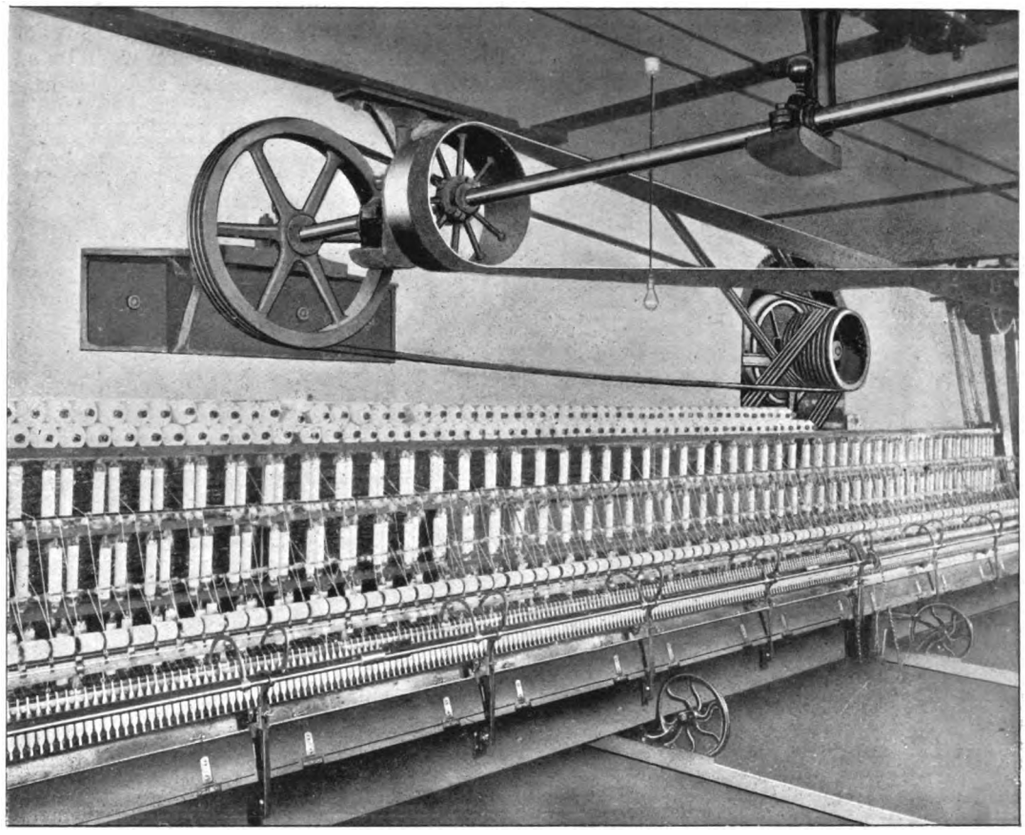
is nothing to fear as regards breakdown"; "that electricity for the transmission of power to machinery, whether group or individually driven, is better than the rope drive, no one having had experience with the two systems can doubt."

An engineering correspondent of our contemporary also criticises the efficiency figures we took in our last issue for purposes of comparison. Among other statements this writer says that apparently we "think that the efficiency would be less with the electrical drive for it is stated that if the steam-driven mill were speeded up until equal to its rival the friction losses would increase." The point we wished to make, and it seems to have been overlooked by this contributor, was that the figures for increased production with electric driving were based on such increased shafting losses as were noticeable at the higher speeds. If the steam drive can be increased in speed also to give greater output, then the losses also must be raised in proportion. In other words, although the steam mill may be speeded up to increase output, its losses will not be less but greater. The writer also takes a table of efficiencies of 60 cycle motors, and endeavours to argue from this that the losses with individual and group driving from steam-driven generators would be respectively 40 and 38 per cent. In the case of group driving, which is at present most commonly adopted, the efficiency of motors of from 25 H.P. to 150 H.P. is taken as 10 per cent. To this must be added a mean of 10 per cent. for the losses in the drive from the motors to the machines, and 8 per cent. for generator and cables (5 and 3 per cent. respectively), or 28 per cent. in all. By some mysterious calculation this figure is given as 38 per cent., or 10 per cent. to the disadvantage of electric driving. On the subject of "friction" load the writer states that 19 to 21 per cent. is a fair average for a weaving shed. Immediately after the term friction load is defined, apparently for our benefit, as the 1 H.P. developed by the engine when driving itself, the rope race, the mill shafting and gearing, together with all belts and ropes connected to cotton machinery, these belts and ropes running on the loose pulleys of the machines." If the friction load or idle loss of a weaving shed is 19 to 21 per cent., what must the running loss be? As another writer, quoted above, remarks, no figures of these losses have been published. While it is true they might not advantage the electric group drive they would probably present the case for the individual drive in a more favourable light. What is badly wanted for purposes of comparison is a batch of figures regarding the total losses in a mill with all machinery working.



Motor built into Wall of Mill driving Three Floors of Spinning Mules by Ropes.
(Drake & Gorham.)

In the discussion to which we have drawn attention there has been constant reference to the use of isolated plants for the generation of the necessary energy. The subject is not dealt with in any detail from the aspect of

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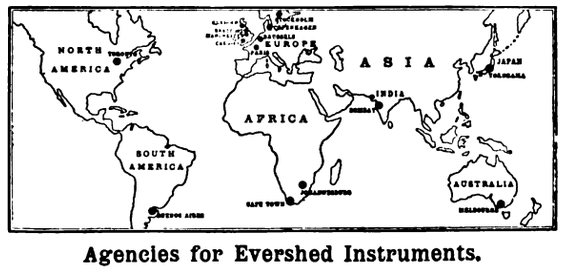

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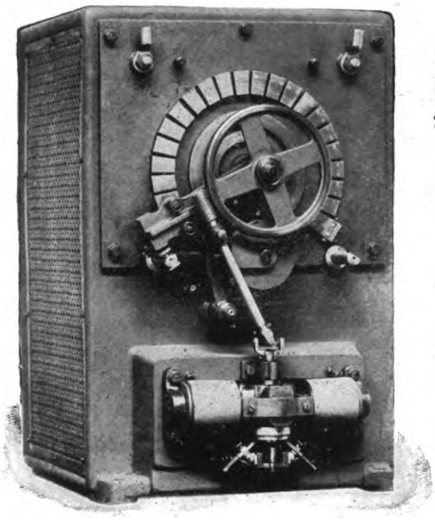

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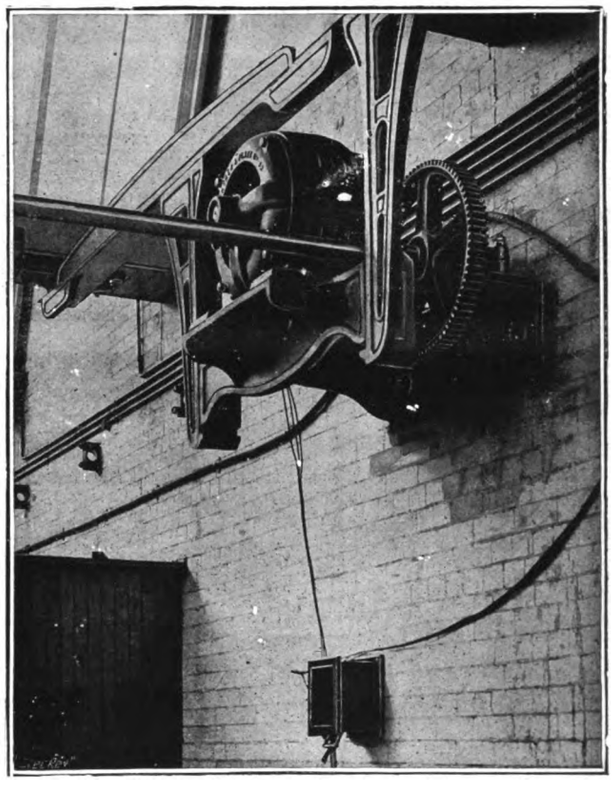
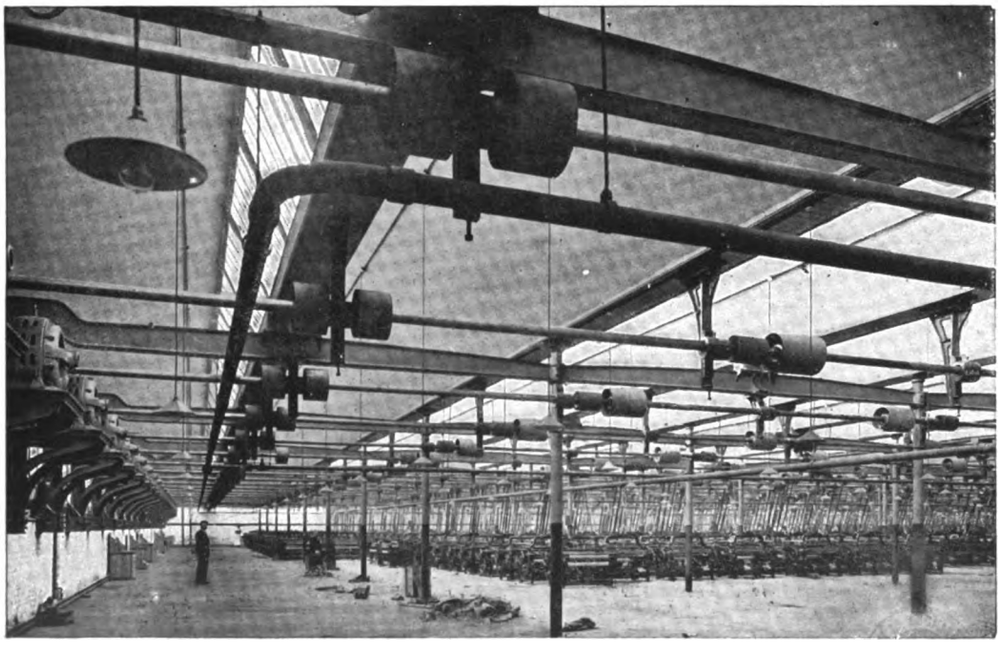
power in bulk supply despite the fact that there is an undertaking in the cotton district ready to give a service. Most of the largest mills at present in operation are driven from independent turbo-generators on the mill site. The relative merits of the two systems will bear comparison, and we hope to see this phase of the subject discussed in an impartial manner at no distant date.

Accompanying this further contribution to the problem of cotton-mill driving will be noticed a number of illustrations of typical methods of applying electric motors.

A matter dealt with by one of the contributors to the discussion is of some importance in its relation to the electric drive. It was claimed for steam operation that any unsteadiness in the engine was partially smoothed out by the flywheel effect of the whole of the mill machinery. Unconsciously this writer has touched upon one of the most valuable features of the electric drive—the steadiness of the machinery actuated by grouped motors. The moving masses in a 100 H.P. induction motor are considerable, and must contribute greatly to the flywheel effect of the mill equipment. The rotor of such a motor would weigh anything up to a ton, and will store up much useful energy at the speeds common to mill practice—300 to 500 revs. per min. Six such motors on the main floors of a mill will do much to give smooth running to the various mules and frames. With mules especially, where the power demanded varies so much, it is desirable, to avoid constant breakages of the yarn, that the shafting speed be regular and free from jerks. There does not appear to be the least doubt that electric motors about a mill acting as flywheels on the power system tend to absorb shocks and also to give out energy when sudden



25 B.H.P. Motor geared to Counter Shaft in Weaving Shed. (Mather & Platt.)



Weaving Shed driven by 21-25 B.H.P. Induction Motors geared to the Tranverse Shafting. (Mather & Platt.)

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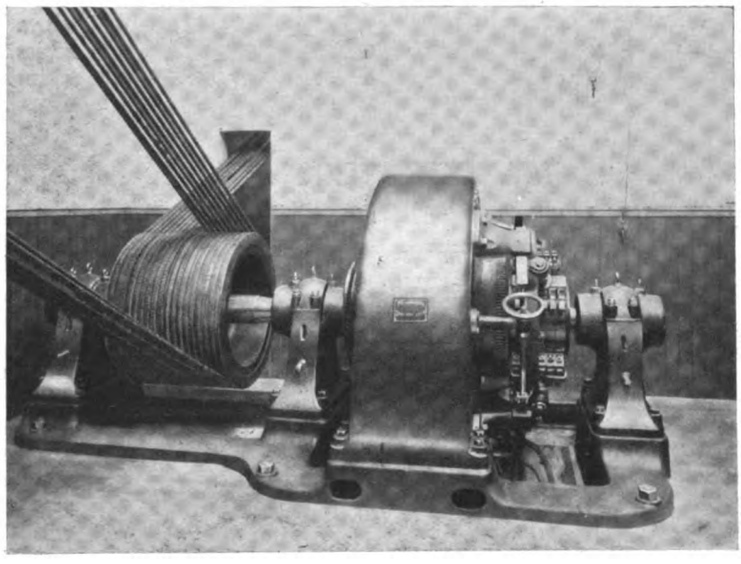
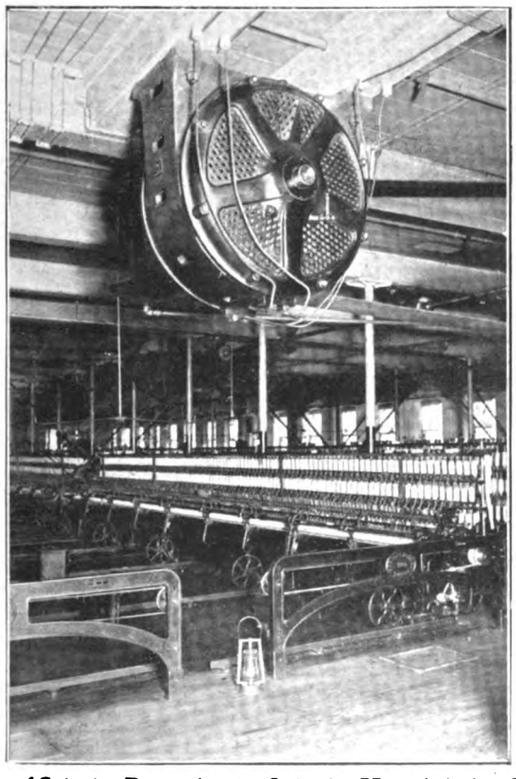
demands are made on the shafting for extra power. If researches were made into this phase of the electric drive and tests conducted with speed-recording instruments, such as the tachograph, the regularity of the turning moment would be conformed in a manner difficult to refute. We have seen speed charts comparing engine and motor driving of mill shafting which showed up the latter to great advantage, but no details accompanied the charts as to the class of machinery driven. Moreover, a test to be severe would be one taken on a floor with spinning mules driven from, say, a single motor. It is also evident that if the flywheel effect of a few large motors is so marked, it would be infinitely greater with many smaller motors, which in the aggregate would represent heavier moving masses than the lesser number of larger machines. It is unfortunate that the conditions of driving textile machinery do not admit of regeneration of energy, particularly as the general use of induction motors would render the problem comparatively simple. At present, however, there does not seem much prospect of anything being accomplished in this direction.



Large D.C. Motor driving Textile Machinery by Ropes.
(Dick, Kerr & Co.)

We feel that the admission to the columns of our contemporary of opinions on this subject will spread interest in electric driving and probably create close investigation into the substitution of steam by electric power in mills. The *Engineer*, in commenting editorially upon the discussion, considers that electrical engineers are too apt to feel that, because electric driving has proved eminently successful in other industries, it will also be found a desirable substitute for steam in textile mills. There is considerable truth in this statement, and the probabilities are that there will need to be greater co-operation between textile experts and electrical engineers to ensure the proper solution of certain problems. Unfortunately that co-operation cannot be expected in a general way for some time to come. There are many interests bound up in the present state of affairs in textile districts. Steam engine builders have works to keep going and orders for steam-driven mills must be obtained if they are to remain in business. Naturally they will oppose electric driving. If individual driving of machines were adopted belt and rope makers, shafting and pulley makers and innumerable allied trades would be deprived of a market for their products. Electric power in simplifying transmission methods will also remove the basis of trade from beneath many who flourished under former conditions. If for no other reason than this the advance of



Interior of Spinning Room showing Induction Motor bolted to Ceiling, and driving Mules by Belt.
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electric driving in the textile industries must be steady and slow. The laws governing the changes necessary to progress, in providing for the uprising of the new order of things, also control the rate at which the old and supplanted methods shall disappear.

We can safely assert that the conditions to be satisfied by electric driving in the textile industries are quite distinct from those met with in other industries. The character of the work and the load it provides, the hours of running, the interdependence of departments and—probably most important of all—the peculiarities of the central interests around which cotton and cloth production turn—these all combine to present a problem of extreme complexity which must be approached with a full knowledge of all the facts. Another factor must also be taken into account, the prejudice against anything new, and as it is termed foreign, which prevails in textile districts. It is the product of a form of local patriotism which is particularly active in this industry. We have reason to believe that it is carried to an extreme and is very difficult to cope with. At the same time, there are undoubted evidences of its being broken down. New ideas are being imported with new mills. Advocates of steam are suggesting alternatives to methods once religiously followed. The spirit which prompts a preference for these will also temper with good judgment the opinions held of proposals which, seemingly drastic, are pregnant with possibilities of success.

Great movements make slow progress. The progress of electric power in the textile industries, though it may be slow, will, we are convinced, be none the less sure. One of its chief barriers is prejudice. A number of mills electrically driven, with data available as to production, costs and quantities, will help to break down this barrier. Its removal will give a marked impetus to the progress of electric power in an industry sorely in need of it.

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Commercial Development of Central Stations.

Contracting Co-operation.

The man in charge of a central station who is an engineer and not a commercial man will usually regard the contractor as something of a necessary evil on the undertaking. From electrical time immemorial the contractor has done his best to "boost" up the station load by getting business, though he has, of course, had both eyes on himself and little or no thought for the station during the process. In fact both the supply authorities and contracting firms have been at loggerheads, and consequently matters have gone none too smoothly for either. A mutual agreement to disagree seems to have been settled between the parties. A contractor in a new district will begin by falling foul of the rules drawn up by the supply authority. Finding it impossible to get these altered he keeps just within the letter of the law and spends much time in endeavouring to evade it altogether. Now we hear much of co-operation in these days, but as far as electricity supply is concerned it seems to amount to co-operation among contending parties. Combination for contention. On the one side the contractors, on the other the station engineers. We know of no occasion on which both have met in conference. There is no combined annual convention at which both sides can discuss their respective grievances or both agree to sink their differences. If the service of electricity for all purposes is to be conducted on sound commercial lines, there must be co-operation wherever that desirable link can be forged. Of late an important concession has been made by the station engineers. An unconscious concession, we admit, but, nevertheless, a concession. We refer to the show of activity on the part of electricity departments to get new business. Hitherto the contractor had to do all this. He will welcome what may appear a trespass upon his preserves as a sign of the unbending of the station engineer, a willingness to undertake work beneficial to himself and the contractor. We hope that this appearance of agreement upon what is, after all, an object for the common good will develop and be the means of binding more closely the interest of contracting firms and electricity departments.

Huckstering.

The dictionary definition of this term is, "dealing in small articles," "petty bargaining." Mr. S. E. Fedden in his presidential address to the I.M.E.A. at Sheffield this week made use of the expression in the sense that it was something to be avoided by station managers in the conduct of new commercial departments. Evidently Mr. Fedden fears that with the circulation of "boosting" literature electricity supply undertakings are liable to lose caste and descend to making use of those trading methods commonly associated with "huckstering." Now we think the use of the term referred to, unfortunate, as it may convey a wrong impression to the minds of many station men and cause them to get a mistaken idea of publicity literature. We must admit that in the character of some of its "boosting" literature, many American undertakings have adopted extreme methods which reduce them to huckstering levels, but then American advertising is peculiar and most difficult to apply outside the United States. British station men have done so little in the circulation of pamphlets and other published matter among their consumers that it is yet too early to raise the cry of "huckstering." Not a tithe of what Americans have already accomplished has yet been attempted in this country, so that we are not in a position to judge whether electricity supply has received good or harm by pamphleteering.

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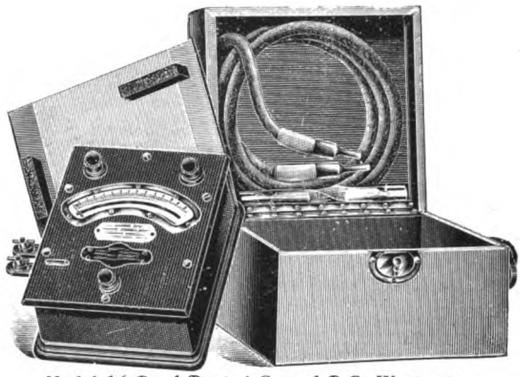

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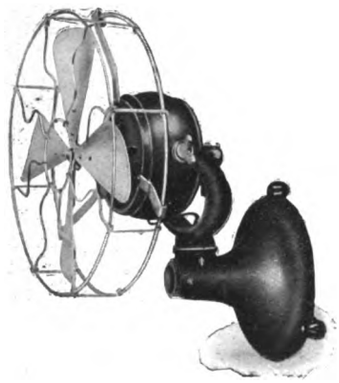

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Progress of Electrical Enterprise. . . . .

WE have frequently directed attention in these columns to the important influence which the development of electrical industries is likely to have upon national affairs. Especially have we emphasised the necessity for encouraging the business of power in bulk supply, so that the industries in the particular districts may benefit by the service given from electric power mains. Much valuable work is being done in the great industrial centres of this country to enthuse manufacturers with the electrical ideal as embodied in a power supply from large generating stations, but very few of these manufacturers know the unnecessary difficulties placed in the way of this branch of electrical enterprise. One of the chief facts which power users, particularly those requiring power on a large scale, are at present badly informed upon, is the marked economy obtained by the concentration of electric power plant at some central point from which energy is distributed over an extensive area. In a series of articles recently contributed to *The Times* Engineering Supplement, and now obtainable in book form,* Mr. E. Garcke points out the great value to the consumer of this concentration of the power plant. "Concentration of the load should be the axiom of modern electric power distribution." That this redounds to the benefit of the consumer is indicated by an example which is taken, and which we quote in full. "In 1901, when the Newcastle Company was emerging from the stage of a simple electric lighting company to that of a large power company, the total costs per unit were 1·05d. The output was then about 2½ million units per annum. In 1905 the output rose to over 30 million units (mostly for power and traction purposes), and the costs fell to 0·56d. per unit, which must be regarded as low, considering that the figure representing the ideal combination of the best points of all the electricity supply undertakings in the country is 0·41d. Between the same two periods the average price per unit obtained fell from 2·10d. to 0·96d." This is a typical example of what has been done by the establishment of a supply centre and distributing electric power "to supply," as Mr. Garcke says, "from one huge station as many demands as possible—railways and tramways, chemical works, shipyards, quarries, mills and every variety of industrial enterprise, large and small."

We find Mr. Garcke in complete consonance with our views on the subject of "industrial redistribution" and the enormous influence which electric power supply is likely to have upon the migration of factories from congested areas to spots remote from crowded districts and adjacent to the more pleasant parts of the country. "Since the ultimate object of electric power schemes is to provide cheap power at any point over a wide area, they afford an agency whereby industrial centres may be induced to move into open districts, where the benefits of cheap land and water, low rates and taxes and freedom from irksome restrictions are obtainable. Cheap transit—the remaining important desideratum—can be supplied by the same agency. From this point of view electric-power schemes will bring about a real industrial redistribution which will encourage the segregation, not the aggregation, of factories and other centres of activity. That this is no theoretical vision is demonstrated by the fact that the Newcastle Company and the North-Eastern Railway Co. are co-operating in a scheme for the development of new sites for factories in districts at present untenanted, but shortly to be made eligible by the provision of cheap power by the one and cheap transit facilities by the other. This movement deserves to be watched with the keenest and most sympathetic interest by all who are concerned with the national welfare." With these trenchant remarks Mr. Garcke concludes his treatment of the power in bulk problem. We think his little book should be distributed widely among the great captains of industry in this country. The chapters on electricity supply in bulk directly concern the future of power undertakings, and consequently are of vital interest to those in charge of important industrial concerns. There is much information on the subject which needs disseminating, and the sooner it is acquired in industrial circles the brighter will be the prospects of the power companies now established in various parts of the country.

* "The Progress of Electrical Enterprise." E. Garcke, M.I.E.E. London: The Electrical Press (Ltd.) 1s.

Induction Motor Planer Drive.

THE most common form of drive for planers, whether from line shafting or individual motors, is by fast and loose belts with jockey pulleys. With this arrangement the motor runs constantly in the same direction, the planer table being reversed from the pulleys and belts. At the instant of reversal the demand for power is at its maximum, and will reach as much as five or six times that required for cutting. Mr. H. P. Fairfield publishes in the "Journal" of the Worcester (Mass.) Polytechnic Institute some results of tests on a 36 in. by 10 ft. planer driven by a 10 H.P. induction motor. The tests were carried out to ascertain the influence on the power consumed, the changing the length of the stroke and by using a flywheel. The weight and diameter of the flywheel were kept as small as possible, and it was fitted to the highest speed shaft on the planer. The wheel was designed to have sufficient inertia to store and restore energy for taking care of the shock of reversal without material change in the speed of the motor. The planer was worked at from one-half to full stroke, a condition which would most probably be met in practice. The problem was resolved into that of a long stroke with a definite number of reversals to surface a given area, and that of one-half the full length of stroke and double the number of reversals to surface the same area. Following are the results obtained: With a short stroke of 5 ft., without the flywheel, the power consumed was 1·848 kw. hours to surface 2,160 sq. in. For the long stroke, without the flywheel, 1·628 kw. hours were required to do the same work. Adding the flywheel, the same area was surfaced with the short stroke with an expenditure of 1·302 kw. hours. The corresponding figure for the long stroke was 1·240 kw. hours. These show that the percentage of gain of the long stroke over the short stroke, without the flywheel, was 12. For the short stroke with the flywheel, over the short stroke without, the gain was 29·5 per cent. The long stroke showed a gain when the flywheel was used of 32·9 per cent. Following are the costs of power per hour for the various conditions: 4¾d. for the short stroke without the flywheel and 4¼d. for the long stroke. The short stroke with the flywheel costs per hour 3½d.; with the long stroke, similarly operated, 3¼d. The price of energy is taken at 2½d. per kilowatt-hour. This latter figure is comparatively high for electrical energy and might reasonably be halved for prevailing practice in this country. It would be interesting to know in what way the flywheel method could be applied with the direct motor drive.

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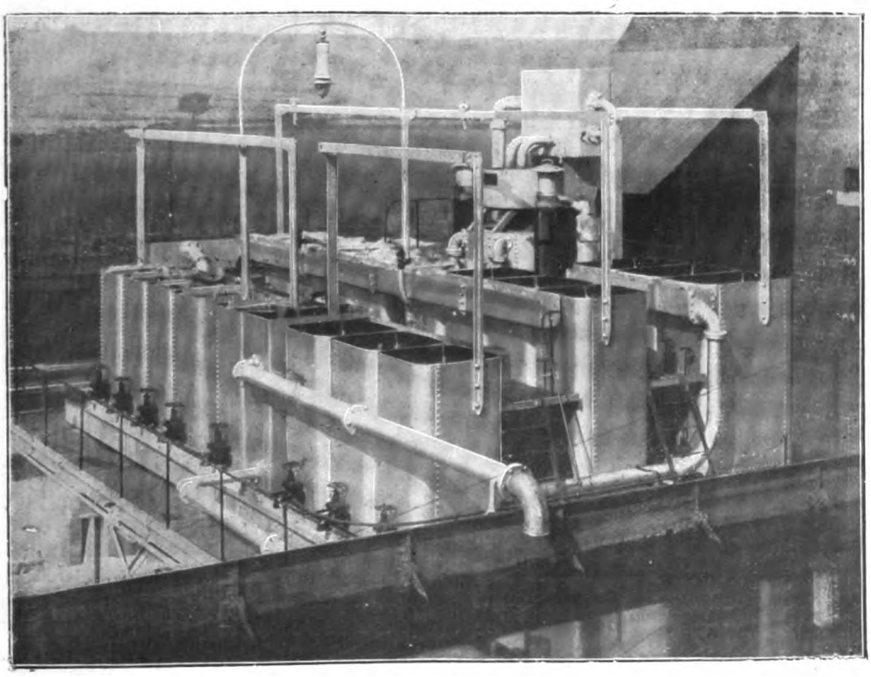

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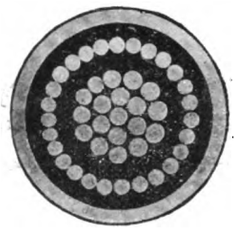

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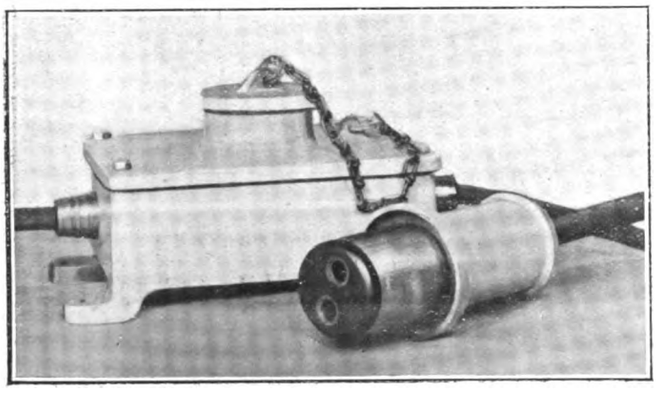
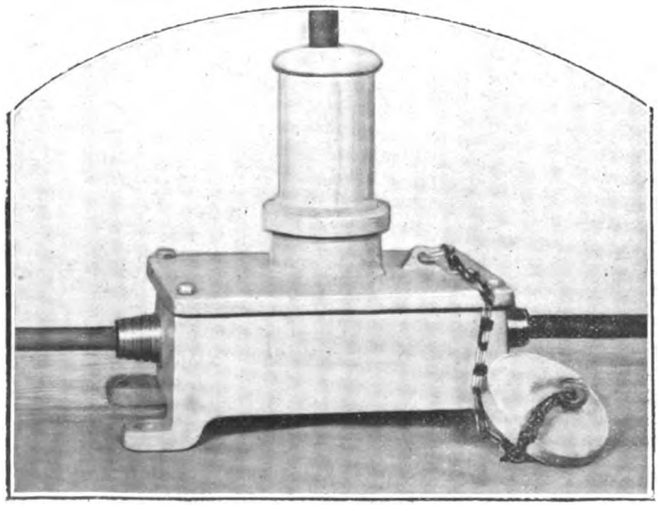
Iron Clad Plugs for Cranes.

THE adoption of electric travelling cranes for docks, wharves, warehouses, &c., has created a demand for a convenient means of coupling the same to the power circuits through flexible cables. It is not always possible to supply these cranes from an overhead trolley, as in most instances the wire would seriously interfere



View of Plug and Socket when closed.

with the lifting and slewing operations. Sockets must therefore be placed in the ground at suitable intervals, and a plug and flexible armoured cable be used. We give illustrations of a new design of crane plug and socket manufactured by A. Reyrolle & Co., Hebburn-on-Tyne. The object of the design has been to produce a



View of Plug fitted in Socket.

piece of apparatus, which while being electrically efficient would also be mechanically strong and capable of withstanding rough usage. The socket and cable terminals are fitted into a large cast-iron box which is sunk into the ground, being secured by four bolts passing through feet at the box corners. The lid is also held in position by four bolts and access to the socket is given through a hole, having a deep flange in the lid. This hole is normally closed by an iron cover attached to the box by a short length of chain. The plug is of the recessed pattern, the two connecting tubes which fit on the socket prongs being embedded in insulating material. The cable end is closed by an iron cap which is ample protection for the connections and the plug contacts.

A.C. Automatic Starters.

THE employment of a solenoid for starting switches is accompanied by a marked reduction in the cost of cables under automatic conditions of control. The apparatus to be operated by motor may, with solenoid control, be situated a considerable distance from the device which governs the motor speed. The provision of a solenoid starter for alternating-current circuits makes it possible to instal induction motors for automatic operation. The Adams Mfg. Co., New Bond-street, W., manufactures a range of such starters, and also small control switches for use with them.

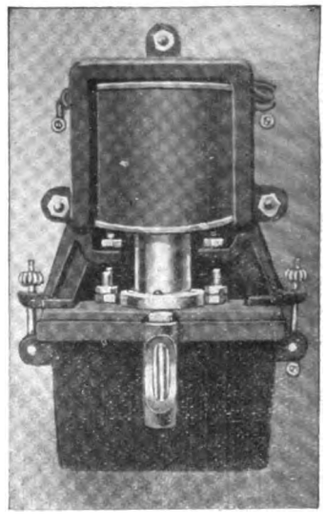


Fig. 1.—A.C. Solenoid Starter.

Fig. 1 illustrates a solenoid switch for use with small alternating-current motors, which are usually started up without the insertion of a resistance. The switch consists of a D.P. knife switch entirely immersed in oil, the moving contacts being operated by a single-phase solenoid. We are informed that the solenoid has no objectionable hum, and that the pull on switch rod is sharp and positive. A pressure regulator is provided for use with these switches when the motors drive air compressors, and this regulator is of the dial type, with central needle. The travel of this needle between certain limits can be adjusted to cause the motor to be started and stopped as desired.

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Industrial Topics. . .

WE have referred in previous issues to the changes made in the construction of machine tools since the introduction of variable speed motors capable of being mounted directly on the tool itself. When this practice was first followed the motor practically took the place of the belt pulley and simply drove the machine by chain or belt as was most convenient. This stage in the development of the motor tool was to be expected as too drastic an alteration could not be made at once. Moreover the right type of motor was not available, and speed changes were made on stepped cones as previously, from the line shafting. The process of evolving the motor tool has been going on, and it is noticeable how the motor is, so to speak, being pushed nearer to its work. Where at one time several mechanical links existed between the motor shaft and the tool driven, the number of these has been reduced and the drive from the armature is more nearly direct than it was previously. Radial drills, for instance, are commonly driven from a vertical shaft by chain or belt, the shaft being in turn belted or geared to another shaft which was in turn driven by the motor itself. A stage nearer the drill spindle was reached when the vertical shaft was dispensed with, the motor mounted at the top of the standard and the spindle driven direct from the motor. The final stage is that in which the motor is mounted over the spindle itself and coupled directly to it. We recently saw in operation a multiple-spindle drill treated in this way, a large motor being fixed to the end of the radial arm and driving the spindle from which all the drills were operated. With a speed variation of from 3 to 1 the motor was equal to any work put on it. Similarly with grinders and polishing tools. The motor here takes the place of the central pulley and the emery wheels or buffing discs are placed on the motor shaft.

Motor Tools.

If this tendency to get the motor nearer to the work, with a view to reducing the losses between the two, is followed logically, we shall find many radical alterations in machine tools in a few years. With a reliable, efficient variable speed motor at command the designer of machine tools has considerable assistance in bringing about this desirable combination of motor and tool. Quite the greater proportion of the operations needed in machine shops depends on rotary motion, and this fact materially helps the adaptation of the electric motor to such operations. The trend of machine tool motor design appears to be in the direction of a type of machine upon which many alterations of speed can be made. This pattern will, as time goes on, be more and more adapted to the driving direct of all those tools which require purely rotary motion. Such machines as planers can also be operated direct, but at the moment the tendency is to drive this type of tool by belt.

Milling cutters, saws, small boring mills, and drills are adaptable for direct motor driving, and it seems to be only a matter of time for subsidiary gearing to be dispensed with. Many electrical manufacturers are setting a good example by arranging their machine shops for individual driving, and much of the experience of machine tool makers has been acquired under the practical conditions prevailing in such shops. In many instances judicious co-operation between the manufacturers of electric motors and the tool maker will result in a combination between the two being effected, the results of which will be reflected in the designs, both of the machine tool and of the motor driving it.

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Copy for text or advertisement pages for next issue should reach the above address not later than July 22nd.

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable his will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms ; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations ; to any firm of Merchants or Agents ; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings ; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Textiles and Electric Power.

WE deal again at some length in the current issue with the subject of electric driving of textile mills. We have recently inspected two large electrically-equipped mills in Lancashire and can vouch for the excellent way in which motors can be adapted to the work. More particularly is this noticeable in old mills driven by wheel gearing and using beam engines. We find on inquiry that the number of such mills is comparatively large, and that, despite the heavy losses in such a method of transmission, these mills continue to run and compete with more modern types. Here is an opportunity for electric power plants and one which might be worth following up. Obviously, the best possible course to adopt to improve the working efficiency is to instal electric motors in preference to rope driving, as the motors can be more readily adapted to a portion of the older shafting than ropes. One of the mills we went through has been converted from the gear drive, and the change appears to have been completely justified by results. Where electric driving must compete with modern mill engines and a uniform rope drive the difference between the merits of the two systems is less marked, and the electric drive must rely on flexibility, ease of control and speed uniformity to carry it through over the head of its rivals, the steam and the gas engine. While we should like to see a greater number of mills driven by purchased electrical energy, we cannot but feel that the isolated plant is doing good by stimulating great interest in the electric power problem as it concerns the textile industry. Competition between the rival methods is likely to continue keen, but each new conquest for electricity will give impetus to the movement and will subsequently create a desire on the part of the many mill combinations to adopt an electrical standard for mill work. The value of the concentration of the power units in large stations will then become more apparent, and motors now actuated by energy from isolated plants may be operated from the mains of a power in bulk undertaking.

Motor Driven Planers.

The development of large machine tools has resulted in the introduction of new methods in handling heavy work. The planer is a type of tool which has been greatly improved and applied extensively in engineering workshops. Its more recent progress has been marked by the use of individual motors for driving purposes. At one time belts driving from line shafts with jockey pulleys and reversing arrangements were commonly employed for the operation of the planer table. By the aid of the single motor drive with reversing controllers a cumbersome rig of belts may be dispensed with and the power required to drive the machine may be reduced appreciably. Much research work has been done in this direction which has resulted in important modifications being made in the planer design. The motor, for instance, if a variable speed reversing machine, can be coupled direct to the threaded shaft by which the table is worked. This dispenses at a stroke with belts and pulleys. The use of a flywheel is also attended with some economy, as is pointed out elsewhere in this issue, but this addition requires the retention of belts and pulleys, as the motor must always run in one direction. The figures given are, however, of some considerable interest.

An Opinion of Bulk Supply.

We frequently hear, during visits to installations of electric power plant, various opinions expressed of the service to be obtained from some central source of energy, such as a large power company. A week or two ago a view was expressed by the manager of a factory operating some 2,000 H.P. of private plant, which may probably represent that of many others similarly situated. We inquired why an agreement had not been entered into with the local power company to supply at a cheap rate. His answer was, that assuming the agreement held for five years, at the end of that time he would be at the mercy of the power company, who might, on the expiration of the agreement, insist on raising the rate. "They could charge me any price they liked," said the manager, "and I should have no redress." If this is the pretext for spending many thousands of pounds on steam-raising plant and generators we can only say that power users are taking too much trouble to be unduly suspicious. While it is true that the factory would depend for its operation on the supply service, it is inconceivable that, after the expiration of any agreement, a power company should be contemptible enough to take advantage of its customers. But quite apart from this, the prospective consumer loses sight of the fact that the charges of the company are fixed at a definite maximum by the bill which gives it power to supply. With opinions such as the above prevalent, it would appear remarkable that the power companies are able to obtain large consumers on their mains. But nothing is more difficult to combat than suspicion.

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DRAFT.

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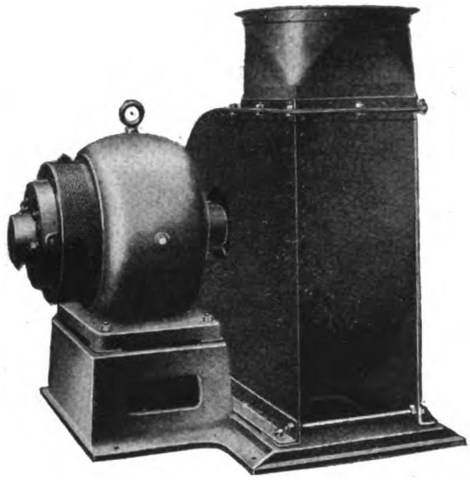

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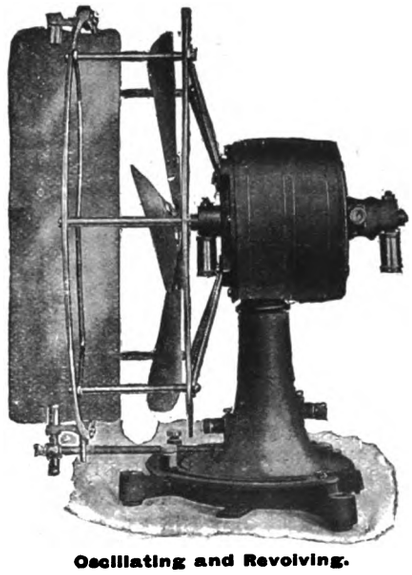
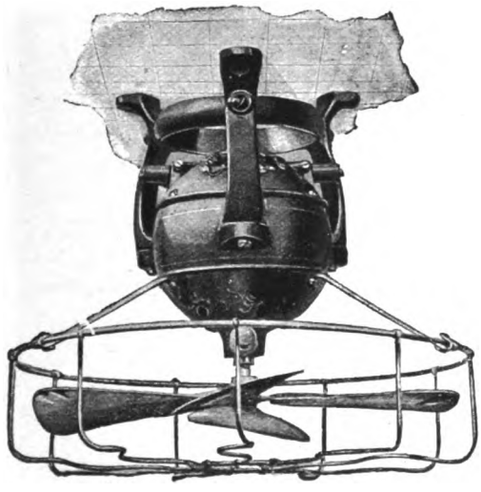


Oscillating and Revolving.



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Electric Capstans.

MESSRS. CROMPTON & CO., LTD., are making a new line of Electrically Driven Capstans at their Chelmsford Works.

These Capstans are built in two principal types, one for railway shunting work, and the other for dockyard purposes. The two types are similar in construction but differ principally in their dimensions and in the arrangement of the accessory fittings.

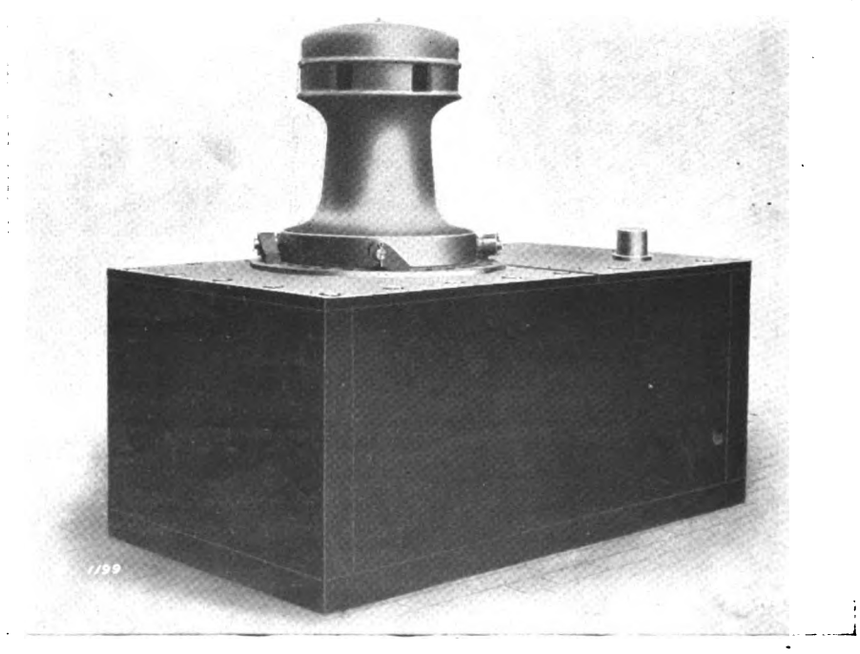
Railway Capstans. The railway type Capstan is usually made to haul a train having a dead weight of about 100 tons at a speed of about 150 ft. per minute on the level, and it must also be capable of starting the train, or a portion of it, on a gradient or against other adverse conditions. The Capstan head is carried on a vertical spindle to which is keyed a worm wheel with phosphor bronze rim and a mild steel worm connected directly to the motor spindle engages in the teeth of this wheel. A ball thrust bearing is provided to take the end thrust of the worm, and the whole of the gear is contained in a cast-iron gear box provided with proper lubricating arrangements.

Control. For starting the Capstan a special form of controller is used, operated by a foot pedal and arranged in such a way that when the pedal is depressed the motor starts, and as it runs up to speed the resistances or other controlling devices are cut out, a period of about 5 seconds usually being allowed before full speed is obtained. This arrangement is provided so as to avoid undue shocks on the gearing and too large a rush of current from the supply. The design of this controlling gear is of the very highest importance, and Messrs. Crompton & Co. have given a great deal of attention to it and evolved controllers for dealing with all possible systems of supply.

Brakes. As there is a considerable amount of energy stored in the motor, gear and Capstan head it is necessary to provide a brake so as to bring the head to rest promptly on releasing the controller pedal. This brake is usually of the double shoe type gripping on to a pulley attached to the motor spindle and operated either directly by the foot pedal or else by means of a pot magnet connected to the motor circuit.

Dock Capstans. Dockyard Capstans are usually much heavier than the railway type, being designed for hauling large vessels into dry dock or alongside a pier or wharf. This requires a pull on the rope of from 3 to 10 tons and the speed is from 25 to 40 ft. per minute, according to whether the vessel is being hauled broadside on to the wharf or end on into a dry dock. With these Capstans it is usual to provide a set of spur reduction gear in addition to the worm gear, and it is often found convenient to attach a pawl to the Capstan head, which engages with a ratchet path in the Capstan case and enables it to be used as a bollard; sockets for hand-spikes are also provided, and provision for disconnecting the Capstan head from the gear is fitted so that in cases of emergency the Capstan could, if necessary, be worked by hand.

Motor Details. In Dockyard Capstans the characteristic curve of the motor is of some considerable importance; for instance, a motor with a series characteristic is the most suitable for dry-dock work, as it enables the Capstan to give increased torque at a reduced speed when hauling the ship against the wind and to haul in the slack rope rapidly, and so keep the Capstan always ready to give a pull if required, when the ship is coming into the dock with the wind behind it. On the other hand, when bringing a ship against a pier or wharf



Crompton Dock Capstan.

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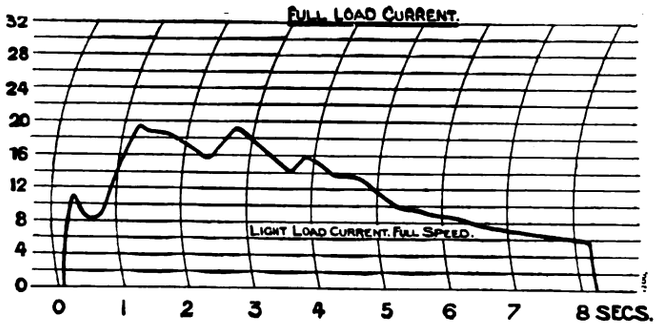


Current Curve of D.C. Series Capstan Motor.

there would be a tendency for a series motor to overload itself, especially if it is not doing the whole of the work, but operating in conjunction with the steam winches on the deck of the ship.

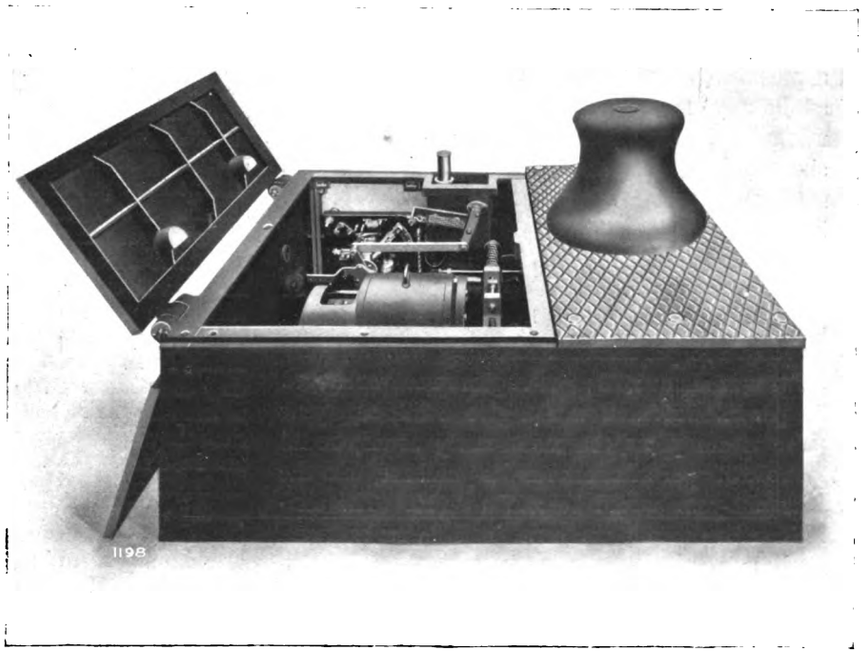
For railway work a motor with a series characteristic is always found the most suitable. The simplest form of Capstan is that in which a series-wound direct-current motor is used. With a properly wound motor in this type of Capstan it is possible to do away with starting resistances and automatic devices altogether, it having been found in several cases that as the motor starts principally on light load, and has a most powerful field at starting, the initial current does not exceed the full load current. There are cases, however, where restrictions are placed upon the initial current which necessitate the use of starting resistances and automatic switches, and above is given a copy of a recorder chart taken with a series-wound direct-current Capstan and one of Messrs. Crompton & Co.'s special Capstan Controllers, such as can be seen in the illustration.

A.C. Motors. When dealing with alternating currents other devices are used. It is best, whenever possible, to use a motor with a short-circuited rotor and limit the initial starting current by means of a star mesh controller with a time device to change over the connections from star to mesh after a period of about three seconds has elapsed. This will enable a Capstan to start and accelerate with a current of not more than about $1\frac{3}{4}$ times full load current, and if it is necessary to still further reduce this current it can be done by adding to the Capstan motor a centrifugal clutch, such as is described later in connection with single-phase Capstans.

Single-Phase Motors. For single-phase circuits Messrs. Crompton & Co. often supply motors of the repulsion type. They have two principal advantages, namely:—A characteristic curve corresponding very closely to that of a series-wound direct-current motor, and a high starting torque with a small starting current. Special attention has been given to the windings of these motors, and a series of them has been designed, having a low power factor and high efficiency and running without sparking at the brushes under the varying conditions met with in Capstan work.

Clutches. There is still another type of motor, however, which can be used for Capstan work, and that is the single-phase induction type provided with a centrifugal clutch. Messrs. Crompton & Co. are making a large number of such motors for the driving of various kinds of machinery, and have had a great deal of success with them. It is found to be a very great convenience to be able to use a short-circuited rotor and so save the expense and difficulties attached to rotor regulating resistances, and it is possible to start up against full load torque with a current not exceeding $1\frac{1}{2}$ times full load current. This clutch will slip when the torque reaches a certain figure, and so prevent the motor falling out of step.

Full particulars of these electrically driven Capstans, together with references to installations which have been put in by Messrs. Crompton & Co., can be obtained on application to the offices of the Company at Salisbury House, London Wall, E.C.



Crompton Railway Capstan, shown open.

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Electric v. Hydraulic Power.

There are many industrial operations in which hydraulic power is still largely used, and the advocates of electric driving have made little or no headway in displacing them, even though superior economies for electrical operation may be shown. Presses and riveting machines particularly remain faithful to hydraulic power, because the latter is found to be both silent and mechanically simple and efficient. By degrees, however, the electric motor is making headway and bids fair to impress the adherents of hydraulic power with its merits. In combination with a screwed shaft, it is possible for a powerful motor to perform riveting both silently and efficiently. The introduction of a magnetic clutch adds a little to the complication, but the device is lighter than a hydraulic riveter of the same capacity. Certain kinds of press work should be possible with a motor driving a threaded shaft operating a ram, by which the pressure might be applied. As with many other operations, the electric motor is brought as near to the doing of the work itself as possible, and we find that force pumps are driven by motors to control the water supply to the hydraulic accumulators. An advantage of the electric drive in this case is that the control can be made quite automatic, the pressure in the accumulator being maintained constant by the starting and stopping of the motor at the desired times. It is some consolation to the electric power engineer that, though he may not be able to drive the machinery direct, he introduces the motor to operate one of the essental portions of it.

Relative Costs of Power.

The relative merits of water, gas, oil and steam for producing power to drive dynamo electric machinery are somewhat difficult to tabulate because the conditions which influence the cost of each vary widely according to geographical situation. No hard and fast lines can be laid down for the use of any one of these sources of power, and local conditions must be the principal index to the selection made. Some figures presented in America before the American Electro-Chemical Society by Prof. Lucke are of interest, though the author of them laid stress on the qualification which must be applied to allow for the factor of location above mentioned. Assuming a 24 hour load in each case, a certain size of plant was selected for each prime mover. In the case of oil six 250 H.P. units, for steam six 5,000 kw. engine driven sets, and for gas six 1,000 H.P. units. Under these assumed conditions the costs for the plant and the energy produced were given as follows: Water power costs per kilowatt £15 to £40, and £1. 12s. to £5 per kilowatt-year; oil engines £43 per kilowatt installed, with a yearly cost per kilowatt of about £16; gas engines were estimated to cost £50 per kilowatt and would give a kilowatt-year for £13, while steam plant, the most costly of all, would require £22 to £30 per kilowatt for its purchase, and the cost per kilowatt-year would be £17 to £19. The estimates were based on a 100 per cent. load factor, and are, of course, only approximate, though they may be taken as fairly comparative of the merits of the respective power sources. Prof. Lucke gave it as his opinion that gas plant would be cheaper than steam with a high load factor and that the difference would be greater the greater the cost of coal.

The Isolated Plant Problem.

THE opinions we expressed in our last issue on the subject of co-operation between makers of electrical plant and suppliers of electrical energy in bulk were of some interest to power-station engineers, and we have received comments upon them which we publish below. Although neither of the letters express coincidence with our views, the opinions given throw an interesting light on the subject.

The letter below is from Mr. A. H. Seabrook, engineer and manager West Ham Corporation. It says:—

"Your article in the May 31st issue of the SUPPLEMENT discusses a matter that is of peculiar interest to us in this district where there are many isolated factory power plants, some having a capacity of 3,000-4,000 H.P. I am glad to say that in many cases we have entered into agreements to supply in bulk, and in some instances the factory plants are being shut down altogether, but the difficulties in the way of forcing in the supply are only appreciated by those who have experienced them. The competition of the electrical manufacturers, however, I would say right here, is one of the smallest difficulties. The best and largest firms co-operate with us and in many cases have endeavoured to push in the supply, in one case to their detriment. A factory which was determined to extend its own plant, regardless of the expense and waste in so doing, refused to send the inquiry for generating plant to a particular electrical manufacturing company because the latter had been recommending them to go on to the supply. Needless to say, we shall not allow the firm in question to lose over the matter. An understanding on the matter between the manufacturers and supply concerns cannot fail to be beneficial."

A "Chief Engineer" contributes the following:—

"My experience is that large industrial users of electrical energy prefer to take their supply from an outside source rather than instal plant of their own, and consequently we do not have competition to any appreciable extent between private users and the local authority, through both purchasing generating plant from the same makers. The majority of manufacturers have already either steam or gas plant of their own for actuating their machinery, but with the decrease in price of the public supply for power purposes, we find that private plants are abandoned when they have depreciated beyond a certain point, and almost every week we get an application from some considerable industrial user who wishes to have his motors connected to the mains. The reason of this growing preference on the part of manufacturers to take their power supplies from the mains would seem, partly at least, to be in keeping with the general trend of the time towards specialisation. There would appear to be a growing conviction among manufacturers that they can more profitably utilise their capital and their energies in the development of their own particular business, such as locomotive buildings, &c., rather than in the generation of electricity. They still think, I believe, that our supply is slightly dearer than what they could do it themselves for, when they are sufficiently busy to keep all their plant going fairly constantly, but at the same time they realise the great convenience and the economy to be obtained from the facility with which they can partially use their plant during times of slackness or during overtime when perhaps only one or two motors are required for a special job. Of course, with private plant the running cost goes on irrespective of output. With regard to the particular suggestions in your article, I do not see that we can interfere with engine builders in the way you mention. The operation of the laws of competition is still I think sufficiently strong and far reaching to enable the engine builders to sell their wares to whom they will, and at whatever prices the state of the market enables them to command."

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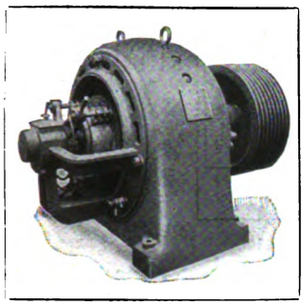

Continuous-Current Motor or Dynamo for Rope Drive.

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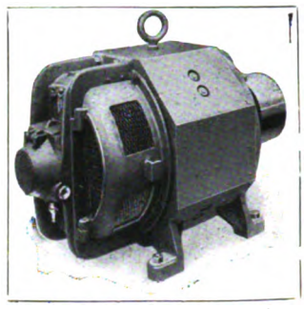
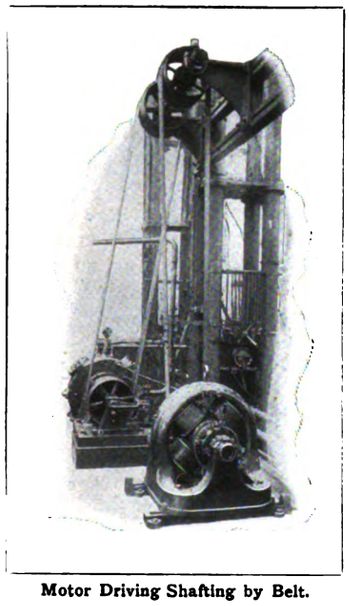
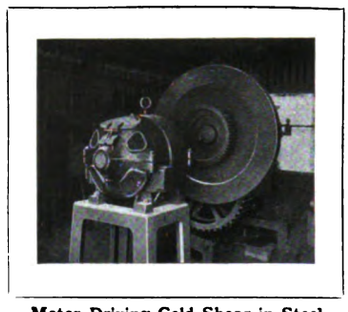


Continuous-Current Enclosed Ventilated Motor.

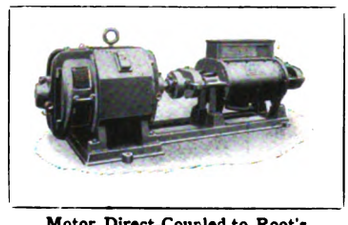


Motor Driving Shafting by Belt.

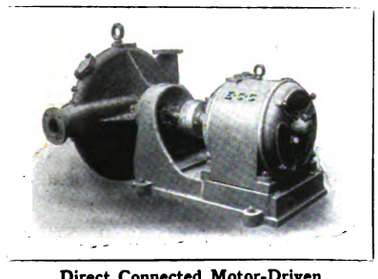
E.C.C.



Motor Driving Cold Shear in Steel Works.



Motor Direct-Coupled to Root's Blower.



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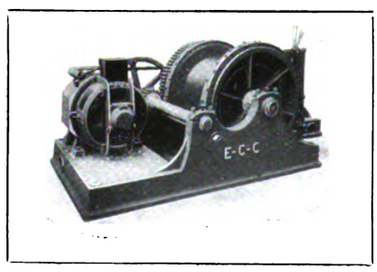

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Automatic Motor Starters.

THERE are many instances in which automatic devices are required for the starting and stopping of motors. Organ blowing, pumping, air compressing, certain classes of machine tool work, &c., can be adapted for the use of automatic controlling devices. Messrs. Siemens Bros. Dynamo Works (Ltd.) have a number of standard automatic starters which can be applied for work of this kind.

A type of starter is made for operation by belt under conditions which allow of the starter being placed close to the motor. It comprises a step-by-step resistance switch, resistance box and governor, which is steadied by a glycerine dash-pot. The switch consists of a row of fixed spring contacts, a varying number of which is caused to make connection with a copper bar by the action of the governor. The governor itself is driven by belt, and the bar is pivotted on one end and moves backwards and forwards by the governor spindle. When the motor stops the governor weights fall together and the copper bar is moved away from the contacts by springs. If the motor speed falls similarly the governor inserts resistances automatically in the armature circuit. This starter is made in sizes from 5 H.P. to 30 H.P. and pressures up to 600 volts.

Another type is a motor-operated automatic starter by which resistance is gradually cut out from the armature circuit. The rate of acceleration is independent of the speed of the main motor. It will be noticed from Fig. 1 that the motor is mounted below the multi-contact switch, and this shaft is coupled through a universal joint through the worm which drives the main wheel. This worm is made to engage with the wheel by a small magnet coupled in paralled with a small motor. A small tripping switch serves to control the motor circuit. The multi-contact switch is moved against the pressure of a spring, so that when the driving motor is disconnected the worm leaves the spindle and the switch returns to the off position. A strong buffer is fitted to take the blow of the switch-arm on the return stroke. Fig. 2 is a diagram of the connections for this pattern of starter.

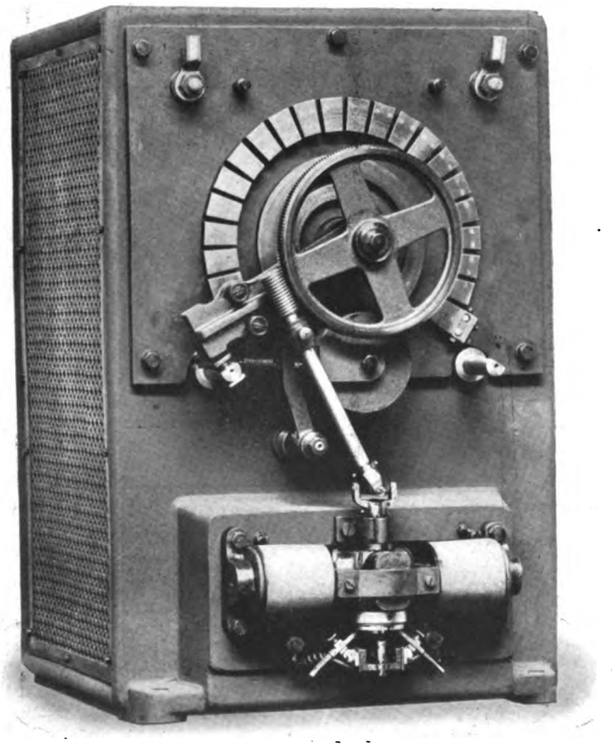

Fig. 1.—General View of Motor Operated Starter.

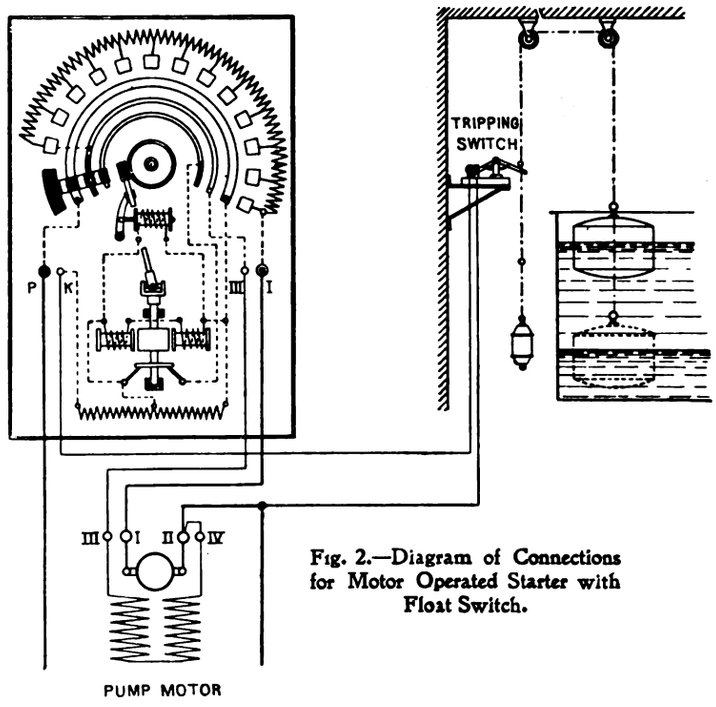

Fig. 2.—Diagram of Connections for Motor Operated Starter with Float Switch.

There is another type of motor-operated starter, which is fitted with a step-by-step spark extinguisher. The motor, starting switch and resistance are all built up on a single iron frame. The motor speed is reduced by double worm gearing to the starting-switch spindle, so as to ensure very gradual acceleration. This motor also operates the spark extinguisher. The latter diverts the motor current from the main contact brush to a more substantial auxiliary switch, upon which the breaking spark takes place. The arrangement made is to shunt each contact of the starting switch with this special breaking switch as the motor is speeded up. When the main brush is moved to the next contact the auxiliary switch opens the circuit in the preceding notch. If the contacts of the sparking switch are badly burned a special contact comes into operation and short-circuits the coil of the no-voltage release, thereby giving warning of the state of the main contacts. The switch motor can also be made to give a variable speed of from 1 to 1·5. This type of starter can be operated from either a hand or automatically actuated tripping switch.

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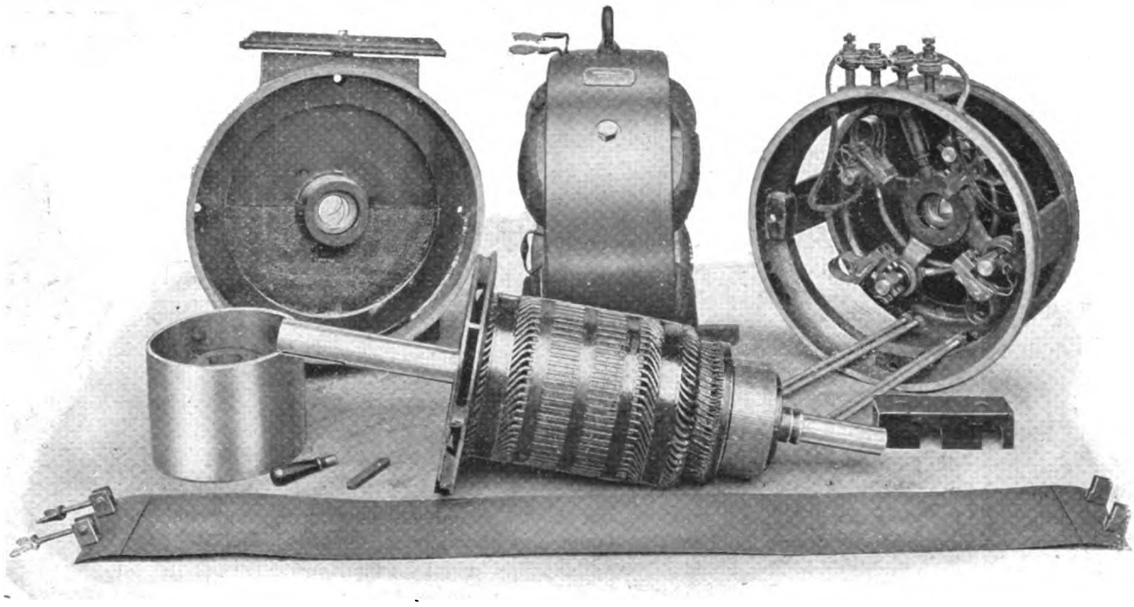

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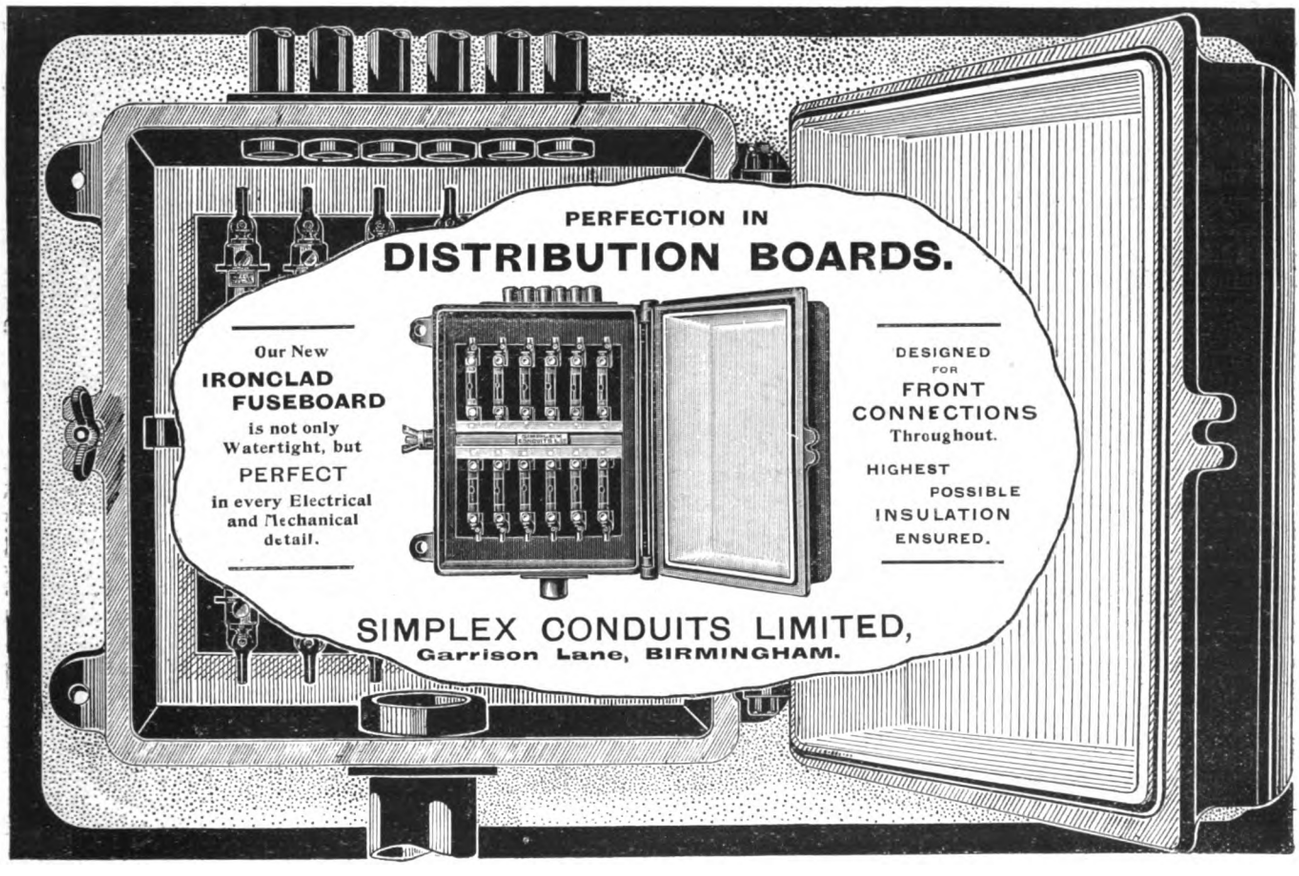

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Electric Centrifugal Pumps.

THE electric motor has been proved suitable for coupling, by means of gearing, to ordinary plunger pumps and is giving excellent service in this connection in many important pumping plants. Whereas it has become a valuable accessory to this type of pump it has practically revolutionised the design and construction of rotary pumps,

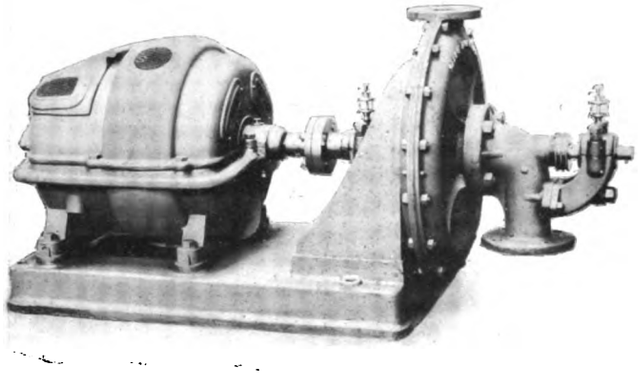

Fig. 1.—2 in. Centrifugal Electric Pump.

more particularly the centrifugal pattern. Centrifugal pumps are essentially operated at high speed and the most efficient power agent to operate them is one, such as the electric motor, which can be designed conveniently to run at any speed.

The direct-connected electric centrifugal pump has now been on the market for several years. It is interesting to note that the multi-stage centrifugal pump is one of the most important results of the combination of the high-speed motor with the high-speed rotary pump. Whereas at one time several motor-driven single-stage centrifugals were connected in series for high lifts, it was found possible to produce the same result with a single motor coupled to a pump which concentrated the revolving elements of several pumps in one casing. This reduction of the pumping sets to a single unit effected a great saving in pipe work and excavations in the case of mining and other underground operations. There appears to be the most conclusive evidence obtainable to justify the existence of the electric centrifugal pump.

We illustrate in Fig. 1 a 2 in. centrifugal Tangye pump, designed for high efficiency. We understand that several of these have been installed in the basement of high buildings in Indian cities to supplement the water pressure on the mains. Also they are useful to raise water to floors beyond the heights reached by the supply pressure. The pump, as will be seen, is direct-driven by an enclosed motor, and its duty is 2,000 imperial gallons per hour raised to a height of 100 ft. The pump is of the single stage, and is mounted with the motor on the same baseplate. Fig. 2 depicts another Tangye pump of a larger pattern, driven by an open type direct-current motor. It is installed in a Liverpool cold storage building, and its duty is to deliver 35,000 gallons per hour against a head of 95 ft. The pump is a combination of two single stage centrifugals, and the outlet branches are 6 in. diameter. The motor is a shunt machine, rated at 42 B.H.P. when running at 965 revs. per min.

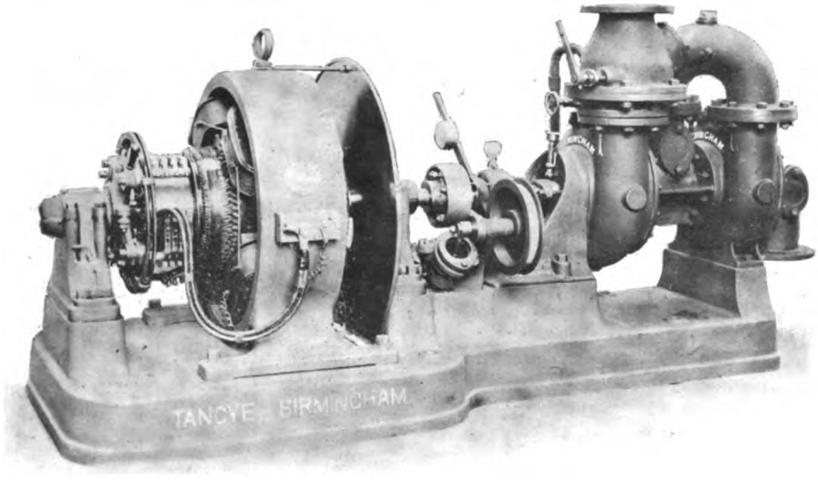

Fig. 2.—D.C. Open Type Motor Coupled Direct to Two-Stage Centrifugal Pump.

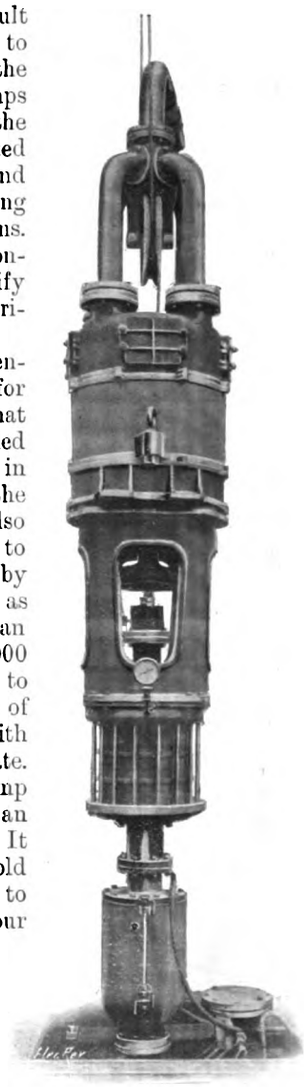

Fig 3.—Vertical Motor-driven Sinking Turbine Pump.

A recent development of the electric centrifugal is the sinking pump for shaft and boring operations. This is usually suspended by chains, and the motor is mounted above the pump, the whole forming a light, compact unit. An illustration of a vertical pump of this pattern is illustrated in Fig. 3, the design being by Mather & Platt. Where electric power service is available these pumps are found extremely useful for temporary water-raising purposes. They are also built in standard sizes and are quickly obtainable.

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Notes and Observations.

IX.—Hot Steel and Cold Facts.

"WE'RE not played out yet in this country. There's another century before coal and steam and mechanical transmission of power."

"Unofficial" chats and a quiet smoke with power users are not often my lot in these hustling days, but this was an exception. William Makepiece, Esq., was also an exception—that is, to the general electrical rule prevailing in the M—— district of S——shire. His name suited him, too. He made steel pieces, or, in other words, he ran a steel works.

"You electrical engineers are a mighty sight too conceited. The earth isn't yours yet, you know," he remarked, with emphasis.

"We are given to looking ahead, I will admit," I replied; "but, you see, we can't help it. Once let yourself be captivated with what I may call 'the electrical idea,' and you imagine yourself at the centre of everything."

"What a conceit! A steam engineer was never guilty of such arrogance," he answered, between vigorous pulls of his cigar.

"Naturally, because it was never in him. He's had no end of a job to keep up with his reputation. One does not rhapsodise over steam boilers and coal heaps, belts and gear wheels. These have only the soul which the engineer puts into them," and I rapped out each point with bangs on the table.

"Excellent, my friend, excellent. But doesn't the electrical engineer want the coal and the steam engine of the mechanical engineer?" said Makepiece, after a moment's reflection.

"The coal, yes, but not the engine, or, strictly speaking, not the same engine," I answered.

"But you must drive the dynamo by steam—" he began.

"— turbines," I interrupted. "That is the revolution in prime movers electrical engineering was intended to effect. Revolution in both senses, for the word, as you see, has a double meaning."

"Gimcrack whirligiging things," he cried. "Fancy a few of them in my steel works!"

"Compare Watts' Soho 'infant' with the engines of a battleship," I suggested, "and you draw a parallel between the steam turbine of 20 years ago with the machine of to-day."

"We are deviating slightly," he remarked. "You said, at the outset, that this country had to fear competition abroad in the applying of natural power means to modern industrial ends, and you set out to prove it."

"So," I said. "But a digression was needed to convince you that electrical engineers had in the steam turbine the best available means of turning the latent energies of coal to good account—that is, of course, in countries where coal exists in abundance."

"Well, go on from there," said Makepiece. "I am as far from conviction that electric power can be of much help to me; but I like to consider possibilities which may become eventualities after my own day."

"Firstly, in the international race for supremacy we are naturally fortunate. Our insular position and abundant supplies of coal and iron give us a long start. With power and materials we can manufacture, and with big ships we can transport, cheaply, too. An enormous coast line and short cross-country railway routes also contribute largely to the net result. We are both makers and suppliers for the world."

"All very palpable," interjected Makepiece. "Now, what about international rivalry and competition?"

"At one time," I continued, "they were both non-existent. But we have no monopoly of coal, iron or other natural resources. Our neighbours have awakened and have started where we left off. They are drawing level, and the competitive factors in the equation will soon have altered values."

"In what way?" he asked.

"Now, it is transport that gives us the lead," I answered. "In production our competitors are already abreast of us. But they have not yet the same facilities for entrance of raw material and the exit of finished goods."

"So that if we can maintain our shipping efficiently we can not only continue to compete but can do so successfully," said Makepiece, with awakened interest.

"Not altogether," I replied. "What time we gain in transport we may lose in production."

"How can that be possible?" he said, appearing puzzled.

"Take your own case," I went on. "You contract for a supply of steel ingots to a rail maker who is competing with American and Belgian firms for railway work. The foreigners have both electric furnaces and electrically-driven rolls. You, as Britishers, rely on steam. The others convert water power into electrical energy for the heating and power processes. Coal is your servant from A to Z."

"What then?" Makepiece inquired.

"Well, they produce more quickly than you can by 25 per cent.; they will guarantee a more regular quality of stuff because of better furnace control and a more uniform section from the mill, which runs steadier. Your gain on

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delivery would disappear entirely when compared with their increased productive capacity; even if you beat them on time the quality would turn the balance against you."

He puffed quietly at his third cigar and watched the smoke curl about the gasolier. (He was consistently anti-electric.) It took some time to arouse him from what was a deep mental analysis of the subject.

"Where are these electric furnaces and rolling mills?" he asked, with a start from his reclining posture. "They have not started to compete with us yet. I saw some toy furnaces abroad five years ago and have heard nothing more of them since."

"You should read the electrical journals," I answered. "You would then see that what five years ago was the cloud on the horizon no bigger than a man's hand has now perceptibly increased in size."

"Well, I consider my business safe for another ten years without making the slightest alteration to the plant. Why, damme, sir, you think a 10 ton electric furnace and a few motor-driven live rolls are going to shut down steel makers of my calibre," said Makepiece. "And because these things are done abroad you imagine we should experiment as well. While we have coal we can make steel."

"Yes, and when your foreign rivals develop cheap water power you will cease steel making altogether," I replied.

"Oh, Aye! Sounds very well," he said; "but water-power and iron don't 'occur' together. We get the pull at the mine in having coal and iron as neighbours."

"Well and good for you that it is so. In fact, this is the greater reason why you should take up the electric furnace."

"What, first convert coal into heat to raise steam, turn a turbine and dynamo, transmit by cable, and then melt steel by electric heat! What a rambling business compared with heat direct from coal or coke!"

Makepiece was getting excited. "You want to increase our difficulties instead of making matters more simple."

"Leave the furnace out of it for a moment," I remonstrated, "and take all the subsidiary operations of handling material, ladles, casting boxes, ingots, and rolling of blooms, rails, &c. You know these are best done by electric power."

"Well," he said, in reply, "I will admit that the electric driving I have seen in steel works is vastly more convenient and expeditious than steam. I have no electric power in my own works, but I will, for the sake of argument, concede this point."

"To get this electrical energy you want gas or steam engines, and of considerable output, too. The only department minus electric power would be the furnace section. If you could get the right type of furnace and be assured of its efficiency, naturally you would put it in for the sake of uniformity throughout the works, and in the interest of efficiency." I made this suggestion knowing he would unconsciously query its feasibility.

"Whatever for?" came his prompt and expected answer. "For the sake of uniformity and efficiency. Why efficiency?"

"The load on the cranes, rolls and other machinery would not as a rule coincide with that of the furnaces. The furnace section would supplement the power section, and uniformity and efficiency would result."

He was wrapt in thought for some time. Then he looked across at me and said:

"It's quite delightful to talk about, but still a dream. Electric power in steel works has made little or no headway."

"Your lack of knowledge surprises me," I retorted at once. "But a moment ago you admitted the value of electric power in the machinery section of a steel works, and confessed to a sneaking regard for the electric drive."

"I did, certainly," he rejoined; "but it's nothing."

"If attacks in the rear are nothing," I answered, "then it does not count. But it certainly is a flanking movement of great importance. We are electrifying the plant about a steel works, and meantime have the electric furnace behind our back. The steel maker already swears by the one, and will very soon want the other."

"Then where does the foreigner come in with his water power?" asked Makepiece, who looked confused.

"He's on the horizon, but we can keep him there a time if you steel makers will be a little less sceptical and grasp the hand of the electrical engineer with more warmth.

I said this as I rose to go, for it was past midnight.

"Anyway," he said smiling, as he took my hand, "I can give you a hearty handshake to-night as an earnest of my regard for an optimist of the first water, who has left me plenty to think about on the future of steel making. Good night."

W. E. W.

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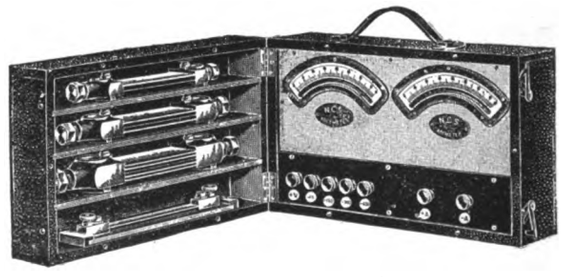

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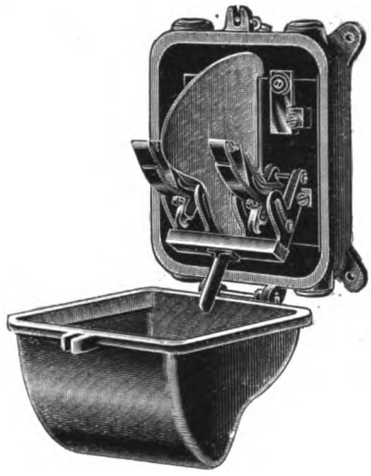

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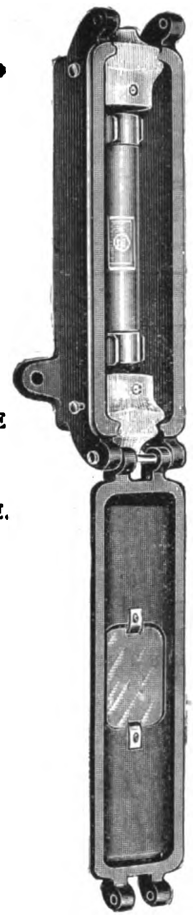

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Competitive Power Supply. . . . .

IN the opening article in the "Supplement" last month we commented on the competition between makers of dynamo electric machinery and large power supply undertakings, suggesting as a remedy some "working arrangement" between the parties which would mitigate the consequences of this class of competition. We give in another portion of this issue the opinions of two station engineers who have expressed their views on the subject. At the moment of going to press we have received the following from another power supply manager:—

"Although the objection you point out certainly exists, I do not see how it is to be eliminated. It might be possible to come to some arrangement with the firm or firms supplying generating plant to power companies not to instal isolated plants within their areas, and then only if they had the monopoly of supply of generating plants to the power companies. I do not see what influence could be brought to bear on other suppliers of plants. Outside of this question altogether it must be borne in mind that a power company has not a monopoly of supply within its area, but is in keen competition with other forms of power, including suction gas, improved steam plants, town gas (the rates for power in many districts have been considerably reduced.)

"To my mind a much more serious obstacle to the industry is the publication of the actual costs to generate and deliver electricity at consumers' terminals and the extravagant statements made by those who ought to know better, published from time to time in the press, of what can be done in the way of producing cheap electricity for power, have done much to increase difficulties of power companies in maintaining their prices.

"These statements and figures are used as levers to force down prices. They have the effect of deceiving the probable consumer, who not unnaturally considers that he will be overcharged; the suppliers of plants do not undeceive them, and so orders for isolated installations are booked. The owner of the isolated plant, who no doubt is expert at his own business, generally fails to grasp the technicalities of cheap electricity production, and the sum total of his bill for power is largely in excess of what he would have had to pay if he had taken it from a power supply company. The error is found out too late to profit the power company; the manufacturer does *not* publish his working figures, so that he cannot be held up as 'the awful example' to others."

This is a matter of considerable importance, and yet is one most difficult to cope with. The manufacturer is in the peculiar position of having to compete with rivals, and naturally he is most unwilling to disclose figures which would give an idea of his productive costs. Electric power engineers are confronted with an obstacle here which tends to block the way to extensions of the power service. A maker becomes a consumer on the power mains, and, reaping considerable benefit, refuses to make public the manner in which the new power agency has benefited him. By so doing he would be helping the power engineer to provide his competitors with the same means of improving their business. The manufacturer who has put down his own plant in preference to the electric power service is naturally averse to publishing his working figures if he has found the experiment more costly than he anticipated, though, even if his experience were to the contrary, he would be even less desirous of making his production costs known.

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Refrigerating Plants.

THE weather now prevailing is rather suggestive of refrigeration than of a need for it. Still if one electric refrigerating plant does not make a summer a number of them can contribute materially to the power load. In this country there is not the same demand for ice as exists abroad, and no serious attempt appears to have been made to encourage the use of refrigerating plant for the production of ice in small quantities. A feature of the more recent patterns of plants is the automatic control which may be procured when the apparatus is electrically driven. With a small motor operated from the supply mains, the temperature of the plant can be made to govern the production of the ice. According to a writer in the *Electrical Review* of New York there are distinct advantages to be gained by the use of automatic plants. It is stated that "in a general way it will pay to instal an automatic plant where the maximum ice consumption is between 800 lb and 12,000 lb. in 24 hours. In an automatic plant 1·5 H.P. will produce in 24 hours an amount of refrigeration which will be represented by the melting of 800 lb. of ice; 2 H.P. represents 1,500 lb. of ice in 24 hours, and so on, up to 15 H.P., which is equivalent to 9 tons of ice. The powers quoted will not actually make the ice specified, because the freezing tank must be kept cold as the ice is being frozen. In practice a well-designed plant will make about 60 per cent. of its refrigerating capacity—that is, a plant which would peform the same amount of work as 10 tons of ice would perform in melting, would make six tons of ice.

"Ice, in a well-insulated refrigerating space of 9,900 cubic ft. (30 ft. by 33 ft. by 10 ft.), can maintain a minimum temperature of 45°F. in hot weather, and will cool about 7,800 lb. of food supplies during 24 hours. This service will require 5,200 lb. of ice each day, or 78 tons a month, which at 12s. 6d. a ton will cost for each hot month about £48. 15s.

"Equivalent mechanical refrigeration, in the same space and under like conditions, will produce the same temperature of 45 deg., or will produce the usually-desired cold storage temperature of 36 deg., but in a smaller space of about 5,800 cubic ft. (24 ft. by 27 ft. by 9 ft.), and will cool about 8,100 lb. of food supplies per day. This work will require about 2,668 kw.-hours per month if operated continuously, and if the rate for electricity be 2d. per unit the cost for each hot month, including the necessary cooling water (43s.), will be £24. 12s.

"In other words, if the current and cooling water used during a hot July or August amounts to £24. 12s., the annual cost of operation should not exceed six times this amount, or £147. 12s. With ice, using 5,200 lb. per day at a cost of £46. 16s. for a hot month, the annual consumption would be about £230. 16s. This would show a saving of £139. 6s., and in about three years would be sufficient to pay for a 5 H.P. automatic plant. In this comparison, an outside temperature of 90 deg. was assumed in calculating the refrigerating work for the cubic foot spaces mentioned, but less severe weather conditions will allow either an increase of cold storage duty or decrease in the running hours of the equipment per day. With the surrounding air at 80 deg., about 11,700 lb. of supplies can be handled, or the equipment will operate 20 hours instead of 24 in cooling the 8,100 lb. previously mentioned. At 70 deg. the apparatus will run 16 hours to cool the 8,100 lb., or will handle a maximum of 17,500 lb. Any less demand for refrigeration will reduce the running hours of the machinery per day, and hence the cost of power."

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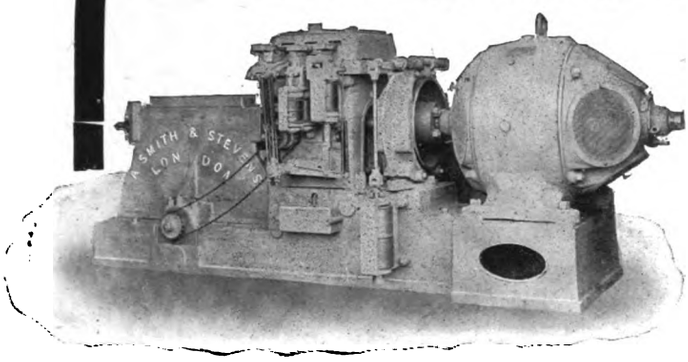

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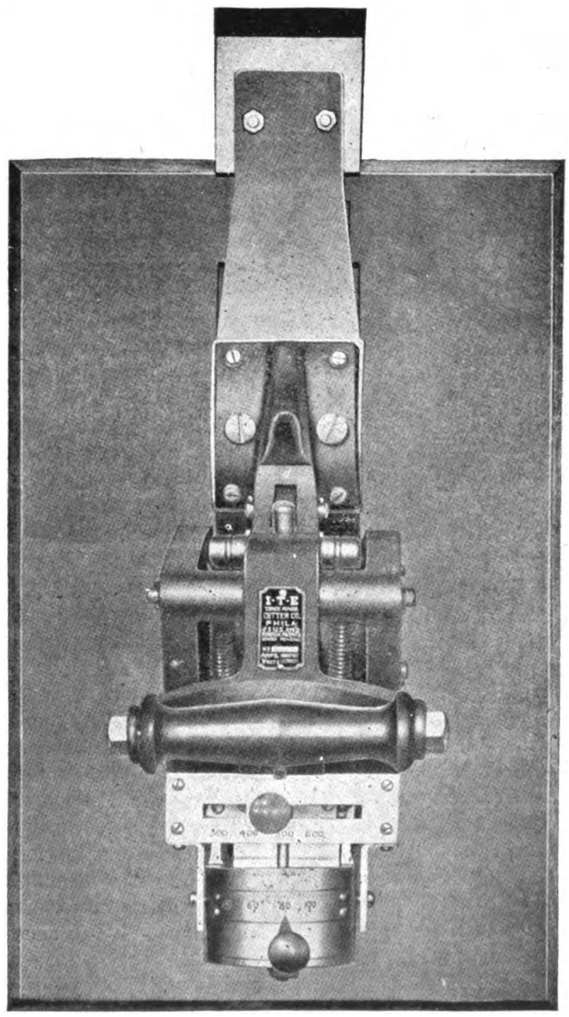
Time-Limit Circuit-Breakers.

THE value of the circuit-breaker for the control of industrial power circuits has been enormously enhanced since the introduction of time-limit devices. The fuse has always been preferred because it possessed a time element by which the circuit was maintained under sudden but short rushes of current. The circuit-breaker without any time check would probably, under similar conditions, open and unnecessarily throw the load off the circuit controlled.

With a time-limit attachment, however, the same circuit-breaker would remain in, and only under sudden and maintained short-circuit or overload conditions would it open circuit. The I.T.E. Electric Co., 20 Great Russell-street, London, W.C., has adopted a form of time-limit device which was due primarily to a British inventor, Mr. J. G. Statter. In the adjoining illustration we show the company's standard overload type "L-L" circuit-breakers fitted with this time-limit attachment. It goes under the name of "Dal-Ite," this word being formed of the initial letters of the sentence, "direct acting limit inverse time element." The device consists of a cylindrical vessel containing a circular disc suspended from the armature attached to the tripping latch. The seat is formed for this disc by the bottom of the vessel referred to. The faces of the disc and seat are accurately surfaced and the disc is supported in such a way that it can adjust itself to the main seat. This disc is surrounded with a shallow bath of special oil which excludes air from the two surfaces, these being supported by a thin film of the oil. The adhesion of the surface and the fact that the disc is connected to the releasing armature of the circuit-breaker give the requisite retardation to the moment of opening. The amount of restraint imposed upon the armature can be regulated by turning through a definite angle the seat with which the disc engages. The shape of both the contact surfaces resembles that of a two-bladed screw, and it is obvious that these surfaces can be so set in relation to each other that either a minimum or maximum of contact is obtained between them. The adjustment required is very simply effected by moving round the surface already referred to as the seat of the disc. The outside of the cylindrical box is graduated for this purpose, and the box bottom is fitted with a knob and pointer which can be set to the required number of seconds at which the device will operate.

It will be readily understood that to separate the disc from its seat a definite pull must be given, and the stronger this is the more quickly the circuit-breaker will be released. Sudden jerky movements of the disc are not sufficient to cause it to leave its seat. The time element of the device is inversely proportional to the pull of the overload magnet, which in turn is proportional to the square of the current. We may say, therefore, that the time required for the opening of the circuit-breaker is inversely proportional to the square of the overload current or directly proportional to its heating effect. The time-limit attachment is fitted to



I.T.E. Circuit-Breaker with Overload and Time Limit Attachment.

the alternate or direct circuit-breakers of the company, and is applicable to circuit-breakers fitted with overload, no load and reverse-current tripping coils. We may remark here that in all the standard circuit-breakers of the I.T.E. Company the release of the latch is effected directly without the use of relays or separately energised tripping coils.

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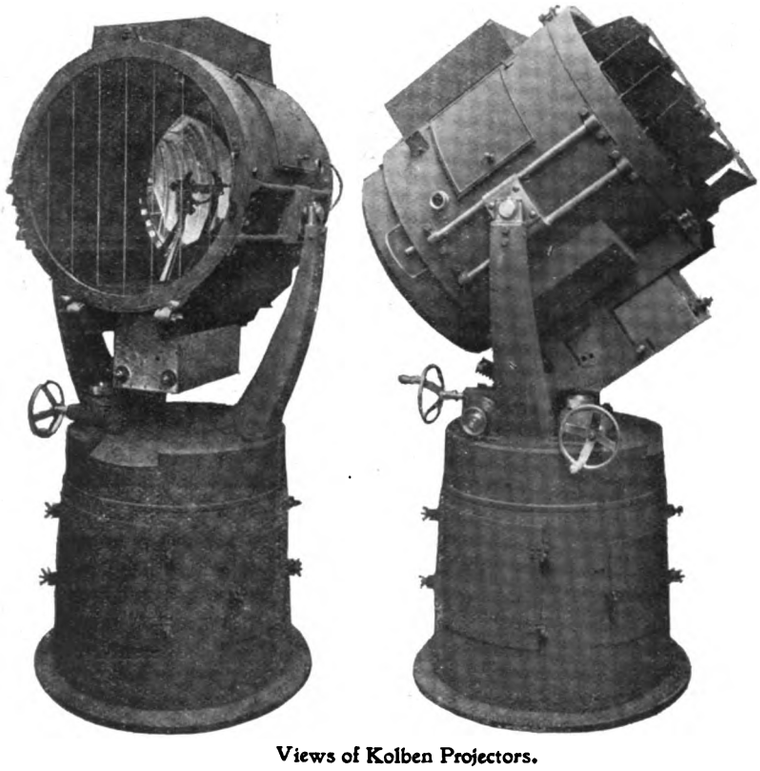
Kolben Projectors.

MESSRS. KOLBEN & CO. are putting on the British market a standard line of projectors, which are made for either hand or distant electric control. The lamp for these projectors is of the horizontal type and can be controlled either by hand or automatically. In the latter case, series and shunt magnets are employed for striking and regulating the arc. The carbon holders are fitted on two small trucks, the travel of which is regulated by a toothed wheel driven by a ratchet and pawl from the magnets. The lamp control can be changed over from automatic to hand by a small switch at the back of the lamp box, which breaks the control magnet circuit. The arc itself is deflected by a special magnet, the core of which is concentric with the positive carbon. This arrangement repels the arc downwards, so that the crater forms in the centre of the carbon.

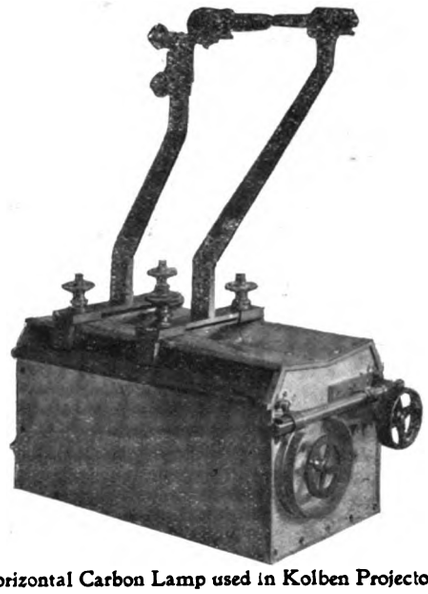
A parabolic mirror of Bohemian glass is fitted, and the silvering medium is covered with a protective coating. It



Views of Kolben Projectors.

is secured by a cast-iron mounting packed with asbestos, a number of spiral springs between the mounting and the end ring of the barrel being provided to absorb shocks from gun concussion. A series of plano-convex prisms with vertical axes is fitted to furnish a beam of light which will cover a wide area at short range. To comply with Suez and other canal regulations a diverging lens is included by which a dark shadow can be thrown straight in front of 5 deg. divergence. Fitments of the barrel are such as to comply with all requirements of ventilation and access to the working parts. Sight holes are fitted for inspecting the arc, and the focus can be adjusted through a peep sight on the barrel top which admits of an inspection of an image of the arc on a small ground glass disc.

Steel sliding rods support the barrel trunnions, and a cast-iron turntable carries the barrel-supporting brackets. This turntable is placed upon ball bearings, the lower race of which is in the top of the pedestal. In the case of distant control of the projectors, two shunt motors are fixed in the pedestal, and these govern the vertical and horizontal movements respectively. The controller comprises

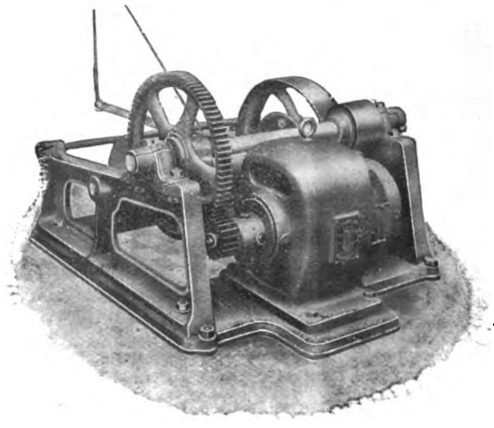


Horizontal Carbon Lamp used in Kolben Projector.

a circular box fitted with six push switches which give six motions as follows: up, down, right, left, middle, slow. The last two relate to the speeds at which the motions are fitted. We give illustrations of this projector and lamp.

Motor-driven Hoists.

LIGHT machinery in warehouses and works is, as a rule, very much neglected, owing in many instances to the out of the way position in which it is placed. It frequently becomes more of a time waster than a time saver, and one often sees small weights being raised to the upper floors of warehouses by means of hand winches at the slow speed of 10 ft. to 15 ft. per minute. This is the more surprising in that there are available at the present time cheap, quick, and economical methods of dealing with these light loads in which the cost for power would work out at a lower figure than the wages of a man with the



Motor-driven Hoist.

hand hoist. We refer more particularly to friction hoists an illustration of a standard type of which is given above, manufactured by Electromotors Limited, Openshaw. This firm have arranged a line of these hoists for speeds of 50 ft., 75 ft., 100 ft., and 150 ft. per minute, and for loads ranging from 1 cwt. to 30 cwts. They consist generally of a barrel driven through combined spur and friction gear by a compound wound semi-enclosed motor of the above firms' standard type. Many builders might with advantage consider their hoisting arrangements, as in the majority of instances the time saved would soon cover the small first cost of these hoists.

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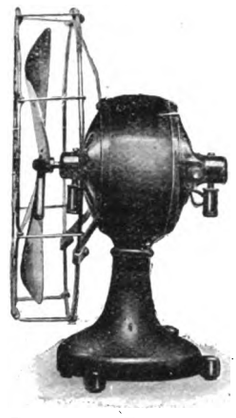
EDISWAN

Box Blade
Bracket
Trunnion
Porthole
Ceiling
Cabin
Ship
Standard
Desk
Oscillating,
etc.

Fans.



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FANS

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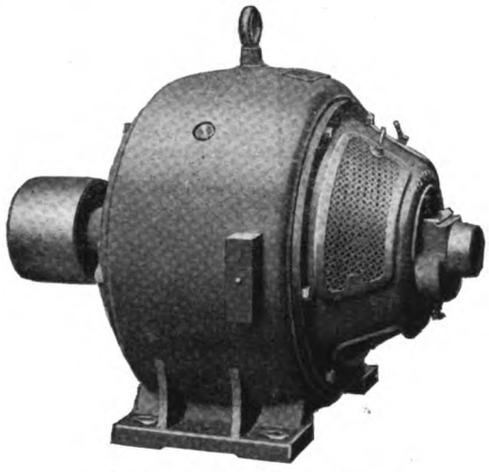
Silvertown Motors.



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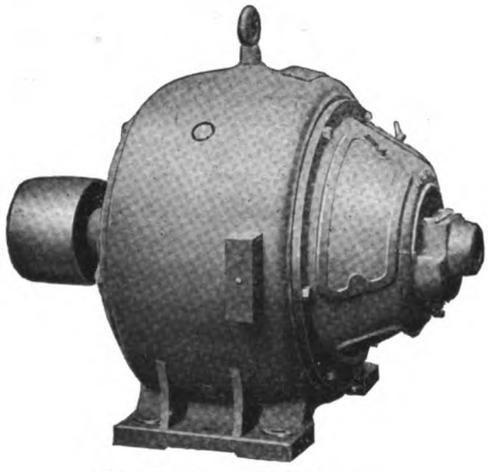

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NOTES.

The Radio-Telegraphic Convention.

LAST Tuesday the Committee appointed by the House of Commons to consider the desirability of ratifying the Radio-Telegraphic Convention concluded their labours by deciding to report to the House that in their opinion adhesion to the Convention would be to the best interests of this country. There is probably little doubt, therefore, that the Convention will now be ratified by Great Britain. Considering the very large amount of evidence given in favour of the Convention, as compared with the small amount of evidence against it, it is surprising to find that the decision of the Committee was carried by only the very smallest possible majority—namely, by five votes to four. There is little doubt among those who are untrammelled by commercial considerations that the Convention as a whole makes for the benefit of this country and for the general progress of wireless telegraphy, but this view does not seem to have been taken by the Committee with such unanimity as might have been expected. It will be remembered that the Committee consisted of eleven members, and therefore, pending the issue of the official report, we can only assume that two of the members refrained from voting on this important question.

The Tramway Accident at Carshalton.

ELSEWHERE we give an abstract of Major J. W. PRINGLE'S report to the Board of Trade upon the fatal tramway accident on April 1st last at Carshalton, when an electric tramcar was overturned. Briefly, the result of the inquiry is to add another regrettable accident to the list of those due to the conflict between the hand mechanical brake and the electric brake. In other words, Major PRINGLE has come to the conclusion that the wheels were locked by the energetic application of the hand brake, so that the electric brake became ineffective. Although the driver released the hand brake and sanded the track, so as to avoid any locking of the wheels, this attempt seems to have been rendered abortive by the action of the conductor, who, with every good intention, applied the hand-brakes from the other end of the car with sufficient force to lock the wheels and to maintain them locked. In the present case the tendency to overturn at the curve due to centrifugal force was complicated by shock, for, as far as can be judged, the speed at which the car was running was in itself insufficient to cause it to overturn; but the truck appears to have received a severe shock when rounding the curve, possibly due to the locked wheels binding in the track, and the sudden shock thus produced seems to have been sufficient to cause the body to carry the car as a whole off the track, and to make it overturn. At the conclusion of his report Major Pringle makes certain recommendations which should receive serious attention. He recommends in particular that men employed as spare drivers should be more constantly worked under service conditions than is generally the case; that on some tramway systems the conductors should undergo the same training as motormen, so that they may know how to apply the brakes with proper effect; and that two sand pedals, one at either end of the car, should be carried on all service cars. No doubt careful attention to these points will serve to increase the safety of the public, but it appears to us that the root of the evil in a case of this kind is the possible interference of an ordinary hand brake with the proper working of an electric brake; and so long as this system is adhered to there will be some danger that the driver or the conductor will fail in an emergency. The electric brake comes to be

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regarded as an emergency brake; thus on an emergency it is apt to be applied when the hand-brake is failing, and when in all probability the latter has locked the wheels and rendered electric braking impossible, unless the driver retains his nerve sufficiently to realise what is going on, and is able to control both brakes absolutely.

Spare Plant.

AN interesting point which was raised in the discussion on the Paper read by Mr. SHAWFIELD before the Incorporated Municipal Electrical Association last week, was the apparent absence in his estimates of an allowance for spare plant. Mr. SHAWFIELD'S reply to this criticism was that he had allowed for a 100 per cent. overload on his generating plant. No doubt this method of adapting the plant to supply an overload when necessary is in many ways superior to the older method of installing an additional machine. It was frequently the custom for this extra machine to be run at half-speed during heavy loads on the generating station, so that it would be ready at short notice to replace any of the other machines in use. In cases where this was not done, it was usual to keep steam on the spare engine, thus in either case increasing the standing losses. If, however, the generating sets are designed with a considerable overload margin, in the case of one of them requiring to be hurriedly shut down or disconnected from the supply the remaining machines will take up the extra load, obviating the slightest interference with the supply of current. The necessary capacity for withstanding a heavy overload seems to be best obtained by the use of turbine sets, for these have been proved in practice to possess this property to an extent impossible with reciprocating engines. Perhaps the only point requiring caution is the rating of the plant. If the overload capacity is taken for rating, the cost per kilowatt is, of course, very low; but if this rating is accepted, then there is no spare plant. On the other hand, it may be objected that, in the case of reciprocating engines, any spare set is generally included in the figure for plant capacity of the station. Where so much is a matter of opinion and definition it would seem more rational to rate generating plant on some such basis as motors, the rating being based on temperature rise and efficiency.

Municipal Wiring in Stepney.

AFTER the recent events at Woolwich, it seems somewhat rash for the Stepney Borough Council to have decided to take up the business of electric wiring in addition to that of electricity supply. Stepney is not, any more than Woolwich, a locality which can well afford to speculate, and therefore the Council might have done well to accept the experience gained at Woolwich without buying further experience, with the probability of throwing a burden upon the rates. The electrical industry is not in a very flourishing condition at the present time, and of all the branches of the business that of the wiring contractor is probably more "cut" than any other. It is, therefore, most discouraging to the contractor to find that he must meet rate-aided competition in addition to that to which he is already accustomed. When the Council have driven out private enterprise and found the golden harvest non-existent, they will, perhaps, welcome the contractor once more.

Incorporated Municipal Electrical Association.

ONE of the problems which the Council of the Incorporated Municipal Electrical Association do not seem able to solve is that of how to arouse the interest of the assistant engineers. When it is remembered that the chief engineers are outnumbered by their assistants by, say, five to one, it is unsatisfactory to note that at the present time the Association consists of 166 chief engineers and only 68 assistants. This latter number is six less than last year and 15 less than in 1905, and this notwithstanding the fact that the subscription has been reduced from half-a-guinea to five shillings. The Council each year have endeavoured to arouse the interest of assistants by offering prizes for the best Papers contributed by them, but there has never been any competition for these prizes. This year an offer of a £10 travelling studentship only brought forward one competitor. It is difficult to understand the apathy of the assistants in this matter, especially as success in this competition would have added considerably to the value of a candidate's testimonials when applying for any municipal vacancy. We think the apathy shown is caused by a feeling among the assistants that, as they are practically all prevented from attending the yearly Conventions, the Association has nothing to offer them in return for their subscriptions except the volume of *Proceedings*, the contents of which, moreover, they can read in advance in the technical journals. Unless meetings are arranged at which the assistants will be able to be present, and at which topics of more particular interest to themselves may be discussed, it is only to be expected that their enthusiasm for the Association will be of a lukewarm character. The interests of assistant engineers, whether in municipal or company undertakings, could probably be best served by means of a larger association not run on purely municipal lines. Much could be done by such an association in the way of improving the status of the assistants, and in removing some of the anomalies as to salaries which at the present time exist. We fear there is little chance of the Incorporated Municipal Electrical Association becoming less exclusive, and embracing all electricity supply engineers; but we hope that, if at any time an association of assistants is formed, it will differ in this respect from the senior institution.

Personal.—Dr. J. C. McLennan, who for some years has been director of the physical laboratory at Toronto University, has been appointed Professor of Physics at the university, in succession to Dr. J. Loudon.

Illumination Formula.—According to the "Brush Bulletin" the number of electric lamps required for lighting a room may be found from the following formula: Multiply the average length in feet by the average width in feet. Suppose, for instance, that the result is 250 sq. ft. If it be an important room, say, a drawing room, allow a quarter of a candle-power to each square foot, according to the decorations. About four lamps of 16 c.p. each or eight lamps of 8 c.p. each would suffice for this room unless it had a very dark shade of paper and furniture.

Cable Interruptions.	Date of Interruption.
Tarifa—Tangier	Jan. 18, 1904
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Panama—Buenaventura	Feb. 28, 1907
Buenaventura—Santa Elena	Feb. 28, 1907

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Public Health Congress.—At the annual congress of the Royal Institute of Public Health, which has been held at Douglas, a Paper was read on Tuesday before the Engineering and Architecture Section, by Mr. H. W. Wilson, of Liverpool, on the use of electricity for domestic purposes. The author dealt with the various uses to which electricity could be put in ordinary dwelling houses besides that of lighting.

Variable Speed Shunt-wound Motor.—According to the *Electrical World*, a patent which has lately been issued to Mr. J. C. Lincoln describes a means of controlling the magnetic field of variable-speed shunt-wound direct-current motors so as to prevent sparking at high speeds. A screw mechanism is arranged for withdrawing the armature laterally from the field structure in order to decrease the value of the flux passing through the armature. Beyond the field structure and adjacent to the armature when moved to its high-speed position is an electromagnet whose coils are connected in series with the armature and afford a commutating field. The auxiliary magnet is provided with three poles; the inner pole carries the main exciting coil, while two coils oppositely wound are mounted on the exterior poles so that their magnetomotive force may decrease the effective magnetism threading the armature and thereby prevent the usual drop in speed under heavy loads.

Franco-British Exhibition, 1908.—A meeting of the chairmen of the Executive committees of the "Engineering and Shipping" group of the Franco-British Exhibition was held on Wednesday afternoon, at which Sir William H. White, K.C.B., presided. Amongst those present were :—Sir Alexander Binnie (constructional engineering), Mr. T. H. Riches (mechanical engineering), Dr. R. T. Glazebrook, F.R.S. (electrical engineering), Mr. H. E. Jones (gas engineering), Mr. M. Deacon (mining engineering), Sir Hugh Bell, Bart. (iron and steel), Prof. W. Gowland (metals other than iron and steel), Dr. Francis Elgar, F.R S. (shipbuilding and marine engineering) and Mr. J. Dixon (shipping). The general opinion was expressed that the engineering section, which already covers several hundred thousand square feet of floor space, of which one-half will be devoted to the British section, should be materially increased, as from present indications it is fully anticipated that the demand will far exceed the space at the disposal of this committee, notwithstanding the fact that it will be the largest machinery hall ever constructed for an exhibition in this country. Meetings of the separate sectional committees are being arranged with a view to making the engineering and shipping departments the most important ever held.

Institution of Electrical Engineers.—We have received a proof of the cover of the reprint of the Wiring Rules, on pages 2 and 3 of which are given lists of the insurance offices and supply authorities who have adopted these rules and recommend their use. The following Insurance Companies are those who have accepted these rules for the basis of their requirements :—

Alliance Assurance Company; Atlas Assurance Company; British Law Fire Insurance Company; Caledonian Insurance Company; Central Insurance Company; Century Insurance Company; Commercial Union Assurance Company; Congregational Fire Insurance Company; Co-operative Insurance Society; County Fire Office; Ecclesiastical Insurance Office; Essex and Suffolk Equitable Fire Insurance Society; Fine Art and General Insurance Company; General Accident Fire and Life Assurance Corporation; Guardian Assurance Company; Hand-in-Hand Fire and Life Insurance Society; King Insurance Company; Law Union and Crown Insurance Company; Leather Trades and General Insurance Company; Liverpool and London and Globe Insurance Company; London and Lancashire Fire Insurance Company; London Assurance Corporation; National British and Irish Millers Insurance Company; National Insurance Company of Great Britain; Northern Assurance Company; Provincial Fire Insurance Company; Royal Exchange Assurance Corporation; Royal Insurance Company; Scottish Union and National Insurance Company; State Fire Insurance Company; Sun Fire Office; Union Assurance Society; West of Scotland Insurance Office; Westminster Fire Office, and Yorkshire Fire and Life Insurance Company.

Rhadoonite.—The *Elektrotechnische Anzeiger* describes a new insulating material known as rhadoonite, which is specially adapted for switchboard work and wherever insulating supports are necessary. Rhadoonite is formed of certain mineral substances combined with an agglutinant, which is partly organic and partly inorganic in composition. This agglutinant becomes soluble when placed in warm carbon disulphide and submitted to a high pressure. When in this state it is intimately mixed with the mineral substance, which is simultaneously submitted to the action of heat and pressure, transforming the whole into plates of Rhadoonite. These plates are from 10 to 40 mm. thick, they are like serpentine or granite in appearance or may be of a black tint and highly polished. This material becomes soft at temperatures between 80°C. and 120°C. according to the proportion of its component parts. Four plates of Rhadoonite which were tested in the physical laboratory at Charlottenburg were of a greyish yellow colour with black marbling. They were 16 cm. square and 23 mm. thick. An insulation resistance of 700,000 megohms was obtained, and after being kept for 24 hours in water the resistance only fell to 600,000 megohms. Rhadoonite is incombustible. This insulating material has the advantage of being easily worked with ordinary tools.

Birthday Honours.—The following are among those upon whom honours were conferred on the occasion of the celebration of the King's birthday :—

New Peer : The Right Hon. Sir James Kitson, Bart., M.P.

The Right Hon. Sir James Kitson is a well-known Yorkshire ironmaster. He was chairman of the Select Committee of the House of Commons which considered the original proposals for the formation of power companies, and many of the clauses inserted in those bills are now regarded as standard clauses. He was also chairman of the House of Commons Committee which dealt with the 1905 bill of the Administrative County of London.

New Baronet : Sir Charles Scotter.

Sir Charles Scotter is the present chairman and was the former general manager of the London & South-Western Railway Co. His electrical work has been chiefly in connection with the Waterloo & City Railway.

New Knight : John Gavey, C.B.

Mr. John Gavey is well known as the former Engineer-in-Chief at the Post Office, and is a past-president of the Institution of Electrical Engineers. He has done a large amount of work in connection with additions and improvements to the telegraph and telephone system of this country.

New C.B. : Dr. J. A. Ewing, F.R.S.

Dr. J. A. Ewing is the Director of Naval Education. He is best known to electrical engineers from the large amount of theoretical work he has done on the subject of magnetism. He invented the "permeability bridge" a "magnetic balance," a hyteresis tester, &c. He is the author of numerous works on engineering and allied subjects, including "Magnetic Induction in Iron and other Metals" in *The Electrician* series.

New Privy Councillor : Dr. R. S. Watson.

Dr. R. S. Watson, solicitor, and a director of the County of Durham Electrical Power Distribution and the Newcastle-upon-Tyne Electric Supply Companies, has been sworn of His Majesty's Privy Council.

The Imperial College of Science and Technology.—It is announced that the governing body of the Imperial College of Science and Technology is to consist of the following :—

Nominated by the Crown, the Right Hon. the Earl of Crewe, the Right Hon. G. W. Balfour, the Right Hon. Sir F. Mowatt, G.C.B., I.S.O., Sir J. C. Wernher, Sir W. H. White, K.C.B., F.R.S., and Dr. MacAlister (Principal of the University of Glasgow); by the President of the Board of Education, the Right Hon. A. H. D. Acland, Mr. F. G. Ogilvie, C.B. (a Principal Assistant Secretary of the Board of Education), Mr. J. C. G. Sykes (an Assistant Secretary of the Board), and Dr. R. T. Glazebrook, F.R.S.; by the University of London, Sir E. H. Busk, Prof. D. S. Capper, Prof. Farmer, F.R.S., Sir H. E. Roscoe, F.R.S., and Sir A. W. Rücker; by the London County Council, Mr. A. A. Allen, M.P., Mr. H. P. Harris (Chairman of the Council), Sir C. Kinloch-Cooke Mr. R. A. Robinson and Mr. J. T. Taylor, I.S.O.; by the City and Guilds of London Institute, the Right Hon. the Earl of Halsbury, F.R.S., (Chairman of the Council of the Institute), Sir J. Wolfe Barry, K.C.B., F.R.S., Sir Owen Roberts (Clothworkers' Company), Sir W. S. Prideaux (clerk to the Goldsmiths' Company), and Sir J. Watney (hon. secretary of the Institute); by the Royal Commissioners for the Exhibition of 1851, Viscount Esher, G.C.V.O., K.C.B., and Lieut-Col. Sir Arthur Bigge, G.C.V.O., K.C.B., K.C.S.I., K.C.M.G., I.S.O.; by the Royal Society, Sir Archibald Geikie, F.R.S.; by the professorial staff, Prof. Tilden, F.R.S., Prof. Gowland and Prof. Dalby; by the Institution of Civil Engineers, Sir Alex. B. W. Kennedy, F.R.S.; by the Institution of Mechanical Engineers, Mr. T. Hurry Riches; by the Institution of Electrical Engineers, Mr. R. Kaye Gray; by the Iron and Steel Institute, Sir Hugh Bell; by the Institution of Naval Architects, Dr. F. Elgar, F.R.S.; by the Society of Chemical Industry, Dr. E. Divers, F.R.S.; by the Institution of Mining Engineers, Mr. A. Sopwith; and by the Institution of Mining and Metallurgy, Mr W. McDermott.

We understand that the Draft Charter for the establishment of the college will be submitted to His Majesty for approval at the Privy Council fixed for the 6th inst.

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ON THE LOSS OF ENERGY IN THE DIELECTRIC OF CONDENSERS AND CABLES.

BY DR. BRUNO MONASCH.

(*Continued from page 418.*)

Summary.—After dealing with the subject historically, the Author gives a method of measuring dielectric losses and discusses the sources of error to be avoided. He then considers the effect of different wave forms, frequency, change of temperature, &c., and gives measurements on various dielectrics and cables. Finally, the loss occurring in cables under working conditions is discussed, and quantitative figures are given.

II. Realisation of the Method.

When using this method for applying it to the purpose in question, we meet with a number of difficulties and causes of error, increasing as higher voltages and smaller capacities are used. Great care was necessary in studying and removing these causes of error before reliable observations were possible. Some remarks may now be made as to these difficulties and the disposition finally arrived at.

1. *Charging-phenomena* in the cross-connection. — Their influence was removed by connecting to the earth the point B of the bridge (Fig. 1) and by reducing sufficiently the ratio of w_3 and w_4 to the impedances of the arms AD and AF.

2. *Leakages* between parts of the bridge and between the bridge and earth.—These were avoided by the use of paraffin on an extended scale for carefully insulating all the parts from one another and from earth.

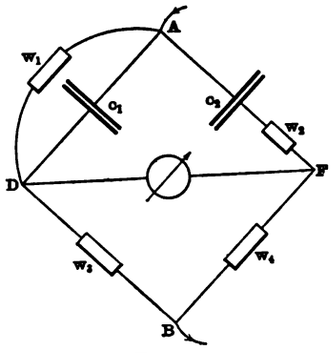

Fig. 1.

3. *Capacity-effects* between parts of the bridge and between bridge and earth.—The first mentioned influences could easily be made innocuous by suitably arranging the leads and the apparatus; not in every case, however, can the same be said of the charging-currents between bridge and earth. As will be explained, one is compelled at high voltages to use auxiliary condensers (c_2) of very small capacity but large surface, and thus of comparatively large capacity to earth. But it is easy to prove that the conditions for the vanishing of current in the cross-connection, deduced by making allowance for this error, are independent of the voltage, just like the equations (1*a*) and (1*b*), and therefore this error does not affect the qualification of the method for verifying the square law.

4. *Capacity of the Resistances Used.*—What has just been said about the last-mentioned error holds good with respect to that caused by the non-fulfilment of the supposition as to w_2, w_3, w_4 being pure resistances. We may easily convince ourselves that this does not at all affect the applicability of the method for verifying the square law. But as it was desirable to avoid errors as much as possible, care was to be taken to obtain resistances the capacity of which was negligible.

In the quantitative measurements, I used: Glow-lamps for resistances of 50-500 ohms; a number of coils (manganin wire) of 1000-5000 ohms wound by myself by Chaperon's method; several resistances of 10,000-100,000 ohms made by winding manganin wire in one layer only on mica plates of about 1 mm. thickness. These resistances were arranged for connecting to the bridge by means of a paraffin plate with mercury cups. I also used a rheostat manufactured by O. Wolff, of Berlin, the coils of which were wound in Chaperon's method, and which had resistance steps from 0·1 to 100,000 ohms. All these resistances were carefully tested as to their constancy with different currents flowing through them, and as to their capacity being negligible, and were found quite satisfactory.

5. *Auxiliary Condensers.*—Serious difficulties had to be overcome in obtaining condensers suited for high voltages, and the loss of which could be neglected. Two kinds of loss have to be considered in this case. It is not very difficult to reduce the loss taking place in the condenser itself sufficiently by choosing an appropriate dielectric; after some abortive attempts with oils, air was recognised as the only dielectric suitable for this purpose. Much trouble was caused, however, by another kind of loss, making its appearance as soon as higher voltages are used—viz., by the point discharges taking place at the coatings of the condenser. This loss was found to increase much more quickly than the square of the voltage; its appearance could easily be observed by a state of unstability, of continual variation in the adjustment of the bridge.

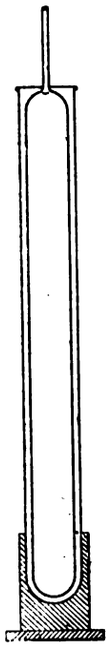

Fig. 2A.

But I must refrain from giving details of the efforts made in constructing condensers free of the defect in question, and confine myself here to giving a description of the condensers used in the arm AF in the definite measurements. I succeeded at last in building an air-condenser which acted satisfactorily up to 9,000-11,000 volts (effective value). It consisted (Fig. 2A) of two brass tubes, 1 m. and 95 cm.

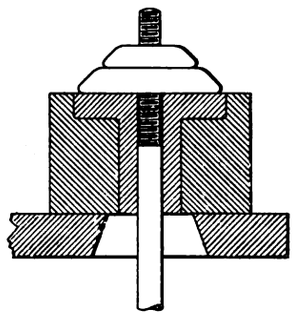

Fig. 2B.

respectively in length, outside diameter 110 mm. and 85 mm. respectively, and 1 mm. in thickness. One end of the outer tube was closed by a hemispheroidal bottom, and then surrounded with a paraffin block 20 cm. in height and 13 cm. in diameter. The inner tube was closed by hemispheres on both ends, and at one end a brass rod, 1 cm. thick and 24 cm. long, was soldered, provided with a screw-thread at its free end for fastening the tube. Fig. 2B shows how it was suspended. There were two nuts on the thread, the upper one of which served for attaching the lead, whilst the lower one and the inner tube with it rested upon a wooden socket fixed in a paraffin block 5 cm. in height. This latter was supported by a wooden board fastened on the table of a wooden stand by wooden clasps. Any edges were carefully avoided in the construction of the apparatus, as may be seen, for instance, at the nuts in Fig. 2B. The capacity of this air condenser, amounting to 0·00023 mfd. as a maximum, could be varied in a continuous way. I could not detect any loss in this condenser, although repeatedly tested in different ways. It was used exclusively as condenser c_2 in the definite "tension tests," which term may be used for designating briefly those tests for determining the dependence of the loss on the voltage. Besides this, an air condenser manufactured by the Gesellschaft für drahtlose Telegraphie, Berlin, was at my disposal, consisting of a number of concentric semi-circular brass plates of equal size, arranged in two systems, one of which could be turned around the common axis of its plates. This condenser had a capacity of $2{\cdot}99.10^{-3}$ mfd. as a maximum; its loss was negligible, the complement of the angle of phase-difference between voltage and current amounting to less than one minute. This also was

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used as condenser c_2 in the definite measurements as far as they were made at pressures up to 1,500 volts. Moreover, it served as a standard condenser for the determination of capacity, for which purpose I gauged it by comparison with a normal coil of self-induction.

As the high-tension air condenser (Fig. 2A) shows, the capacity effects taking place between it and the earth cannot be made negligibly small. One is forced to use large surfaces of the auxiliary condensers when working at high voltages, because (*a*) only air can be used as dielectric, (*b*) the thickness of the dielectric cannot be made smaller than a certain figure, about 1 cm., and (*c*) since to avoid point discharges as simple forms as possible must be used, it is not permissible to encase several coatings in each other. In the tension tests, therefore, the measurement cannot be entirely freed from these causes of error, but this does not prejudice the applicability of the method for controlling the square law. If the measurements are intended to give quantitatively correct results, the effect of all the causes of error must, of course, be made negligibly small. This is only possible by keeping the capacities c_1 and c_2 above a certain limit, which was found to be about 0·001 mfd. in my arrangement.

6. *Coatings of the Condensers Experimented Upon.*—In the condensers to be tested also the point discharges mentioned above involve a cause of error which can be removed, or at least made innocuous, only by special precautions. Owing to its rapid increase the energy loss by point discharges soon exceeds the loss in the dielectric if the voltage is raised. This latter loss then becomes negligible in comparison, and if regard is not had to the removal or at least the restriction, of this radiation loss it is a matter of indifference in high-tension condensers if a material of large or small dielectric loss is chosen for the dielectric.

The removal of the radiation loss being a preliminary condition for the exact determination of the dielectric loss by the method here used, the proper measurements could only be begun after a coating responding to this demand had been found. After trying, with negative results, various kinds of coatings, such as tinfoil, silver coatings produced by means of chemical methods, circular metal plates, 4 mm. thick, with carefully rounded edges, these same plates with paraffin melted around them, and finally mercury, I succeeded at last by placing a layer of oil over the mercury coatings. These oil-covered mercury coatings proved to be a satisfactory, and, indeed, the only means for removing the influence of the point discharges; they were extensively used in the definite measurements.

7. I have to mention some further apparatus used in the investigations: As has been said already, an optical telephone was used in the cross-connection. Its tuning first was adjusted for 86 vibrations per second; later on it was tuned down to 50 vibrations per second. The frequency was measured by means of the phonic wheel. In the battery-arm there was inserted an inductorium, built for 30 cm. spark-length; the voltage on the secondary was measured by an electrometer of the Braun type. The primary was supplied in most of the measurements with an intermittent current obtained by interrupting the current of a storage battery by means of an electromagnetically driven chord. In some of the measurements an alternating current was used in the primary, taken from a three-phase generator for 550 volts, $3 \times 3{\cdot}5$ amperes and 50 periods. This latter was driven by a direct-current motor, and by varying the field-excitation of this motor the frequency of the alternating-current could be adjusted with sufficient accuracy.

Measurements and Observations.

A part of the measurements and observations reported in what follows was carried out with different dielectrics, from which I made the condensers required for the investigations; but some of them were at my disposal already in the manufactured state in the form of condensers or condenser-plates. In addition, however, I had the opportunity of investigating a number of power-transmission cables made for working voltages of 700–20,000 volts.

The cables throughout were of the stranded type, and, except one, had impregnated paper insulation. Further particulars are given in Table II.:—

Table II.

No.	Working voltage.	Section of copper.	Length in metres.	Insulation.	Maker.
I.*	20,000	3 × 0·05 sq in.	30	Impreg. paper.	Allgemeine Elektrizitäts Gesellschaft, Berlin.
II.†	11,000	3 × 95 sq. mm.	86		
III.‡	10,000	3 × 70 ,,	39	Rubber and impreg. jute	
IV.	3,000	3 × 16 ,,	11	Impreg-nated paper.	Siemens Schuckert-Werke, G.m.b.H., Berlin.
V.	5,000	3 × 10 ,,	16		
VI.	700	3 × 50 ,,	6		
VII.	700	2 × 25 ,,	6		
VIII.	700	2 × 16 ,,	7		
IX.	5,000	4 × 25 ,,	20		Felten & Guilleaume-Lahmeyerwerke, A.-G., Carlswerk, Mülheim-on-Rhine.
X.	5,000	3 × 25 ,,	20		

For more convenient tests pieces of respectively 5·4, 5·3 and 5·1 metres in length were cut off from the cables I., II. and III. and were laid over wooden stools in the room, the floor of which was covered with linoleum. This manner of insulating the cables from the earth proved perfectly sufficient and was used also for all the other cables, which, however, being shorter and smaller, could be tested in full length.

I.—Comparative Measurements with Voltages of Different Wave Form.

First of all a set of tests may be mentioned undertaken with P.D.s differing considerably in wave form. Fig. 3 shows the arrangement used in these tests. The primary of the trans former T could be inserted into the circuit of the interrupter or into that of the machine simply by turning over the tumbler switch S. U is the interrupter with its two mercury cups. A special circuit, shown on the left hand, served for driving the chord. R are variable resistances. In the secondary c_1 and c_2 are the two condensers in the bridge. A cable is drawn here as the condenser c_1, and as condenser c_2 the variable brass plate air condenser was used in these measurements. R*h* is the previously-mentioned rheostat affording the resistances w_2, w_3, and w_4. E is the Braun electrometer, T*e* the optical telephone.

After tuning had been effected, as regards the chord, by varying its tension, and the generator by varying the field excitation of its motor so as to correspond to the frequency of the optical telephone, the bridge was first brought into balance with the interrupter current,§ the sensibility of the adjustment was ascertained, then the tumbler switch was turned over, the image observed and the sensibility determined again. It will be sufficient to quote one example of these tests, which all gave the same result.

Cable X.—The three conductors were connected to the point A, the sheathing to the point D of the bridge.

$\frac{n}{2\pi}=50{\cdot}1$		E	c_2	w_4	w_3	Δw_3	w_2	Δw_2
	Interrupter current....	1400	$1{\cdot}51_9.10^{-3}$ mfd.	500	137·7	<0·1	31,300	≷300
	Machine current....	1400	,,	,,	137·7	<0·1	31,300	300

w_2 and w_3 served for producing balance: Δw_2 and Δw_3 denote the smallest alteration of w_2 and w_3 producing a perceptible effect. The voltage given here and in the measurements that follow is that read on the electrometer, and therefore, strictly speaking, not the P.D. between the coatings of c_1. In fact, however, the voltage drop in w_3 is perfectly negligible.

In all these comparative tests the image remained perfectly distinct. Thus, although the wave forms of the two alternating voltages differed considerably, owing to their entirely different origin, not the least variation of the bridge adjustment was noticeable. This proves experimentally the fact already stated in the discussion of the method—viz., that the

* Cable I., at the time I tested it, was just being made for a large power-transmission plant (about 80 km.) near Newcastle-on-Tyne.

† Cable II. is in use in the power distribution (60,000 kw.) of the London Underground Electric Railways.

‡ Several hundred kilometres of cable III. are in use in the network of the Berlin electric central stations.

§ By this term we may indicate the alternating-current which was obtained when the coil was traversed by an intermittent current as described.

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adjustment of the bridge by means of the optical telephone is independent of the wave form. Moreover, we may conclude from this that an effect of the upper harmonics on the loss due to the fundamental component, conceivable though not very probable, does not take place.

II.—Tension Tests.

The arrangement used in the tension tests was quite similar to that shown in Fig. 3. In all these tests the high tension air condenser, already described, was used as condenser c_2, and the other resistances mentioned were inserted besides the rheostat R*h* for forming w_2, w_3, w_4.

(A) *Sundry Dielectrics.*—Throughout these tests an interrupter current of 85·6 periods per second was used; c_2 and w_2 served for producing balance.

1. A tube of flint glass, 40 cm. in length, 5 cm. outer diameter and 4-5 mm. thick, was sealed at one end, filled with mercury to a height of 8 cm., and dipped into mercury to the same depth. Upon each of these mercury coatings a layer of paraffin oil, 5 mm. thick, was poured. Into the mercury coatings the leads were plunged in such a way as not to come into contact with the glass tube itself. This condenser was inserted into the bridge as c_1. The results of one of the series of measurements made upon this condenser are given in Table III. c_2 remained perfectly constant in this series of measurements. As the table shows, the same is true of w_2 within the limits of experimental error. If the loss here increased, for example, in proportion to the 2·1th power of the voltage, w_2 would have to amount only to 44,400 ohms at 2,000 volts for attaining the value of 51,000 ohms at 8,000 volts, as may be easily calculated.

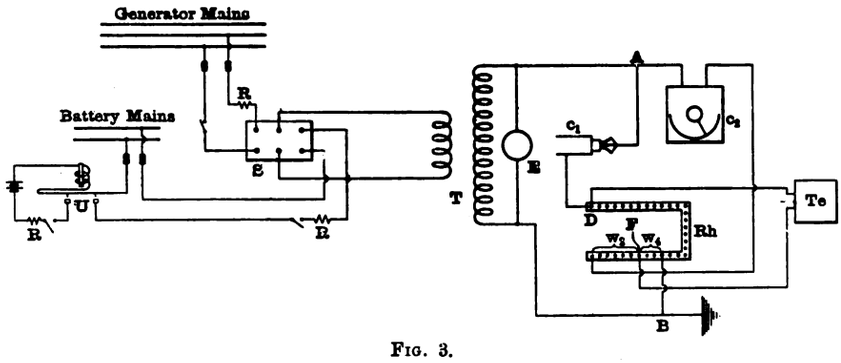

Fig. 3.

Table III.

E	w_2	Δw_2	E	w_2	Δw_2
2,000	51,000	2,500	6,000	51,000	..
3,000	50,000	2,500	7,200	51,000	1,200
4,000	51,000	<2,500	8,000	51,000	..
5,000	51,000	<2,500			

2. We may now compare this example with another one. As was to be expected by the results hitherto published, in all cases such a perfect constancy of w_2 at different voltages is not found. Indeed, most of the measurements which I carried out with other condensers gave undoubtedly larger values of w_2 for higher voltages than for lower ones. For more exhaustively investigating this fact and to determine if this increase of w_2 was due to the heating of the dielectric, I made a condenser to exhibit this effect in a special way. The following points were borne in mind in its construction: The dielectric used should give rise to a sufficient loss; its thickness had to be the least possible; at the edges of the coatings, on the other hand, the dielectric had to be thickened as much as possible for sufficiently high voltages to be attained (of course, the part of the dielectric most exposed to the danger of being pierced is that situated under the edges of the coatings where the electric density is a maximum. Moreover, the point discharges, even if oil covered mercury coatings are used, cannot be totally eliminated at higher voltages if the thickness of the dielectric at the edges is too small). A condenser fulfilling all these requirements was made as follows: One end of a capillary tube (thermometer tube) was blown out to a very thin-walled globe of 17·3 mm. outer diameter. This bulb was filled with mercury and immersed in mercury; the leads consisted of wires, one of which was plunged into the outer coating whilst the other was introduced into the tube. Both coatings were provided with a layer of paraffin oil. In this way a condenser was obtained approaching as nearly as possible to the ideal form of a high-tension condenser, the globe condenser. The length of the edges of the coatings and thus also the danger of point discharges was reduced to the lowest possible, and the required thickening of the dielectric under the edges of the coatings was complied with.

Table IV.

E.	w_2.	E.	w_2.
1,000	165,000	4,000	177,000
2,000	167,000	5,100	195,000
3,000	171,000	..	..

Table IV. refers to a test with this condenser. In all the measurements with this condenser the following effect was noticeable: If the voltage was suddenly altered, the image continued to change during several minutes, and this variable state was longer if the voltage was lowered than if it was raised. For investigating this phenomenon I brought the bridge to a balance at 5,000 volts, opened the circuit and left the bridge for a quarter of an hour without any current flowing in it. After this time the circuit was suddenly closed again, the pressure being 5,000 volts, as before. The deflection observed at the optical telephone was considerable at first, but returned to zero in the course of a minute. When, subsequently, the voltage was suddenly reduced to 2,000 the image first remained clear, but in the course of several minutes a deflection took place. I repeatedly carried out this observation in most varied ways and on different days. The result was always the same and could be stated quite definitely. Thus it is proved that in this case also the adjustment of the bridge at different voltages is exactly the same, and that the increase of w_2 with increasing voltage as found in the measurements, that is to say, the observed departure from the square law, is attributable merely to some secondary influence, *i.e.*, to some source of error. It appeared probable that this effect was due to heating.

In order to determine this point I made the following test: The same thermometer-bulb condenser was placed in an oil-bath (paraffin oil) which could be heated by some turns of wire carrying a current. The temperature of the oil-bath was measured by a thermometer immersed in it. After the condenser and its oil-bath had been left standing for a time in order that all parts could attain the temperature of the room (18·5°C), a series of measurements at different voltages was first taken without heating; this series was in accordance with that given in Table IV. After this the pressure was adjusted to 3,300 volts and left unaltered, and the heating-circuit was closed. A few moments after the heating-circuit was closed the image in the mirror of the optical telephone began to become indistinct. The temperature of the oil-bath was now kept constant at 22 deg. during a quarter of an hour, and the measurement carried out after that time gave

$w_3 = 10{,}200$ ohms, $w_4 = 10{,}000$ ohms, $w_2 = 197{,}000$ ohms.

As the temperature of the oil-bath had now been raised to 24 deg., the measurement made four minutes later gave the result:—

$w_3 = 10{,}130$ ohms, $w_4 = 10{,}000$ ohms, $w_2 = 218{,}000$ ohms.

For comparison I quote two of the results found before the heating was applied—

E		w_3		w_4		w_2
3,300	....	10,300	....	10,000	....	172,000
5,000	....	10,250	....	10,000	....	195,000

The values of the capacity (w_3) as well as of the loss (w_2), obtained at 22 deg., are thus very closely concordant with those found at 5,000 volts. A rough calculation of the quantity of

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heat developed per minute in the tested condenser at 5,000 volts gives 1·2 gramme-calories, an amount by no means inconsiderable if the small capacity for heat of the shell of this thermometer-bulb is considered, the volume of which is calculated to be 0·18 cubic cm. I may, therefore, express the opinion that in the case also of this thin-walled thermometer bulb the loss itself exactly obeys the square law, and that the departure from this law and the increase of capacity observed at increasing voltage is only caused by a secondary influence—viz., the rise in temperature that the dielectric undergoes owing to the loss taking place in it, and thus that this increase of w_2 and the capacity does not represent a change with voltage but one with temperature. In this way also is explained why, in the series of measurements with the flint-glass tube reported in the first example, not the least change of w_2 was to be found. For while the capacity for heat of this condenser was many times as large as in the last example, the loss at the same voltage, and thus also the quantity of heat developed in the dielectric during the same length of time, was less than $\frac{1}{3}$ of the amount observed with the thermometer-bulb. It may be considered as a further advantage of the method used here that it allowed a glimpse into what takes place in the dielectric, and allows the separation of the voltage and temperature effects.

From another point of view also this observed increase of the loss in glass, with slight increase of temperature, is not without interest. As was shown by A. Wüllner and M. Wien,* the conductivity of glass also exhibits, with a small rise of temperature, an increase, together with an increase of the specific inductive capacity. This analogy seems to point directly to an intrinsic connection of the loss with the conductivity, and therefore may be considered as supporting the view that the loss is caused by some kind of conduction phenomenon.

3. A tube of ebonite, 2 mm. thick, 41 cm. in length, 16 cm. of outer diameter, was provided with mercury coatings upon which a layer of oil was disposed. I must restrict myself in this article to recording that the results obtained with this ebonite tube were fully consistent with those found in the last-mentioned example. A gradual increase, with increasing voltage, and vice versa, was observed, showing w_2 to change with temperature but not with voltage.

4. As already mentioned, paraffin was used extensively as an insulation material. In order to see if there was any objection to the use of paraffin for this purpose, I made a paraffin condenser. The coatings were formed of three plates of sheet zinc, 13 × 15 cm. and 1 mm. thick. They were perfectly embedded in paraffin at a distance of 3 mm. apart. The paraffin, which was fairly pure, was filtered and cast in thin layers to avoid air-bubbles. The finished condenser represented a paraffin plate about 15 mm. thick. No loss could be detected in the dielectric of this condenser. As soon as the capacity adjustment was accomplished the image remained perfectly clear up to 4,500 volts. As the voltage was raised above that value, crackling and hissing announced the beginning of point discharges, a deflection rising with increasing voltage, varied in an irregular manner, and so excluded the possibility of any measurement. This is an example of the fact already mentioned, that even perfect enveloping of the coatings by the dielectric does not remove at higher voltages the point discharges and the energy loss brought about by them.

5. Exactly the same phenomenon was observable in a very great number of other cases. I will quote here but one example more to show how in the case of a dielectric exhibiting a small loss in itself the point discharges multiply the loss at higher voltages. I take the following from a series of measurements on "Grisson" condenser plates :—

Table V.

E.	w_2.	Δw_2.
2,700	75,000	5,000
4,650	90.000	2,500
6,000	>175,000	..

As in the case of the paraffin condenser, the coating, represented here by a circular plate of sheet metal, was entirely enveloped by the dielectric. As is shown by Table V., the loss, though not very much larger than that in flint glass at 2,700 volts, is, nevertheless, at 6,000 volts already greater than that found in the thermometer bulb.

* A. Wüllner and M. Wien, *Annalen der Physik* (4), Vol. IX., p. 1,217, 1902.

Table VI.—*Cable V.*

E.	w_3.	w_4.	w_2.	Δw_2.
1,300	325·8	3,500	93,600	2,000
2,100	325·8	3,500	93,600	1,200
3,000	325·8	3,500	93,600	1,000
4,100	325·8	3,500	93,600	<1,000
5,400	325·8	3,500	93,600	<1,000

Table VII.—*Cable X.*

E.	w_2.
1,400	158,000
2,300	158,000
3,200	158,000
4,100	158,000
5,000	158,000

Table VIII.—*Cable I.*

E.	w_2.
2,100	133,000
3,000	133,000
4,200	133,000
5,200	133,000
6,600	133,000
..	..

Table IX.—*Cable II.*

E.	w_2.
1,300	105,500
2,000	105,500
3,000	105,500
4,000	105,500
5,200	105,500
6,200	105,500

Table X.—*Cable III.*

E.	w_2.
1,300	46,000
2,000	46,000
3,000	46,000
4,000	46,000
4,800	46,000
..	..

(B) *Cables.*—Tables VI., VII., VIII., IX. and X. refer to tension tests I carried out on cables. In the tests given in Tables VI., VIII. and X. one conductor of the cable was connected to the point A, the two other conductors and the sheathing to the point D of the bridge; in the other two cases (Tables VII. and IX.) two conductors were joined to the point A, the third and the sheathing to D. The frequency of the current used was 50·7 per second in the test given in Table VI., 50·1 in that of Table VII. and 86·1 in the three other cases. All the five tests were made with interrupter current. The test on cable X. (Table VII.) was repeated with machine current and gave strictly the same result.

In all the tension tests on cables the image remained perfectly distinct as soon as the bridge was once balanced, and not the least alteration of the adjustment had to be made; by this result the strict validity of the square law is proved. The limit of voltage beyond which the rise in temperature of the dielectric has an appreciable influence on the loss in the case of the cables is probably far above the working voltage. According to the results given, the square law is followed with equal accuracy by the loss in all the dielectrics tested, provided the temperature remains unchanged. Thus, when using this method, we are entirely freed from the necessity of making measurements at high voltage if the loss is to be determined. In the bridge exactly the same quantity is measured at low voltages as at high ones, with the advantage that the difficulties involved in measurements at high voltages are avoided. Further, at low voltages we are able, by using auxiliary condensers of sufficiently large capacity, to remove sources of error, and thus to carry out correct quantitative measurements. Again, since the sensibility of the adjustment can be made high at low voltages if condensers of somewhat larger capacity are used, we possess in the application of the method a simple means for obtaining accurate quantitative information as to the loss in a dielectric. Measurements in which this means was adopted are given in the following :—

(*To be concluded.*)

Copper Castings.—According to the *Electrical Railway Review*, sound copper castings of high electrical conductivity can be obtained by adding about 2 oz. of stick magnesium to each 100 lb. of pure Lake copper. This can most easily be done by making an amalgam of magnesium and copper in the following manner. Melt 45 lb. of pure Lake copper under a good layer of charcoal, and when at a good red heat add 5 lb. of pure stick magnesium, and stir well with a plumbago rod. The magnesium must be forced under the surface of the melted copper, or it will float on the surface and burn. Pour the amalgam out into small strip ingots which are easily cut. To add 2 oz. of magnesium to 100 lb. of copper, melt the copper and add 20 oz. of the amalgam. This avoids errors in weighing small quantities, and the foundryman is more sure of the amount of magnesium which actually enters the copper.

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A NEW VARIABLE SPEED ELECTRIC MOTOR OR VARIABLE VOLTAGE DYNAMO.

BY DR. L. TORDA.

The arrangement ordinarily used to control the speed of a continuous-current motor, fed off a constant voltage, or to regulate the pressure of a dynamo, driven at a constant speed, consists in the variation of the field excitation. This is achieved by inserting a regulating resistance into the circuit of the shunt-field winding. Another arrangement is based on the variation of the resistance of the magnetic circuit or the reluctance of the machine. This latter regulation is generally effected by means of moving iron masses provided in air spaces of the field-magnet system of the machine.

Hitherto the regulation by an electric resistance has been almost exclusively applied, the reason for which is to be attributed to the manufacturers, the works of whom are naturally laid out for making standard machineries in greatest demand, such as constant voltage generators and constant-speed motors. Considering that the application of and the demand for variable speed motors has largely increased in latter years only, since the recognition of the advantages of the application of the electric drive for machine tools, printing machinery, rolling mills, &c., it is obvious that the simplest way for manufacturers was to adapt their standard machine types for these purposes, in using external resistances with same.

However, with the increased application of the independent electric drive, the users were induced to put down more stringent conditions, which such machines have to fulfil, and thus it became desirable to develop the second type of variable-speed motors, which is destined not only to meet certain requirements, which the electric regulation cannot fulfil without complicated arrangements, but which offer for the most usual applications valuable advantages.

In considering the users' requirements, he has to make comparisons as regards price, efficiency, reliability and convenience, when choosing a machine for a certain specified work.

As regards price and efficiency both types of variable-speed motors are equivalent.

As to reliability the machine with reluctance control has in its favour the fact that it is self-contained; the regulation is effected entirely by mechanical means, being not liable to get out of order, which is noteworthy, inasmuch as most of the mishaps in electric motor drives originate in electrical breakdowns in the auxiliary apparatus. One of the common occurrences, for instance, in connection with metal-working tools is that metal chips damage or cause short-circuits between contacts or parts of the regulating resistances. Such trouble is entirely avoided with a mechanically controlled and self-contained machine.

As regards convenience, both types can be considered as equivalent for ordinary purposes, although for special cases each has some points in its favour. For instance, in a case where the motor is to be regulated from a great distance, the electric resistance control will be found more adaptable, while in case of a finely graded or perfectly smooth regulation the only suitable arrangement is that with reluctance control.

With special reference to machine tool drive, it may be pointed out that it is often required that the handles of the starting and speed-regulating devices shall be within the easy reach of the operator, whilst the motor is situated at a distance. For such a case, the device for reluctance control can be actuated from the operator's stand by means of a flexible shaft or gearing, in connection with which it may be noted that the force required to move a properly designed controlling device is quite small.

In consideration of the aforesaid, it will be of interest to give a description of a variable speed motor or a variable voltage generator with reluctance control which has been devised and developed by the author.

In Fig. 1 are shown a side elevation and an end view, partly in section, of such a machine. As can clearly be seen, air ducts are formed in the magnet cores between the field coils and the yoke. Iron masses in the form of plates are placed in the air ducts, and they are so arranged that they can easily be moved in axial direction inwards or outwards in the air ducts. Two of the plates are supported at one end on rollers, mounted to rotate in slots in the ends of the plates and running freely on the surfaces forming the bottoms of the air ducts. Each plate is fixed at one end to a ring secured by stud bolts to a traversing frame, which is provided with a screw-threaded central boss for the reception of the adjusting spindle. The spindle is mounted to rotate in the two-arm bracket fixed to the frame of the machine. The illustration shown in Fig. 2 gives a clear idea of the whole device for moving the plates. It can be observed that the whole regulating device is mounted on one of the bearing brackets of the machine. In Fig. 3 an illustration is given of the frame showing the air ducts. It may be metioned here that the magnet yoke is that of an ordinary standard machine with slight modifications. Figs. 4 and 5 are reproductions of a machine complete with the regulating device in two different positions—viz., the adjustable plates "full in" in Fig. 4 and "right out" in Fig. 5.

It is interesting to note that hitherto in machines with reluctance control the construction has been so arranged that the insertion of the reluctance, while weakening the main

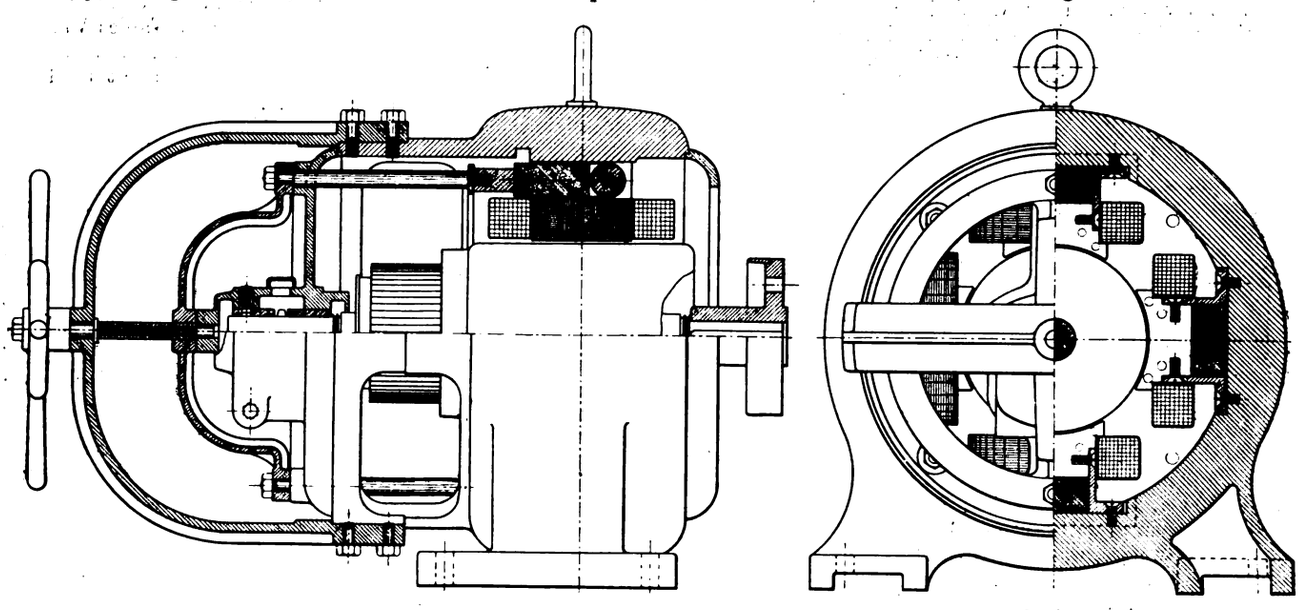

FIG. 1.—ELEVATION AND END VIEW. Scale = 1:8.

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field, reduces the field distortion. However, this point is of little importance. Variable speed motors or variable voltage generators, in which no provision is made to counteract the field distortion, if otherwise properly designed, will give entire satisfaction.

Looking at Fig. 1, it will be quite clear that in the machine here described no attempt has been made to influence the field distortion, as the air ducts and the adjustable iron masses are placed inside the field-magnet system remote from

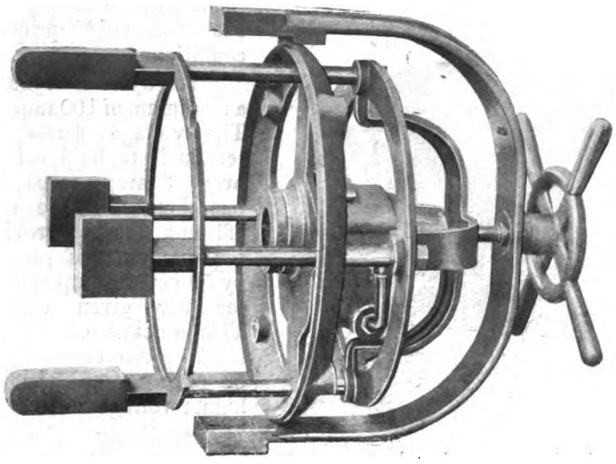

FIG. 2.—THE REGULATING DEVICE MOUNTED ON THE END BRACKET OF THE MACHINE.

the armature. This arrangement, which from a theoretical standpoint might appear somewhat disadvantageous, has a number of practical advantages. First, the adjustable plates can be fixed direct to an iron ring, by this means forming the four plates into a rigid body. Were the plates arranged near the armature—*i.e.*, between the field coils and the armature—the ring would have to be made of brass or other non-magnetic material, in order to prevent magnetic leakage through the ring. With the arrangement shown in the above illustrations, where the adjustable masses are placed between the field coils

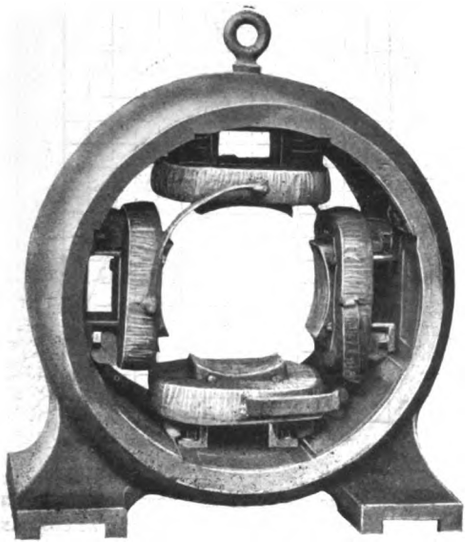

FIG. 3.—THE MAGNET FRAME.

and the yoke, the iron ring constitutes a magnetic shunt merely to the yoke. Furthermore, from the constructional point of view, a simpler and safer arrangement is obtained with movable parts farther away from the rotating armature Secondly, the new arrangement allows the air-gap between the armature and the pole-faces to be made as small as mechanically admissible, abolishing all massive iron parts in close proximity to the slotted armature, and thus preventing the setting up of any appreciable eddy currents. The smaller the air-gap the thinner and lighter can the iron plates be made, in order to obtain a certain specified range of regulation. At the same time the adjusting device and the whole machine—also on account of reduction in copper for the field coils—becomes lighter and less expensive. As a third advantage may be mentioned the reduction of the weight of the adjustable masses by arranging the air ducts and the plates in places inside the field-magnet system, where the magnetic induction is the highest. The places of the highest magnetic induction are usually the

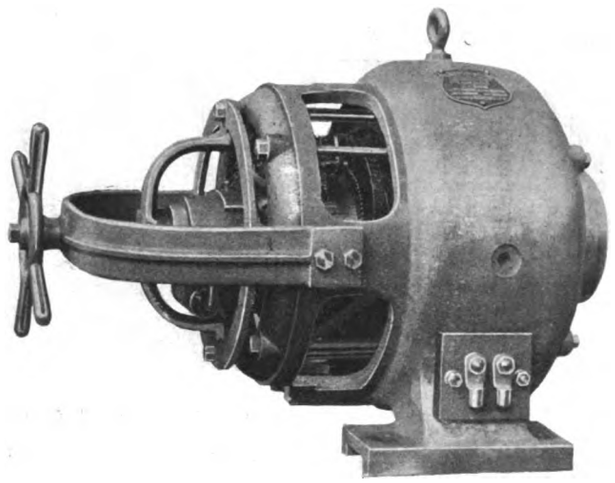

FIG. 4.—ADJUSTABLE PLATES "FULL-IN."

magnet cores, and arranging the adjustable plates in their neighbourhood has, in a smaller degree, the same effect on the reduction of the weight of the movable masses as the shortening of the air-gap between the armature and the field.

A special feature of this machine are the rollers, which are used mainly for the purpose of diminishing friction. At the same time, the size of the roller determines the width of the air duct, and as the diameter of the roller is made only slightly larger than the thickness of the plate, the clearance between the plates and the adjoining parts of the magnet frame is very small. Through the application of these rollers the friction is greatly diminished and, in fact, the movement

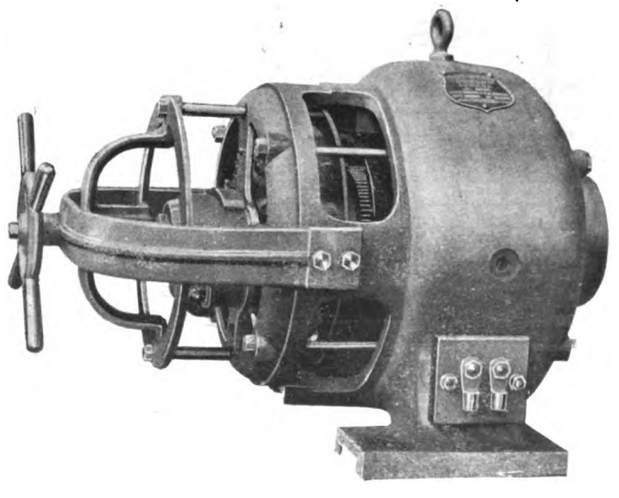

FIG. 5.—ADJUSTABLE PLATES "RIGHT-OUT."

is made so easy that the handle can be turned round by one finger. Of course, besides the friction the magnetic pull must be taken into consideration. Owing to the fact that the plates are moved in a direction at right angles to the direction of the main part of the magnetic lines, the magnetic pull is not considerable. When pulling out the plates the resisting force through friction acts in the same sense as the magnetic pull, and when pushing in the plates the magnetic pull helps to overcome the friction.

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To ascertain the relative magnitude of these forces some tests have been carried out by measuring the force which was necessary at each point just to turn the handle.

The plates being pulled out to about one-third of the total length available for the adjustment with an unexcited field, a weight of 18 oz. was required to make the handle move. This weight was applied on one horizontal arm of the hand-wheel, the leverage being 6 in. Leaving the hand-wheel in the same position and exciting the field with 1,780 ampere-turns

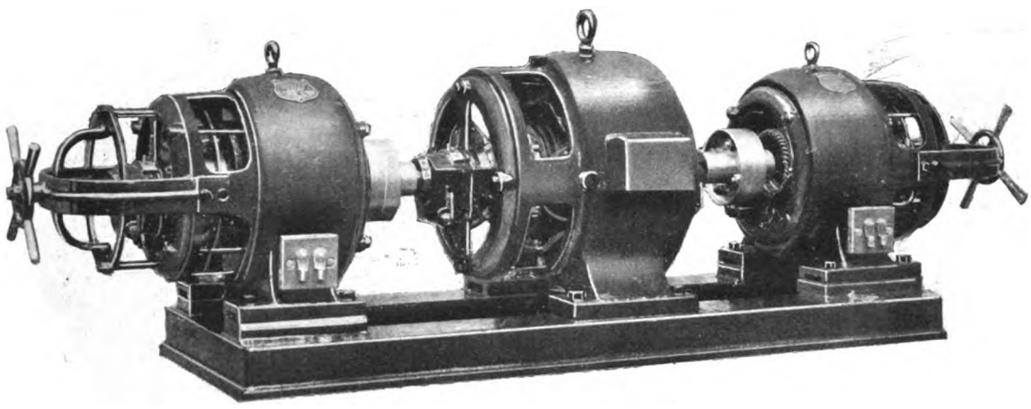

Fig. 6.—2 × 5 kw. Booster Set.

per pole, a weight of $3\frac{1}{2}$ lb. acting on the same radius of 6 in. was required to make the hand-wheel turn in such a direction as to move the adjustable plates outwards, and $1\frac{1}{2}$ lb. to move them inwards. A glance at these figures shows that through the magnetic pull the friction becomes increased, particularly between the screw-spindle and the central boss of the traversing frame. Assuming that the total friction remains constant for either direction of motion, then half the difference of the two values—*i.e.*, 1 lb.—would give the weight which would have to be applied on a 6 in. radius just to counterbalance the

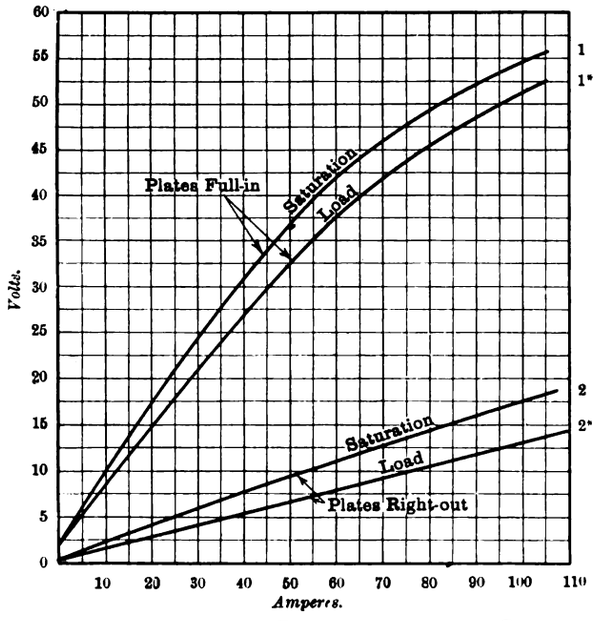

Fig. 7.—Curves showing the Relation between the Current and the Voltage.

magnetic pull alone. Pulling the plates right out and keeping the excitation at its maximum value of 2,550 ampere turns per pole, the weight of 26 oz. on a 6 in. radius was required for the outward and 20 oz. for the inward movement. In the same manner as above a weight of 3 oz. is obtained, which would correspond to the magnetic pull in the "right out" position of the plates.

According to these tests the ratio between the magnetic pulls in the two positions is about $5\frac{1}{2}$: 1, and correspondingly the ratio of the magnetic inductions in the direction of the movement is $\sqrt{5\frac{1}{2}}$: 1, or, roughly, 2·4. That this ratio is approximately correct can be ascertained by the characteristic curves of this machine given below.

In Fig. 6 is illustrated a set of machines consisting of two variable voltage generators, each of a capacity of 5 kw., driven at a speed of 1,250 revs. per min. by a constant speed motor, arranged between the two dynamos. The dynamos are series wound and have to serve as feeder boosters for a three-wire system. Each dynamo had to be built to comply with the following principal conditions:—

"The dynamo to be for a maximum of 100 amperes. The voltage across the terminals to be 1 volt for every 3 amperes passing, but there must be some efficient means provided for varying this pressure by 50 per cent. up or down for any given current. This amount of pressure for a given current may be reduced somewhat for higher voltages."

Accordingly the required range of voltage regulation was 3 to 1, For the maximum current of 100 amperes this range is from 16·7 to 50 volts. The actual range obtained for the maximum current is from 13 to 52 volts, as shown in Fig. 7. Here the lines 1 and 2 are saturation curves, and 1* and 2* are the load curves of the dynamo, curves 1 and 1* corresponding to the "full in," and curves 2 and 2* corresponding to the "right out" position of the plates. From these curves it can be gathered that the ratio of voltage variation is a maximum for currents below 30 amperes, viz. 5 to 1; for larger currents

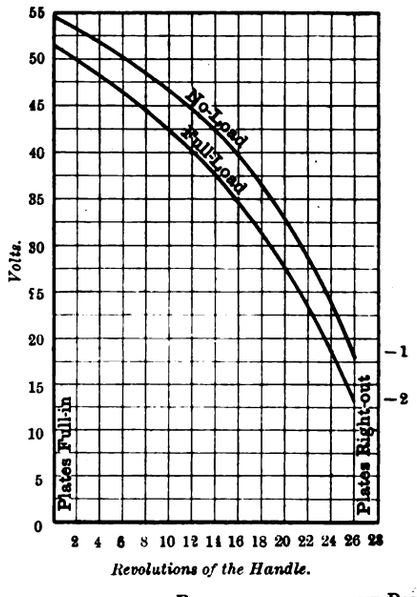

Fig. 8.—Curves showing the Relation between the Position of the Movable Plates and the Voltage of the Machine at Constant Excitation, with the Full-load Current of 100 amperes.

this ratio decreases, at the maximum current of 100 amperes same being 4 to 1.

Two curves of interest are shown in Fig. 8. Curve 1 represents the variation of the terminal voltage with the position of the plates, when a current of 100 amperes is passing through the field winding, the armature circuit being open. Curve 2 gives the voltage variation with the same current of 100 amperes passing through both field and armature windings. These curves supply an explanation why the plates are made axially

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somewhat shorter than the corresponding dimension of the magnet core—namely, when moving the plates outwards from their "full in" position the decrease in voltage is at first only a slight one, so that the plates can be shortened without materially affecting the range of regulation.

The main particulars of the machine are :—

Armature.	
Diameter	8 in.
Gross length of lamination	4½ in.
Number of slots	45
Depth of slot	0·848 in.
Width of slot	0·254 in.
Kind of winding	Series, single
Number of conductors	178
Cross section of conductor	$\frac{5}{16}$ in. by 0·055 in.
Number of conductors per slot	Four
Number of commutator segments	89
Field.	
Number of poles	Four
Cross section of core lamination	10·9 sq. in.
Cross section of the yoke	18 sq. in.
Kind of winding	Series
Number of coils	Four, all in series
Number of turns per coil	25½
Cross section of conductor	⅜ in. by 0·09 in.

The air-gap between the armature and the field is $\frac{1}{16}$ in. The thickness of the adjustable plates is 1½ in. and the clearance between each plate and the magnet frame is $\frac{1}{64}$ in. on each side.

The total weight of the adjustable body is 45 lb., the screw spindle, hand wheel and the two-arm bracket weighing 15 lb. The whole device complete weighs 60 lb. and consists, with the exception of 2 lb. of phosphor bronze for the rollers, of inexpensive iron. The total weight of the machine excluding the regulating device is 620 lb., of which 85 lb. are copper and brass and the remaining iron. Accordingly the weight of the material used for the regulating device is less than 10 per cent. of that of an ordinary machine of the size described. For larger size machines the percentage weight of the regulating device would, of course, be still smaller.

As regards space a sliding-plate machine does not require more room than a machine with resistance control, together with its regulator.

The machine described has been manufactured by the Morris-Hawkins Electrical Co. (Ltd.), to whom I am indebted for permission to publish the illustrations and test data.

Some similar but larger size machines are now going through the shops. In these the construction of the regulating device is slightly modified with a view to further reduce the weight and to make the device still more easy to actuate. A description of these machines will be published at a later date.

ELECTRIC POWER HOUSE OF THE CAMBRIAN COLLIERIES (LTD.)

The Cambrian Collieries, situated in Clydach Vale, a branch of the better-known Rhondda Valley, Glamorgan, is one of the largest collieries in South Wales; the coal produced in the three pits of the company averages about 1,000,000 tons per annum, and employment is found for some 3,500 men.

Up to a few years ago, steam power was exclusively used for operating the machinery both above and below ground, and this agency is still used for a number of purposes above ground. About three years ago, however, the company fully realised the advantages to be gained by electric power, more particularly for underground purposes, and decided to introduce electricity for working haulages, coal-cutting machinery, pumps and so forth. Current was accordingly bought from the South Wales Power Co., and distributed to various motors in the mine and on the surface.

Electrical working proving satisfactory, the progressive management, advised by their consulting engineer, Mr. C. P. Sparks, decided to go a step further and to produce their own current. The result was that Messrs. Siemens Bros. (Ltd.) were entrusted with the entire work. All the electrical plant in connection with the power house has been supplied and erected by this firm, the engines, boilers, condensers and so on being sublet.

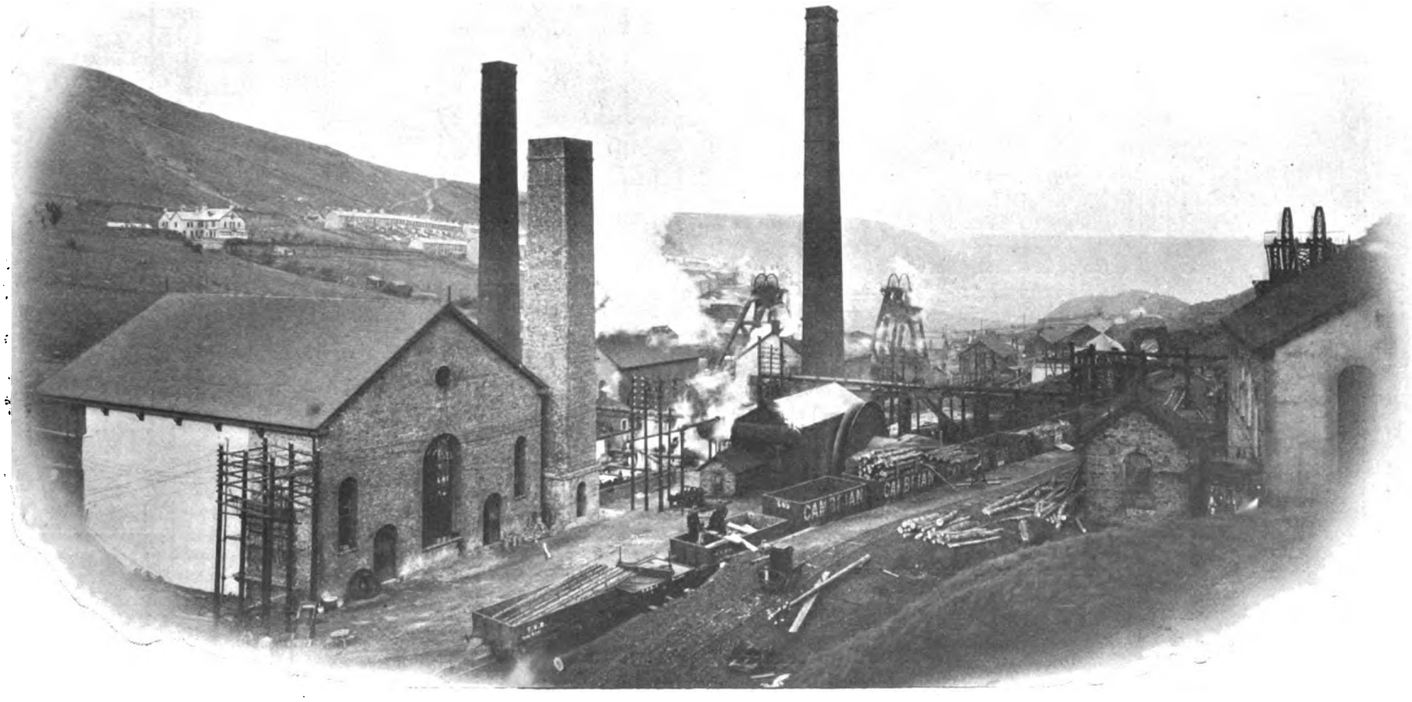

FIG. 1.—GENERAL VIEW OF THE POWER HOUSE.

The electric power developed by the two 1,000 k.v.a., 2,200 volt

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generating sets at present installed is principally used for operating induction motors for a great variety of purposes in all parts of the mine. There are at present some 21 induction motors in use, ranging in size from 220 to 3 H.P., the total horse-power of motors being 1,890. Motors on the surface are supplied with three-phase current at low tension, the current being transformed for this purpose by static transformers from 2,000 or 2,200 volts to 400 volts. The bulk of the supply, however, is conveyed in cables at a voltage of from

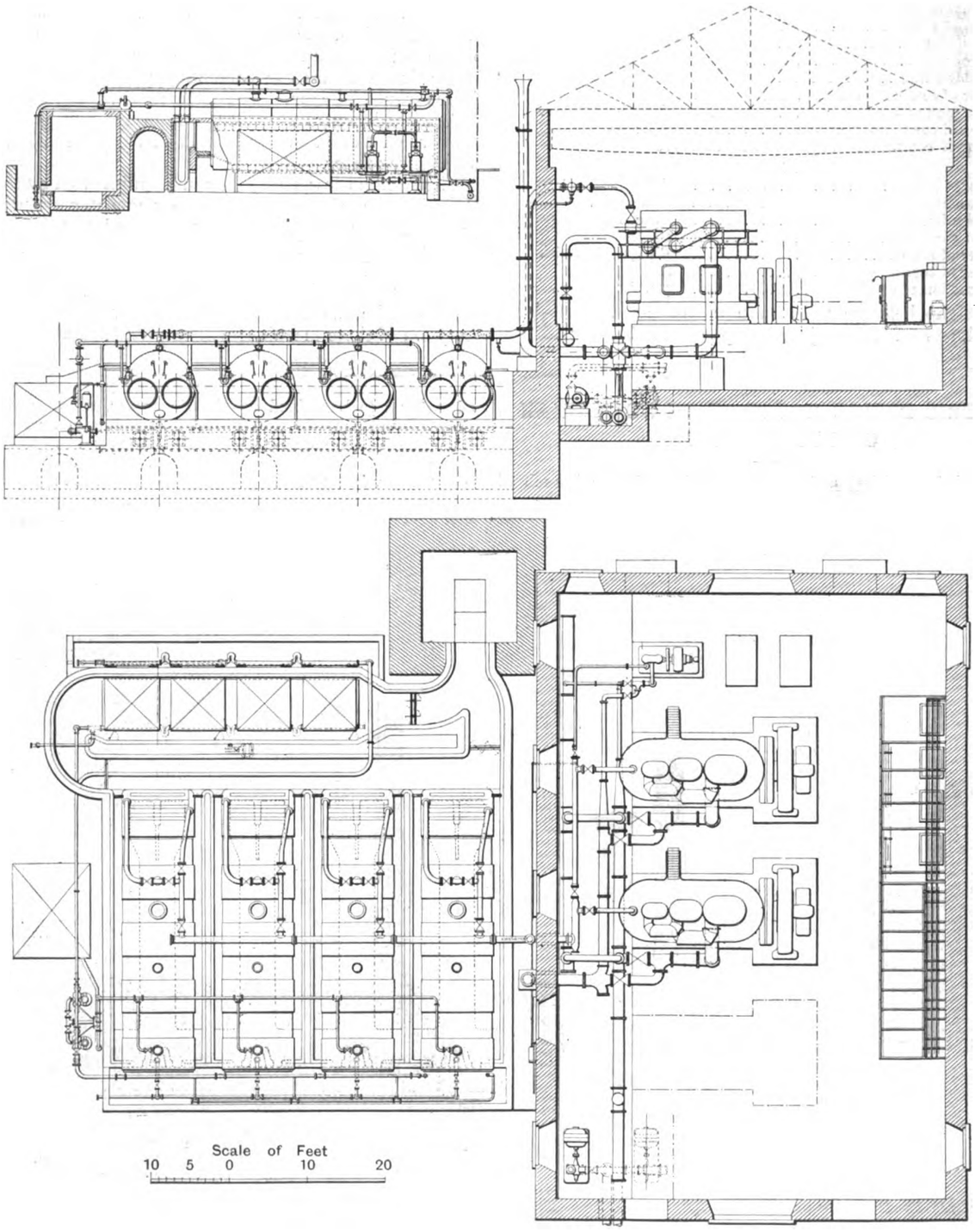

FIG. 2.—PLAN AND SECTION OF POWER HOUSE.

2,000 to 2,200 volts down the pits, and distributed to the various motors at this pressure. Continuous current for exciting the main alternators and for lighting and working the original motors is supplied at a pressure of 110 volts by a 36 kw. steam-driven dynamo, or by two 70 kw. motor generators, the motors of which are fed from the alternating-current 'bus bars.

Only part of the electric energy available is utilised at present, but as electric motors are being constantly added, the power house will be fully loaded at no distant date. Space has been left in the engine house for the erection of a third generating set, when this becomes necessary, and ample provision has been made in the design of the switchboard, boiler and condenser plant so as to carry out this extension with a minimum amount of expense or alteration.

Engine House.—The engine house, of which an external view is given in Fig. 1, is a substantial and lofty stone building built by the Colliery Company. It contains one room only, which is provided with very large windows on three sides, and is, therefore, exceptionally well lighted. Its floor is covered with red tiles and the walls are painted. The engine room is spanned by a 15-ton hand-operated crane. The lighting equipment consists of six powerful arc lamps; these will be supplemented by further arc lamps and incandescent lamps when required.

Boilers.—As shown in the general plan of the station, the boilers are erected at the side of the engine house They are covered with a 1½ in. layer of asbestos composition and built into brickwork, but are not at present under a regular roof. The fronts of the boilers,

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however, are provided with a short overhanging roof for the protection of the stokers. The boilers are quite close to one of the pit-heads, and it was, therefore, not necessary to instal any coal-conveying plant.

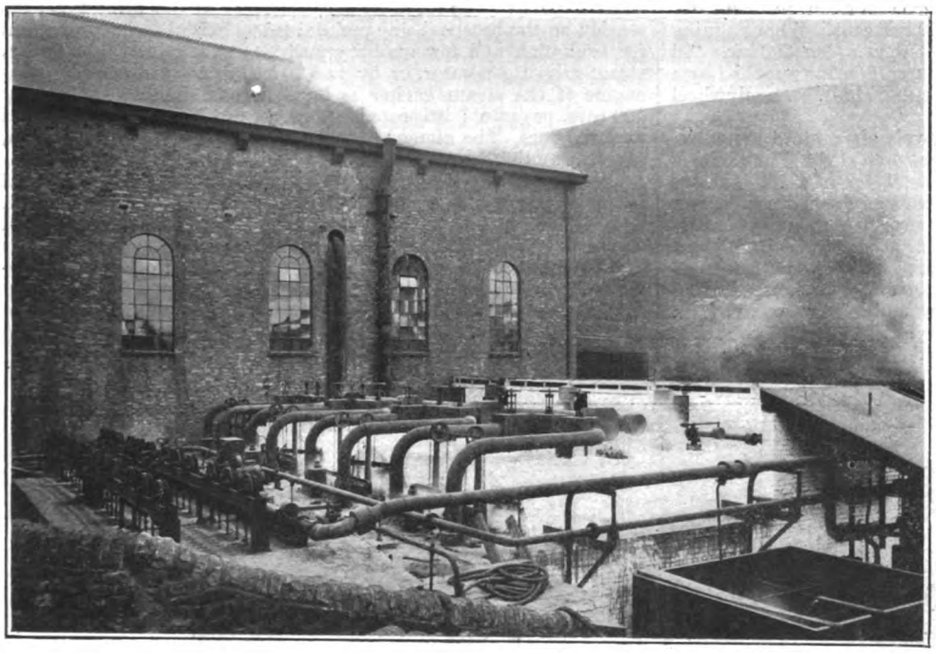

FIG. 3.—VIEW OF TOP OF BOILERS.

Water for the boilers and condensers is obtained from a pond at a short distance from the engine house, the head of water being about 50 ft. Before entering the boilers the feed water is softened in a water-softening plant erected close to the engine house. Usually the water from the condensers is run to waste, but in case of prolonged dry weather it may be returned to the pond through a separate pipe line.

There are four Lancashire boilers by Messrs. Tinker, Shenton & Co., Hyde. These are 30 ft. long and 9 ft. in diameter, and are suitable for a working pressure of 160 lb. per square inch, at which pressure the safety valves are set. They are hand-fired and provided with sliding grids for the prevention of smoke. Each boiler is equipped with a Sugden superheater to give 150°F. superheat when the boiler is evaporating 9,000 lb. of water per hour. The complete superheaters and boilers were subjected on the site to an hydraulic pressure of 280 lb. per square inch. The Green's economiser raises the temperature of the feed water from 60°F. to 200°F. when the boilers are evaporating at the rate of 30,000 lb. per hour. A Siemens' three-phase 3 B.H.P. 400 volt motor is provided for driving the scraping gear. A view of this motor is given in Fig. 4. The economiser was tested at a pressure of 280 lb. per square inch after erection.

Feed water from the water-softening plant is supplied to the boilers by Weir's vertical single-cylinder double-acting feed pumps. There is a cast-iron feed-water storage tank holding 5,000 gallons of water.

All live steam piping is suitable for a working pressure of 160 lb. and a temperature of 520°F. The main steam range over the four boilers consists of solid-drawn mild-steel piping with 9 in. bore, and provision is made for draining off any condensed steam when starting up. The steam pipes between the boiler superheater and steam range are of 6 in. diameter. One end of the steam main is fitted with a blank flange, and the other end is connected by a bend to the engine-room range of 7 in. piping. Arrangements are made for cutting off the superheaters when it is desired to supply saturated steam to the engines.

All steam and hot-feed mains, including bends, valves and tees, are efficiently lagged with white asbestos plastic non-conducting composition. An auxiliary steam main for the feed pumps, &c., runs across the top of the boilers at the front end, and consists of a 3 in. solid-drawn steel main. The pipes between the feed pumps and the boilers are so arranged that the feed water may be either fed directly to the boilers or by way of the economiser.

Engine Room Plant.—As shown in the general arrangement of the engine room, space is provided for three generating sets. At present, however, the generating plant consists of two Siemens-Belliss & Morcom sets only. These two sets are alike in all respects, each consisting of a vertical steam engine direct coupled to a 1,000 k.v.a. three-phase 2,200 volt 25 cycle alternator. The normal speed of each set is 250 revs. per min., and it was found from tests on one of the sets that the speed rose momentarily to 263 revs. per min., settling to 254 revs. per min. when full load was switched off, while it dropped momentarily to 240 revs. per min., settling to 250 revs. per min. when full load was switched on. The duration

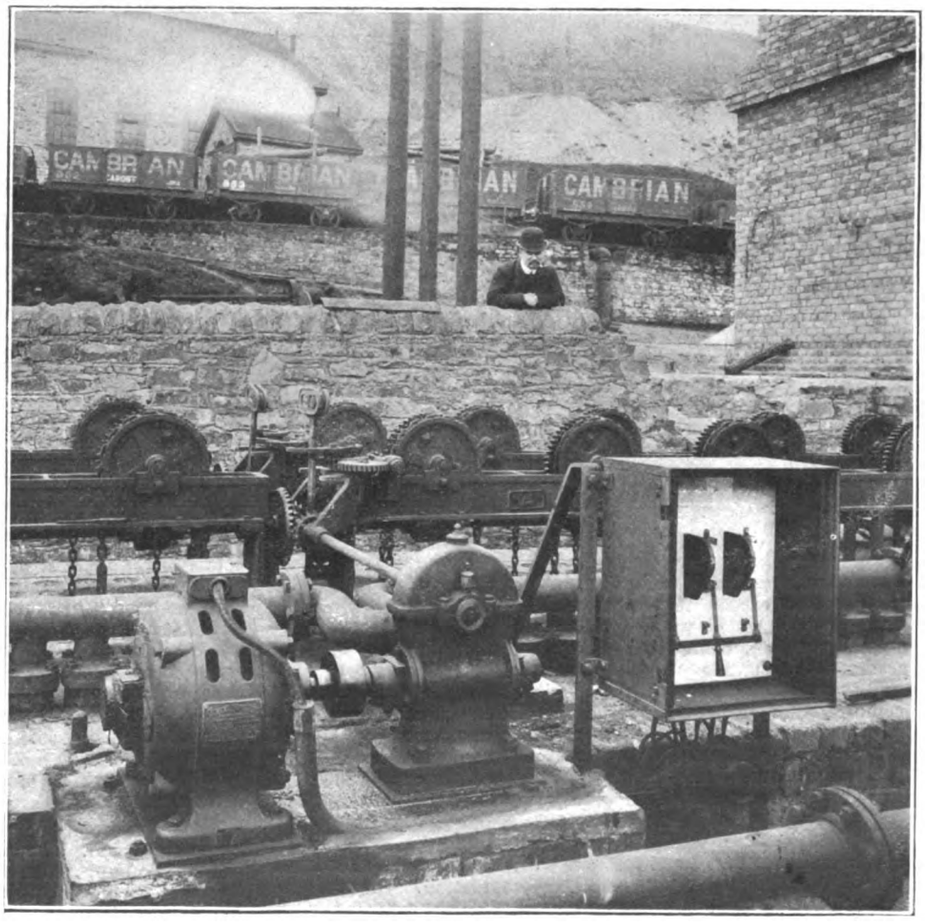

FIG. 4.—SIEMENS 3 H.P. MOTOR-DRIVEN ECONOMISER SCRAPING GEAR.

of the momentary rise and fall in speed was 7 sec. and 5 sec. respectively. Steam consumption tests were carried out at the makers' works with the following results: Steam consumed per kilowatt-

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hour at full load 17·3 lb. of steam at a pressure of 155 lb. per square inch, and a temperature at the stop valve of 472°F., the vacuum being 25·9 in. of mercury. At half load, the steam consumption was found to amount to 18·6 lb. of steam at a pressure of 163 lb., a temperature of 461°F. and a vacuum of 26 in. These figures are highly satisfactory and considerably lower than the specified figures. The engine is capable of carrying an overload of 25 per cent. for two hours and momentary overloads of 50 per cent. When running non-condensing the engine is capable of developing 680 kw. All working parts are lubricated under pressure, oil being supplied by a valveless pump worked direct from the crank shaft. The flywheel weighs 12½ tons.

The Siemens three-phase 2,000-2,200 volt alternators are of the rotating field type, the phases being star-connected. They have a continuous rating of 750 kw. at a power factor of 0·75, and are capable of dealing with the same overloads as the engines. After a six hours' run at 750 kw. and unity power factor, no accessible part of the machine, with the exception of the stator iron, has a temperature rise of more than 35°C. above the surrounding air, as measured by thermometer; the temperature rise in the stator iron does not exceed 45°C. The machine is wound to have a wave form as nearly sinusoidal as possible. When full non-inductive load is thrown off the percentage rise of voltage does not exceed 6 per cent.

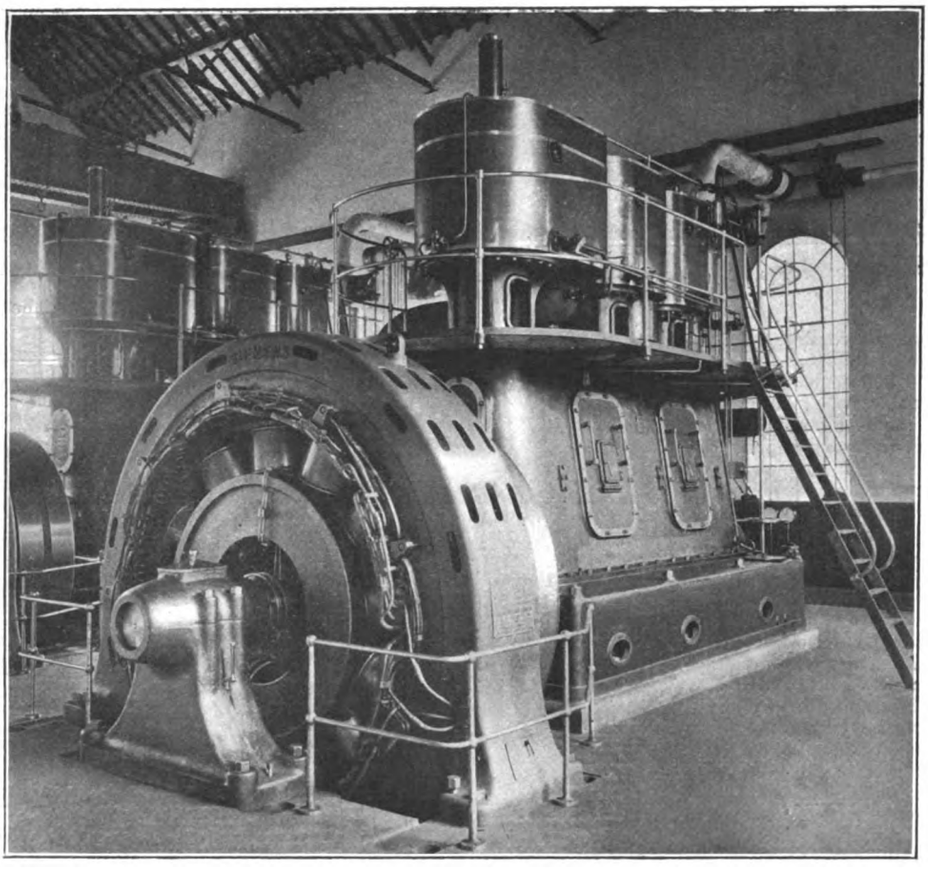

Fig. 5.—View of Siemens-Belliss & Morcom Generating Set.

at constant speed and excitation. At a power factor of 0·75 the rise does not exceed 18 per cent. Before leaving the works the armature was tested with an alternating pressure 2½ times the normal pressure, while the field system was subjected to a test pressure of 1,000 volts.

With regard to the mechanical design it may be mentioned that each alternator stands on its own independent bed, and is split horizontally, so that the upper part of the armature may be readily removed, if necessary, by the overhead crane in the engine house. The rotor is directly bolted to the engine flywheel, and the energy stored in the rotor field magnets and engine flywheel amounts to 2,000 ft.-tons at normal speed. The poles are circular in section and the poles shoes are laminated. The stator is of cast iron and of such a design as to combine great stiffness with light weight. Particular care has been taken to ensure thorough ventilation. The armature core is built up of laminated stampings, and the armature coils, after being placed in the open slots, are firmly held in position by wooden wedges The coils are amply insulated, both inside the slots and outside, to withstand all voltage fluctuations which are likely to occur in practice, and the end connections are well supported to prevent distortion from very heavy currents. They are protected against external injury by the shields on the frame, which cover them completely; these shields were not on the machines at the time the photographs were taken.

The exciting current at 110 volts is fed to the rotating field by copper gauze brushes impregnated with carbon, which are pressed against the two slip rings by brush holders of the lever type, the tension on the brushes being maintained by helical springs. Current for excitation and for auxiliary purposes is supplied by a 36 kw. steam-driven generator, or by two 70 kw. motor-generators. The engine of the steam exciter is by Belliss & Morcom and runs at 600 revs. per min.; it is capable of carrying a 10 per cent. overload for two hours. The Siemens dynamo, to which it is directly coupled, supplies continuous current at from 100 to 110 volts.

The two main engines exhaust into Körting condensers, placed in the basement underneath the floor, each capable of dealing with 13,000 lb. of steam per hour, and producing a vacuum of 26 in. of mercury. A smaller Körting condenser, capable of maintaining the same vacuum when condensing 1,000 lb. of steam per hour, is provided for the steam exciter. The piping and valves are so arranged that any one of the condensers can be shut down without interruption to the service. The condensers discharge into a tank 20 ft. by 10 ft. by 6 ft. built up of cast-iron plates.

The centrifugal pump for pumping the condenser discharge back into the pond is of Messrs. Körting Brothers' make, and is capable of delivering 50,000 gallons of water per hour against a head of 80 ft. when rotating at 1,450 revs. per min. It is directly driven at the speed mentioned by a Siemens three-phase squirrel-cage ventilated type 40 H.P. motor, which is fed with current at 25 cycles per second from the 400 volt alternating supply. Starting is effected by a star-delta switch. Near to the motor, and in a handy position for the attendant, is a motor-control panel equipped with one three-pole quick-break 50 ampere switch, three 50 ampere fuses, one ammeter and one lighting fitting.

Switchboard.—The switchboard (Fig. 6) is erected at one end of the engine room. It is built of fire-proof material throughout. The high-tension apparatus is mounted near to the wall, but the operating gear for the high-tension apparatus is mounted on separate panels in front of and at a certain distance from the high-tension gear. The operating panels contain only low-tension instruments and apparatus, and the high-tension oil switches are operated from this board by a system of suitable levers. The low-tension operating board is separated from the high-tension gear by a passage of

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a clear width of 8 ft 6 in. There are three alternator panels of which one is blank, and six feeder panels, of which three have so far been fitted up with apparatus. Each of the two motor-generators is controlled from one continuous-current and one alternating-current panel. There is also a lighting panel in the centre of the board, an exciter panel and three transformer panels, and a number of blank panels are provided for future extensions. The main panels facing the engine room are of white marble and are supported on an iron framework.

Access to the chamber between the high-tension apparatus and the low tension operating board is gained through two doors of expanded metal, one at each end of the switchboard, and unauthorised persons are prevented from entering by providing the doors with a lock, which can only be opened from the outside by a special key. The high-tension panels next to the wall are insulated from one another by slate division pieces, and the front of each high tension panel facing the passage way is provided with a substantial metal screen, so arranged that the screen cannot be removed until the isolating switch has been opened. It is, therefore, impossible for an attendant to come into contact with the high-tension switch gear while it is under pressure.

The switchboard is equipped with all the usual instruments and apparatus necessary for an efficient and reliable control. The equipment includes low-tension integrating watt hour meters with the requisite potential transformers, single-phase high-tension fuses, synchronising gear, electrostatic leakage indicator to indicate a fault developing on any one of the three phases, overload releases with time limit relays, and so on. The secondary windings of all instruments, as well as the switchboard frame and screens, are permanently earthed. The bus bars are carried above the high-tension chambers on porcelain insulators. There are four single-phase 2,200/400-volt transformers for reducing the high tension current to a pressure suitable for the motors on the surface of the mine. Three of these transformers are connected up for three-phase working, while the fourth is a spare. They are placed at one end of the switchboard near to the wall.

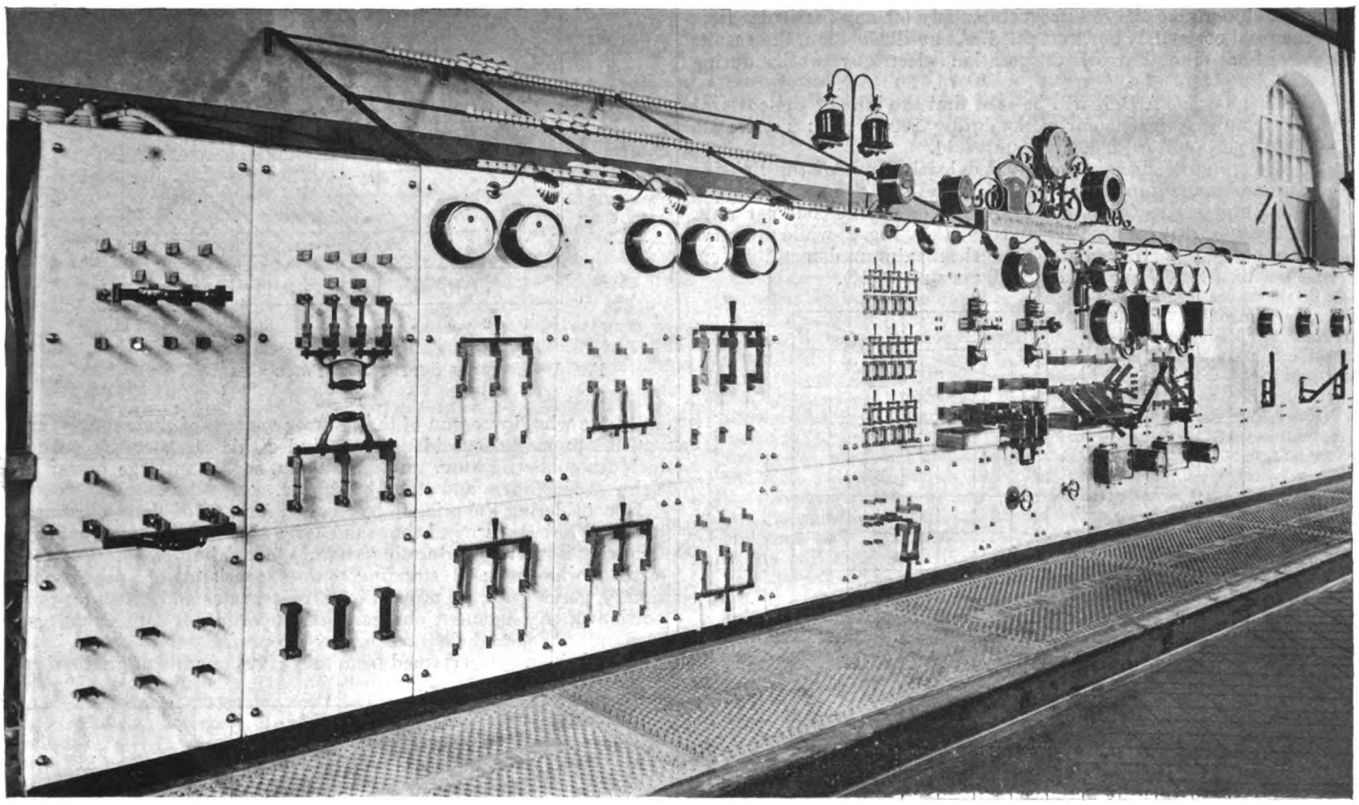

FIG. 6.—SWITCHBOARD.

The power station is to be formally inaugurated on Tuesday, July 9.

TWELFTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

On Thursday afternoon, June 27, three Papers were read. The first of these, by Mr. Shawfield, appeared in our last issue. The second Paper, which we now give, was discussed at the same time as that of Mr. Shawfield.

THE COSTS OF ELECTRICITY SUPPLY AND THEIR RELATION TO SCALES OF CHARGES.*

BY H. R. BURNETT.
(Chief Electrical Engineer, Barrow-in-Furness.)

It will be generally admitted by anyone who has made a study of the scales of charges in force in connection with many of the electrical undertakings of this country, that, not only are the methods of charging in many cases unnecessarily complicated and numerous, but the charges themselves do not bear that relation to the costs of production which one might reasonably expect to find. That greater uniformity of action and simplicity in the methods of charging are desirable will hardly be denied. With a view to obtaining the opinions of members of the Association upon this subject, the author proposes briefly to describe the methods which he has adopted of ascertaining the costs of supply from the works for which he is responsible, and the manner in which he considers the information thus obtained should be applied in fixing the scale of charges.

In order that the costs of supply may be accurately ascertained, it is essential that the books of the undertaking should be so arranged that the expenditure can be readily watched week by week. The author includes in his Paper a form of works costs book for the information of those engineers who have not paid attention to the subject. A book of station records such as this made up weekly serves the double purpose of enabling the engineer to at once detect and check any excessive expenditure, and also facilitates the preparation of quarterly balance-sheets and annual records in connection with the works. The "estimated cost of repairs" and not the "actual cost" is recorded each week, the reason for this being that the actual cost during any particular week cannot reasonably

* Paper slightly abbreviated.

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be charged against the units generated during that week, and would be liable to vary to such an extent as to destroy all comparison between one week and another. The method adopted in dealing with this item has been to make an estimate of the cost of repairs and output for the year and to debit each week's expenditure with a fixed amount per unit generated. If at the end of the year it is found that there is an appreciable discrepancy between the estimated and actual cost of repairs, the quarterly figures are adjusted accordingly.

From the "Works Costs" and other books, a balance-sheet showing the receipts and expenditure on electricity supply is prepared quarterly. The figures obtained from these quarterly balance-sheets are plotted as in Fig. 1, and curves are obtained from which the law underlying the total costs of supply (or any particular item of the total costs) may be ascertained. As an illustration, the results obtained at the Barrow Corporation electricity works during 1905-6 are given.

From the curve A.B. it will be seen that the law for the costs of supply from these particular works during 1905-6 was: Total costs = £2,242 per quarter + 0·60d. per unit sold.

If the standing charges are divided by the sum of the lighting consumers' maximum demands,* it is found that the costs of supply were: Total costs = 6·74d. per kilowatt per day + 0·60d. per unit. This law is shown graphically by curve C.D. Fig. 2, while the curve E.F. represents the price charged on the maximum demand system (6d. per unit for 1 hour per day, 3d. per unit after).

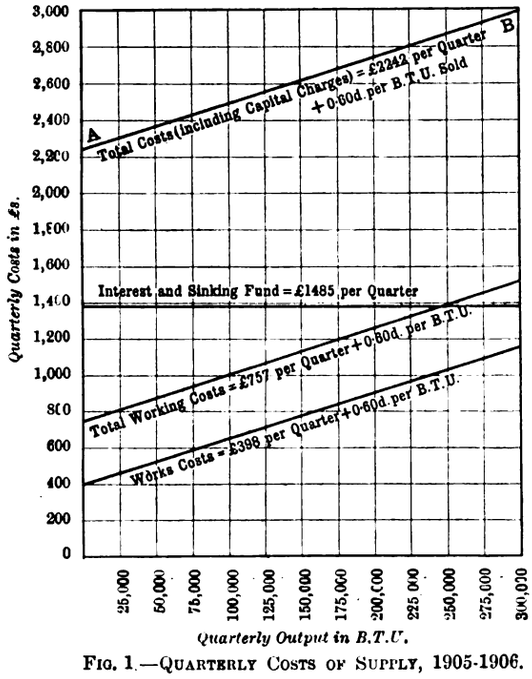
Quarterly Costs in £s.
Total Costs (including Capital Charges) = £2242 per Quarter + 0·60d. per B.T.U. Sold
A
B
Interest and Sinking Fund = £1485 per Quarter
Total Working Costs = £757 per Quarter + 0·60d. per B.T.U.
Works Costs = £398 per Quarter + 0·60d. per B.T.U.
Quarterly Output in B.T.U.

FIG. 1.—QUARTERLY COSTS OF SUPPLY, 1905-1906.

In Fig. 3 are given the curves representing the total costs (including capital charges) at the works for which the author is responsible during each of the years 1899-1900, 1902-3, 1905-6. While it is not suggested that the method of ascertaining the costs of supply, which has been briefly described, is infallible, the author is confident that it will be found to be sufficiently accurate for all practical purposes.

Having described the methods by which the costs of supply from any particular works may be ascertained, the author proposes to consider to what extent the information thus obtained may be applied in fixing the scale of charges.

Broadly speaking there are three classes of supply for which practically all works have to cater and for which scales of charges have to be fixed: (1) Lighting. (2) Power and Heat. (3) Special, including supply for public lighting, traction, large power and other consumers

1. *Supply for Lighting.*—The scale or scales of charges for supply for lighting are necessarily based upon the maximum demand system, and the curve representing the cost of production (Fig. 2) is of considerable assistance in deciding what the scale should be. Having decided what is the maximum demand scale upon which the works can supply at a profit, the fixing of flat rates for various classes of consumers is a simple matter.

2. *Supply for Power and Heat.*—The fixing of a scale or scales of charges for power and heat supply upon an equitable basis is a very much more difficult matter than in the case of lighting supply, owing to the great variety of purposes for which the supply may be required. Where the maximum demand system is adopted for power supply the rough-and-ready method of fixing the scale of charges appears to be to make the initial and final prices per unit about one-half of those decided upon for the lighting supply. It is generally found expedient to have an alternative flat rate or sliding scale, in which the price per unit is usually about the same as that to which the consumer would be entitled on the maximum demand system by two hours' daily use of the supply.

3. *Special.*—The third and perhaps most important class of consumers for whom the engineer has to decide upon scales of charges

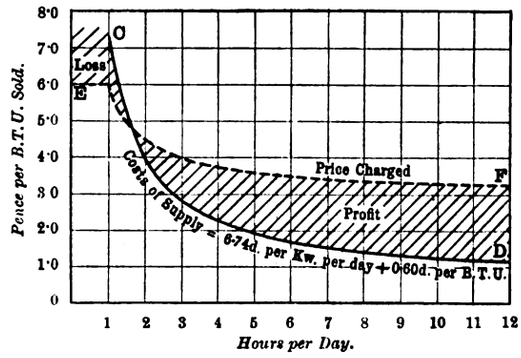

FIG. 2.—COSTS OF SUPPLY AND PRICE CHARGED, 1905-1906.

are those who, by reason of the nature or extent of their supply, are entitled to special consideration. Under this category the author includes public lighting, traction supply, supply to large power or lighting consumers and stand-by supply.

In considering the price to be charged for any of these purposes, it is well to bear in mind that the charge should be made up of the following items:—(1) Running charges, consisting of a proportion of the works costs; (2) standing charges, consisting of: (*a*) Proportion of works costs, (*b*) proportion of rents, rates and taxes, (*c*) proportion of management charges, (*d*) proportion of capital charges (general), (*e*) special capital charges; (3) profit.

1. This item is ascertained from the curves of costs of production, Fig. 1.

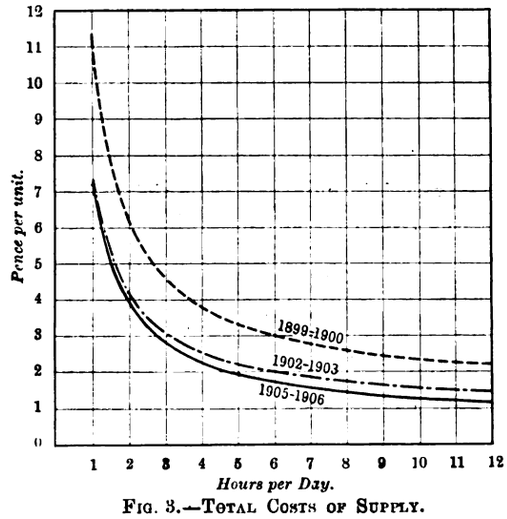

FIG. 3.—TOTAL COSTS OF SUPPLY.

1899-1900 - - - - - - = 9·75d. per day per kw. of demand + 1·39d. per unit.
1902-1903 — · — · — = 6·57d. " " + 0·93d. "
1905-1906 ——— = 6·74d. " " + 0·60d. "

2 (*a*) (*b*) (*c*) (*d*) (*e*). It is usual to apportion all these items according to the maximum demand of the consumer, and in cases where the consumer's maximum demand is liable to occur simultaneously with the maximum load upon the generating station, this is a rational course to follow.

3. When the above charges have been properly apportioned, it is only necessary to add a small percentage, say 10 per cent., for profit.

When the supply is only given at such hours that it will not increase the maximum load upon the generating station, the standing charges (2) (*a*) (*b*) (*c*) (*d*) will not be materially affected by the supply, and the price charged should therefore be made up of the following items:—(1) Running charges; (2) (*e*) capital charges on special capital expenditure, if any; (3) profit.

The running charges are ascertained, as before, from the curves, and the effect of any special capital expenditure (such as an exten-

* At the works referred to it is found that the sum of the lighting consumers' maximum demands is approximately 33⅓ per cent. in excess of the maximum load observed at the generating station.

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sion of mains) entailed by the supply is easily calculated and must be allowed for.

The allowance for profit should, however, in this case be considerably increased to cover the use of plant, mains, &c. Exactly what margin should be allowed is, of course, a matter of opinion; but in justice to the consumers, who have the capital charges upon the plant to bear, and as a matter of sound business, the allowance should, in the opinion of the author, be in the neighbourhood of 50 per cent. on the cost. Even with this margin for profit, it will be seen from the following example that the prices arrived at are quite moderate:—

1. Running charges as obtained from curve AB, Fig. 1..	0·60d.
2. (*e*) Capital charges on special capital expenditure (if any), say	0·10d.
Net cost of supply	0·70d.
3. Add for profit, use of plant, &c., say 50 per cent.	0·35d.
Price to be charged.....	1·05d.

The important bearing which even a comparatively small special capital expenditure may have upon the price which should be charged is often overlooked. In order to illustrate and emphasise this point, the author includes in his Paper a curve* showing the cost per unit resulting from a capital expenditure of £100 on a sale of from 1,000 to 10,000 B.T.U. per annum, the capital charges being calculated at 6½ per cent. on the expenditure.

The author suggests that, with a view to obtaining greater uniformity in tariffs for electricity supply, members of this Association in advising their committees should recommend tariffs based upon the following lines:—

Supply for Lighting.—1. A maximum demand rate so arranged that the price charged to a consumer using the supply for two hours per day is from 10 per cent. to 15 per cent. in excess of the ascertained cost of the supply.

2. (*a*) An optional flat rate for any consumer based upon two hours daily use of the supply on scale (1).

2. (*b*) Optional flat rates for particular classes of consumers, such as hotels, clubs, public-houses and dwelling houses, based upon scale (1), the rate being fixed according to the ascertained average daily use of the supply by these consumers.

Supply for Power and Heat.—3. A maximum demand rate in which the initial and final prices are each one-half of the prices charged on scale (1).

4. An optional flat rate for all consumers, based upon two hours' daily use of the supply on scale (3).

Supply to Special Consumers.—5. The price charged to be the ascertained cost of supply plus 10 per cent. to 15 per cent. for profit.

Restricted Hour or Two-rate Supply.—6. The price to be based upon the ascertained "running costs" of supply, plus 50 per cent. for proportion of standing costs, use of plant and profit. Any supply taken between sunset and 12 midnight to be charged at maximum price on scale (1).

In cases where it is deemed desirable to adopt a sliding scale the scale should be obtained by varying the discount upon the flat rate according to the consumption as follows:—

For the first 1,000 B.T.U. (or other quantity) per quarter, price = flat rate, net.

For the next 1,000 B.T.U. per quarter, price = flat rate less 10 per cent.

For the next 1,000 B.T.U. per quarter, price = flat rate less 15 per cent.

For all over 3,000 B.T.U. per quarter, price = flat rate less 20 per cent.

By arranging a sliding scale in this manner the anomalous position of a consumer being able to reduce his total bill by increasing his consumption (which is possible upon the scale of charges in force in some towns) is avoided.

There was a combined discussion on Mr. Shawfield's and Mr. Burnett's Papers. In what follows we give an abstract of this discussion, except the first part of the remarks of Messrs. J. F. C. Snell and S. L. Pearce, which appeared in our last issue.

DISCUSSION.

Mr. J. F. C. SNELL, commenting on Mr. Burnett's statement that special consumers were entitled to special considerations, took tramways as an illustration. If this meant a higher price than power users, he concurred; but if the opposite he disagreed. From his more recent experience of power supply in many large towns, if the tramway load continued to increase, it would not be possible to cover the cost (if supplying at a cheap rate). He thought the tendency was away from many different methods of charging towards a uniform system of initial charge with graduated scale of discounts. Mr. Burnett was to be congratulated on the manner in which he kept his accounts. The moral to be drawn from the Papers was that the competition with gas for lighting was becoming more keen, and, although there was also power competition, this could be more successfully met. In fixing power tariffs it was necessary to keep in mind the rapid rate at which the power load was increasing. If this factor were left unconsidered the power load might preponderate over the lighting and the revenue account might appear on the wrong side.

[* We have omitted this curve.—Ed. *E.*]

Mr. S. L. PEARCE (Manchester), in continuation of his remarks (given in part in our last issue) on Mr. Shawfield's Paper, thought it would be very difficult to separate the lighting and power load charges as suggested by Mr. Shawfield. The transmission costs given both by Mr. Shawfield and Mr. Snell he could not agree with. £10 per kilowatt would not, in his opinion, cover the cost of transmission, distribution and transforming plant on consumers' premises. An authority had recently published some figures based on 120,000 kw.; it was estimated that the transmission costs for that load were £16 per kilowatt, and he thought this was a more accurate figure, though it might be even higher. The system used made a difference, whether it was three-phase all through or a conversion to continuous current. As to the method adopted of fixing charges in large towns, about which Mr. Shawfield inquired in his Paper, he thought that the principle referred to in the first paragraph of the Paper was mainly adhered to. There were, however, cases in which the authority would be justified in remitting a portion of the fixed charges for power consumers, and this would probably be sound policy for the undertakings as a whole, though it might result in a loss for a year or two on that particular consumer, just as a short hour consumer or even a tramway load might prove a loss. The effect as a whole was undoubtedly beneficial. He would debit every new consumer with his own capital charges—each penny of the capital expenditure involved in mains and transforming plant. As to Mr. Burnett's Paper, he did not agree with giving discounts on quantity; this was wrong in principle. Any reduction made should be based on load factor and hours of running.

Mr. A. M. TAYLOR (Birmingham) thought with Mr. Pearce that Mr. Shawfield's £10 per kilowatt of maximum demand was too low. He believed the cost at Manchester (he had not Mr. Pearce's authority for saying so) must be about £40 or £50 per kilowatt of maximum demand, including sub-stations, and in other towns it was quite as high. With high-pressure three-phase supply to large consumers it might be reduced considerably, but not to anything like the figure suggested by Mr. Shawfield. As regarded the cost of generating plant, Mr. Shawfield was considering the cost of certain extra units put down for dealing with the power load. It must be borne in mind that the figures were per kilowatt of maximum demand, which meant that, since he had just given them the bare costs and divided by the kilowatts of maximum demand, he had allowed nothing for spares. All Mr. Shawfield's figures would have to bear a proportion for spares. The figures were no doubt for a generating station put down with a view to rapid extension in the future, and which had room for putting down, say a couple of sets, and he proposed to debit the scheme with those two sets and their accessories. He disagreed with Mr. Shawfield's allowance of £3 per kilowatt of maximum demand for buildings and foundations. In one case that he knew of the cost of the buildings, with room for future extensions, was £12 per kilowatt of plant capacity, equal, say, to £15 per kilowatt of maximum demand. £2. 7s. was probably not far wrong per kilowatt of plant capacity for boilers, stokers, economisers and feed pumps, and would have to be increased to about £2. 17s. per kilowatt of maximum demand. He would allow 12s. or 15s. per kilowatt of maximum demand for steam and exhaust piping in place of Mr. Shawfield's allowance of 5s., and he would put the total at something between £25 and £30 per kilowatt of maximum demand, against Mr. Shawfield's £13. Had Mr. Shawfield taken into account cost of conveyors, storage tanks, circulating water plant, overhead crane, balancers, boosters, and so on; and, if considering alternating-current plant, cost of exciters? These little items amounted to nearly another £8 per kilowatt of plant capacity, or, say, £3. 10s. per kilowatt of maximum demand, and brought the total to something like £30 to £35, against Mr. Shawfield's £13. He suggested Mr. Shawfield had just considered the bare cost of supply for a particular element of his system, and had rather overlooked that a good many motor-power consumers had to be taken off the lighting mains, and that in cases of that sort the capital costs would not come down in anything like the same ratio as they would where two or three specially large consumers were supplied from a high-tension supply. Therefore, although he agreed with Mr. Shawfield to some extent in charging the power load only with the additional costs involved, he thought Mr. Shawfield had very much underestimated the costs both of the generating station and of the distribution service, including the sub-station.

Mr. S. CLEGG (Lincoln) emphasised the influence of the power supply on the costs of a comparatively small station. He quoted an instance of an inquiry from a large works in his area, at a time when his total output was 400,000 units per annum, 10 per cent. of this being for power. The maximum load was 300 kw. and involved the laying of a special main ⅝ mile long. His ordinary power tariff would not meet this case, so after inquiries in the town as to power costs in other works he offered a price of 0·9d. per unit, on a basis of 600,000 units per annum, which was accepted. This arrangement had been in vogue for 12 months and had had an interesting influence on the costs. When this offer was made the works costs were 1·07d. and the total costs 1·61d., including interest and sinking fund. Last year 1,280,000 units were sold, of which 568,000 were for the works in question, 164,000 for traction and 80,000 for ordinary motor load, making 800,000 in all for power, as against 400,000 for lighting. The works costs were reduced to 0·75d. and the total costs to 0·993d., the improved figures giving a profit last year of £3,000 out of the £11,000 revenue. The price to lighting consumers was also reduced under the new arrangement. In a new agreement recently made with a large consumer, for an extension of the supply, a coal clause had been included.

Mr. W. W. LACKIE (Glasgow) said he was a maximum demand enthusiast, and he strongly believed that in large cities if the flat rate were adopted the best customers would be lost. By offering a maximum demand rate the engineer could offer a sliding scale to long-hour consumers. In the supply of power there was a steady supply of 10 hours a

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day. In lighting, the load varied from month to month, with peaks. If a complete supply of power could be given, then in course of time the lighting might be thrown in as a by-product. Mr. Shawfield's maxim was not sound. It was, he thought, impossible to lay down a scale of charges applicable in every case. He could not agree with Mr. Shawfield's costs, and was sure there was not a station where the cost was under £30 per kilowatt. In Glasgow it was £35 to £40. Mr. Shawfield had allowed a profit of 5 per cent., after allowing 9 per cent. for interest, sinking fund and reserve fund. If Mr. Shawfield got 10 per cent. he was perfectly sound financially, but the cost given for repairs and maintenance was very little for the number of units. In regard to Mr. Snell's objection to Mr. Shawfield's figure for coal, he thought Mr. Shawfield's cost was all right. Dealing with Mr. Burnett's paper, Mr. Lackie said in regard to the two kinds of consumer mentioned under the maximum demand system of charging, each of these consumers would pay half the standing charges, which he thought fair. Mr. Burnett's curve showing the cost per unit resulting from a capital expenditure of £100 on a sale of from 1,000 to 10,000 B.T.U. per annum was, in his opinion, misleading. The additional expenditure would alter the price per kilowatt. Regarding Mr. Burnett's suggested basis for fixing scales of charges, in his opinion the basis should be undoubtedly on the maximum demand system, and should be worked out on the average number of hours for which the energy was used.

Mr. E. E. HOADLEY (Maidstone) said that in many of the smaller towns there was a big market for power supply for factory and other purposes. When he first went to Maidstone the power rate had been fixed for about two years. From figures furnished by factories in the town he worked out roughly their yearly cost for power, and then presented a scheme to his committee, fixing a power tariff which was very low for a town where coal was expensive. From that time the financial position of the undertaking began to change. The number of units generated went up enormously, and the works costs came down. In their town of about 35,000 people they had now very nearly 1,000 H.P. of motors connected, and last year sold nearly 400,000 units for power, not including the tramways. A power load was a very desirable thing to have, and he agreed with Mr. Shawfield that the advantages could not all be put down in black and white, but a good power load with the ordinary supply would certainly increase the revenue and reduce the works costs. He thought a system of charging for the number of units used per horse-power demanded much better than a flat rate. In making agreements with large factories they had in Maidstone for the past three years put in a coal clause, which he thought was very important. In some towns power given at a cheap rate during restricted hours had been a success, but it was very difficult to get people to shut off their works at 4.30 or 5.0 in the winter months. At Maidstone he had found the overlapping of the two loads of little importance. It would, he thought, be to the advantage of many of the smaller towns if they treated their power supply somewhat in the manner indicated by Mr. Shawfield in his paper.

Alderman WEST (Coventry) remarked that the maximum demand system had been in use with them a considerable time, but now they had adopted the flat rate. He thought that the flat rate was the best. They should ascertain as far as possible the cost of generating current in large quantities, and then settle the price for lighting and power. In Coventry they used to charge 6d. for the first two hours and 3d. after, but it did not pay. Then they altered the charge to 4d. for motive power, which also did not pay. They then made the price for lighting 6d. for the first hour, 3d. for the second hour and 1d. for the remaining hours. There was a good deal of grumbling, and he advised the committee to give a flat rate of 4½d., but this again was unsatisfactory. Knowing it was of little use reducing the price for power unless they did something more, they obtained sanction to let out motors on hire. At first only a few very small motors were let on hire, but soon the business began to grow rapidly, and whereas in the first full year under the new policy the units sold were 112,463 at an average price of 1·75d., last year they sold 3,211,090 units at an average of 1·09d. The price for power was reduced to a flat rate of 1¾d. per unit for the first 10 H.P. of maximum demand and 1d. for all afterwards. The total cost in 1902 was 4·89d., and this had steadily fallen until last year it was 1·26d., including standing and capital charges. Although the revenue from current sold was low, only by supplying in large quantity and pleasing all customers could they make a profit.

Mr. C. E. C. SHAWFIELD, in reply, said he had fully anticipated a good deal of hostile criticism, and his anticipations had to a considerable extent been realised. At the same time he was agreeably surprised to find his contentions had been largely borne out by the actual experience of other engineers. Dealing with Mr. Snell's reference to the apparent absence of spare plant, he would point out that the generators in question had an overload capacity of 100 per cent. and that the overload of the turbine was, he believed, even greater than that. In a large power house in the North he believed it was the practice to run the generating sets constantly at somewhere about 70 or 80 per cent. overload, and they had no hesitation in going to overloads even beyond that amount. He was of opinion that in future, in fairly large generating stations, the policy would be to provide spare plant by depending upon the overload capacity of the station. In regard to the maxim to the effect that "if you reduce your prices to suit your competition the cost of production would adjust itself to the tariff," which Mr. Snell had objected to, other speakers had shown that the maxim was to a very large extent correct. He did not mean that it should be carried to the extreme of a man getting his power for nothing, but he contended that to sell electricity in competition with other forms of motive power it must be sold at a price which would appeal to the consumer. Mr. Snell was, he thought, in a somewhat unique position, inasmuch as he had at Sunderland obtained prices for power supply which must make the mouths of other engineers water. It was out of the question to attempt to quote such prices in the Midlands. It was because he had found the ordinary power rates useless that he had gone into the question from what was perhaps a somewhat original standpoint. Mr. Snell had also criticised his figures for running costs. The figure for coal consumption was perhaps on the low side, but it was quoted him by the manufacturers of the plant and he would not cast doubts upon the veracity of their statements. According to the makers' guarantees, the figure would be considerably under 4 lb. with a plant load factor of 100 per cent., and with a plant load factor of 75 per cent. the increase in coal consumption was very small, again according to makers' guarantees. He knew these figures were obtainable in two stations in this country, but had not the authority of the engineers to give further particulars. Mr. Pearce had also spoken unfavourably of his maxim, and then to his surprise had practically admitted its truth, inasmuch as he said it did not matter so much about the question of profit because a large power load, given in considerable quantities, had a favourable effect upon the costs, which was, in his opinion, only another way of saying your costs of production adjust themselves. His transmission cost of £10 per kw. demanded had also been adversely criticised by several speakers. He would say, however, it was a figure he had arrived at from actual experience. He thought if they would select a power consumer within a reasonable distance from the station and ascertain the cost of running a main from the station to his works, they would find the cost of that main, assuming the streets had to be opened, would come under £10 per kw. He had not, up to the present, found a case in which this figure was exceeded. Mr. Taylor had chiefly directed his criticism to the cost of the plant and buildings. He would mention that the whole of the figures were taken from actual tenders received. In the case of the buildings and foundations, chimney and flues, they represented accommodation for not 2,000 kw., but nearly 5,000 kw. It might be possible his figures for steam and water piping, &c., were low owing to local circumstances, but they did not represent a very large amount per kilowatt capacity of plant. With regard to the items Mr. Taylor had suggested he had omitted, out of the whole of the auxiliaries mentioned the only one not included in the estimate was that of conveyors, which he had not included because it was almost impossible to gauge this item, which might vary from a few shillings to a a few pounds per kilowatt, and conveyors were not a necessity for power stations. Mr. Clegg had practically shown what he (Mr. Shawfield) had endeavoured to enunciate as a principle he had been following in practice with satisfactory results. Ald. West had also, he thought, shown that a policy of drastic reduction in price for motive-power purposes was followed by more drastic reductions in the cost of production. Mr. Hoadley had also found that reduction of price to power consumers was followed by very satisfactory results, which tended to prove the correctness of his theory. Mr. Lackie had confessed himself to be an ardent disciple of the maximum demand. It was difficult to argue from such opposite standpoints, as if they applied the maximum-demand system rigidly to power supply he thought the results practically precluded the securing of more than the skimming of the consumers in the area. It might be his application was wrong, but after trying in every possible way it was a case of dropping either the maximum demand or the power supply, and he preferred to drop the former.

Mr. H. R. BURNETT, in his reply, remarked that much of the criticism had been directed to Mr. Shawfield's paper and there were very few points left for him to deal with. Perhaps his statement that the tramway supply was entitled to special consideration had received most attention. What he meant to convey was that the capital charges on the plant installed for tramway supply were considerably lower than the average capital charges on the station, and therefore the tramway supply should be given the benefit in arriving at the tariff to be charged. Mr. Snell had disagreed with his Fig. 2. He had put down the actual price charged. A better charge would probably be 8d. for the first hour and 1d. afterwards, but considerations of expediency or perhaps the statutory powers would prevent one from charging more than, say, the maximum price of 6d., and would make the final charge considerably higher than it would otherwise be. They could not help losing over the short-hour consumers, and they must, therefore, increase the profits on the long-hour consumers, or the nett result would be on the wrong side. Mr. Pearce had thought that he laid undue stress on the profit, but it was very desirable to so adjust the tariffs that they did not get adverse results at the end of the year. He did not think the profits he had suggested any too large to ensure a surplus at the end of the year, because it must be remembered there were a large number of consumers who must be supplied at a loss. They could not help having a number of consumers who did not bear their reasonable share of the costs. Mr. Lackie admitted being an advocate of the maximum-demand system. So was he, but he thought an optional flat rate was necessary.

The PRESIDENT congratulated Mr. Shawfield and Mr. Burnett upon the interesting discussion evoked by their Papers. He would like to say in regard to the coal figure of 3·75 lb., he had been well below this figure for the past three years in Sheffield, where their figure had been 3½ lb., with banked fires, per unit sold. It was a charming idea of Mr. Lackie's that coal was going to make all the power and the ashes all the light. He agreed with Ald. West with regard to the hiring out of motors being a good business producer. Five or six years ago they had no motors in Sheffield. They commenced hiring, and business came in, and very shortly people bought their motors. Although they had obtained a loan of £10,000 for the purpose, he did not think more than £5,000 had gone up to the present time, although they had turned the amount over time and again. The motors totalled 7,000 H.P. at the present time, and they were still coming on. In regard to supplying some consumers at a loss, they must do a little advertising. The supply of a 4 H.P. or 5 H.P. motor was a dead loss at first, but from experience he found that within a few years they got 200 H.P. or 300 H.P. in the same place, and all the lighting, and private

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house lighting as well. This had happened over and over again in Sheffield. In regard to adjusting the tariff to suit the competition, they had to go very carefully into this matter, and in the case of Sheffield he had carried out that principle. The gas competition in Sheffield was so keen that some three or four years ago they had to bring the price down and institute a sliding scale of discounts.

On the motion of the President a hearty vote of thanks was accorded to the authors of both Papers.

The third and concluding Paper on Thursday was as follows:—

DEPRECIATION AND RESERVES FOR ANTIQUATION AND OBSOLESCENCE FROM AN ENGINEERING STANDPOINT.*

BY C. H. YEAMAN.
(Chief Electrical Engineer, Hanley.)

The author first deals with the claims which electricity consumers have for a reduction in the price of electricity before profits are utilised for reduction of the rates. He then shows that the value and utility of the plant as a factor of economical production are not maintained by keeping it in the same condition as it was at the time of purchase if, during the period it has been so upheld, the progress of the industry has led to more efficient and cheaper plant being put upon the market.

To sustain the fight industrially, it is necessary that the plant and other fixed assets should be maintained, not merely in as good a position as they were originally, but equal to similar plant which might be employed by a competitor. In practice this resolves itself into debiting against each year's balance such sum as will provide new plant when that now in use ceases to be sufficiently cheap in its working costs to run in competition.

Municipal electricity works are constructed with borrowed capital and this is obtained in much the same way as a limited company issues its debentures, but the security is more than the assets created by the expenditure of such capital. A potential liability, unlimited in extent, is imposed on the ratepayers, who, to all intents and purposes, guarantee the repayments of the borrowings. No principles for fixing the periods which may properly be allowed for local loans for different purposes have ever been laid down by authority, and consequently it is found that the practice of the sanctioning authorities for Scotland, for England and in the County of London differs. Borrowing by means of mortgage deeds seems to be the most popular method of contracting loans. Repayment is made, either at a fixed date, by setting aside annually sums to sinking fund from revenue which at the expiration of the loan period are available for its extinction, or by paying off a sum each year. The latter method has two variants. An equal instalment of principal, together with interest on the outstanding debt, may be paid yearly on the instalment plan, or an equal sum as will cover the interest and repay the principal within the prescribed period may be allowed on the annuity system. In either case the redemption, repayment, sinking fund or loan charges are such that the debt incurred is liquidated by the end of the period authorised for borrowing, and this period is, as a general rule, so limited as to warrant the expectation that the schemes and works on which the money is spent will remain in good condition and render efficient service throughout the whole of the period allowed. Although in the Metropolis 42 years were allowed for repayment, this was not based upon an estimate of the equated life, but was in the first place selected as the maximum period for which a company would, under the Electric Lighting Acts, be allowed to carry on its undertaking before the option of purchase could be exercised by a local authority. Hampstead has been courageous enough to voluntarily provide for the liquidation of its capital expenditure in 25 years, and thus "occupies the most favourable position of the borough councils."

In the Board of Trade model form of electricity accounts, where the undertakers are a local authority, there are included in the net revenue account the following items: Interest on mortgage debt, instalments repaid, sinking fund payments, payments to reserve fund, sum applied to local rates, balance carried forward.

In the company model form, in the revenue account is included a section omitted from the local authority form:—

To depreciation: (1) Depreciation of leasehold works, (2) depreciation of buildings, (3) depreciation of plant, machines, &c.

While the net revenue account contains: (1) Interest on debentures, mortgages and bonds, (2) interest on temporary loans, (3) dividend on preference stocks, (4) balance applicable as dividend on ordinary shares.

The word "profit" does not appear in either form.

In provisional orders and the Electric Lighting (Clauses) Act, 1899, it is enacted that all moneys received shall be applied in payment of working, establishment and maintenance expenses, interest, dividends, instalments, sinking fund payments; and in providing a reserve fund, "if they think fit," such fund not to exceed one-tenth of the aggregate capital expenditure on the undertaking. The net surplus shall be carried to the credit of the local rate or, "at their option," in reduction of the capital moneys borrowed for electricity purposes. The order in which these appropriations appear is significant, and while again no mention is made of "profit," ample provision is given for the wiping out of capital "if they think fit."

In 1902 the council of this Association received a report from a sub-committee appointed to deal with the repayment of loans, and on February 21st of that year a resolution was passed at a special general meeting stating "That in the opinion of this Association, electricity supply undertakings having to be maintained in a thorough state of efficiency out of revenue, no depreciation or further writing off of capital is necessary when the period allowed for repayment of loans is not greater than 30 years, as the equated life of the plant exceeds that period." As a rule, in municipal borrowings the period granted for the repayment of loans is supposed to be the equivalent of the life of the object for which the loan is sanctioned, but this principle is not applied in the case of undertakings granted an equated period for extension as well as original loans. The period granted on this basis is determined by the average life of each item specified in the capital account, so that taking the amount and life of each the weighted mean gives the equated period. In first or foundation loans the sites and buildings are items, and these entering into the calculation prolong the equated period. When extensions are required, should the same period be sanctioned the loan extends far beyond the probable life of the assets upon which the money is spent, as they are probably only plant, mains and perhaps meters, all of which, by themselves, would on the basis of calculation of the foundation loan be entitled to a shorter equated period than was allowable when the amount included long-lived assets such as site and buildings. The principle, therefore, of allowing an equated period at all is regarded as unsound by accountants, who frequently suggest that it should no longer be continued, but that each loan should be borrowed for a period corresponding to the estimated life of the object for which it is required.

Where there is an equated period for loan sanctions, the question arises whether a second loan may be, or in principle should be, granted for the replacement of a section of the assets, admittedly a short lived portion, before the whole amount of the loan has been repaid. As the period was originally calculated upon the supposition that such section would only have a short life, it is argued that a replacement loan should be permitted, on the ground that the longer items are being paid off at a too rapid rate. While, strictly speaking, this may be the case, there is the objection that the rule of refusing sanction to reborrowing during the currency of a loan would be infringed, and the growing practice to sanction each item or class of asset separately has much to recommend it. Apart from the period being long or short, it is very desirable that the expenditure upon each item and against each sanction should be shown, or at least known by the accountant, and also that the amount redeemed should be ascertainable, so in the event of displacement the exact amount outstanding can be written off. To effectually do this requires a certain amount of trouble being taken in prime costing work carried out. The Local Government Board inspectors have frequently protested against the too common practice of lumping all sanctions together on one side of the capital account, and in like manner taking the total of the expenditure, everything being considered satisfactory so long as there is a balance of sanctions over expenditure.

Net profit correctly stated is the balance of earnings after charging all sums that ought properly to be taken into account. How are these sums to be ascertained? If in order to arrive at the profit earned it is necessary in the case of a company for due provision to be made for the depreciation of wasting assets, what relationship does such depreciation bear to the sinking fund of a local authority? The sinking fund, by intention, will have reached an amount equal to the original purchase price of an asset by the time such asset has fallen to zero value, or a negligible residual value; and, therefore, if the currency of the loan be equal to the true life of the asset, sinking fund and depreciation fund are equivalent if not synonymous terms. Assuming that it has been proved that depreciation is chargeable against revenue in the profit and loss account, it is not then necessary or desirable to charge also sinking fund. On the principle that the greater includes the less, if the depreciation allowance be sufficient it covers sinking fund in any case. Sinking fund payments or direct repayments of capital may not equal the full depreciation required, but they certainly are means to that end.

The argument on the other side is that if the betterment, additions to and repairs of a plant from year to year are charged to maintenance and operation instead of to capital or construction account, it is for all practical purposes maintaining the plant at 100 per cent. value.

It has been very clearly put that a balance in the net revenue account cannot be properly considered profit until the reserve fund has been built up to such an extent as to make the undertaking

* Abstract.

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perfectly safe against all possible emergency demands, whether due to rise in prices or in working costs, to special maintenance or renewals, or to the necessity for adopting new methods or more modern machinery to replace those already existing.

Were it not necessary to the very existence of an undertaking to keep generating plant and mains more or less up to date, the contention that once statutory obligations had been met nothing else is essential would carry the day. Engineers are constantly being offered plant which is being discarded by other undertakings, showing that, recognised or not, the process of eliminating the unfit is going on naturally all over the country. In such cases the unredeemed portion of the loan must be met by immediate calls upon revenue if a fund or balance in hand is not available for the purpose.

The comparison between a company's management and municipal control requires to be very carefully made to show the exact differences. With a local authority the difference between the total assets and the total liabilities is a sum which represents the net profit and provision for redemption of debt made by the undertaking since the commencement.

Does a company usually pay off its debentures on their termination and reduce its capital by the amount wiped out? This hardly seems the practice, and those who claim that a company's debentures are on all fours with a corporation loan should be called upon to explain why in so many instances one set of debentures is cleared off by the creation of another. Indeed, in the model form of accounts for electric lighting companies no mention whatever is made of any sinking fund for this purpose. The writing down of a company's capital is too often effected at the expense of the shareholders, who, willy-nilly, have to suffer the loss consequent upon the re-establishment of a sound commercial position.

There is an admitted diminution of value of small dynamos and alternators purchased 8, 10 or more years ago, to say nothing of the minor portions of plant equipment. Where such plant has been removed to make room for large and efficient sets of modern design it has invariably been sold at a residual value, but little above scrap or breaking-up price. In the days when many of our present successful undertakings were established, day-load sets of under 50 kilowatts were quite common; occasionally such things as 15 kilowatt generators were put down, and these have given place to larger because they became useless with a minimum load many times their capacity, well within their expectation of life. Utility and durability were shown to have different periods, yet where similar sets remain to-day they appear in the balance-sheets at full value, and against this there is only half the purchase-price in the sinking fund. The author takes the case of Taunton as an example.

The amount of depreciation which should be allowed is fairly definite. The Income Tax Commissioners allow four to five per cent. in calculating income-tax upon industrial undertakings. For purposes of extreme accuracy a professional valuer may be called in and his opinion taken, say, triennially, depreciation for the ensuing three years being allowed upon the rate at which the assets are diminishing in value according to such valuations. The engineer of an undertaking can usually give a figure sufficiently accurate for the purpose, and in the most prominent case of accounts made out in this way that was the course followed.* The five instances where depreciation is debited in the accounts are Aberdeen, Bolton, Darlington, Devonport and Glasgow, while Bristol has now followed suit.

The figures for the last complete year published are given in the annexed tables, together with the various opinions expressed as to duration of life of plant, &c., and a summary of the accounts set aside at Glasgow.*

Table of Estimated Life of Electrical Appliances for Loan Purposes.

——	Mr. Robert Hammond, April, 1907.	L.G.B.	L.C.C.	Mr. J. F. C. Snell, M.E.A., 1905.
Land	60	..	60	100
Buildings	60	30	50	60
Boilers	20	15	20	20
Engines	20—25	15—25	20	25
Elec. generators	25	20	20	25
Accumulators	15	5—7	20	10
Static transformers	15	15	20	20
Rotary converters, switches and instruments	20	15	20	20—25
Mains	25—30	12—15	mains, 30; services, 12	ducts, 60; solid mains, 25; cables, 15
Meters	10	5	10	15
Arc lamps	10	7—10	Not granted	15

*"Mr. Chamen had put down a period for the various portions of the electrical undertaking at Glasgow. One-third of the equipment at from 50 to 100 years, and others at 10 years. They had written off their depreciation according to this list."—Bailie Willock, M.E.A. Convention, 1906.

The sinking fund may be regarded as a depreciation fund for capital and the "depreciation" proper as a similar provision for plant and mains. If, in addition to sinking fund, from 1 to 2 per cent. on the whole capital be set aside annually for the latter purpose and either invested or (what is the same thing) employed in the business as working capital, thus saving the payment of bank interest which should be credited to this fund, the minimum considered desirable would be available. Out of this regular renewals on change of old plant for new could be made.

The amount of depreciation desirable to allow in America was considered at the Boston meeting of the U.S.A. Institute of Electrical Engineers in 1899, and the general feeling was that 10 per cent. on the cost of any electrical plant was a fair allowance annually. The New York Edison Company allowed 8 per cent., this amount covering the wearing out of machinery, its profitable replacement by other forms, and the limitation of the useful life due to greater competition of the central station companies.

The life of electricity generating plant constructed at this date is considerably greater than that turned out, say, 10 years ago. But the useful life depends upon more than the possible working life. It must be borne in mind that not only has diminished value by reason of wear and tear to be provided for, but the probability of an expensive machine becoming obsolete and requiring replacement, well within its expectation of life, has also to be taken into account.

From the engineer's point of view, having the best interests of the consumers and ratepayers before him, depreciation allowances should cover antiquation, obsolescence and ineffectiveness, enabling machinery which may be in good working order to be scrapped and replaced when it has become ineffective.

It has been said that the Local Government Board is adverse to the specific provision for depreciation.† This can hardly be the case, as the tendency of the Board is to shorten and not to lengthen the period of loans, thus tacitly admitting that the former periods granted are too long. Yet it is found that several corporations have, by majorities against the building up of a depreciation fund, shown that they consider their undertakings "on a sound financial basis" without it and prefer "to leave things as they were."

Doubts have been expressed as to the legality of supporting a depreciation charge by the equivalent of a call on the rates. In addition to providing adequately for depreciation, a local authority owning electricity works may have to face special unforeseen or extraordinary expenditure, the result of accident, change of system, &c. These expenses would in the ordinary way fall upon repairs and maintenance account, but to meet them in any one year might and probably would entail a call upon the rates for aid.

The method sometimes adopted to avoid a call on the rates, *i.e.*, to create a (deficit) suspense account and wipe it out by payments thereto from revenue over a period of years, is undoubtedly not in accordance with the Electric Lighting Acts. A reserve fund built up beforehand from surplus revenue acts as an Equalisation Fund, and it is on all fours with the now much favoured hire-purchase system.

Another reason why surplus balances should be retained in hand, or in readily realisable investments, until the reserve has reached the full amount of 10 per cent. on capital permitted by the Electric Lighting Acts, is that when the annual accounts are made up to the end of a financial year the charges for the fourth quarter of that year have only just been rendered to the consumers, and the surplus shown in the net revenue account is therefore not really available in cash, but is represented principally by book debts.

The author's conclusions are that there is very little real disagreement on the question of depreciation, and the necessity for providing annually such sums as will meet it, between engineers and accountants.

DISCUSSION.

Mr. ROBERT HAMMOND, who was asked by the President to open the discussion, said that they would all like to do the things Mr. Yeaman said ought to be done, but it was not always possible. Mr. Yeaman at Hanley had not found it possible in connection with the last filed accounts to write off more than 3·15 per cent. Had he written off upon the basis urged, the figure would have been more. Mr. Yeaman pleaded for two things, not only the writing off of an amount annually representing the gradual wearing away of the plant, but also another amount for its gradual antiquation. No industry could stand that. While he protested against putting aside considerable sums for possible obsolescence, he certainly advocated the principle of setting aside adequate sums for depreciation. Some of the London local authorities had been lent by the L.C.C. sums for repayment over 42 years and they seemed perfectly satisfied as long as they put aside a sinking fund on the 42 years basis that they were doing what was right. The mere fact that money was borrowed for 50 years or 100 years did not enter into it at all. If the money were borrowed for 42 years the fact that only a small sinking fund would be necessary to cover that period should not be relied upon, but it should be made up to the sinking

*[We only give one of the Tables mentioned by the author.—Ed. *E.*]
† Treasurer Brown, Edinburgh Council, June 12, 1906.

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fund, which would probably have obtained, if the money had been borrowed for 25 years. All their difficulties would disappear if for a loan for, say, £50,000 or £100,000, they divided it up, say 10 years for this, 20 years for that, and 25 years for something else. His way of dealing with depreciation would be supposing the plant were depreciating at the rate of £3,000 a year, to take that £3,000 and put it into a bank until the time arrived when the whole sum was wiped off. He did not think he would set aside another £3,000, and to urge the provision of this further amount entirely nonplussed him.

Mr. L. ANDREWS said he was on the council of the association when the resolution was passed in 1902 (mentioned by Mr. Yeaman in his Paper), referring to 30 years as being a sufficient period. He voted for that then and would vote for it again if he were still a municipal engineer. He agreed with Mr. Yeaman and other advocates of setting aside something for depreciation, that it was wise to build up a reserve fund, not so much to provide for depreciation of plant as for modern plant later on to compete with other supply undertakings. It would seriously hamper any undertaking to have to set aside year by year something and to call upon the rates to build up that depreciation if it had not been earned out of profits. The great difficulty and objection in calling upon the rates, was that it gave the ratepapers who were not consumers, and the gas people, the opportunity of saying that the prices charged were too low. Municipal financiers were apt to overlook the fact that municipal undertakers were doing a great deal for posterity already. He was at present associated with a small company started some years ago. They knew exactly what its load was to be, and they were able to put down a plant to deal with that load. The building and mains and everything for that load began earning their full income at once, and in a case of that sort they were quite right in setting aside a very small sum for depreciation, as they had nothing to provide for future extensions.

Baillie STEVENSON (Edinburgh) said he wanted to put in a plea for not only sound finance, but also for a means of putting their undertakings on such a basis as would make the possibility of their ever coming on the rates very unlikely. In Edinburgh they never had any difficulty in getting the money (laughter). They had always borrowed it at 30 years, and had never been asked what they were going to do with it (loud laughter). The Board merely wanted to know that it was for the electricity undertaking, and the money was spent as the Corporation thought proper. The next point was the question of depreciation and reserve fund. At Edinburgh the reserve fund stood at its 10 per cent. maximum. £850,000 had been spent and the reserve fund was £85,000. The question then was, "What should be done with the profits?" He thought that, as municipal electrical undertakings, they had no right to have any profit at all. They were practically making the consumer pay his rates twice if they had a profit. He did not believe in applying profits to relief of rates. He thought that if the ratepayers once got this relief they would not be satisfied if they did not get it every year. At the annual meeting that morning there was a discussion as to what wages should be put to capital and what to revenue. In Edinburgh they had provided an extra column in their cash statement, and now voluntarily paid wages out of revenue that had previously been paid for 12 years out of capital. Ratepayers sometimes complained that the electricity undertakings were put down on the security of the rates, and that they obtained nothing in return. If the reserve fund were kept up to its maximum, under no circumstances could the burden come upon the ratepayers.

Mr. W. W. LACKIE (Glasgow) thought the object of every undertaking was to supply current at a low price to the consumer. Relieving the rates was nothing more or less, in his opinion, than robbing the consumers for the benefit of those who were not consumers. It might not be in accordance with law to create a suspense fund, but they had created a suspense account in Glasgow of £24,000, and they wiped out £8,000 each year. He was sorry Mr. Yeaman had not come to any conclusion in his Paper. He recommended that they should take the estimated life of the power plant, write off the corresponding depreciation yearly, use this depreciation in reducing capital, carry out ordinary repairs out of revenue and any replacements or renewals charge to capital account. If this plan were followed, and the life of a plant had been carefully estimated, the undertaking would be in a very sound financial condition. The difference in value of plant had nothing whatever to do with depreciation. If it had, what about appreciation? Most of them knew that they could sell their undertakings at the present time at anything from 20 to 100 per cent. more than they cost.

Ald. PEARSON (Bristol) thought Mr. Hammond's views would be found to be correct. The question of depreciation was one on which they were attacked more than on any other point in connection with the management of municipal electrical undertakings. Two extremist views had been cited. The truth generally lay between the two extremes, and the present question showed the correctness of that axiom. According to Garcke's Manual for the year ended March, 1906, the municipalities received 3½ millions income, out of which they set aside £245,687 for depreciation or reserve, or whatever title the various committees chose to give the provision they made over and above their sinking fund. The figures for the companies were £2,157,000 and £210,561 respectively. This showed the municipalities had about a million pounds in excess of the companies in income, and had provided about £35,000 in excess in depreciation, but the companies did not possess the other items which appeared in the figures for the municipal accounts. £709,000 was last year set aside to the credit of the sinking funds of the various municipal undertakings, which therefore provided over £950,000 for depreciation and sinking fund accounts, whilst the companies provided under £250,000. When the sinking fund had been provided, there should be another fund from which they could draw. Thus, it was necessary to provide a reserve for renewals, or whatever they liked to designate it. They found in Bristol the equation of their loan worked very badly for them, and for that reason he had been worrying the Local Government Board to alter the ordinary equated period. Twenty-five years did not represent anything like the average for the buildings, and they were therefore paying too much on that particular work. On the other hand, some of the machinery would not last 25 years. Therefore, in his opinion a smaller provision ought to be made for the long life plant and a larger sum for the short life plant. Unfortunately, under the present conditions this could not be done. They thought they would like to know in Bristol whether they were really setting aside in the shape of depreciation and sinking fund the right amount as prudent business men. They called in a prominent accountant, who figured out that they ought to have paid £2,500 a year more than their sinking fund, which they immediately did. Subsequently they were visited by a gentleman who had obtained fame, and those present would be astonished to find that this gentleman pooh-poohed the whole of the accounts, and immediately proceeded to write off certain amounts, and as a result they wrote off £1,000. If they were to have the depreciation of Mr. Yeaman, the depreciation of Prof. Dicksee, and the sinking fund of the Local Government Board, where were they going to end? Electrical committees were trustees between users of current and non-users of current; they were also trustees as between ratepayers of to-day and of the future. They had no right to unduly burden ratepayers of to-day, and to put the electrical undertaking in such a position that the ratepayer in the future would first of all have the works handed over to him revenue-earning, and then, by means of depreciation or reserve, have the money given him to buy a new plant if he wanted to scrap the old plant. Therefore, they should hold the balance fairly and impartially between the two classes.

Mr. C. H. YEAMAN, in replying, thought several statements had been credited to him which he neither held nor had made. Machinery laid down 15 years ago was scrapped at breaking-up price to-day. He asked how they were to write off the difference of the value of the machinery in the capital account and the breaking-up price, allowing, of course, for the sinking fund. Where was the difference coming from? If out of revenue in any one year, they would be in a much worse position that year than in other years, or in too good a position if they could stand the strain that particular year. He did not care whether they called it reserve, or depreciation; so long as they got the money and could call upon it as required. If they went through the accounts of many undertakings they would be unable to find that there was any money in the bank besides the sinking fund, and yet these undertakings were alleged to be making a profit and to be relieving the rates. It was absolutely necessary to safeguard the financial as well as the engineering side of an undertaking, and before they relieved the rates of those who burned gas they must help their own friends and look after the financial side of their undertakings.

The PRESIDENT said he thought that for the first few years of an undertaking it was important that they should do their best to get a big output, and that they should then take care of the depreciation or reserve fund and put the concern on Board of Trade lines.

On Thursday evening the members' annual dinner was held at the Royal Victoria Hotel, Mr. Fedden presiding.

We hope to give an abstract of the Papers read on Friday, together with their discussions, in our next issue.

Electric Steel-making in Philadelphia, U.S.A.—The issue of *Electro-Chemical Industry* for June contains some interesting details of the Colby Electric Induction Furnace, which has been tried experimentally at the tool works of Messrs. Henry Disston & Sons, Tacony, near Philadelphia. The trials are said to have resulted satisfactorily, and the installation of a large electric furnace plant for the manufacture of special tool-steels is now being considered by the managers of the Tacony Works. The original furnace used at the Tacony Works was manufactured by the Induction Furnace Co. of America, and was of 131 kw. capacity. The primary consisted of 28 turns of copper tube, $\frac{3}{8}$ in. inside and $\frac{5}{8}$ in. outside diameter, cooled by internal water circulation. A maximum current of 540 amperes at 240 volts could be employed for this primary, with a frequency of 60. The annular crucible holding the metal which formed the secondary was $14\frac{7}{8}$ in. internal diameter and $24\frac{1}{4}$ in. outside diameter. The trough was $6\frac{3}{8}$ in. deep, and had a working capacity of 190 lb. The maximum current available for the crucible was 15,148 amperes at 8·57 volts. The method of working this furnace was similar to that used for the Kjellin type of furnace (see *The Electrician*, Vol. LVIII., p. 812, 1907). Ingots of steel weighing 90 lb. were poured off every hour and fresh material (scrap, &c.) was then added to the 100 lb. of molten metal left in the furnace. The furnace is held on trunnions, so that the charge can be poured by tilting. Working under these conditions, from 27·5 to 37·5 kw. hours were used per 100 lb. of ingot metal, and the maximum power utilised by the furnace was 40 kw. The fusion of the added metal was found to be complete in 30 minutes, and another 30 minutes was required to carry out the refining process. The ingot metal was stated to be dense and homogeneous.

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COSTS AND CHARGES IN ELECTRICITY SUPPLY.

It is scarcely necessary to dwell upon the importance of knowing accurately the cost of generating electrical energy in order that a suitable tariff of charges may be drawn up, for the effect of a small profit or loss per unit upon large quantities becomes so important where prices are "cut fine" that a consumer may very easily cause a heavy loss instead of a profit to an electricity supply business if the costs are not accurately known. Doubtless most engineers who are responsible for generating stations in areas where keen competition exists have already looked into these matters very carefully; but to such as have not done so the Paper read by Mr. H. R. BURNETT before the Incorporated Municipal Electrical Association, of which we give an abstract elsewhere, will be read with interest.

As a practical instance, Mr. Burnett considers the state of affairs in Barrow-in-Furness, where a maximum demand rate of 6d. for the first hour per day and 3d. thereafter, is in force. Curves are given showing how the cost varies with the conditions. From one of these it is seen that, if

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the demand is less than about one and a half hours per day, the Corporation suffers a loss, but if the demand is for a greater period there is a profit, which becomes very considerable if the demand exceeds, say, three hours per day. From the appearance of the curves it would seem that the lower limit for the maximum demand is too high, and the upper limit possibly too low, and probably the more familiar rate of 7d. and 2d. would give a more suitable result. Possibly this rate has been left unchanged without taking into consideration the growth of the undertaking. Naturally the smaller the undertaking the higher must be the lower limit of the maximum demand system, but as the undertaking grows this limit should be reduced, for otherwise the most desirable consumers (namely those who take a supply for a large number of hours per day) are penalised for the sake of consumers that are much less profitable.

In fixing the tariff, Mr. BURNETT suggests that consumers should be divided into three classes—namely, (1) Lighting, (2) Power and Heat, and (3) Special, the latter including public lighting, traction supply, supply to large power or lighting consumers, and stand-by supply. Generally speaking, it is difficult to see why any consumers should be classed as special, with the exception of "restricted-hour" consumers and stand-by supply, the latter really forming a class by itself to which no rules can well apply. So long as any consumer requires power during times of peak load we do not think that he should require any special consideration except in detail. For example, public lighting and traction supply should both be controlled by the maximum demand system, except so far as they may differ from other consumers in the proportion of management charges, and possibly in some slight works costs. The same is true of large power or lighting consumers. A restricted hour supply, on the other hand, should fall into quite a different category, as in such a case the upper limit of the maximum demand system cannot be applied, and therefore it becomes necessary to consider what such a supply does actually cost and then to add a certain proportion for profit, for which we think, however, that Mr. BURNETT'S figure of 10 per cent. scarcely allows a sufficient factor of safety.

By some people sliding scales showing a certain amount of ingenuity are regarded with much favour. Occasionally they are designed in such a curious way that the consumer is able to have a smaller bill by increasing his consumption than he would have had if his consumption had been somewhat less. This, obviously, is not a rational system. In the scales suggested by Mr. BURNETT quantities above 1,000 units per quarter are subject to a discount varying from 10 to 20 per cent. Such large discounts appear to us to be generally based upon a want of appreciation of the conditions involved. Provided that the system of maximum demand is properly applied, then the charges for management are the only charges which become seriously reduced when a consumer takes a large quantity. If the question of maximum demand and its relation to the peak load are disregarded, then it is quite possible that a large consumer with a bad load factor may be a somewhat unprofitable consumer, notwithstanding his large consumption; yet he will be getting a discount of, say, 28 per cent., whereas he ought to be classed with those unprofitable consumers which Mr. BURNETT admits must always exist to a small extent on every network.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Synchronmaschinen für Wechsel-und Drehstrom. By W. WINKELMANN. (Hanover: Dr. Max Jänecke.) 3·40m.

Herr Winkelmann's book on alternators and motors of the synchronous type forms the fourth volume of a series of electrical hand books, known collectively as the "Repetorien der Elektrotechnik," issued by A. Königswerther. The subject matter touched upon in the present volume is too comprehensive to be treated at all exhaustively in a book of less than 140 pages, and the author has confined himself to a discussion on the principal theoretical problems which confront designers of synchronous machines. The volume opens with the time-honoured exposition of the properties of an alternating current and of an alternating-current circuit possessing resistance, capacity and inductance in various combinations. In the second chapter the author explains, with the aid of a number of simple illustrations and diagrams, how an alternating current is obtained in commercial alternators, and in what manner the wave form is affected by the design of the winding, the shape of the pole shoes, and the form and number of the slots. This leads up to a discussion on the various possible methods of predetermining a given wave form, more particularly a pure sine wave. The third chapter deals with the calculation of the losses in and the efficiencies of synchronous machines. In discussing the virtual increase in the resistance of copper conductors due to skin effect, the author states that the resistance offered to an alternating current is from about 1·5 to 2·5 times that offered to a continuous current of the same strength. This bare statement, unqualified by a mention of the frequency and copper section to which these figures refer, is misleading, and would only be correct, at the usual frequencies, for conductors of such sizes as are not employed in practice. It is a generally accepted fact that the skin effect is negligible in copper conductors up to $\frac{1}{2}$ in. in diameter and at the customary frequencies, and that it amounts to no more than 1 per cent. for a conductor of a diameter of 1 cm., supplied with alternating current at a frequency of 80 cycles per second. The next chapter treats briefly of the determination of the temperature rise in various parts of electric machines. In the following section the author goes at some length into questions relating to the calculation of the different magnetic fluxes, the armature reaction and kindred subjects. Two short chapters are devoted to synchronous motors and to the parallel running of alternators respectively. The chapter on self-exciting and compounded alternators is largely taken up by an exposition of the well-known method of compounding alternators as elaborated by Heyland. A few pages are devoted to a discussion on the properties of the iron used in the construction of alternators, and the last chapter contains the complete calculations of a 500 kw. 5,000 volt three-phase alternator. These calculations are carried out in commendable detail, but an efficiency of 92 per cent. (excluding excitation) seems somewhat small for a machine of this size.

The book is not altogether free from small misprints, and the author is decidedly anticipating events when he states, on page 97, that a certain well known American firm builds alternators for outputs up to 20,000 kw.

As will be gathered from the above that the book contains no original matter; the writer has borrowed freely from recognised authors, but has been careful to mention their names and to ind cate where the complete publications can be found. These references form one of the most useful features of the work.

Although the book under review is not likely to appeal to experienced dynamo designers on account of its wholly theoretical nature and the lack of new matter, it should form a useful source of information to students interested in the subject.

Was sind und wie entstehen Erfindungen? By JOSEF LÖWY. (Vienna: A. Hartleben.) 1m.

Although this short philosophical study on the inner nature and origin of invention offers but meagre help to the practical inventor, it will afford pleasurable and interesting reading to

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those of a reflective turn of mind. The author's chief conclusion is that invention, far from being artificial and haphazard, is a strictly logical evolutionary process which furthers the natural development of mankind by either extending or supplementing the limited powers of the human organism by immeasurably greater powers drawn from nature's inexhaustible store.

THE SUPERPOSITION OF MECHANICAL VIBRATIONS (ELECTRIC OSCILLATIONS) UPON MAGNETISATION, AND CONVERSELY, IN IRON, STEEL AND NICKEL.*

BY JAMES RUSSELL.

Summary.—Vibrations may be superposed upon a constant field, or change of field may be superposed upon permanently acting vibrations. Under the former conditions, vibrations lessen those differences of magnetisation to which hysteresis without vibrations has already given rise. Under the latter conditions, hysteresis loss, for instance, is increased or decreased as the fields are low or high; and in quenched nickel vibrations increase residual magnetism, when the field producing the same induction with and without vibrations is in both cases withdrawn. Such results cannot be concisely stated in terms of magnetic hysteresis, but they are subject to this condition—that vibrations increase the differential permeability in low fields, diminish it in high fields. The effects of electric oscillations upon magnetisation, when superposed under both the above conditions, are essentially the same as those produced by purely mechanical vibrations.

That mechanical vibrations affect magnetism has been known since the time of Gilbert. About twenty years ago Ewing published investigations upon the effects of vibrations upon magnetisation.† It is also recognised that disturbances other than mechanical, produce magnetic effects essentially vibratory. A rise or fall of temperature‡, the superposition of a transverse magnetic field, increase induction, decrease residual magnetisation. Other examples might have been given. But the disturbing element has also direct magnetic effects and sooner or later the analogy becomes imperfect.

On the other hand, it appeared reasonable to suppose that, as the direct magnetising action of high frequency currents is very greatly reduced, the vibrational effects due to the high frequency would be increased, and that consequently the analogy between the effects of electric oscillations and mechanical vibrations upon magnetisation would be more complete.

It became immediately apparent, as soon as this investigation was commenced, that, had the experimental methods of earlier investigations dealing with the magnetic effects of vibrations been such as to elucidate the various phenomena involved, the results of later investigators (Ascoli, Arno, Walter and Ewing, Garibaldi, Marconi, Maurain, Piola, Rutherfoord, Wilson, and others) relative to the effects of electric oscillations upon magnetism would have fallen more readily into line with each other§ and with the effects of purely mechanical vibrations.

Apparatus.—To obtain satisfactory quantitative measurements the vibrations must be produced in such a way that they can readily be put "on" and "off," and that when on they remain constant in character and intensity. Such a result was very approximately attained by experimenting with wires attached to the gong of an ordinary electric bell. The wires were hooked at their ends, and one extremity of a wire could be linked to the gong, the other to the vertical arm of an L shaped lever, preferably by means of a short length of thread. A weight of 11 oz. suspended from the horizontal arm of the lever subjected each wire to a pulling stress not greater than 0·5 kilo per square millimetre of sectional area. The effect of the load and the possibility of torsion are discussed in the Paper. Iron, steel and nickel wires, 100 cm. in length and approximately 0·092 cm. diameter, were used in an annealed and also in a quenched condition. Each wire under test was in a horizontal position, at right angles to the earth's field, and coincided with the axis of a magnetising solenoid 41 cm. long. An exploring coil and ballistic galvanometer measured the magnetic intensity at approximately the central position of the wire.

Superposition of Vibrations and Field.—The effects of vibrations have in general been investigated by tapping—that is to say, vibrations have been superposed upon field. But the effects of vibrations cannot be limited to one method of relative superposition of vibrations and field. Change of field may be superposed upon the magnetic metals kept in a state of continuous vibration. These methods are entirely dissimilar, and the recognition of this fact is of primary importance. Both experimental methods were adopted and are as follows:—

A. Mechanical vibrations are superposed upon constant field.

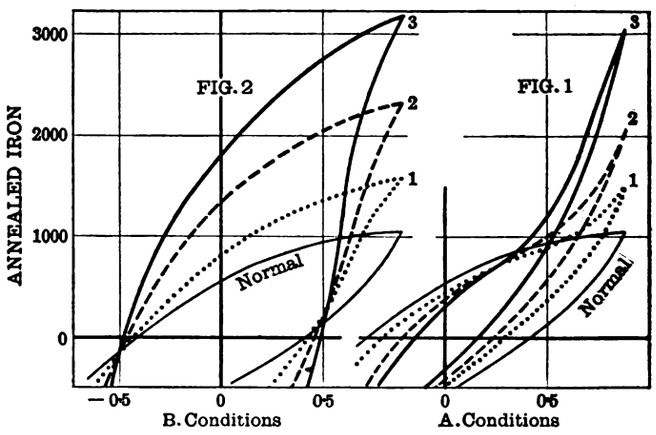
B. A change of field is superposed upon mechanical vibrations permanently acting.

These methods are fully described in the Paper. Suffice it to say here that, under the (A) conditions, mechanical vibrations are superposed by simply ringing the electric bell. This *necessitates* that demagnetisation by decreasing reversals must follow upon every superposition of vibrations, before the next observations are made. Under the (B) conditions, on the other hand, the bell is rung after demagnetisation, and continues ringing until any set of readings has been completed.

Intensity of Vibrations, Varied.—Figs. 1 and 2 show for annealed iron, and for one value of field at cyclic extremes, H = 0·92, the experimental results under the (A) and (B) conditions respectively, for three different intensities of vibrations obtained by suitably altering the voltage at the terminals of the electric bell. The normal loops without vibrations are the same in both cases. The other curves show the effect of increasing the intensity of vibrations in the ascending order indicated by the numerals 1, 2 and 3. A glance at the curves shows that the order of superposition under the (A) and (B) conditions produces apparently very different results. Note that the horizontal and vertical ordinates H and B are in C.G.S. units in all the diagrams.

Intensity of Vibration Constant.—In the experiments now to be described the strongest vibrational intensity, corresponding to curves 3 of Figs. 1 and 2, is used.

Permeability and Retentivity Diagrams.—Figs. 4 and 5 show for annealed steel and nickel, and Figs. 13 and 14 for quenched steel



CURVES 1, 2, 3, WITH VIBRATIONS OF INCREASING INTENSITY.

and nickel, B H curves, and curves of residual magnetisation (likewise plotted against H), obtained by withdrawing the field at all values of induction measured. The full and faint dotted and continuous lines are the induction and residual magnetisation curves respectively, with and without permanently-acting vibrations (B conditions). The full and faint dash lines show the ratios B_v/B and $B_v - R_v/B - R$ respectively for all values of H. B_v, R_v and B, R signify the induction and residual magnetisation with and without vibrations respectively. The values of these ratio ordinates are to the left of the diagrams and are to the same scale throughout. The different scales to which H and B are drawn should be noted when comparison is made between these figures.

Cyclic Diagrams.—In Figs. 6, 7, 8, 15, 16 and 17 the continuous lines represent the normal loops without vibrations, the dotted curves the loops with permanently acting vibrations (B conditions). Figs. 6 and 7 (annealed steel) show four sets of hysteresis loops with and without vibrations, corresponding to four-field values at cyclic extremes—viz., H = 0·16, 1·46, 2·6 and 11·0. The induction amplitudes (without vibrations) cover the wide range between B = 56 and B = 15,750. In Figs. 7, 8, 16 and 17 comparison may be made between the smaller and larger normal loops and the dotted loops with permanently-acting vibrations in each figure for the same value of field and induction at cyclic extremes. Fig. 7 is for annealed steel, Fig. 8 for annealed nickel, Figs. 16 and 17 are both for quenched nickel, the former for low, the latter for high cyclic amplitudes. In Fig. 15 for quenched iron the comparison is for the same low value of induction only.

On the other hand, the dash line curves of Figs. 16 and 17 show for quenched nickel the effect of superposing vibrations under the (A) conditions at all stages of the smaller of the normal loops in each case. Compare with curve 3 of Fig. 1 for annealed iron under the same conditions.

* Abstracted from the *Trans.* R.S.E., Vol. XLV., p. 491.

† *Phil. Trans.*, 1885, p. 564.

‡ "Magnetic Induction in Iron," 3rd edition, p. 181 (Wiedeman).

§ "Notes on the Effect of Electric Oscillations on Magnetism," L. H. Walter, *The Electrician*, May 5, 1905; also *Science Abstracts*, Vol. VIII. A, Abstract 1,290.

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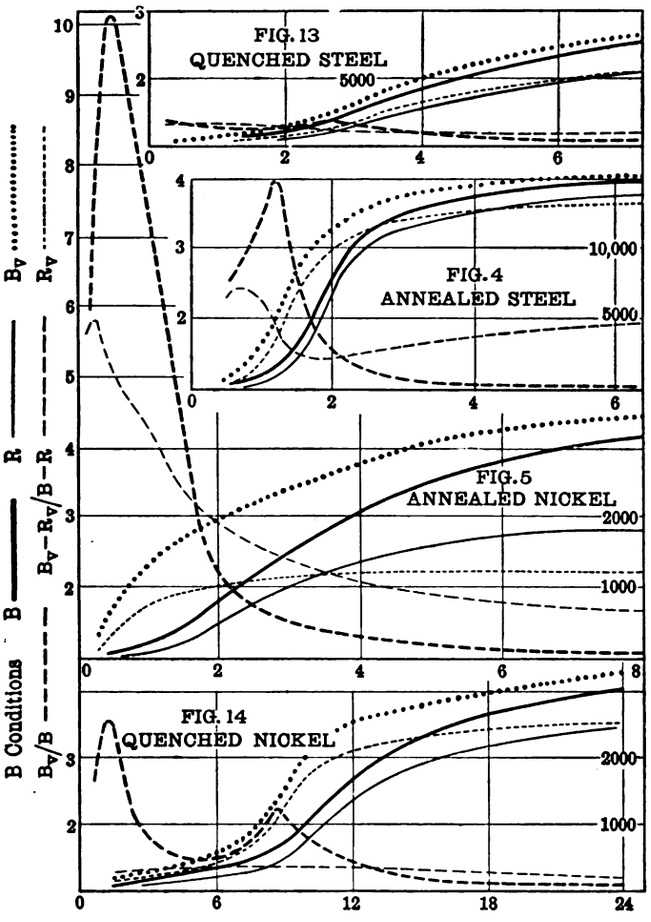
Results.

The summary of results given below is based on all the experimental work. In this abstract it has been impossible to reproduce all the diagrams.

A and B Conditions.—In all cases vibrations increase induction. In high fields B_v/B approximates to unity. In nickel the induction reached is greater (if field be not unduly increased) when vibrations are superposed (A conditions) than one half the induction change on reversals when vibrations are permanently acting (B conditions). The reverse is the case for iron and steel.

B Conditions.

Permeability.—In all cases B_v/B is approximately a maximum when dB_v/dH is a maximum. In annealed nickel the maximum value of $B_v/B = 10$, in annealed iron and quenched nickel about 3, in annealed steel 4, and in quenched iron and steel a decided minimum. In quenched nickel the B_v/B curve shows two well-marked maxima: the second when dB_v/dH is a maximum, the first at a lower value of field. Two corresponding maxima are merely indicated in



quenched steel. In no other case are they observable. On H being further increased, maximum values of $B_v - B$ occur, so far as observed, a little earlier than maximum values of dB/dH. In annealed steel the maximum value of $B_v - B = 4{,}500$, in annealed iron 2,800, in annealed nickel 1,250, but in quenched iron and steel rather less (700) than in quenched nickel (1,000).

Negative Induction Change.—The ratio of the negative induction change when field is withdrawn, with and without vibrations $(B_v - R_v/B - R)$, distinguishes the quenched from the annealed condition. In the quenched metals this ratio does not differ greatly from 1·3 for all values of field other than the lowest. In the annealed metals, on the other hand, it varies largely with field, reaching a maximum in annealed nickel (5·8) and minimum values (1·6) in annealed iron and steel, when H is approximately = 2. (In quenched iron a corresponding minimum is merely indicated.) In annealed nickel $B_v - R_v/B - R$ is much greater in low than in high fields. In annealed iron and steel this difference is less marked.

Coercive Force, Retentivity and Hysteresis Loss in Relation to Field.—These are increased or decreased as the field is low or high, but in quenched nickel the decrease of residual magnetisation, if it exists at all, is very small.

The relative increase of coercive force is greater in annealed and quenched nickel than in iron and steel. Increase passes into decrease earlier in the case of coercive force than of residual magnetisation. The increase of hysteresis loss in low fields is relatively greater than its decrease in high fields, and increases with the increase of vibrational intensity. In annealed and quenched nickel its relative increase is enormously great in the lowest fields used. There is nothing corresponding to this when field is unduly decreased in iron and steel.

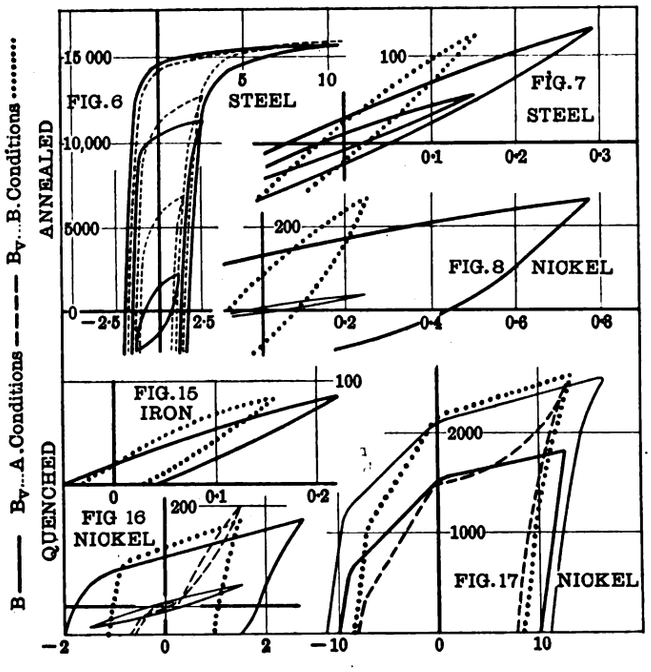
Coercive Force and Hysteresis Loss in Relation to Induction.—In all cases for the same value of induction at cyclic extremes, coercive force and hysteresis loss are so far as yet observed decreased. At high inductions the decrease of energy loss is relatively smaller than at lower inductions. At very low inductions the decrease of loss produced by vibrations is a decided maximum in *annealed* nickel.

Retentivity in Relation to Induction.—Vibrations do not in all cases decrease residual magnetisation. In quenched nickel, when the field producing the same induction of the order of hundreds in both cases is withdrawn, *the residual magnetisation is greater with* than without permanently acting vibrations. At low inductions in quenched iron R_v may equal R; in all other cases R_v is less than R.

The effect of permanently acting vibrations in reducing residual magnetisation at high inductions is greater in annealed nickel than in annealed or quenched iron and steel. In quenched nickel this effect, if it exists at all, is very small.*

A Conditions.

When vibrations are superposed at all points of the normal hysteresis loop, the induction change as the cyclic extremes are departed from is first against, afterwards with, the field change. The position of the neutral point depends upon the intensity of the vibrations and of the cyclic field (induction) The smaller the cyclic



field and (so far as my experiments go) the greater the vibrational intensity, the closer is the neutral point thrust towards the vertical axis; the higher the cyclic field and the less the vibrational intensity, the closer is the neutral point thrust towards the cyclic extreme. Thereafter the induction change continues to follow the field change until the other cyclic extreme is reached.

In all cases the induction change is greater when vibrations are superposed on the normal loop when the field is increasing. For low fields the maximum change occurs at or near cyclic extremes, where the slope of the curve is greatest. But as the cyclic field is increased the maximum induction change occurs at an earlier stage of the increasing field, where in this case also the normal curve is steepest. Vibrations of increasing intensity produce a progressive collapse, by no means complete, of the two arms of the loops.

In quenched nickel the neutral point is not so well defined as in the annealed condition of the three metals or in quenched iron and steel. Residual magnetisation is very little reduced by superposed vibrations.*

Magnetic Hysteresis.

In "Magnetic Induction in Iron" Ewing states (§ 84, 3rd edition) the "influence of vibration and mechanical disturbances generally"

* Compare with "Note on Heusler's Magnetic Metal," by Prof. And. Gray, *Proc.* Roy. Soc., Vol. LXXVII., Series A, p. 256.

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—"may be succinctly described by saying that vibrations lessen those differences of magnetic condition to which hysteresis gives rise." Although Ewing's experimental methods, in which field change and tapping alternated, almost certainly precluded the observation of the neutral points, the statement is nevertheless quite applicable to the (A) conditions whatever the intensity of the vibrations. It is, however, not applicable to the (B) conditions when the intensities of the vibrations are such that their effects have not reached a limiting value, and results cannot be concisely stated in terms of magnetic hysteresis. To do so requires as complete a knowledge in each case of the B H loop as is required without vibrations. Moreover, loops obtained when vibrations are permanently acting are stable at any point to subsequent "offs" and "ons" of the same vibrations.

Molecular Theory.—§ 182 of "Magnetic Induction in Iron" may be consulted. The general nature of the argument is shown by the following quotation:—"Any kind of disturbance that will give the molecular magnets intervals of freedom, or of diminished constraint, will tend to do away with hysteresis." This statement also appears completely applicable if the disturbances be superposed under the (A) conditions. Under the (B) conditions I prefer a deduction relative, not to hysteresis, but to the rate of magnetic change with field change, subject to any condition which molecular theory may demand. If the differential permeability in low fields be greater with than without vibrations, in high fields the reverse necessarily follows.

My deductions therefore are: (1) That if the cyclic amplitude be not unduly increased the differential permeability will be greater with than without permanently acting vibrations; (2) that the increase of differential permeability with vibrations may be associated either with increase or decrease of residual magnetisation, coercive force or hysteresis loss, but that there is greater probability that those magnetic properties which depend upon hysteresis will be increased with vibrations for the same value of field than for the same value of induction, and conversely, that there is greater probability that they will be decreased with vibrations for the same value of induction than for the same value of field. The experimental results support these deductions, which in the Paper are illustrated by diagrams.

Electric Oscillations.

The effects of electric oscillations in coils surrounding the iron previously dealt with* are precisely the effects of vibration upon magnetisation. The experimental methods being the same in both cases facilitates comparison. Under both the (A) and (B) conditions (omitting minor differences between codirectional and transverse oscillations) the similarity extends to details.

Conclusion.

A Conditions.—The effects of mechanical vibrations (summarised above) or of electric oscillations, superposed at all stages of the normal loop are, generally speaking, to lessen those differences of magnetisation to which hysteresis *without vibrations has already given rise.*

B Conditions.—When change of field is superposed upon permanently acting mechanical vibrations or electric oscillations, the results (summarised above in the case of vibrations) cannot be concisely stated in terms of hysteresis. They are, however, subject to this condition, that vibrations or oscillations increase the differential permeability in low fields. In sufficiently high fields vibrations or oscillations must delay demagnetisation.

This investigation affords a general survey of the effects of vibrations upon magnetisation under these two distinct methods of relative superposition of vibration and field, and cannot in any sense be regarded as exhaustive. It was directly suggested by previous work on the effects of electric oscillations upon magnetism, with which it is intimately associated. The results obtained with vibrations undoubtedly facilitate further investigation in its theoretical and practical aspects (magnetic detectors) dealing with the primary objects of these researches, for which the Royal Society of London placed at my disposal a Government grant, which I desire to acknowledge.

Addendum.—In a Paper on "The Effect of Electric Oscillations on Iron in a Magnetic Field,"† read to the Physical Society on June 22, 1906, Dr. Eccles, referring to my previous Paper (mentioned above), calls attention to the fact that I applied to the iron "the oscillations passing through a coil connected directly in series with a small induction coil." On July 14 and 15 last I experimented with oscillations produced in the usual way by means of two small Leyden jars, induction coil, spark gap and oscillation transformer. The oscillations could either be passed directly through a long iron wire, 0·041 cm. diam., or through a coil surrounding it. In both cases the effects of these oscillations, when superposed under the (A) and also under the (B) conditions were essentially the same as the effects of mechanical vibrations. Any of the corresponding curves of Figs. 1 and 2 (present Paper) show the results obtained with sufficient accuracy.

The precise method in which oscillations are generated does not appear to be material, and I should like to point out wherein Dr. Eccles' experiments differ essentially from my own. He states that he found it possible "to get over and over again practically the same magnetometer deflection for every spark, provided the effect of previous oscillations was wiped out by taking the iron through *a cycle.*" The fact that the observations could be repeated does not prove that the effect of previous oscillations had been wiped out. The cycle so obtained, and upon which the sparks are superposed, is not symmetrical about the origin, its want of symmetry being determined by the "set" given to the magnetisation by the preceding oscillations. Moreover, I found, previous to determining my own experimental methods under the A conditions that *repeated reversals of the cyclic field* were not sufficient to wipe out the effect of immediately preceding oscillations, and that to do so the magnetic metal must be *demagnetised by decreasing reversals* after each superposition of an electric oscillation or of a mechanical vibration.

The results are recorded "as if the observations had been taken only on the ascending half of the hysteresis curves." The readings are all positive and one of the conclusions arrived at is as follows: "It is evident, moreover, that the magnitude of the effect at any point is closely connected with the slope of the hysteresis curve." The occurrence of a neutral point, now well established after a cyclic extreme is departed from and which may occur close to the vertical axis, disposes of any connection between the value of dB/dH *at any point* and the magnitude of the spark effect.

Dr. Eccles' experimental method reproduces to a certain extent the working conditions of the first form of Marconi's magnetic detector, and confirms the latter's experience that the magnitude of the spark effect is small as a cyclic extreme is departed from. But in neither case are oscillations superposed upon a hysteresis loop which has not already been modified by the effect of previous oscillations. In neither case are the (A) conditions fulfilled.

* "Notes on the Effect of Electric Oscillations (Co-Directional and Transverse) on the Magnetic Properties of Iron." *Proc.* R.S.E., Vol. XXVI., p. 33, 1905. Also *Science Abstracts*, Vol. IX. A, Abstract 1,119.

† *Phil. Mag.*, August, 1906. *The Electrician*, August 24, 1906. *Science Abstracts*, Vol. IX. A, Abstract 1,619.

PHYSICAL SOCIETY.

At the meeting held on June 14th, in the Pender Electrical Laboratory, University College, by invitation of Prof. Fleming, Mr. H. M. Elder, vice-president, in the chair, a Paper on the

"Electric Arc"

was read by Mr. Upson. It dealt with observations made during the past session at the Pender Electrical Laboratory, at the suggestion and under the direction of Prof. Fleming, F.R.S., with the object of elucidating some of the facts connected with the production of electric arcs between cooled metal and carbon terminals, in air and hydrogen. Apparatus was exhibited for maintaining the arc in various gases, while one electrode was cooled by means of a water circulation. Arcs were described in which the electrodes consisted of carbon, copper, iron and aluminium in different combinations, maintained in air, hydrogen and coal-gas. With 110 volts supply, metal arcs in hydrogen took the form of a spark discharge. At that voltage the maximum length of arc it was possible to obtain, with current up to 15 amperes, was 0·05 in., except where both electrodes were of the same metal. When carbon is one of the electrodes a true arc is formed. If carbon is negative the maximum length of arc with the above voltage is 0·07 in. Volt-ampere characteristic curves were shown for arcs in air and hydrogen of length 0·05 in. The general position of the curve is determined by the material of the negative electrode. With carbon negative, in hydrogen, the curves for various positive electrodes very nearly coincide. With carbon positive, they keep the same curvature, but vary in distance apart, according to the material of the negative. In general the position of the curve is governed by the negative, but its particular shape seems to come from the influence of the surrounding gas. The slope of the curve (amperes horizontal, volts vertical) of the carbon arc in air is much less steep than that of the curve of any arc in hydrogen. The former curve cuts the latter in the neighbourhood of 6·5 amperes. The curve for the arc with carbon positive, aluminium negative, in air, is very steep, being equal in this respect to the curves for arcs in hydrogen. Volt-ampere characteristics were shown for copper arcs in air, with (1) positive electrode cooled, (2) negative electrode cooled and (3) neither cooled. Equations for various arcs were obtained giving the voltage in terms of current and arc-length. It was much more difficult to obtain a carbon arc in hydrogen with alternating currents, and no arc could be obtained when the electrodes were copper positive and carbon negative, with 100 volts supply and frequencies of 50 and 80. Similar results were obtained in coal-gas. Apparatus was devised, in accordance with a suggestion by Dr. Fleming, to interrupt the arc for a definite period of time. Experiments were tried to determine how long the arc could remain extinguished

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without losing the power of restarting itself when the E.M.F. was again applied. Curves were shown for arcs with electrodes of solid and cored carbons in air. With cored carbons the time of interruption is greater than with solid, and both are much greater than that for the copper-carbon arc. In hydrogen the copper-carbon arc could not be made to restart itself if the E.M.F. was removed for more than 0·04 of a second, and for this arc the minimum interruption possible is far shorter than for any carbon arc in air.

Mr. W. DUDDELL said the Paper was a most interesting one. He asked if the author had noted the character of the different arcs which he had used. The characteristic curves for arcs in coal-gas or hydrogen were steeper than those in air, and therefore arcs in coal-gas were more suitable for the production of oscillations. He asked if the curves remained steep when the current was quickly changed. He had noticed the phenomenon of an arc between two-cored carbons relighting, and said that on high-voltage circuits the length of time was considerable and amounted in some cases to seconds.

Mrs. AYRTON said the Paper was a valuable one, but she was sorry the author had not given a careful description of the appearance of the arcs and carbons under different conditions, and also the observations upon which the curves were founded. It was difficult to arrive at any general conclusions from the author's curves. The steep parts depended not only on the composition of the electrodes, but on their size and on the length of the arc. The author had only used short arcs which with carbons only gave the flat part of the curve. With metal-carbon you got the steep part. Mrs. Ayrton also expressed her interest in the relighting experiments shown by the author.

Mr. A. CAMPBELL asked if the characteristic curve of a mercury arc was similar to that of the other metal arcs investigated. He pointed out that the use of unscientific units (inches and feet) in giving the results of such interesting researches was most deplorable. In all standard works on the subject the lengths of arc were always given in millimetres, and even in commerce the diameters of carbons were similarly expressed (*e.g.*, 12 mm. and not 0·47 in.).

Mr. ALEXANDER RUSSELL stated that Mr. Upson's Paper would be extremely useful to all engaged in research in connection with the electric arc. He agreed with the author that coal-gas was very unsuitable for experiments with the arc. He had recently been experimenting with high-voltage alternating arcs in coal-gas, and in most cases the enclosing vessel was soon filled with black cobwebs. When, however, the high-voltage high-frequency arc between iron-iron electrodes was shunted by a Leyden jar in series with a small coil of wire the discharge between the electrodes became simply a torrent of sparks and no appreciable quantity of soot was formed. The difficulty the author experienced in certain cases in obtaining an arc was due probably to the low voltages used. When high voltages were applied it was easy enough to maintain an arc. More experimental research was wanted on the upper part of the statical characteristic curve of the arc. A good deal of exploration had already been made in this direction in Dr. Simon's laboratory at Göttingen with the help of a motor generator from which three or four amperes of direct current could be obtained at 5,000 volts. The results already obtained were of great importance. The success of the statical characteristic method as an instrument of research was mainly due to the care with which Mrs. Ayrton had specified the method of obtaining the curve. He hoped that Mr. Upson would make further researches at high voltages.

Dr. FLEMING congratulated Mr. Upson on his Paper, and said that it represented a considerable amount of careful work, and even if all the conclusions to be drawn from it were not yet absolutely clear, it would furnish a statement of facts which would assist in future theorising. He said that the interesting part to him at the moment was the difference between the form of the volt-ampere characteristics for the carbon-carbon arc in air and the metal-carbon arc in hydrogen, but on that matter he would defer his remarks until he had shown some other experiments.

Mr. UPSON, in reply, stated that the primary object of the Paper was to compare metal arcs with carbon arcs. He had also performed some experiments with change of voltage and variations in the length of burning of the arc, and he hoped to carry out a series of experiments using high voltages.

Experiments were then exhibited by Dr. J. A. Fleming, F.R.S., **on the Poulsen Arc** as a means of obtaining continuous electrical oscillations, repeating some of those shown by him at the Royal Institution on May 24 last. Dr. Fleming showed and described an apparatus for forming an electric arc in atmosphere of coal-gas between a carbon rod kept in slow rotation and a cooled copper anode, the arc being formed in a magnetic field of 600 to 1,000 C.G.S. units. The arc was supplied with continuous current at a pressure of 400–500 volts. A condenser of 0·003 mfd. capacity in series with an inductance of 200,000 cm. was shunted across the arc, and experiments shown to prove the existence of high frequency oscillations in the condenser circuit. A long resonance helix of insulated wire was then joined to the condenser circuit, and when tuned to it created a powerful high-frequency field round it in which vacuum tubes glowed brilliantly. By vibrating or rotating a Neon vacuum tube of spectrum type near the helix, and showing that the band or disc of light was cut up by dark spaces, Dr. Fleming supported the contention that the oscillations so produced are not absolutely uninterrupted but cut up into groups. Another experiment was shown to confirm this. The oscillations produced by the arc in one circuit were caused to create secondary oscillations in another circuit in which was a condenser shunted by one of Dr. Fleming's oscillation valves and a telephone. The valve rectifies the secondary oscillations, and if they were absolutely continuous the telephone would be traversed by an uninterrupted direct current. But, as a fact, a discontinuous sound is heard in the telephone which can arise if the primary oscillations come in batches or groups.

Dr. Fleming then gave some figures showing the kind of values obtained for the efficiency of transformation of continuous to oscillatory current by the arc, and compared them with similar measurements for the spark method. He concluded with some discussion of the modus operandi of the metal-carbon arc in the production of oscillations in a shunt circuit containing capacity and inductance. In the first case the curve was (as shown from Mr. Upson's diagrams) much steeper than in the second. This implied that the same amount of energy could be conveyed to the oscillatory circuit by means of a condenser of smaller capacity, and therefore give higher frequency. This was confirmed by the fact that the curve for small currents in the case of the carbon arc in air was steeper than for large currents, and it was found that a Duddell carbon arc could give high frequency oscillations when actuated with small currents. He thought that there was still much work to be done before the whole of the phenomena of the oscillatory arc would be understood.

Mr. W. DUDDELL expressed his interest in the experiments, especially those in which it was shown that the oscillations were broken up into groups. He pointed out, however, that it was possible to obtain continuous oscillations with a musical arc using high frequencies. The question as to the measurement of the power put into the Poulsen Arc was of great interest, as also was the question as to the amount of power which could be taken from the secondary without stopping the arc. He questioned Dr. Fleming's statement that the power put into the arc was equal to the product "A V," and said that the power should be measured with a wattmeter.

Mr. A. CAMPBELL remarked that Mr. Altberg in Odessa had lately shown that sparks of high oscillation frequency produce actual air vibrations of the same frequency, and by measuring the wave-lengths of these air vibrations by diffraction methods he had been able to determine the high frequency.

Dr. FLEMING, in reply, said he was prepared to accept Mr. Duddell's criticism that the power put into the Poulsen arc should be measured with the wattmeter. The really important matter, however, was the reason why the metal-carbon arc in coal-gas could produce oscillations of so much higher frequency than the carbon arc in air. This he thought was intimately connected with the slope of the characteristic curve.

Mr. ROLLO APPLEYARD exhibited a direct reading conductivity bridge for testing rods of steel or other material, where there is considerable range of conductivity between successive specimens and where it is necessary to eliminate the resistance of end contacts. The instrument is provided with two scales and with corresponding sliders. By setting one of the sliders with reference to its scale compensation is made for any small difference of diameter or of mass between the standard rod and a test rod. The second slider is then adjusted to the position of balance, and the conductivity is read off the second scale as a percentage, according to Matthiessen's standard, or in terms of any desired unit. All arithmetic is avoided, and the results are obtained at the rate of two or three a minute. Mr. Appleyard gave the equations for the calibration of the scales, and showed that the errors involved by the use of the compensation scales were for practical purposes negligible.

Mr. A. CAMPBELL said he had used the author's conductometer and testified to its convenience. He objected, however, to the measurement of conductivity in terms of Matthiessen's standard, and suggested that for work with nickel steels, &c., the bridge should be graduated in resistivities.

CORRESPONDENCE.

CORRUGATION OF TRAM RAILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Briggs' letter in your last issue, might I again ask him to take particular notice of his "straight" roads, which "appear" to be as straight as it is practicable to make them, and to state if the corrugations are only found on one rail at once, and not on two rails opposite each other. This is my strong point. I say the corrugations dodge from one side to the other, but there is a reason for this, and one reason only. The road not being straight forms a series of curves, and the trouble is found to exist on those portions of the rails that form the outer or longer rail of those curves. I quite understand Mr. Briggs' idea that by strengthening the axles and frames so as to allow of no play, the corrugations could be reduced to half the usual pitch, but I cannot see how it could act in practice; it is going against all latest improvements, bogies, radial trucks, &c. Let us understand each other on the question of the absence of corrugations on sharp curves. The cars travel slowly on these curves, and the outer wheels have a continual grind on the outer rail, and consequently leave no marks on the tread; but if they travelled quickly (and kept on the road) corrugations would form as on a curve of large radius. It is not

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the radius that determines whether there will be corrugations or not, but the speed; it is the speed that sets the outer wheels jumping rather than slipping wherever there is the slightest curve. I cannot agree with Mr. Briggs' brake theory. The fact of the brake spindle being on the right, and admitting that the right wheel will get a more direct and stronger braking than the inner wheels, does not account for the right-hand rail on a left-hand curve (and vice versa) being corrugated; it is nearest the brake. The same holds good with the end drive. It does not matter in the least which side either the brake or drive is on, the outer rail of the curve will corrugate if the cars run quickly enough, whether they be bogies, stiff radial trucks or strengthened trucks.—I am, &c.,

June 25. ROAD INSPECTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to "Road Inspector's" letter dated June 25, any answer I can give will only be a repetition of what I have already said, as, if a rail is not straight it must be curved and all I have written before is about curves. In travelling along a line nearly straight, when the car comes to a part out of alignment, the outer wheels at once lag because they may have, say, ¼ in. of negative slip to submit to; this brings the leading outer wheel-flange and trailing inner flange into frictional contact with the gauge edges of their respective rails; the leading one has a tendency to climb the edge and the trailing one the reverse. I have no doubt this climbing tendency materially assists and is a necessary factor (in conjunction with curve or gradient slip) in forming corrugation. If the curve changes over, the above conditions and actions are at once repeated on the other side, and if the gauge is correct the leading flanges cannot be in frictional contact with both gauge edges at one time, therefore it cannot corrugate both rails. This, of course, also applies to curves of shorter radius, and the end drive cannot corrugate the inner rail, because the lagging of the outer wheel has a very powerful action in keeping the leading outer flange in heavy frictional contact with the gauge edge. The result is the same when cars travel both ways on one line.

I don't think we can agree as to the reason of absence on curves of short radius. If "Road Inspector" will excuse me saying so, I should expect to find corrugation result from slow speed and be absent with high speed if variation of speed was the cause.

As to the brake question, from observation I have come to the conclusion that when brakes are applied on slight curves corrugation is more prevalent on the left-hand rail.

In conclusion, I wish to thank you for allowing the use of the columns of your valuable journal for a discussion of this puzzling subject.—I am, &c., J. H. BRIGGS.

[This correspondence is now closed.—ED. *E.*]

ELECTRICAL TRANSMISSION GEARS ON MOTOR VEHICLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was somewhat surprised to find in your paper of last week a brief description by Mr. H. A. Mavor of an electrical transmission gear very similar to an arrangement for which I took out a patent some little time ago. In my arrangement I preferred to have G (*see* p. 427) the primary of the motor, whereby slip-rings are not *essential* except for exciting B. The absence of rubbing contacts is most desirable with heavy vehicles, as the vibration always causes trouble, even with slip-rings. I further proposed to obtain other efficient speeds by changing the number of poles in either B or D, though in general three speeds should be quite sufficient. Only under the condition that D has a greater number of poles than B, can three speeds in one direction be obtained, otherwise C will either reverse its direction when the winding F is reversed, or when the poles are equal it will remain stationary.

In operation B runs at an approximately constant speed and C is started up with its winding E connected to D (in my case G). It then runs up to a certain fractional speed of B with correspondingly greater torque than is exerted by B. By short-circuiting E the speed of B can be approximated to and the higher speed obtained (if possible) by reversing the motor D. The whole arrangement is analogous to the cascade system of connecting induction motors, and intermediate speeds can be obtained by the insertion of resistances in the secondary windings or varying the flux as with induction motors—that is, varying the field strength of B. The efficiency and simplicity of the arrangement, combined with the absence of brush gear troubles, are much in its favour compared with those systems using commutators for speed variation.—I am, &c.,

Wolverhampton, July 1. ROBERT D. ARCHIBALD.

"THE PRINCIPLES OF ELECTRIC WAVE TELEGRAPHY."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is to be regretted that it is necessary to make the same criticism of Dr. Fleming's correspondence as was made of his book. Doubtless without any intention of so doing, he misquotes and misrepresents.

As illustrating the former, he says (*The Electrician*, Feb. 22, 1907, p. 732): "His (my) next astonishing statement is that 'all the important contributions (to wireless telegraphy) by other workers (except Mr. Marconi and Dr. Fleming) are entirely ignored.'"

What I *said* (*The Electrician*, Feb. 15, 1907, p. 676) was "That *almost* all the important contributions made by other workers are entirely ignored." In that article I gave a number of specific instances in support of this statement, and have as yet seen no reason for modifying it.

On the following page (p. 733) he states:—

"Again, Prof. Fessenden says I have made no reference to his patent No. 706,741, November 5, 1901, for a spark discharger in compressed air. I ask him to look again at pages 511 and 512 of my book. He will there see a long reference to this very patent, and a reproduction of his diagram in Fig. 48. Surely I am not responsible for Prof. Fessenden's too hurried perusal of my work if he overlooks the reference and then complains that it is non existent. It will be seen from this on how frail a foundation one, at least, of Prof. Fessenden's accusations against my book rests."

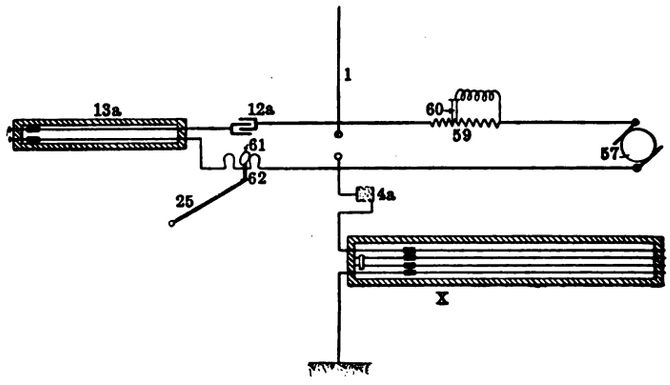

FIG. 1A.

What I *said* (page 676) was: "Dr. Fleming, *in describing the enclosed spark-gap on page 72 of his book*, states that 'the author has devised' this plan, and makes no reference to the writer's patent 706,741."

The fact that in some other portion of his book he refers to patent No. 706,741 has no bearing on my statement, which is absolutely correct, both literally and substantially, since there is nothing in the reference where it occurs on page 511 to connect the erroneous statement made on page 72 to the effect that Dr. Fleming had devised the plan, and the reader would naturally assume that the patent was subsequent to Dr. Fleming's use of the device instead of being, as it actually was, some years prior to it.

As examples of misrepresentation Dr. Fleming says, p. 732 (the italics throughout are mine):—

"Take his first reference. He says I have not correctly described the contents of his United States specifications Nos. 706,735 and 706,736 of December, 1899. Let any unbiassed person look at these specifications and see what they actually describe. The first contains 11 claims and the second 35. In each case the diagrams represent an 1896 Marconi transmitter pure and simple, consisting of an induction coil with one spark-ball earthed the other connected to a radiating antenna. *The trifling modification is that a condenser is joined across the spark gap, which is merely equivalent to an extension of antenna surface.*"

In both of the patents referred to the function of the condenser is specifically described in identical terms (for example, 706,735, p. 3, lines 21 to 35, and 706,736, p. 3, lines 94 to 109) as follows:—

"It is preferred to place a shunt-circuit containing a condenser across the terminals of the induction coil at the sending station for the purpose of maintaining sustained radiation. *This shunt circuit must be tuned to the receiving conductor*, otherwise the oscillations produced by it will have no action upon the wave responsive device at the receiving station. This shunt circuit, by virtue of its capacity, stores up an additional amount of energy, and when a spark passes across the gap, since the sending conductor can radiate energy at a given rate, it must continue to radiate for a longer time in order to dissipate this additional stored-up energy."

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These substantiate my statement, page 676, that these patents disclose for the first time "the local tuned oscillating circuit in combination with a tuned antenna," and show conclusively that the condenser shown is not, as Dr. Fleming states, "merely equivalent to an extension of antenna surface."

As regards the device being a trifling modification, it will be sufficient to state that there is probably not a single Marconi station in existence which is not using this device and infringing my patent. If its use were discontinued at Cape Cod and Poldhu the range of these stations would be cut down to a small fraction of the present one.

As another example, Dr. Fleming says (p. 733):—

"In the next place he refers to his United States patent No. 706,742, June 6, 1902, which he says is not simply for his hot-wire barretter receiver, but includes methods for producing oscillations by means of an arc, a method of telegraphy by varying the tune, protecting from atmospheric discharges, &c. I am unable to find a word in this specification about producing oscillations by means of an arc. As regards the transmitter there described, Prof. Fessenden shows an alternator and transformer with a variable inductance or resistance in series with it, and a

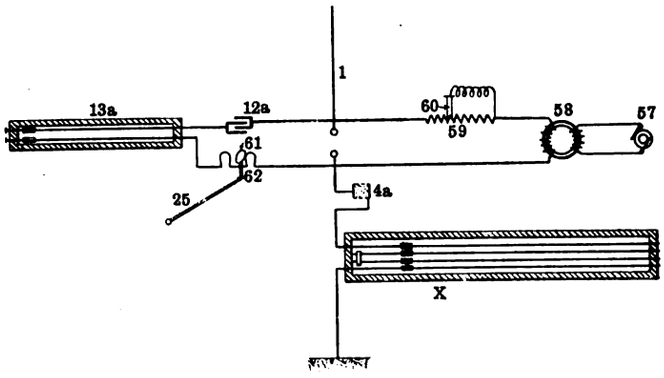

FIG. 1B.

condenser shunted across a spark gap. If he will look at my United States patent No. 758,004 of April 8, 1901, or the corresponding British No. 3,481 of February 3, 1901, he will see much more elaborate arrangements of the same kind described by me a year previously, and such arrangements had before that time been put into practice on a large scale in stations erected for electric wave telegraphy."

Referring to United States patent 706,742, p. 5 (lines 88 to 111) this describes the function of the apparatus shown in Fig. 10 as follows:—

"As shown in Fig. 10, a *continuous current dynamo* or an alternating-current dynamo 57 with a transformer 58 may be employed as the generator. When using such form of generator, a high resistance, 59, preferably having a low inductance, is in series in the sending circuit. Any suitable means, as a plug 60, for shunting a part of the resistance is preferably employed for cutting out more or less of the resistance. In operating the dynamo charges the condenser 12A in the circuit in parallel with the receiving circuit, and when the potential has risen sufficiently a discharge across the spark-gap will occur, discharging the condenser and setting up oscillations in the sending conductor. On account of the

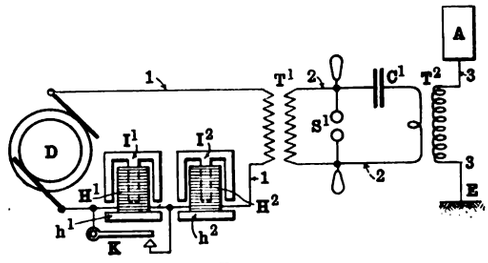

FIG. 2.

high resistance 59 some time is required to recharge the condenser to sparking potential, hence the discharge is intermittent and *may be made to occur as many times per second as desired* by plugging out more or less of the resistance."

This description of the function of the apparatus may be compared with Dr. Fleming's statement of it above. The patent states that the method is one in which, from a continuous-current dynamo as well as from an alternater, any desired number of discharges per second may be obtained. In actual practice a recent set of this apparatus, on a test made at the Bureau of Standards, gave an output of some 325 watts in the high-frequency circuit at a frequency of 3,500,000 per second, with an efficiency, as measured by the ratio of the power in the oscillating circuit to the power in the continuous circuit, of about 62 per cent., and with a variation in intensity and frequency too small to be detected, and certainly less than a quarter of 1 per cent.

This device is shown in Fig. 1A or Fig. 1B, where, as stated in the specification, 57 may be either an alternator or a continuous-current dynamo.

The device shown in Dr. Fleming's United States patent 758,004 is shown in Fig. 2, and is the device which Dr. Fleming states is "A more elaborate arrangement of the same kind" than my method shown in Fig. 1.

It will be noted in the arrangement shown in Dr. Fleming's patent the inductances or resistances are used for an entirely different purpose—*i.e.*, the old and well-known one of bridging a relay or key to prevent sparking, or, when used in series with the key, to prevent the maintenance of an arc. In his specification, p. 1, lines 49 to 53, Dr. Fleming states:—

"It is not desirable that the alternating-current transformer shall start a permanent alternating-current arc between the spark balls closing the second circuit of the transformer."

In other words, Dr. Fleming seeks to avoid the exact thing which I seek to accomplish, and so far from the devices being, as Dr. Fleming states, "of the same kind," they are, perhaps, as far apart as it is possible for them to be, since my method operates on continuous currents as well as alternating and I seek to maintain the arc, while Dr. Fleming seeks to prevent this.

Moreover, Dr. Fleming's own book shows conclusively that he *did* understand that this patent was for producing continuous trains of oscillations. At the bottom of page 515, referring to the divisional application 730,753 (April 9, 1903), he says:—

"This specification . . . . has reference to methods *for producing continuous trains of electric waves* by means of alternators or continuous-current dynamos."

Now this divisional specification referred to does not say a word about the use of an alternator, it being the subdivided case, including only the continuous-current dynamo. It consequently follows that, as 706,742 is the only case which describes the use of both alternator and continuous-current dynamos for producing continuous trains of waves, Dr. Fleming must have read the specification of 706,742 and understood what its purpose was in order to obtain his information to the effect that my method included alternators as well as continuous-current dynamos.

Moreover, this companion case referred to by Dr. Fleming specifically states that the writer had tested the Thomson arc method for wireless telegraphy prior to 1903, and found it unsuitable in its original form, gives the reasons why it is unsuitable, and describes the method patented as an "improvement and modification" of the arc method, whereby, for the first time, this method was made constant in intensity and frequency, and so for the first time applicable for wireless telegraphic purposes, and for which reason a broad patent—*i.e.*, this patent of April 9, 1903—was granted, the writer covering broadly the use of the continuous-current arc for wireless purposes, just as my original patent of June 6, 1902, covers the use of both the alternating and continuous-current arc for this purpose. (This patent and its corresponding foreign patents are, of course, infringed by Poulsen.)

The above examples will, I think, justify and corroborate the position taken in my previous letter, that Dr. Fleming's statements of the work which has been accomplished by other investigators outside of the Marconi Company are incorrect and unreliable.

In this connection, I would say that, while I have the very highest respect for Dr. Fleming's engineering and scientific ability, I feel justified in criticising his historical methods. I do not consider that they are sound.

For example, Dr. Fleming very justly refers to the great number of patents which have been issued and the difficulty of determining what is in them. I admit this, but hold that this difficulty is exactly what makes a careful and accurate piece of historical work valuable, and why inaccurate work is so objectionable. The reader of a book purporting to give a correct account of certain researches has the right to assume that a sufficient amount of time and trouble has been spent to make it fairly accurate.

The only two real alternatives are either to omit any attempt at giving a historical résumé of the subject or else to actually make a careful research for that purpose.

Again, Dr. Fleming states that he has omitted mention of a great deal of work for the reason that "until independent evidence is forthcoming that some particular arrangement or combination is novel and effective we have only the patentee's word for it that it has ever been tried," and that he "wishes to confine himself to the region of work with which I (he) was practically familiar." This bears out my statement, made in my previous letter, that Dr. Fleming has practically confined his book to the work of himself and Mr. Marconi, and has almost entirely overlooked the work of other inventors. As I stated before, if this is the plan on which Dr. Fleming wrote his book, the facts should have been so stated in order that the reader might not be misled, and my criticism has been based on the fact that, so far from stating that this is the case, the book purported to give "the contributions to electric wave telegraphy by various workers."

In my opinion, it is not advisable for the author of a work on a technical subject to confine himself to those particular

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devices with which he may be familiar. It may be that he is familiar with only a small fraction of the work which has been done in that particular line. For example, Dr. Fleming appears familiar with the art as it was in 1899, but he gives hardly anything of the subsequent development. A whole new art of wireless telegraphy has sprung up since 1899 based on developments such as the following :—

1. The use of balanced circuits for cutting out interference and atmospheric disturbances.
2. The use of circuits resonant to a particular frequency only when that frequency is being received, and its application to cutting out of atmospheric disturbances.
3. The use of series circuits resonant at the same time to different frequencies.
4. Operating without interfering with near-by stations by continuous discharge and signalling by shifting tune.
5. Methods of continuous generation of waves by inductive dynamo, condenser dynamo, and National Electric Signalling Co.'s arc method.
6. Wireless telephony and relaying telephonically from wire to wireless lines, and vice versa.
7. The use of amplifiers for amplifying and selecting feeble signals.
8. The direct mechanical receiving systems, such as the "heterodyne" system.
9. Methods of sending and receiving simultaneously.
10. Multiplex telegraphy.
11. Methods of localising the absolute position of ships at sea and for relative position and course in fog.
12. Details necessary to practical commercial operation, such as automatic means for indicating the busy and free state of a station, the condition of the receiving circuits, &c.
13. Methods of accurate wave measurement.
14. Quantitative methods of measuring wireless efficiency.

All this art, and much that has not been referred to, and which has grown up since 1899, is hardly mentioned in Dr.

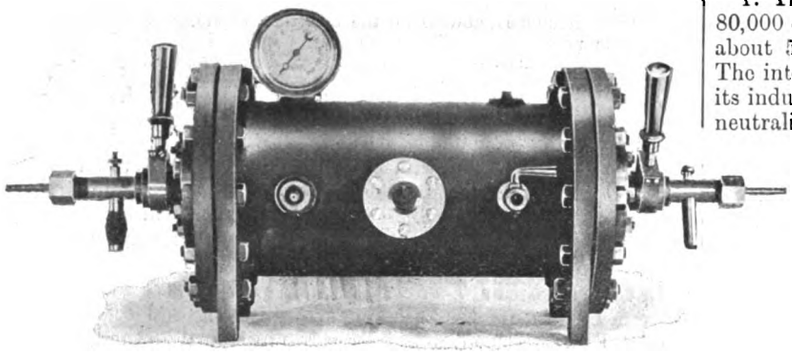

Fig. 3.—National Electric Signalling Co.'s Arc Apparatus.

Fleming's book. This may be considered as a demonstration of the fact that it is not advisable for the writer of a technical treatise to confine himself solely to the methods with which he is acquainted. In the interest of his readers he should seek to become familiar, so far as possible, with the work which has been done by others if his treatise is to give a correct representation of the state of the art.

Though we differ in some points, I am glad to note that Dr. Fleming and I are in thorough agreement on many others.

I note that Dr. Fleming entirely confirms the statements made by me in my 1902-1903 American patents for arc methods in wireless telegraphy, and that his experiments, as given on p. 722, agree entirely with those given by me on p. 711 (*The Electrician*, Feb. 22, 1907). Dr. Fleming's statement that "when examined in a revolving mirror I (he) see(s) the arc spark image intermittent" is explained in section 2 of my article, p. 710.

I am glad to be able to supply some of the information asked for by Dr. Fleming in regard to arc methods and high frequency dynamos.

A series of tests on the National Electric Signalling Co.'s 1902 type arc method were recently made by Dr. Austin at the Bureau of Standards in Washington.

I understand that Dr. Austin intends publishing a report of these tests in the bulletin of the Bureau, so it would be improper for me to anticipate this. I can, however, state the following facts :—

1. Frequencies as high as 3,500,000 were obtained with an output of approximately 325 watts and an efficiency of about 62 per cent.

2. No variation in the frequency or intensity could be detected, and a variation of a quarter of 1 per cent. would have given a large deflection.

3. The energy of the secondary circuit was measured by using it to light a 200 c.p. incandescent lamp; consequently, the measurement of the energy in the secondary circuit was not dependent upon the measurement of the phase or voltage.

4. Much higher frequencies could doubtless have been maintained, but above a frequency of 3,500,000 all the inductance had been cut out except that in the leads, and, on diminishing the capacity, at about 4,500,000 frequency the capacity was too small to give a steady arc. By using leads with less inductance higher frequencies could doubtless have been obtained.

5. With this form of apparatus the amount of hissing in the arc is not sufficient to be noticeable when the apparatus is used for telephoning.

6. The apparatus runs continuously without any attention.

In this connection I would say that the same terminals have now been used at our Brant Rock station for several months without need of renewing.

Speaking generally as regards the National Electric Signalling Co.'s arc method, it may be stated that the method is an entirely commercial one, and that high-frequency dynamos and condenser dynamos, and another method which I cannot describe at present, will entirely supplant the old spark methods.

As regards the dynamo, I would say that there are at present three types :—

1. The belt-driven dynamo, which has been operated up to 80,000 cycles, but is generally worked at 60,000. This gives about 50 to 60 volts at 60,000 cycles and about 6 amperes. The internal resistance of the armature is about 6 ohms, and its inductance quite small and unimportant, as in practice it is neutralised.

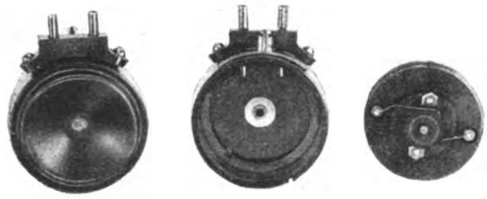

Fig. 4.—"Heterodyne" Receiver.

When applied to wireless telephony about 8 amperes are used in the aerial, this giving a range of about 150 miles or so.

2. The gear-driven dynamo. This has also been completed, but the tests on it are not finished. It runs at 100,000 cycles per second, but is generally run about 75,000 cycles. Some new armatures are being constructed with considerably less ohmic resistance, and it is anticipated that an output of approximately 1 kw. will be obtained from these machines, with which it is expected to establish telephonic communication between Boston, Massachusetts, and Washington, D.C.

3. The 10 kw. turbine-driven high-frequency alternator. This will be run regularly at a speed of 100,000 cycles, and will be used for Transatlantic telegraphy. My experiments have shown that it will be even possible to accomplish Transatlantic telephony with this machine, and the experiment will be made as soon as the company's new station is erected in England. In case this frequency should seem to be low, I would say that the best results in working *in daylight* between Brant Rock, Massachusetts, and Cuba, a distance of some 1,700 miles, have been obtained with a frequency of about 90,000. A frequency of 200,000 is equally good for night-time, but for daylight work over distances of more than 1,500 miles it has been found that a frequency of 90,000 is preferable.

Special means, of course, have to be taken for maintaining the frequency of the dynamo constant, but this problem has now been satisfactorily solved.

Fig. 3 is a photograph of one of the National Electric Signalling Co.'s arc apparatus. Fig. 4 shows one of the

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"heterodyne" receivers. I have nothing at present but a blue-print of the gear-driven high-frequency dynamo, but expect later to be able to give a photograph of it, with some efficiency tests. Fig. 5 is a photograph of the telephonic relay and amplifier, which amplifies the faintest speech about 15 times and the faintest signals from 50 to 60 times. It, of course, makes speech and signals which would otherwise be quite inaudible audible and loud, and will ring a bell on receipt of any signal which can be detected by the ear. A full description of this will be given later.

When used for relaying telephonic conversation the articulation of an amplification of 15 is exceedingly clear and distinct. When the amplification is pushed to 50 times the talking becomes drummy. The apparatus is entirely self-adjusting, and when once set up needs no attention except at long intervals.—I am, &c,

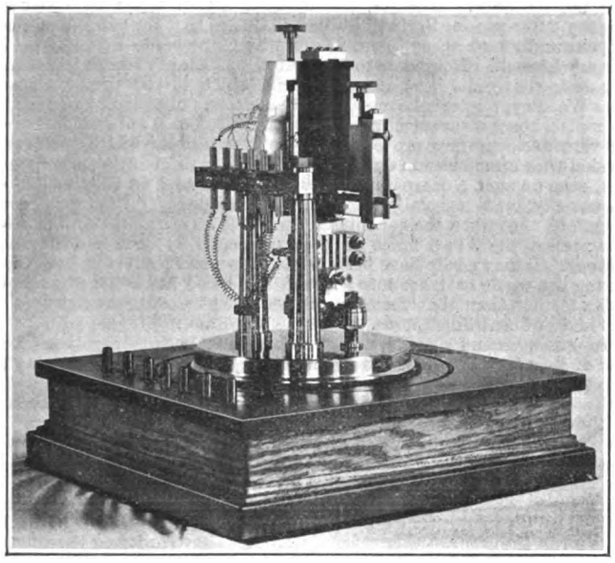

FIG. 5.—TELEPHONIC RELAY.

REGINALD A. FESSENDEN.

Brant Rock, Mass, U.S.A., May 22.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I regret to find myself again compelled to trouble you with a reply to the long letter of Prof. Fessenden re-opening a controversy I thought was closed four months ago. It is curious he should have allowed so much time to elapse before answering my letter, considering the strength of his feeling on the points at issue. But although he reiterates his opinion as to the unsoundness of my historical methods and again brings general charges that my statements of the work which has been accomplished by other investigators outside the Marconi Company are incorrect and unreliable, yet when he descends to details it all ultimately reduces to the complaint that I have not been able to take precisely the same view of his own inventions and patents that he does himself. To be as economical of your space as possible, I will follow his criticisms seriatim and briefly. He is welcome to take any controversial advantage he pleases from the fact that I wrote "all" for "almost all" in quoting his remark respecting the contributions of other workers; but if he lays so much stress now on this fine distinction it is a pity he did not more carefully define originally what he meant by "almost all." In the next place, he complains that on p. 72 of my book I have not referred to his patent No. 706,741, and claimed for myself the form of spark dischargers there described which he thinks his specification embraces. On p. 72 I describe a form of silent discharger comprising a thick-walled cast-iron vessel with ball dischargers operating in compressed nitrogen or carbonic acid, and on p. 507 a further modification in which the balls are made to rotate, a very practically important matter. This is something quite different from the appliance described by Prof. Fessenden in his patent, in which the discharge takes place between a sharp point and a plate. The latter would be quite unsuitable for large powers, and, in view of the previously-known electrical properties of compressed air, cannot be accepted as a generic type covering any form of discharger, however made, which operates in gases under pressure. Hence, although his patent is referred to on pp. 511, 512, no reference was considered necessary in other places.

Thirdly, he now claims for his specifications 706,735 and 706,736 that these patents disclose for the first time "the local tuned oscillatory circuit in combination with a tuned antenna"; and, further, he adds "that there is probably not a single Marconi station in existence which is not using this device and infringing my patent." In the diagram in these specifications what he shows is an ordinary plain Marconi transmitting antenna having a condenser joined across the spark balls, which I said was equivalent merely to an extension of the antenna. There is no inductance shown in series with the condenser for tuning. In the text of the specification he says, "This shunt circuit must be tuned to the *receiving circuit*." There is nothing said about tuning it to its own transmitting antenna, and yet on the basis of this vague sentence, and entirely regardless of the appropriation by himself of the Marconi antenna and earth connection, he now proceeds to set up an all-embracing claim to syntonic telegraphy with direct-coupled antenna, coupled with the assumption, in which there is not an atom of truth, that such an arrangement is "infringed" in all Marconi stations. Could there possibly be a better instance of the unwarrantable use of a single detached sentence in a specification?

Fourthly, he takes me to task for not having sufficiently described the contents of his specification 706,742, which he now evidently wishes to be regarded as a fundamental one, including all the arc methods of producing continuous oscillations, and most confidently states: "This patent and its corresponding foreign patents are, of course, infringed by Poulsen." I need not undertake to fight Mr. Poulsen's battles for him. I am merely concerned to show that no one fairly reading the sentence Prof. Fessenden now puts in italics—viz., "may be made to occur as many times per second as desired"—could possibly derive the idea that this specification was one describing all arc methods for the production of continuous oscillations. Prof. Fessenden seems to hold the opinion that a specification is a document out of which one may at any time take a single sentence and ingeniously adapt it to cover subsequent history. Nothing could be more erroneous. A specification is intended to describe something the patentee has *already* achieved, and it must be lucidly described and definitely claimed if it is to convey to him rights in an invention.

I do not think I need follow out in detail the rest of Prof. Fessenden's letter. He lectures me on the manner in which he thinks a treatise on wireless telegraphy should be written, and implies that I know very little about the history of the subject since 1899, and furnishes a list of matters in which my book is deficient. All this is exceedingly kind and very valuable, but, as a book has to be limited in size and concluded at a certain point of time, I had to exercise my own judgment what should be included in it, and preferred to occupy the bulk of the space rather with general principles than with minute descriptions of various inventions taken from patent specifications without regard to their demonstrated value or even objective existence. I have tried to give a broad outline of the contributions of all the principal workers, but I adopted a critical attitude, and did not merely place myself in the position of being an echo of every patentee's personal wishes or opinions in regard to his specifications.

Prof. Fessenden differs from me, but controversy between us will not, I am afraid, bring our opinions into line, and accordingly I must excuse myself from further discussion of these differences.—I am, &c., J. A. FLEMING.

University College, The University of London, June 18.

[This correspondence is now closed.—ED. *E.*]

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REPORT TO THE BOARD OF TRADE ON THE ACCIDENT ON THE CROYDON AND DISTRICT ELECTRIC TRAMWAYS.

In what follows we give an abstract of Major J. W. Pringle's report on the fatal tramway accident which occurred at Carshalton on April 1st last, when a tramcar was overturned with fatal results :—

At the time of the accident there were from 65 to 69 passengers on the car. About 22 of these appear to have been inside the car, and the remainder, of whom it is stated that 10 were children under the age of five years, were outside on the top deck. About 36 of the passengers were injured more or less seriously. Two, unfortunately, subsequently died from the effects of the injuries received. The driver of the car was not seriously hurt, but the conductor was cut about considerably. The tramways have a gauge of 4 ft. 8½ in. and are worked by electric traction on the overhead trolley system. Tramcar No. 19 is of the single-truck (four-wheeled) double-decked type. It has seating accommodation for 22 inside and 33 outside passengers. The four wheels are fitted with brake blocks worked by hand from both ends of the car; in addition there is the ordinary rheostatic electric brake for use in emergency. There are four sand boxes, two at each end. The brakes appear to have been in good order at the time of the accident. The weather was fine, warm and sunny; but water-carts had been playing on the road, so that it is probable that the rails were greasy with soft mud.

The route was by Park-lane with a right angle turn into Ruskin-road. The track is double, with gradients varying from 1 in 18 to 1 in 36, the latter being near Ruskin-road. The roadway is straight for about 514 yds. in approaching Ruskin-road, where the right angle occurs. Here the double tracks are curved and spaced at a central interval of 10 ft. The radius of the inner track (on which the car was travelling and was derailed) is 55 ft., of the outer track 65 ft. The falling gradient continues round the curve with an inclination of 1 in 32.

Major Pringle found the gauge to be "true"; it varied from 4 ft. 8¼ in. to 4 ft. 8⅝ in. The superelevation of the outer rail at the tangent was ⅝ in. and 1⅛ in. at the centre of the curve. The permanent way generally was in good order, the rails being comparatively little worn. The paving was composed of granite setts. The route was inspected in August, 1906.

The car was 27 ft. 8 in. long over all, with 6 ft. wheel base, 7 ft. wide over all, 9 ft. 8 in. high from rail to top deck, and diameter of wheels 2 ft. 6 in. The weight of car body was 3¾ tons, and of truck 3½ tons. A compulsory stop had been fixed by the Board of Trade and one by the company. The maximum speed had been fixed by the Board of Trade at 8 miles per hour in descending Park-lane and 4 miles per hour on the curve.

Conclusion.—After the accident the body of the car was separated from the truck at the scene of the disaster, and they were removed separately to the sheds at Carshalton. The truck was run back on its own wheels.

Major Pringle made an examination of the truck and the body before any repair work had been done. The wheels were of cast iron with chilled tyres. He found one well-developed flat on the tread of each of the four wheels. In the case of the rear outer wheel the flat was more extended and the colour of the metal in the neighbourhood of the flat appeared to indicate great heat had been set up.

The truck was of the fixed wheel base pattern of Messrs. Milnes & Co.'s standard design of 1903. The wheels were single blocked, and there appeared to be no doubt that the blocks were in proper adjustment and the braking equipment in good order.

The total available clearance between the wheels and rails was :—On the leading axle $\frac{6}{32}$ in., on the trailing axle $\frac{7}{32}$ in. This was somewhat less than was often provided, but that it was sufficient to allow the truck to move round the curve at slow speed was proved by past experience. The wheel flanges were ⅞ in. thick and had a depth in the rail groove on a straight road of $\frac{2}{16}$ in. The car was re-wheeled in July, 1906, and overhauled in February, 1907. It had run 8,760 miles since re-wheeling.

He found the track in Park-lane and on the curve in question in good order when he examined it. The width of groove was 1⅛ in. and the rail lip or check was level with the head of the rail. The gauge of the rails on the curve might be described as "true" and the superelevation of the outer rail at the tangent was ⅜ in. and 1½ in. at the centre of the curve.

After the accident the car was found lying on its right side, with its centre about 65 ft. from the tangent point of the curve. It evidently had come to rest almost immediately the side of the car came in contact with the ground, as there were no serious marks of wear on the woodwork. The weight of the car and passengers might be estimated at 10¾ tons (car 7½ tons, passengers on top deck 2¼ tons). The centre of gravity of the unloaded car might be taken as approximately 4 ft. above rail level, and of the loaded car at about 6 ft. above rail level.

Calculation showed that at a speed of about 18 miles an hour on a curve of this radius a car so loaded was on the point of overturning entirely from the effect of centrifugal force, assuming the car to be a rigid body. Further calculation showed that the limit of safe speed on the curve, if the necessary superelevation (about 1⅓ in.) was provided throughout the curve, was only about 5 miles an hour, due to the effect of live load, springs, &c.

Motorman Woodley stated in his evidence that about 100 yds. from the curve into Ruskin-road he applied the brake to reduce the speed, and noticed that the wheels were skidding. He released the brake, applied sand, and then re-applied the brake, reaching the corner at a speed of four or five miles an hour. The car entered the curve as described, and then came almost to a standstill, gave a violent lurch, balanced itself momentarily on its outer wheels and then fell over on its right side. Woodley had not worked a service car fully loaded round this curve previous to the accident. He stated that both hand and electric brakes were fully applied when the car fell over. The rails were wet and greasy with mud, as the road had been recently watered.

Conductor Linney confirmed Woodley's evidence regarding the passage of the car past Springfield-road. The car then gained speed, until when about half-way to the corner—*i.e.*, 100 yds. from Ruskin-road—he thought it was as much as 14 miles an hour. The speed was higher than he had ever known it, and he therefore rushed down the stairs from the top deck and applied the hand brake as hard as he could from the rear platform. He thought that there would be danger at the corner owing to the high speed. He also estimated the speed of the car, when the curve was reached, to have been about 5 miles an hour.

Major Pringle concludes his report as follows :—

The whole evidence, in my opinion, proves that the car travelled down Park-lane at a speed considerably in excess of the authorised limit—8 miles an hour. Further, the unusual action taken by conductor Linney, after passing Springfield-road, indicates that the car had attained an unusually high speed, possibly quite as high as the figure given by Linney himself. It appears to me that it was Linney's action in screwing down the brake hard on greasy rails which locked the wheels, and that Woodley, whatever he may have thought, was unable on that account to control the movement of the car or stop it before it entered the curve. Previous accidents have proved that a heavily-loaded car, which commences to skid with a momentum due to a velocity of 12 to 15 miles an hour, will not, even on such a comparatively easy gradient as 1 in 36, readily lose its velocity, more especially when the rails are greasy. I am persuaded, therefore, that when the car entered the curve its speed was considerably in excess of the 3 to 5 miles an hour estimated by both Woodley and Linney. It may easily have been as much as 8 or 10 miles an hour. But taking the whole evidence into account, the speed must have been considerably less than that theoretically necessary to cause overturning by the effect of centrifugal force.

In passing round a curve, a car truck should be free to rotate round one of its wheels as a centre—generally the inside rear wheel may be taken as the pivot. The remainder of the wheels are constantly slipping either longitudinally or laterally, and thereby accommodating themselves to the change in direction as far as the clearance and axle play permits. In this case freedom of movement was interfered with by the action of the brake. The wheels being unable to accommodate themselves to the change in direction, the flanges must, I think, have got jammed in the grooves, with the result that the truck came to a sudden stop as described by Woodley. The tendency of the heavily-loaded body would be to overrun the truck, and a severe lurch must have followed the sudden stoppage of the truck. All the live weight on the car must have swung outwards with the lurch, and, acting with the effect of centrifugal force, must have suddenly tilted the car so that, as it appears to me, the flanges lifted out of the grooves. The truck was then free to jump forward and skated on its outer wheels for 10 ft. or 16 ft. The car was unable to recover its equilibrium owing to the probable displacement of the live load on the top deck, and fell over on its side, just as its inertia was exhausted.

It can be shown by experiment that a vehicle with freely rolling wheels will travel safely round a curve, where proper superelevation is provided, but will, on the same curve and at the same speed, overturn, if the wheels are prevented from rolling, and thereby become track-bound.

My conclusions on the case are as follows :—

1. That the car entered the curve at a higher speed than that authorised by the regulations or justified by the superelevation, and therefore ran the risk of derailment.

2. That the overturning of the car was caused by the wheels being locked by the severe application of the brake blocks.

I hold that driver Woodley is mainly responsible for the speed of the car, which should not have exceeded eight miles an hour down Park-lane, and that Conductor Linney is responsible for the locking of the wheels, although his intentions were good. Both these men have first-class characters, but have small experience.

I wish to draw the attention of the company to the following points in connection with this accident :—

(*a*) Men who are employed as spare drivers, unless they have had long and continuous experience in driving, require to be more constantly exercised under service conditions than is generally recognised. Woodley's experience of driving—about two months during May and June last, and occasional weekly trips subsequently—was small. He cannot, with this record of service, have acquired such judgment of speed, intimate knowledge of brake effect, &c., as a tried motorman will possess. His action in applying both his hand and electric brakes on entering the curve at considerable speed, with the avowed intention of stopping quickly on the curve, showed want of judgment, accounted for by his inexperience. More practice, not with empty, but with fully-loaded cars, under bad conditions of rail, is advisable, in my opinion, for men who are only occasionally employed as drivers.

(*b*) On some tramway systems conductors have to undergo the same training as motormen. This is the best system, but even where it is not followed it is necessary that conductors should be trained in the proper use of the brakes, and taught how to obtain the maximum braking effect on good and bad rails, as well as the danger incurred by locking the wheels. Linney's knowledge on these points appears to have been nil, and his ignorance is a feature in the case.

(*c*) The instructions lay down that only one sand pedal is to be taken on service cars. This is an instruction common, I understand, on most tramway systems. I cannot but think it is a mistake. If Woodley obeyed this instruction, it is evident, from Inspector Bassom's evidence, that he was unable to use sand in Park-lane, as one pedal only was found after the accident at the rear platform. Woodley states that he took two pedals with him on this occasion, and therefore had not to change the

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pedal at the Croydon terminus. But no second pedal was found on the overturned car, and there is grave doubt as to whether Woodley's statement is correct. It is not improbable that a man only occasionally employed as a driver might forget to change the sand pedal at a terminus. Moreover, in the event of a car running backward, if there is no pedal at the rear platform there is no possibility of using sand on the rails. An alteration in the instruction on this subject is, in my opinion, desirable.

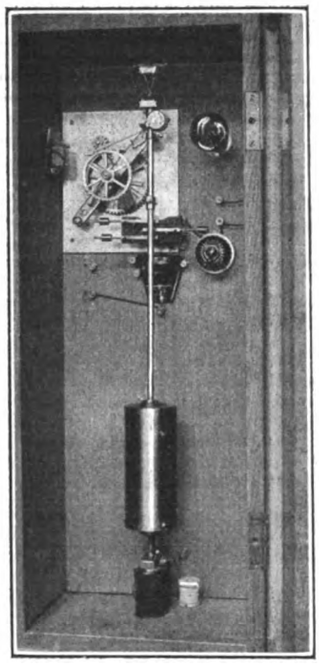
(*d*) The wording of the company's regulations regarding compulsory stops requires revision. Woodley appears to have understood that a stop anywhere on the curve was implied. The Board of Trade regulation reads that all cars should be brought to a standstill "immediately before reaching the junction of Park-lane and Ruskin-road."

(*e*) It is very undesirable to allow the top deck of cars to be overcrowded by more passengers than there is seating accommodation for, and it is dangerous to allow passengers to stand on the upper deck. Instructions on the last point are advisable.

(*f*) The superelevation at the tangent points of the curve between Park-lane and Ruskin-road should be at least 1 in. and preferably 1½ in.

ELECTRIC TURRET CLOCK.

The accompanying illustration represents an electric turret clock made recently by The Standard Time Co. (Ltd.) The dial is 5 ft. 6 in. in diameter, and the hands are of copper, weighing 8½ lb. The case, which contains all the movement as no weights, pulleys, or cords are used, is 34 in. long, 14 in. wide, and 10 in. deep. The pendulum which serves the dual purpose of measuring the flight of time and driving the hands, is practically a reciprocating action



electric motor, and is 28 in. long, and weighs 20 lb. The necessary rate of motion is given to the hands through a simple sun and planet gear, driven by the equivalent of an escape wheel, worked tooth by tooth by the balanced pawl pivoted near the pendulum suspension. The latter is of an old type having three springs mounted in the form of an X, and is designed to ensure the pendulum swinging without any gyratory motion.

Current from the 100 volt lighting mains is used, and three ordinary cells provide a secondary source of energy, which is coupled up automatically should the main current be switched off or accidentally interrupted.

The magnet seen on the left of the movement is the synchroniser, actuated by an hourly Greenwich mean time signal, and lifts the pawl off the escape wheel of the clock, which has normally a gaining rate. In this way the clock is corrected hourly and maintained correct with Greenwich time. The magnet just below the movement keeps the secondary source of energy out of circuit as long as current is available from the main source. The magnet beneath the pendulum is excited when the contacts are closed and gives motion to the pendulum. The contacts, which are on the Hipp principle, are closed automatically when the amplitude falls below a given point. A main switch, lamp resistance and a shunt coil, to prevent sparking at the contacts, complete the arrangement.

We are informed that a similar clock, which was erected some two years ago by the same company, has made a non-stop run exceeding 20 months without any attention whatever.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

The Committee of the House of Commons appointed to consider and report upon the advisability of this country ratifying the Radio-telegraphic Convention of Berlin, 1906, has issued its report. We have been unable to obtain a copy of this report from the Government printers, although we were given to understand that copies were available on Tuesday. We have, therefore, been compelled to take the "Manchester Guardian" version of the Committee's report, which is as under:—

Sir John Dickson-Poynder's Committee on the Radio-telegraphic Convention finally agreed upon the terms of their report on Tuesday. It is understood that, besides expressing the view that the effect of the adhesion of this country to the Berlin Convention of November, 1906, would be advantageous to national and public interests, and that its non-adhesion would be seriously detrimental to those interests, the Committee decided upon a definite recommendation in the matter of compensation to the Marconi Co. In reviewing the relations of the Government with the Marconi Co. the Committee state that two points stand out especially clear in the light of subsequent events:—

1. If when the Post Office gave to Mr. Marconi cordial and courteous assistance the Government had secured a right of pre-emption of his invention and intended patents, this would have prevented an enterprise of national importance from passing into the hands of a private company, and would have averted most of the difficulties which have arisen.

2. The fact that the Post Office has largely refrained from issuing licences to other companies has given the Marconi Co. something approaching a monopoly during an important period, and may therefore have encouraged their dreams of a general monopoly.

Compensation to Marconi Co.—The Committee see no reason to apprehend that the obligations of the Convention, if faithfully carried out by all concerned, will prove injurious to the Marconi Co., but consider that it will be to their ultimate advantage. The Committee do not believe, looking at the Post Office-Marconi agreement, that the Marconi Co. can make any equitable claim to compensation. But, in view of the particular circumstances of the case, the Committee recommend that, provided the Marconi Co. loyally co-operate in carrying out the Convention and the policy which it represents, and in the event of its being shown under proper conditions of audit that the Marconi Co. during the transition period under the new conditions brought about by the Convention have suffered diminution of business at their British stations, they should be granted compensation for a period of three years from the day of the Convention's coming into operation, and that the compensation should be based upon a comparison with the average annual net traffic receipts from their British stations during the three years preceding ratification.

Reasons Against Non-ratification.—In pronouncing against non-ratification of the Convention the Committee point out that Great Britain took a prominent part in the Berlin Conference, and that the Convention was modified in many important respects in order to meet her wishes and secure her adherence. If Great Britain now refuses to ratify, therefore, they entertain the view that doubt will be thrown on her sincerity at the Conference, and that her action will not be regarded with equanimity by other countries. The contrast between the attitude of the British Government at the time of the Conference and its attitude in refusing to ratify would be emphasised by the fact that the next Conference was invited to meet in London. They add that non-ratification would create a direct and powerful motive for the erection on foreign territory of stations which would be in no way subject to British control in time of war or emergency; that foreign ships and coast stations would seriously interfere with British stations, for not only would other nations be forced to erect additional shore stations, but those stations and the ship stations as well would be obliged to use additional energy, and that natural interference would very probably be increased by intentional actions; that without the Convention British stations would have no remedy, and in the absence of international arrangements and rules for working, accounts, collection of charges, &c., the development of the service would be seriously embarrassed; that these drawbacks would be specially detrimental to Great Britain, owing to the predominance of her maritime interests and her geographical position; that inasmuch as under the terms of the Convention the nations adhering are bound to refuse to licence on board of ship or at shore stations the apparatus of any system which declines to accept the principle of intercommunication, if Great Britain refuses to ratify the Marconi apparatus at present installed at foreign shore or ship stations will be removed, and its place taken by some system that accepts intercommunication; and that if Great Britain does not ratify the Convention will probably be modified by the Powers which adhere in a manner injurious to British interests.

Special Advantages of the Convention.—The special advantages claimed by the Committee for ratification may be thus summarised:

(*a*) A general obligation is imposed on all stations not to interfere with the working of other stations.

(*b*) Exempted stations are allowed and given international sanction. Certain wave-lengths are reserved for naval use, so as to be absolutely free from interference by commercial stations.

(*c*) International sanction is obtained for such censorship arrangements as may be necessary.

(*d*) The effect of the Convention, if adhered to by Great Britain, is directly to encourage the erection of stations at suitable points in British territories and the general development of the use of wireless telegraphy in the British mercantile marine, thus providing a widely extending

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system, over which the Admiralty would have control in time of emergency.

(*e*) The Convention has been framed with careful regard to the interest of His Majesty's dominions beyond the seas, several colonies and India being able to adhere and withdraw separately as may appear to them expedient, and adequate representation at future conferences has been obtained for such colonies or dependencies as may subsequently adhere.

(*f*) At any time if Great Britain finds the Convention to be in any way detrimental to her interests she can, by giving a year's notice, retire from the Convention. Meanwhile if she ratifies no alteration to her detriment can be made in the Convention without her consent, and the Bureau has no initiative or executive powers of any description.

TELEGRAPH (MONEY) BILL.

The debate on the motion for the second reading of this Bill was resumed on Friday last.

Sir FREDERICK BANBURY said the actual amount already spent on the telephone and telegraph system was £15,000,000, and it was now proposed to raise a further £6,000,000; while in 1911 the business of the National Telephone Co. was taken over. As far as one could tell, the capital value of that undertaking at present was £10,000,000, so that the total amount of money invested in the Post Office telegraph and telephone service would be something like £31,000,000. Up to the present no allowance had been made for depreciation. He urged that the House should proceed cautiously in regard to the spending of further large sums of money on that service, and to see that the undertaking was conducted in a businesslike and economical manner.

In reply to criticism of the bill, Mr. S. BUXTON said that the money being raised would be expended on telephones. He desired to separate the telephone from the telegraph service. The former was being run at a fair profit and the latter at a heavy loss. As to the loss on the telegraph service, while he agreed that no great service of the State ought to be carried on at a loss, the blame in that matter should not fall on the Post Office, but on the House of Commons itself. It was the action of the latter which had rendered it impossible for the telegraph service to be profitable. The three items on which there was a loss were the reduction to the 6d. telegrams, free delivery and cheap rates to the Press. He had been engaged lately in reducing the rates for the small user at the expense of the large user, and he was afraid when the new rates came into force there would be some outcry on the part of the large users.

Mr. AUSTEN CHAMBERLAIN said, with regard to State control of the telephone service, the alternative was competition, which would lead to hopeless confusion. The telephone was essentially a subject for monopoly. One object was to give a better service to the poorer districts. If left to private enterprise, the latter would be left without a service. As regarded the telegraph system, this must remain unremunerative unless the Government abolished some of the privileges it had forced the department to grant. The telephone service had a bad effect on telegraph receipts. The Postmaster-General was, in fact, competing with himself.

Mr. H. COX withdrew his amendment, and the bill was read a second time.

LEGAL INTELLIGENCE.

Greenwell v. Lewis.

A verdict was given on Tuesday in this case, which occupied the Lord Chief Justice and a special jury for several days. Plaintiffs (a firm of solicitors), carrying on business (in the City of London) under the style of Clarkson, Greenwell & Co., and (in Marylebone) under the style of Greenwell & Co., sued defendant, a member of Marylebone Borough Council and a member of the London County Council, for damages for libel stated to be contained in a circular caused to be printed and distributed by defendant.

DEFENDANT denied that the words complained of were libellous or that the words had the meaning put upon them by plaintiffs. It was alleged by plaintiffs that in October, 1906, defendant falsely and maliciously wrote and caused to be printed and published of plaintiffs, in their profession as solicitors, a circular which was sent to the members of the Marylebone Borough Council and the members of the London County Council and certain voters in the Parliamentary Division of Elland, Yorkshire, reflecting on their conduct in connection with the application for a provisional electric lighting order for Marylebone.

A vast amount of evidence was given on both sides, and on Tuesday the jury returned a verdict for plaintiffs, assessing the damages at £3,000.

Judgment was entered for this amount, with costs.

Townsend v. Swindon Corporation.

At the Bristol Assizes on Wednesday, plaintiff claimed damages against Swindon Corporation for personal injuries sustained in the tramway accident at Swindon in June, 1906 (reported in *The Electrician* for June 29 and July 6, 1906).

After hearing evidence, the jury returned a verdict for plaintiff and awarded £8,000 damages.

On the application of Mr. Foote, K.C. (for defendants), a stay of execution was granted for 10 days.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Malvern District Council invite applications for the position of working assistant to the electrical engineer at a salary of £84 per annum, rising by annual increments to £120. Applicants must have had sound mechanical and electrical training, with experience in alternate-current working. Further particulars from the Chief Engineer. Applications to the town clerk (Mr. H. L. Whatley), Council Offices, Malvern, by 10 a.m. July 11. See an advertisement.

A lecturer in electricity and physics is required in September next at the City of Birmingham Municipal Technical School. Commencing salary £140. Particulars from the secretary (Mr. George Mellor), Suffolk-street, Birmingham. See also an advertisement.

A draughtsman is wanted, used to high-tension switch gear. See an advertisement.

An assistant designer is wanted, one accustomed to induction motor, alternator and transformer work, with technical training and preferably test-room experience. See an advertisement.

An assistant is required in a merchant's office, with some experience in electrical contractors' costing or export department. Salary £150 per annum. See an advertisement.

A chief draughtsman is wanted for high and low-tension switch gear. See an advertisement.

Whitby Borough Electrical Engineer (Mr. L. H. King) has a vacancy for a pupil. See an advertisement.

A transformer draughtsman is required for single and three-phase power transformers by Ferranti Limited. See an advertisement.

An assistant is required for an electrical laboratory, chiefly commercial development of instruments of various kinds. See an advertisement.

The governing body of Battersea Polytechnic, London, S.W., require a head of the department of mechanical engineering and building trades, to commence in September. Particulars can be obtained up to July 8 from the secretary.

Stirling Council require a burgh electrical engineer. Applications to the Town Clerk by July 16.

London County Council want visiting teachers of electrical instrument making, &c., for 1907-8 session. Forms from the clerk. Applications by 11 a.m. July 13.

Dunedin (N.Z.) and Perth (W. Australia) Councils recently advertised for electrical engineers at salaries of £700 and £800 respectively.

Mr. H. J. Hawkins, of Enfield, has been appointed deputy borough electrical engineer at Salford.

Mr. T. H. Birrell, late chief assistant engineer at Worcester, has been appointed engineer and manager of the Pontypool Electric Light & Power Co.

Maidstone Council have appointed Mr. Saunders as manager of their light railways at £160, rising by increments of £10 to £200 per annum.

Mr. Frank Shaw has been appointed instructor in electric light and power distribution at Bury (Lancs.) Technical Institute.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the Institute's Colleges are held in September. Particulars of the entrance examinations, scholarships, fees and courses of study may be obtained from the respective colleges or from the head offices of the Institute, Gresham College, Basinghall-street, E.C. The City and Guilds Central Technical College, Exhibition-road, W., is a college for higher technical instruction for day students not under 16 preparing to become civil, mechanical, or electrical engineers, chemical and other manufacturers or teachers. The College is a school of the University of London and the Faculty of Engineering. The City and Guilds Technical College, Finsbury, is a college for intermediate instruction for day students preparing to enter the engineering and chemical industries, and for evening students.

University College of North Wales.—A systematic course of instruction in electrical instruments and practical electricity for students proposing to enter the electrical engineering profession commences in October next. The course extends over two sessions. The physical laboratory at the college is very well equipped. Prospectuses, &c., from Mr. J. E. Lloyd, M.A., secretary and registrar.

Aberdeen.—The tramways committee have decided to introduce a system of parcels delivery in connection with their service.

Accrington.—The Council intend to apply for a provisional order for Clayton-le-Moors and district.

Amersham.—The Chesham Electric Light & Power Co. intends to obtain powers to supply electricity in this district.

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Australasia.—The first general meeting of the Electrical Association of Victoria for the 1907 session took place recently.

In his presidential address the newly-elected president (Mr. A. U. Alcock) said the number of members was 49. He had given some attention to the application of electricity to military and naval uses. As the question of the formation of an Australian navy was under consideration, with the prospect of being carried into effect in the near future, it behoved them to take a special interest in the matter. Unless they displayed independence and self-reliance with a strongly developed enthusiasm for the advancement of the commonwealth they could never hope to make their association the highest authority on electrical science in the State and the recognised voice of the electrical profession in Victoria. They had two Papers promised by prominent members and he invited Papers from other members. Mr. Alcock then referred to the scheme proposed by Mr. Thwaites, engineer-in-chief of the Metropolitan Board of Works, for the utilisation of the Yarra for the generation of electricity to supply Melbourne and suburbs, and said the dominating factor in a water-power scheme was the cost of the waterworks, which might be such that the interest on the capital outlay more than outweighed the cost of fuel for a steam generating plant located at the most favourable point of distribution.

A vote of thanks was accorded to the president, and the remainder of the sitting was devoted to the discussion of short notes on interesting experiences. Messrs. H. R. Harper and Noel Murray are the vice-presidents and Mr. J. H. D. Brearley is hon. secretary.

Wangaratta (*Victoria*) Council (says the *Australian Mining Standard*) are considering an offer by a company to establish electricity works and to supply current for public lighting at the prices now paid for gas, and also give a supply for private lighting.

Messrs. Noyes Bros., who have been consulted on the question of the erection of electricity works and the construction of electric tramways at *Leonora* (*Western Australia*), advise that the venture should prove a success and that the present cars and track can be utilised.

Mr. H. G. Alder, manager of *Boulder* (*W. A.*) Electricity Works, has introduced a system of charging for current to private houses at 4s. for the first lamp and 1s. 6d. per additional lamp per month, and it is stated that the experiment has been successful.

Electricity works are to be erected at *Kadina* (*S. Australia*).

Bexley.—Sanction has been received to a loan of £3,500 (repayable in 19 years) for electricity supply extensions.

Birkenhead.—The price of electric current for power and heating has been reduced to 2d. per unit up to 1,500 units per quarter, 1½d. up to 5,000 units and 1d. per unit beyond.

Bolton.—The salary of the station superintendent (Mr. W. J. Wood) has been increased to £230 per annum.

Burglary.—On Tuesday night burglars entered the showrooms of Mr. R. W. Paul, the well-known electrical instrument maker, at 68, High Holborn, but we are glad to learn they only secured a few pounds in cash and some cigars, as the cashier's department was removed on the previous day to the works at New Southgate.

Calverley.—The Council have decided to transfer their provisional electric lighting order to the Electrical Distribution of Yorkshire (Ltd.) Negotiations are to be re-opened with Leeds Corporation for the transfer of the tramway order which expires in August, and the Board of Trade have been asked to extend the period of the order for six months.

Ceylon.—The Ceylon Government "Gazette" of May 3 contains the text of new regulations under the Patents Ordinance, 1906, which came into operation on May 15 and which may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

Cheltenham.—Sanction has been received to a loan of £6,825 for extensions of the electricity works.

Customs Duties.—A supplement to the "Australian Commonwealth Customs Tariff Guide" announces that, according to recent revised decisions, shades for arc lamps are classified under electrical materials and are free of duty, and zinc tubing for bell fittings (under machinery and appliances, n.e.i., electrical) are subject to a duty of 12½ per cent. ad val.

Under the new tariff of the Dutch East Indies copper and bronze telephone wire and similar electric conducting wire are admitted free.

Dudley.—It was reported to the Council on Wednesday that there was a net profit of £67 on the past year's working of the electricity undertaking.

Electric Mining Regulations.—In the Dunfermline Sheriff Court on Friday Sheriff Sherman gave his decision in the proceedings taken at the instance of the Home Office against Mr. Thos. Borland, jun., manager of the Hawkhill Colliery, Kincardine, where an accident was recently caused by coming in contact with an endless haulage rope connected with an electric coal-cutting machine.

The accident was due to the rubber covering of the wire becoming worn and allowing the copper to come in contact with the metal, resulting in the motor and all its metal fittings becoming alive. The manager was charged with (1) having failed to see that a competent person was in charge of the machine; (2) having failed to have the trailing cable heavily insulated and the split ends where they entered the coal-cutter protected; and (3) having failed to see that the holes where the wires entered the machine were properly bushed with insulating material.

The case was a test one, and his Lordship found the first and second charges not proven. His Lordship, in finding the third charge proven, said his general impression of the skilled evidence for the defence was that it was directed solely to the question whether that was substantial covering or bushing, and ignoring the real question—viz., whether it was substantial bushing with insulating bushes. The last three words were not to be taken as mere surplusage. It was to be presumed that they added something to the requirement that the holes must be substantially bushed, and indicated the method which was to be employed. Among the various definitions of bushing there was general agreement that it means the lining of a hole, and at an early stage of the case it was suggested that the 18 in. length of indiarubber tubing was the insulating bush for that hole, 1¼ in. thick. It came out, however, that the tubing was required as a protector for the 14 in. of conductor that remained outside the hole, and accordingly the contention came to be that for 12 in. or 13 in. of the portion the tubing was a protective insulation, and that it changed its designation within an inch or so of the hole, and there became an insulating bush, although there was no visible change in its quality or thickness. Now, that seemed to him a hopeless defence. There was no getting away from the fact that the cotton-covered wires in the rubber tubing constituted together the "unarmoured cable or wires" referred to in the official rules. The rubber tubing was simply the method of "efficiently covering or safeguarding" the conductor as required by rule 7 (*a*) of the special rules. That rubber tubing was used for a similar purpose on other electric machinery. The contention that at some imaginary point the rubber tubing ceased to be a covering to the wires and became an insulating bush for the whole was ingenious, but he could say no more for it. The rule plainly required something different from the cable to be used as an insulating bush—some entirely separate mechanical contrivance, such as the fibre bush produced. He did not express any opinion as to the sufficiency of the fibre bush. It was of use only as an illustration of the kind of thing which the rule plainly required. His finding was that the machine had no insulating bush as the rule plainly required it to have. It was futile to prove that the method adopted was a good and effective method. The rule specified that an insulating bush must be used, and he doubted if anyone could seriously contend that there was anything there which any engineer (mechanical or electrical) would have called a bush before the case was raised. He was further of opinion that the rubber tubing could in no case be called "substantial" bushing. He agreed with Mr. G. S. Ram (of the Home Office) in thinking that it would not be difficult to invent a method of complying with the express requirements of the rule. The offence on respondent's part was, of course, purely technical. No moral blame could attach to him for using a machine with so good a reputation. But it seemed clear that he (as manager) was responsible for having in use a machine which did not meet the requirements of the rules. It was the duty of the manager to see that the machinery was such as the law allowed to be used. A nominal fine of £1, with the alternative of eight days' imprisonment, was imposed.

Notice of appeal was given.

Electricity Show Rooms.—The formal opening of premises fitted up by Ilford Council for the display of electric lighting fittings, motors, cooking and heating apparatus, &c., took place on Wednesday last week.

The opening ceremony was performed by the chairman of the Council (Mr. T. Philpot), who said that, like other commercial people, the Council must advertise their business. They wanted to show the ratepayers how electricity could be adapted for almost every purpose, and how convenient it was as an illuminant. The current could also be used for heating and cooking. Their show premises were in a prominent position in the town. He believed the coming year would show that the outlay would be well repaid, and if it led to an increase of consumers it would be an advantage to all. Electricity was the motive power of the future, and he prophesied that electricity would be used for every purpose—they would want nothing but electricity in the house.

Electricity Supply Development.—We have received from the electrical engineer and manager of the Marylebone electricity works (Mr. F. A. Wilkinson) a number of pamphlets, leaflets, cards, &c., which are being issued by the department in connection with the efforts that are being made to develop the business side of the electricity undertaking. The circulars are used chiefly as enclosures with quarterly accounts, and the postcards are for general distribution and for the acknowledgment of consumers' letters, &c. The pamphlets treat of "Charges for Electricity, the Maximum Demand Indicator System," "Electric Power," "Electric Lighting" and "Domestic Electricity." The leaflets and cards deal with electric fans, radiators, heaters, small motors, X-ray apparatus, &c. Booklets and cards both make effective publicity literature.

Electrification of Australian Railways.—The Premier of Victoria (Mr. Bent), before leaving London for Australia on June 28, arranged (in conjunction with Mr. Thos. Tait, Chief Commissioner for State Railways) that Mr. Charles Merz should go out to Melbourne and report upon the advisability of converting the suburban railways of that city from steam to electricity.

The North Eastern Railway Co.'s electric lines at Newcastle were examined by Mr. Bent and Mr. Tait, and they considered the satisfactory manner in which the work had been carried out to justify the appointment of Mr. Merz. Mr. Redman, who was closely associated with Mr. Merz in the conversion of the Newcastle lines, will probably also go out to Australia. A full report is to be presented for the guidance of the State Government, together with recommendations as to the most serviceable system and the probable financial results. The St. Kilda and Port

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Melbourne lines are to be taken in hand first, and Mr. Merz is to prepare plans and specifications and conditions of contract with regard to these in readiness for tenders to be invited. Mr. Merz is also to report upon the equipment with electric power of the machinery and plant at the Government railway workshops at Newport. While in America Mr. Bent and Mr. Tait will inspect the New York Central and Pennsylvania electric lines.

Fatality.—On Tuesday morning a man named Rose, engaged in cleaning insulators at the Great Western Railway sub station at Acton, came in contact with a live wire carrying electric current at 6,000 volts, and was killed.

Fort William McKinley (Philippines).—The "Electrical World" states that the United States Government have recently placed a contract for an entire electric lighting equipment for Fort William McKinley. Current is supplied from the plant at the Manila power house, about six miles away.

It is said that this post, when completed, can lay claim to being one of the best-appointed of any throughout the world. It includes the engineering, artillery, infantry and cavalry arms of the service, and these, together with the medical staff, or about 4,000 persons in all, occupy over 200 buildings. The post is in conjunction with the lighting installation, the Manila Railway & Lighting Co. will extend its railway line to the fort and will carry a three-wire 3,300 volt transmission line to the central distribution station in the centre of the reservation. The distribution station will contain the switchboard and arc lighting apparatus and the secondary distribution from this point to the various buildings will be four-wire 220 volt two-phase. Each building will be supplied with a meter, distributing boxes, switches, &c. Westinghouse series arc lamps will be employed for street lighting and 6,600 incandescent lamps will be installed for the interior lighting of the various buildings. The Manila Company's power plant, which contains three 1,000 kw. and one 2,000 kw. Westinghouse-Parsons turbines, is quite modern. Current is generated at 360 volts 60 cycles and stepped-up to the line voltage. Babcock and Wilcox boilers, with superheaters, are used, also Alberger high-vacuum condensers; and the coal for all fuel used is shipped to Manila from Newcastle, Australia. The value of the contract which the Government has placed with Messrs. German & Co. (Manila) for the lighting equipment is approximately $75,000, and Mr. F. H. Thompson has been sent to the States as representative for the purchase of the equipment. Mr. Putnam A. Bates, acting as consulting engineer to Morewood & Co., the export shippers, has prepared the specifications under which the bids have been made and the orders will be placed.

Hartlepool.—A special meeting of the Council is to be held to consider the proposed transfer of the powers, under the Corporation's agreement with the Northern Counties Electric Supply Co., to the Cleveland and Durham Electric Power Co.

Hastings.—The electricity supply department have decided to revise the charges for electric current as from 1st inst. as follows:—(*a*) To consumers using over 250 units per quarter (from 251 to 500) at 5¾d. per unit, 501 to 750 at 5½d., 751 to 1,000 at 5¼d., 1,001 to 1,250 at 5d., 1,251 to 1,500 at 4¾d., 1,501 to 2,000 at 4½d. and 2,000 and above at 4¼d.; (*b*) for outside lighting by arc lamps through separate meter (to be supplied without charge to consumer) at 4½d. per unit, subject to consumer consenting to take current for this purpose for three years.

Hayling Island.—A company has given notice of an intention to apply for a provisional order.

Haywards Heath.—The Haywards Heath Electric Supply Co. proposes to apply for a provisional electric lighting order for Haywards Heath and Cuckfield.

Hoddesdon.—The Council have transferred their provisional electric lighting order to the North Metropolitan Electric Power Supply Co.

Kensington (London).—The Works committee has been in negotiation with the three companies supplying electric current in the borough, and the following revised quotations have been submitted by them for supply for public lighting during the ensuing five years:—

Energy for street lamps kept alight all night 1d. per unit; ditto, if lamps are extinguished at midnight, 2½d.; ditto for public buildings, depots, &c., 2½d.

The price at present paid is 2½d. per unit, and there are 67 arcs in the borough kept alight all night and 41 extinguished at midnight. The Lighting Engineer has prepared a tabulated statement showing the estimated cost of electricity for street lighting, and after allowing for extra carbons which will be used by extending the hours of lighting of certain lamps it is shown that a considerable saving will be effected by all the arc lamps being kept alight all night and thus securing an all round rate of 1d. per unit. The committee have, therefore, decided that agreements be entered into with the three companies accordingly.

The charge for current supplied to public buildings, &c. (2½d. per unit) is to be subject to a rebate where the energy is used for a long period. The draft agreement reserves to the council the right to call for a revision of charges at the expiration of three years, should any provision be made for bulk supply within the respective areas of supply of the companies other than those in existence at present.

Knottingley.—The Electrical Distribution of Yorkshire (Ltd.) intend to apply for a provisional electric lighting order.

Leeds.—The Council have applied to the Board of Trade for sanction to a rectification and adjustment of various borrowing powers for tramways and for borrowing £15,562. 15s. 1d. further (£13,964. 18s. 9d. for permanent way and £1,597. 16s. 4d. for electrical equipment) in respect of the Horsforth extension, and £8,365 for the Chapeltown depot extension.

Licensing of Tramcar Drivers, &c.—At a recent meeting of the Metropolitan Association of Electric Tramway Managers the question of licensing came under consideration, and it was decided that Members of Parliament should be approached with the object of securing their support and co operation in endeavouring to obtain the reconsideration of the Home Secretary on several matters in connection with the subject.

Light Railway Assessment.—Wakefield Corporation have just issued a circular to all local authorities in England and Wales asking them to join, on the basis of a pro rata contribution according to the assessment of the tramways within their respective areas, in carrying the case of Wakefield Corporation *v.* Wakefield and District Light Railways Co. to the House of Lords. The decision of the Divisional Court and the Court of Appeal has been adverse to the contention that tramways should be rated on the full and not on the one-fourth part of their capital value.

Liverpool.—The Tramways, Electric Power and Lighting committee recommend the Council to apply for sanction to a further loan of £200,000 for electricity supply extensions.

London County Council.—The L.C.C. will enter into an agreement with Lambeth Council to provide that the tracks and clearway of the tramways from Vauxhall to Brixton, proposed to be constructed for electric traction, shall be paved with wood.

Electric Supply Bill.—A lengthy report was submitted by the Parliamentary Committee describing the proceedings before the Hybrid committee on the rejected Electric Supply Bill. The committee report as follows: It was not to be expected that a matter of such importance would be dismissed in this summary manner, particularly in view of the strong report of the Hybrid committee which dealt with the Council's bill of last session and upon which the scheme placed before the Committee was based. The only inference we can draw is that the committee thought the Council should itself carry out and find the money for the proposed undertaking and that there should be no transfer of the powers. This of course would have been contrary to the policy to which the Council is pledged, and to the clearly expressed wishes and mandate of the people of London at the last election. It would have been contrary even to the views of the Finance committee, which has pointed out the risks and speculative character of the enterprise. It would also have ignored the suggestion in the report of the Select committee of last session with regard to powers of leasing. We should have been ready to consider any suggestion which the committee might have put forward in order to find at last a solution of a question which has been so long outstanding, and we gave a proof of our readiness to meet the wishes of the committee by preparing the new conditions providing for purchase in 1931. The experts advise us that one of the results of the loss of the bill will probably be the growth or extension of small and uneconomical generating stations and undertakings. The prospects of a large and cheap bulk supply, though favourable to-day, must in the near future become hazardous and speculative. Success in this case hinges on the question of time, and we may never be able to retrieve those opportunities which have been so lightly thrown away. The result is that the Council is no nearer a solution of this question, which is admitted on all hands to be one of the utmost urgency, and, whilst left without any guide from Parliament for the future, we are face to face with the fact that apparently Parliament intends, in this matter, to override the expressed wishes of the people of London. We recommend that the following resolution be passed by the Council—namely, "That, in the opinion of the Council, it is a matter for deep regret that the London County Council (Electric Supply) Bill, 1907, has been rejected, thereby depriving the elected representatives of municipal London of the opportunity of securing the provision of a cheap supply of electricity subject to public control."

Mr. GORDON moved an amendment, "That with a view of ascertaining what steps should be taken to place again before Parliament a comprehensive scheme for the development of electricity for London and adjoining districts, the Highways committee be instructed to convene a conference of the various local authorities concerned, and to report the results of such conference to the Council as soon as possible."

Considerable discussion ensued of a political character in the course of which it was intimated by Mr. Robinson, the leader of the majority, that the Council would not promote another bill next year.

The amendment was rejected and the report adopted.

London County Council Accounts.—Mr. W. B. Peat, president of the Institute of Chartered Accountants, has selected as his colleague for the special investigation of the accounts of the tramways, steamboats and working-class dwellings, Mr. Francis W. Pixley, an expresident of the institute and a member of Messrs. Jackson, Pixley, Browning, Husey & Co.

Manchester.—The report of the Electricity department was presented by the chairman (Mr. Howarth) at the Corporation meeting on Wednesday.

The report points out that in five years the average price per unit of current has been reduced from 3·07d. to 1·73d. Working expenses had been reduced very considerably, and a renewals suspense account of £100,000 had been accumulated. The increase in consumption last year was 46 per cent.

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The Council assented to reductions in price recommended by the committee, to consumers on the flat rate a reduction from 4½d. to 3¾d. per unit, and to long-hour consumers from £7 per kilowatt of maximum demand and 1¾d. per unit to £7 per kilowatt and 1½d. per unit. Mr. Howarth said he believed the committee would be able to propose a further reduction at the end of the current year.

Mexico.—The "Diario Oficial" for June 6 contains copy of a law authorising the construction of two electric tramway lines in Mexico City by the Compañia Limitada de Tranvias Eléctricos de Mexico.

The "Diario" of June 13 contains copy of a Law authorising the Empresa del Ferrocarril Industrial de Puebla to use electric traction on their lines, and the company are authorised to import free of duty all the rolling stock required for the new system of traction provided all materials required are imported at the same time.

Music Hall Strike.—Our readers may not be aware that there has recently been a great strike amongst the "variety artists" and the staffs and employés of the music halls. The matters in dispute were referred to arbitration with a view to fixing the rate of pay of persons employed in these houses of entertainment. The arbitrator's decision as to the electricians (of whom a large number are employed in these establishments) is as follows: "So much diversity prevails in the skill of electricians that no award (as to rate of wages) is made."

National Institution of Apprenticeship.—A meeting of the above institution was held at the Mansion House, London, on Friday last under the presidency of the Lord Mayor. The institution has been founded with the idea of apprenticing young persons to skilled trades. It lends money or premiums where necessary, and generally supervises the course of instruction. Although actual apprenticeship under the ægis of this institution was only started in 1905, the results have been satisfactory, the number of applicants being now about 40 per week.

Lord AVEBURY, in moving a resolution setting forth the importance of every child learning a skilled trade, drew attention to the unemployed problem, and contended that a proper institution of apprenticeship would go a long way towards solving the problem.

The secretary of the Institution is Mr. J. Ballin, 5, Clarence-terrace, Regents Park, London, N.W.

New Sanding Device.—In December last, Liverpool Tramways & Electric Power & Lighting committee gave instructions for 50 cars to be fitted with the new sanding device, designed by the traffic manager (Mr. C. W. Mallins, A.I.E.E.). The cars were accordingly equipped with the apparatus, and have been in service some considerable time. At a meeting of the committee held on Friday last general satisfaction was expressed with the result of the working of the device. From the experience already gained in connection with the cars fitted with the apparatus, it will (it is stated) be a means of preventing accidents and making the skidding of the wheels impossible wherever it is applied, and the committee gave instructions for the whole of the cars to be fitted with the invention.

Norwich.—An unopposed inquiry was held here on Wednesday into the application of the Council to borrow £25,000 for extensions of the electricity works.

Presentation.—The staff of Harrogate electricity works have presented a case of cutlery to Mr. F. A. Plenderleith (assistant engineer) on his marriage.

Rotherham.—On Wednesday a recommendation of the Electric Light and Tramways committee to increase the salary of the borough electrical engineer and tramways manager (Mr. Edward Cross) from £350 to £400 a year was referred back.

Rye.—Messrs. Foote & Milne notify the Council of their intention to apply for a provisional electric lighting order.

Secret Commissions and Bribery Prevention League.—Sir Edward Fry has been elected first president and the Archbishop of Canterbury, Earl Fortescue, Lord Avebury, Sir W. H. Holland, Sir W. Mather and Mr. David Howard vice-presidents of this league. Mr. R. M. Leonard is secretary; offices, 3, Oxford-court, Cannon-street, London, E.C.

Shoreditch (London).—The special sub-committee appointed to consider the financial position of the electricity undertaking have issued their report and recommend that the illuminating power of the arc lamps in six circuits be reduced by 20 per cent., at an estimated cost of £150, but the ultimate saving is estimated at £720 per annum.

The steam raised by burning the refuse is utilised in generating electricity at the Coronet-street station, but the borough electrical engineer reports that the time has arrived when the Coronet-street station could be shut down except as a stand-by, and the whole of the generation of electricity undertaken by the plant at Whiston-street. By this arrangement the destructor steam would not be utilised, and the general rate would bear the whole cost and upkeep of the refuse destructor, and the Baths committee would have to make other arrangements for obtaining steam for heating and motive power. The committee consider such a course would be detrimental to the borough, and that, even at some sacrifice, the electricity department should generate electricity at Coronet-street to the extent that the refuse alone is capable of producing steam; the electricity department to take and pay for all electricity which it is possible to generate from refuse, the price per unit to be based on the coal and oil cost per unit at Whiston-street plus 20 per cent. for stand-by charges. In reference to the financial results, the committee point out that the electricity department has borne all charges and met all payments for interest and repayment of capital without making any call on the rates, but the scavenging department and the Hoxton baths have benefited considerably during the past 10 years at the expense of the electricity department. It is estimated that the scavenging department saves £2,000 a year. The committee are of opinion that the sinking fund payments cannot be regarded as equal to a depreciation fund unless the life of the plant coincides with the terms of repayment, and as nearly all the loans at Shoreditch are for 42 years, the department has not, up to the present, accumulated sufficient funds to meet the requirements of a depreciation fund.

The report and recommendations were adopted.

South Shields.—In moving the adoption of the minutes of the Electrical committee,

Ald. RENNOLDSON stated at the meeting on Wednesday that it had been decided to abolish meter rents. He proposed that the balance of net profits on the undertaking for the past year (£5,188) be placed to reserve.

Mr. HENDERSON moved as an amendment that £500 be voted to relief of rates.

Ald. BOWRAN seconded the amendment, which was carried by 34 votes to 10.

Stepney (London).—On Wednesday the Electric Lighting committee reported that in view of the opinions expressed at the previous meeting of the Council, Mr. Arthur Wright, their former consulting electrical engineer, had been asked to attend the meeting of the committee.

Mr. Wright intimated that although he would be shortly going abroad and would not return until October, he could arrange with his staff for the work in regard to Blyth's Wharf scheme to proceed during his absence, if he received instructions before he left, and he would be prepared to carry out the work upon the Council entering into an agreement to employ him as their expert for the further development of the electric light undertaking upon the following terms:—(*a*) The term of employment to be for six years, (*b*) the remuneration to be on the basis of an annual salary of £800, (*c*) the council to pay quantity surveyor's fees in respect of the erection of the station building at Blyth's Wharf, Mr. Wright to employ his own architect therefor and to pay such architect, the quantity surveyor to be also selected by him, (*d*) the Council to pay the fees of the district surveyor, and other fees of a like description payable in respect of the river work at the wharf, Mr. Wright to design and to pay for any advice he may require in connection with such river work.

It was stated that the Committee were divided in opinion on the matter and made no recommendation.

After a long discussion the matter was referred to the General Purposes committee.

Telephony in Italy.—The telephone in Italy, which has hitherto been in the hands of 74 different companies, has just passed into the control of the State. The Government has arranged to purchase the principal urban telephone systems for a little over £610,000. Later on the tariff will probably be reduced, though in Rome it is only about £6. 15s. a year for the ordinary subscriber.

Tramway Telephones as Fire Alarms.—Arrangements have been made between the Watch and Tramways committees at Birmingham by which the public may use all the telephone boxes on the tramway standards for summoning the Fire Brigade, or for obtaining assistance in the event of accidents or other emergencies. There are already a hundred tramway telephone boxes available. Each of the standard boxes contains a telephone connected with the Central Tramway Office in Corporation-street, and a private wire is to be run through from the latter place to the Central Fire Station.

Trunk Telephone Facilities.—At the last meeting of the Halifax Chamber of Commerce a communication was read from the Postmaster-General notifying that alterations are being carried out to improve the trunk telephone services to Manchester, Liverpool, Huddersfield and Sheffield, and that at an early date the work will be put in hand for the construction of three additional trunk lines to Bradford, and two additional to Leeds, giving improved telephonic facilities between Halifax and the more distant parts of the country.

Widening of Blackfriars Bridge.—In connection with the widening of Blackfriars Bridge, London, to provide space for the electric tramway, the first caisson was electrically lowered on Wednesday last.

Worthing.—In a report on the present position of the electricity undertaking,

Mr. P. E. Rycroft stated that, in his opinion, the site selected for the station was unsuitable; that the plant was capable of more efficient working; that the purchase of a gas-suction plant was a doubtful and, in any event, an inadvisable experiment, and premature; that the chief engineer (Mr. G. Porter) was overburdened with trivial office duties; and that a clerk should be appointed at once. Mr. Rycroft also recommended that the furnaces, flues, boilers, steam mains, engines and condensers should be thoroughly overhauled this summer and that mechanical stoking might be considered when the minor defects had been righted. Very careful tests should be made before a fresh coal contract was entered into. The public lighting should be at 3d. per unit, but

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the cost of carbons, cleaning and maintenance should not fall upon the department. The recent reduction to 1½d. for power, heating and cooking was thoroughly sound. Vigorous commercial methods were necessary for pushing the sale of current. The annual £500 "grant in aid" should be discontinued as soon as possible, even at the risk of decreasing the amount placed each year to reserve. With strict supervision, the cost of production could, he believed, be materially decreased, and there were also possibilities of a largely increased business.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Beckenham.—During the year ended March 31 the electricity department generated 1,112,757 units. Revenue from sale of current, rent of meters, &c., was £14,666. 11s.

At the last meeting of the Council, the Chairman, Mr. G. Sutton stated that the year under review was the first complete year under Council control. After deducting interest there was a profit of £3,259. 5s. 6d. In the case of a private undertaking that sum would be a balance for depreciation and reserve, but, being a municipal concern, they had to apply a part of it in reduction of capital indebtedness. The amount so applied was £2,795. 17s. 10d. and the surplus was £1,550. 13s. 2d.

Brighton.—During the past year the electricity department sold 7,849,194 units of electric current, against 8,000,200 units in 1905-6, a decrease of 151,006.

The report of the borough electrical engineer (Mr. John Christie) states that the decrease is due to the reduced consumption by the tramways department (73,350 units less) and by private consumers (77,656 units). The reduced demand by private consumers is attributed to the extensive use of the new high-efficiency lamps. There was a considerable increase in the day load for power which has to a large extent neutralised the loss of lighting units. The alternative flat rate of 4d. per unit was adopted last July. Mr. Christie estimated a loss of £2,800 if all consumers who were paying more than 4d. per unit adopted the system. Only 1,180 out of 1,600 had changed over, which showed that the total loss under this heading had not yet been reached, and had to some extent been neutralised by some of the 1,700 consumers who had already adopted the tariff, but in all probability were paying slightly less than 4d. per unit under old conditions. Owing to delays in getting the Southwick plant into regular operation, it was necessary to maintain the North-road works under steam and fully manned, ready to supplement Southwick, for some 10 months of the year. Since February, however, supply had been almost entirely from the new works, and in consequence great economies had been effected in the general operation of the works both at Southwick and North-road. Mr. Christie feels sure that, if no unforeseen circumstances arise necessitating steaming the North-road works to any extent, works costs will be reduced to 0·75d. per unit. Business seemed to be slightly improving as regards new connections and increased output, and he estimates the output for the current year at over 8,000,000 units, and on this basis the saving indicated above would amount to £11,600.

The total revenue for the year was £81,415 (against £86,076 in 1905-6), the total costs were £47,444 against £48,645. Gross profit was £33,971 (against £37,432). Interest absorbed £21,355 and sinking fund £22,263, leaving a deficit of £10,233. The total works costs were 1·14d. (against 1·11d.) and the total costs 1·33d. per unit (against 1·44d.). There are 4,500 consumers, and the average price obtained for the units sold was 2·39d.

Bury (Lancs.)—The revenue of the electricity department fo the year ended March was £14,575. 5s. 8d., compared with £13,514. 9s. 10d. for the previous year.

The cost of management, production and distribution has been £6,215. 14s. 5d., leaving a gross profit of £8,359. 10s. 10d. Interest and sinking fund charges were £5,411. 13s. 7d. leaving a net profit of £2,947. 17s. 3d., out of which £1,947. 17s. 3d. has been set aside for depreciation and £1,000 has been voted to relief of rates. The total capital expended is £85,409. 0s. 5d., an increase of £1,797. 6s. 8d. 2,375,510 units were generated; 1,230,799 units were supplied to the tramways, 984,116 to private consumers and 61,351 to the public lamps. The load factor was 18·1 per cent. (against 18·6), and the total maximum supply demanded was 1,540 kw. Progress is reported in the use of electric motors for industrial purposes, and during the year 17 motors (of 151 H.P.) were hired out and 27 motors (208½ H.P.) were put in by consumers. There are now 79 hired motors (of 542 H.P.) and 85 owned motors (of 543½ H.P.) connected to the mains

Cardiff.—For the year ended March 31, the total revenue of the electricity department was £35,576. 7s. 6d., including £22,702. 19s. 6d. for sale of current by meter, £193. 15s. for heating, £1,180. 17s. 8d. for power, £1,812. 19s. 4d. for special power, and £8,394 9s. 8d. for street lighting.

The total expenses came to £25,930. 2s. 2d., leaving gross profit £9,646. 5s. 4d. After paying interest and sinking fund instalments, &c., there is a deficit of £2,426. 14s. 7d. 4,436,716 units were generated; 1,165,758 were supplied to public lamps, 2,285,294 sold to private consumers by meter, and 14,827 units were supplied under the "minimums and contracts" arrangements, or a total of 3,465,879 units sold. The total maximum supply demanded was 2,204 kw.

The city electrical engineer (Mr. ARTHUR ELLIS) reports that this loss on the year's working was due to the reduction in prices necessitated by similar reductions in the price of gas. However, there had been an increase in the units sold. A large extension of plant is just now commencing to earn revenue, and he, therefore, anticipates a large profit during the current year.

In the report of the city treasurer (Mr. J. Allcock) on the accounts, it is stated that the assessment for local rates on the undertaking has been increased, and arrears of former rates which were left unpaid pending appeal (£482. 10s. 8d.) have been charged to revenue. Capital account shows an expenditure of £28,408. 9s. 7d. (a bank overdraft), and up to the present the revenue account has only borne bank charges for interest in respect of this overdraft. Mr. Allcock states that the true position of the undertaking cannot be shown unless contributions to sinking fund are regularly set aside, irrespective as to whether the money had been temporarily lent by the bank or permanently raised. According to calculations made by him, with a sinking fund accumulating at 3½ per cent. per annum for 25 years, the revenue account would have had to bear an additional sum of £3,366. He, therefore, recommends that this sum be withdrawn from revenue and carried to a suspense account pending the issuing of a further loan.

The accounts of the tramways undertaking for the year ended March 31 show total income of £119,115, including £106,550. 11s. 6d. for traffic receipts. The general expenses were £71,261, and the loan and other charges came to £43,448, leaving a profit of £4,405. Mr. Allcock points out that the capital account shows an over-expenditure of £30,531. 14s. 4d., which has been provided by a bank overdraft, and in this case the revenue account also has only borne the bank charges for interest.

Darlington.—The accounts of the electricity department for the year ended March show capital expenditure £63,528, increase £2,719, of which £1,776 was upon engines, dynamos, boilers, &c., £522 upon mains and services, and £243 on meters.

Gross revenue was £9,742 (including £2,235 for traction supply) and £6,435 net. Expenses were £3,677, gross profit was £6,065 (or 9·756 per cent. on capital), and there was a balance in hand from previous year of £1,400. £1,691 was required for interest, £2,965 was allowed for depreciation, £151 placed to reserve, and £1,249 to district fund, leaving £1,410. Coal and other fuel cost 0·270d. (against 0·324) per unit and total working and general expenses 0·805d. (0·894d.). 1,226,578 units were generated (against 1,030,154), 81,431 (79,070) supplied for public lamps, 429,105 (434,842) for traction, 341,266 (308,638) to private consumers for lighting and 243,485 (115,451) for power. The maximum supply demanded was 747·6 kw. (682·8 kw.) and the load factor was 16·93 (17·22). The capacity of the plant is 970 kw. (922 kw.), and the equivalent of 53,721 (44,223) 8 c.p. lamps is connected.

On the Corporation's tramways the total capital expenditure is £76,293 (increase £1,026). Revenue was £11,143, traffic expenses £3,543, general expenses £671, general repairs and maintenance £890, power expenses (current at 1½d. per unit) £2,235, making total working expenditure £7,338, and leaving a gross profit of £3,805. After meeting capital charges there was a deficit of £700. Traffic expenses were 2·279d. (against 2·166d.) per car mile, cost of current 1·440d. (1·446d.), total working expenses 4·722d. (4·731d.). 3,169,036 (3,285,150) passengers were carried, and 372,912 (375·755) car miles run. 429,105 (434,842) units were used, equal to 1·150d. (1·157d.) per car mile.

Dover.—The accounts of the electricity department for the year ended March show total revenue £19,580. 10s. 7d., including £16,754. 14s. 7d. from sale of current for lighting and power and £1,968. 18s. 9d. from public lighting.

Total expenses were £9,307. 7s. 4d., leaving £10.273. 3s. 3d. to meet interest on capital (£6,000), other interest (£1,388. 8s. 8d.) and sinking fund (£4,009). After taking into account £653. 14s. 3d. from last account, it was necessary to take £470. 11s. 2d. from reserve. 1,575.795 units were generated, 713,210 supplied to private consumers, 438,325 to the tramways and 144,651 for public lighting. The total maximum supply demanded was 451 kw. alternating and 350 kw. direct current. The total capital expended is £179,823. 13s. 8d., an increase of £6,615. 14s. 10d. on the year.

Exeter.—The city electrical engineer (Mr. H. D. Munro) has issued his report for the year ended March 31st.

The total receipts of the electricity department were £16,382 and the expenses £8,004, leaving gross profit £8,377. Interest and sinking fund charges required £6,974, and the net profit was £1,403. Various special charges, amounting to £488, have been met out of revenue, including cost of the Heavitree provisional order (£222). An adjustment of the sinking fund on the 1904 loan has also increased the special charges by about 1,250, so that but for these items the surplus would have exceeded £2,000. £191,233 units were sold, an increase of 10 per cent. for light and power, 50 per cent. for public lighting, and nearly 40 per cent. for tramways. The revenue from supply of current increased by 17½ per cent., and the total costs of production and distribution by 10 to 12 per cent. The Electric Lighting committee recommend that the surplus (£1,403) be carried to profit and loss account, and that £2,588 expended upon works at the new power station in excess of the amount sanctioned for borrowing be then charged to the profit and loss, leaving a surplus in hand of £452. The committee also recommend that a contract be entered into for the supply of 5,000 Osram lamps in the next twelve months.

Glasgow.—For the year ended May 31 the gross revenue of the tramways department was £899,351 and the expenses were £485,256.

After setting aside £168,408 for renewals and depreciation and paying rent of leased lines (£9,953), interest (£63,769), sinking fund (£49,777), income tax (£9,932), Parliamentary expenses (£6,977) and voting £35,000 to the common good, the net balance was £70,279. Of this sum £45,000 has been placed to special depreciation and £25,279 to general reserve.

Huddersfield.—The traffic revenue of the tramways department for the year ended March was £78,114. 16s. 10d. (equal to 10·38d.

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per car-mile), and with sundry receipts the total was £81,196. 0s. 4d. (10·79d.).

Working expenses were £40,041. 2s. 9d., leaving £41,154. 17s. 7d. to meet interest (£12,185. 2s. 3d.), income tax (£805. 18s.), rent of leased lines (£1,205. 12s.), sinking fund, repayment of mortgage loans, &c. (£9,807. 12s. 5d.). After placing £12,427. 9s. 11d. to reserve, the balance is £5,025. 17s. 4d. 1,804,745 car-miles (1,794,691 cars and 10,054 coal trucks) were run, 15,252,150 passengers were carried and 3,722,598 units of electric current were consumed.

Loughborough.—The gross profit on the past year's working of the electricity department was £604. 5s. 7d., against a loss of £251 in 1906.

Interest and sinking fund came to £1,716, leaving a deficit of £1,112. The consumers last year had increased by 50 per cent., while the amount of current sold increased 300 per cent.

The chairman (Ald. Bumpus) said the year had been one of satisfactory progress, and the staff had worked cordially and efficiently for the success of the undertaking.

Melbourne (Australia).—The Corporation electricity department made a net profit of £17,601 for the year ended Feb. 28.

The revenue was £81,189 (increase £8,975), including £7,966 from power and heating supply (increase £738). Expenses were £35,660, and capital charges £27,927. The amount standing to credit of depreciation and renewals account has been increased from £37,223 to £59,002. The number of consumers increased by 375, against 228 in the previous year.

Sunderland.—The total income of the Corporation tramways was £72,396. 1s. 2d. for the year ended March.

Expenses came to £40,822. 9s. 1d. (including power expenses £12,840. 4s. 8d., and traffic expenses £18,417. 9s. 3d.) Gross profit was £31,573. 12s. 1d., and the balance £23,055. 14s. 8d. Repayment of loans required £9,014, and £6,258. 11s. 11d. was placed to reserve. £7,123. 15s. 8d. was voted in relief of rates. 17,483,132 passengers were carried, and 1,535,425 car miles were run. 1,826,167 units of electrical energy (at 1⅛d.) were used. The percentage of working expenses to receipts was 55·66, and the average traffic revenue per car mile 11·261d. Gross capital expenditure is £298,306.

Tunbridge Wells.—The accounts of the electricity supply department for the year ended March show capital expenditure £81,476, an increase of £341 over 1906.

Revenue was £13,995. Total working and general expenses were £7,818, leaving £6,178 gross profit (against £6,601 in previous year). Dividends to stockholders required £1,633, sinking fund £2,742, and mortgage loan interest and instalment of principal £347. £2,000 has been placed to reserve and the net profit was £1,515 (against £1,900). 1,049,110 (1,043,567) units were generated and 597,605 (581,454) supplied to private consumers and 265,327 (323,506) to public lamps. There is the equivalent of 62,158 (57,853) 8 c.p. lamps connected. The total maximum supply demanded was 671 kw.

Mr. Horace Boot, who has recently resigned his position as resident engineer, but is retained by the Council as permanent consulting electrical engineer and supervisor, has prepared figures showing the progress of the undertaking since its inception, and these show that £21,567 has been paid off capital, leaving an indebtedness of £59,908, and £17,550 has been paid as interest. The cost of maximum demand indicators, of new lamps necessitated by change of voltage and all small items (such as meters, service cables, &c.) has been charged to revenue, which has resulted in capital expenditure being kept at a low figure. Mr. Boot considers the results very satisfactory, as the area is sparsely populated and coal costs 28s. per ton and water 1s. 6d. per 1,000 gallons. During the period from 1897 to 1907 the total gross profit was £48,217 and the total net profit £11,808, equal to about 6 per cent. on the capital. The price of current has been reduced 25 per cent. and £2,750 has been contributed in relief of rates.

Wellington (N.Z.)—A profit of £4,000 has been made on the past year's working of the municipal electricity supply and tramway undertaking.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Electricity committee of *Stepney* (London) Borough Council invite tenders for supply, delivery and erection at their electricity works of a testing switchboard, motor-generator and transformer; also a three-pole distribution board and earthing panel. Specifications, &c., from the engineer and manager, Mr. Wm. C. P. Tapper. Tenders to 27, Osborn-street, Whitechapel, E., by noon July 22. See also an advertisement.

Wednesbury Corporation invite tenders for balancer boosters and accumulators (alterations of and extensions to) in connection with the scheme for the extension of the electricity works. Specifications from the consulting engineer (Mr. W. Fennell, A.M.I.E.E.), Camp-street, Wednesbury, after 11th inst. Tenders to the town clerk (Mr. Thomas Jones), Town Hall, Wednesbury, by midday Tuesday, July 23. See also an advertisement.

Beckenham Urban District Council are prepared to receive tenders for the supply of meters for their electricity department. Specifications, &c., from the Resident Engineer, electricity station, Church Fields-road, Beckenham. Tenders to the clerk of the Council (Mr. F. Stevens), Council Offices, Beckenham, by 4 p.m. Monday, July 22. See also an advertisement.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

Schemes and tenders are invited for the electric lighting of *Uffculme*, Devon, by overhead or underground mains. Current is supplied at 200 volts d.c Tenders to Mr. S. B Sparkes, Coldharbour, Uffculme, Devon, by July 12. See an advertisement.

London County Council invite tenders for (*a*) supply and erection of 78 tramway feeder pillars for the Council's tramways and (*b*) supply, delivery and erection of overhead electrical equipment for 2,400 yds. of double track for the Council's tramways in the borough of Woolwich. Tenders, on official forms, from the Clerk of the Council, County Hall, Spring-gardens, S.W., by 11 a.m. July 16.

London County Council also want tenders by 11 a.m. July 16 for the manufacture of oil tanks, filters, &c., for their generating station, East Greenwich. Forms from the office, Spring-gardens, S.W.

The *Metropolitan Water Board* want tenders by 10 a.m. July 24 for supply of two 25 kw. generators, motors, four triple-expansion marine type engines, three hydraulic turbines, 10 water-tube boilers, mechanical stokers, coal conveyor, ash hoist, pumps, valves, economisers, pipes, &c. Specification, &c, from the Engineer, Southwark Bridge-road, S.E.

Manchester Tramways Committee want tenders by 5 p m., July 15, for supply of steel girder rails, fishplates, tie-bars, bolts and nuts, steel poles, span wire brackets and rail bonds and for special track work. Specifications from Mr. J. M. M'Elroy, 55, Piccadilly, Manchester.

Bristol Docks committee want tenders by 10 a.m., July 26, for supply, erection, &c., of 10 2 ton electric waggon capstans, and two 10 ton, two 3 ton and 16 30 cwt. movable electric jib cranes for the new Royal Edward Dock, Avonmouth. Specifications from the engineer, Cumberland Basin, Bristol.

Cardiff Guardians require tenders by 10 a.m., July 16, for alteration of telephone service at Cardiff and Ely workhouses and provision of telephones, wiring, switchboard, &c. Forms from the Clerk, Queen's-chambers, Cardiff.

Leeds Sewerage Committee want tenders by July 15, for supply and erection of a 34 kw., 110 volt c.c. steam dynamo. Particulars from Mr. Geo. A. Hart, Municipal Buildings, Leeds.

Wallasey Tramways committee want tenders by July 16 for supply of points and crossings. Particulars from Mr. W. H. Travers, Egremont, Cheshire.

Handsworth District Council invite tenders for traction and lighting feeders, fibre ducts and roadwork. Tenders to the Council House, Handsworth, by noon July 10.

Pontypridd Council invite tenders for supply and laying of about 3,000 yds. of triple concentric feeder and distributing cables, paper-insulated. Tenders to Town Clerk by July 8.

Tenders are invited for the lighting by gas, oil, electricity or other illuminant of the streets, thoroughfares, &c., of the city of *Calcutta*. The city comprises approximately an area of 20 square miles, containing about 170 miles of main thoroughfares and 130 miles of smaller streets, besides several squares, markets, latrines, slaughter houses, &c., which are now lighted by gas and oil lamps. The new contract is timed to commence on May 1, 1911, and the successful tenderer will be required to have all arrangements completed and ready to begin and continue the lighting with effect from that date.

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Tenders should be for 10, 15 or 20 years. Further particulars are given in an advertisement, and tenders will be received by the Vice-Chairman of the Corporation up to 3 p.m. Jan. 2, 1908.

TENDERS RECEIVED AND ACCEPTED.

The following tenders were received by London County Council for switchgear :—

	A	B
Johnson & Phillips (*accepted*)	£12,692 1 6	£7,664 17 10
Evered & Co.	20,057 15 0	10,236 2 6
Ferranti Limited	16,565 3 0	9,512 14 9
Electric Construction Co.	16,254 17 4	9,305 15 6
Whipp & Bourne	15,198 1 10	9,036 13 2
J. E. Spagnoletti & Co.	——	8,924 0 0
General Electric Co.	14,801 12 0	8,548 3 8
British Westinghouse Co.	14,197 0 0	8,348 10 0

A.—Switchgear for Islington, Holloway, Hackney, Clapton and Stockwell sub-stations. B.—Switchgear for Lewisham, Forest Hill and Tooting sub-stations.

Dartford Council have accepted the following tenders :—

Chamberlain & Hookham, meters (£118 18s.); S. W. Gibson & Co., fuse wire, &c. (£4. 12s. 6d.), and oils, &c. (£49. 5s. 3d.); E. E. Beavin, tools and screws (£5. 12s. 4d.). and joint rings, packing, &c. (£7. 3s.); W. T. Henley's Telegraph Works Co., house service cable, jointing materials and accessories (£185. 10s. 8d.).

Walthamstow Council have accepted the tender of W. T. Henley's Co. for supply of cables. Contracts for tramway uniforms have been entered with H. Lotery & Co., H. Price & Son and Spencer Bros.

Essendon Council have accepted the offer of North Melbourne Electric Light and Tramway Co. for erection, supply of current to, and maintenance of about 450 32 c.p. lamps for public lighting for 10 years.

For wiring the new London offices of the London, Edinburgh & Glasgow Assurance Co. for electric light and power the following tenders were received. :—

Lea & Warren (*accepted*)	£656 15	H. J. Cash & Co.	£811 0
Peto & Radford	1,261 0	Belshaw & Co.	754 5
Benson & Co.	1,079 14	Roger Dawson (Ltd.)	696 14
Foote & Milne	834 4	H. M. Leaf	664 7

Messrs. Morgan Williams & Couzens are consulting engineers, and Mr. Beresford Pite, F.R.I.B.A., is architect for the building.

Cheltenham Council have accepted the tender of the British Thomson-Houston Co. for meters and switchgear, and that of Heenan & Froude for a refuse destructor and steam-raising plant at £4,266.

Luton Corporation have accepted the tender of Ed. Bennis & Co. (Little Hulton, Bolton, and 28, Victoria-street, London, S.W.) for one double stoker and self-cleaning compressed air furnace for a 30 ft. by 8 ft. diameter Lancashire boiler.

Portsmouth Education committee have accepted the tender of Southey Limited for wiring for experimental purposes and for electric light fittings for the new Technical Institute at £1,146. 6s. 6d.

Luton Council have accepted the tender of G. W. Buckingham for the extension of the power station building at £1,857.

Rochdale Council have accepted the tender of W. A. Peters & Sons for extensions of the electricity station buildings.

Derby Council have accepted the tender of Cowans Limited for enlarging and remodelling the high-tension switchboard at £133 10s.

Exeter Council have accepted the tender of the General Electric Co. for 5,000 Osram lamps.

Marylebone (London) Council have accepted (at £604 9s.) the tender of Cowans Limited for switchboards. Delivery in eight weeks.

Electric Pumping Plant in Collieries.—The British Westinghouse Co. are supplying to the Powell Duffryn Steam Coal Co. two 950 H.P. three phase 3,000 volt 50 period squirrel cage induction motors, to run at 1,450 revs. per min. These motors are for driving, through flexible couplings, two Worthington six-stage turbine-type centrifugal pumps, each capable of delivering 1,350 gallons per minute, against a head of 1,645 ft., including suction, lift and friction of discharge mains. The guaranteed efficiency of each set, from input at motor terminals to output at surface, is 69 per cent. It is proposed to run the sets at nights, when the haulage gears and other machinery is shut down, thus providing a night load for the power house and making the fullest use of the generating plant.

BUSINESS NOTICES.

Messrs. Wheatley Kirk, Price & Co., engineering valuers and auctioneers, of 46 Watling-street, London, E.C., and Albert Chambers, Albert-square, Manchester, have opened offices at 26, Collingwood-street, Newcastle-on-Tyne, and have appointed Mr. W. T. Stutchbury as resident district manager there.

Mr. John G. Ames, who has been for many years connected with R. W. Blackwell & Co., as the manager of their Manchester branch, has severed his connection with that firm, and, after visiting the United States, has been appointed manager of the Barrett Mfg. Co., Spencer House, South-place, Finsbury Pavement, London, E.C.

Messrs. W. & R. Jacobs, 39c, King William-street, London, E.C., notify that, with the active help of Messrs. Hale, late of Upper Thames-street, E.C., they are carrying on business as wholesale suppliers of electrical materials.

Mr. V. J. Delebecque, until lately branch manager at Birmingham for the Electrical & Ordnance Accessories Co. takes charge (from July 1) of the company's Manchester branch, in succession to Mr. D. C. Bate, whose agreement with the company has terminated. Mr. J. Booker has been appointed to succeed Mr. Delebecque at Birmingham.

Messrs. R. J. Nicholson & Co., of Manchester, have opened branches at Newcastle-on-Tyne (77, High Bridge) and Bath (Northgate Works). Mr. T. R. Martin will supervise the North of England work from the former offices, and Mr. C. G. Smith and Mr. Talbot will look after the west of England from the Bath office.

Mr. H. E. Brain, A.I.E.E., will shortly be in this country again in connection with his business in Buenos Aires. On the expiration of his agreement with the Buenos Aires & Pacific Railway, Mr. Brain has decided to undertake on his own account the carrying out of contracting work in South America. He will combine this with his practice as a consulting engineer.

Mr. Brain was for seven years chief electrical engineer to the Buenos Aires & Pacific Railway, and was responsible for the installation of the electrical plant at Bahia Blanca, both in regard to the electrical equipment at the docks, where there is a most extensive installation of polyphase cranes, and in regard to the lighting of that city. Mr. Brain was also responsible for the design and supervised the manufacture of the extensions to the direct-current generating station at Junin and for the equipment of the Buenos Aires & Pacific Railway Co.'s new carriage and waggon shops at Caseros on a polyphase system.

Joseph A. Harfield & Geo. Diggins, electricians, &c., 13, Abingdon-road, Kensington, London, W., have dissolved partnership. Debts by Mr. J. A. Harfield, who continues in his own name.

Messrs. F. C. & W. S. Bracher (trading as F. & W. Bracher), electrical engineers, &c., Redcliff-street, Bristol, and Malmesbury, have dissolved partnership. Mr. W. S. Bracher continues.

The registered offices of the British Columbia Electric Railway Co. have been removed to 34, Nicholas lane, London, E.C.

Mr. F. A. McCarty (formerly of Noyes Bros.) has started in practice as a consulting engineer at 31, Queen-street, Melbourne, Australia.

W. D. Angier and H. E. Sterns, engineers' agents, 101, Leaden hall-street, London, E.C., have dissolved partnership.

BANKRUPTCIES, LIQUIDATIONS, &c

Rich. S. Blackburn, electrical engineer, Osborne-street and Ribstone Works, Hebden Bridge, has been adjudicated bankrupt.

Claims against the P.M. Electric Mfg. Co. are to be sent by July 29 to Mr. Elles Hill, 79, Mark-lane, London, E.C.

The I. T. E. Electric Co. (Ltd.) is being wound up voluntarily. Mr. P. F. Huddleston, 72, Finsbury-pavement, London, E.C., is liquidator.

A meeting to receive an account of the winding up of the A. B. P. Accumulator Co. (Ltd.) will be held on Aug. 1 at 39, Victoria-street, London, S.W.

Sale by Auction.—Messrs. Horne & Co. will sell by public auction, by order of the Secretary of State for War, at the Royal Arsenal, Woolwich, on July 18 at 11 a.m. obsolete and unserviceable stores including lead and founders' ashes, broken crucibles, wrought and cast iron, steel, brass, copper, gunmetal, mixed metal, lead, antimony, aluminium, platinum, pewter, phosphor bronze, tin, cupro nickel and lead, lathes, pumps, electric cable, ebonite, batteries, telegraphic instruments, lamps and lanterns, tools, dermatine, glass sheets, &c. Can be viewed at the Royal Arsenal, Woolwich, on Monday, Tuesday and Wednesday previous to and on morning of sale. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower, E.C.; and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Plant for Sale.—Some electric lighting plant, consisting of 8½ H.P. Hornsby engine coupled to a Canning dynamo (giving 85 amperes at 65 volts), with switchboard, &c., is advertised for sale by the Rev. J. R. Mills, D.D., the Vicarage, Gedney, Lincs.

CATALOGUES, &c.

"*Everything Electrical.*"—This is the title of a booklet from Johnson & Phillips (Ltd), which deals briefly with a number of the specialities manufactured by this firm. The various kinds of cable, including the recently-introduced "Paterson's Patent Fireproof Cables," are described. Starters for alternating-current machines are illustrated. These are made in four types: (1) Suitable for inserting the rotor circuit of two and three-phase motors for starting up under ordinary conditions; (2) a variation of above allowing the speed to be reduced if necessary; (3) wire-wound starters for use in the stator circuit; (4) Auto starters for inserting in the stator circuit of motors with short-circuited rotors. All these starters are of the same general design as those made by this firm for direct current work. There is much additional information to make the booklet useful and interesting reading.

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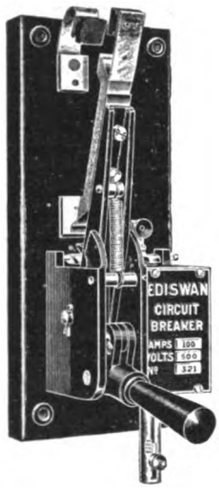
Motors.—We have received pamphlet No. 204 from the British Thomson-Houston Co. relating to two- and three-phase induction motors. The pamphlet is well illustrated with the different forms of motor manufactured by the company, and also with the various types of starting switches, rheostats, &c., which are specially designed for this work. All sizes of motors are made in two designs, those with squirrel-cage rotor (Form K) and those with wound rotor (Form M). The pamphlet concludes with a useful table of ratings for standard and other motors and with a table of weights and dimensions for the necessary starters.

"Ediswan" Leaflets.—The Edison & Swan Co. have issued leaflets No. A2,092 and A2,093, the former dealing with circuit-breakers of the 500 volt single pole maximum current type, and the latter with ironclad power fuse boads suitable for circuits of from 200 to 600 volts. We illustrate the former piece of apparatus, which is designed to automatically open the circuit in case the current passing equals or exceeds the amount for which the instrument is set, or in case of short circuit. The handle of the circuit-breaker is loose and independent of the switch arm, so that the breaker cannot be held in circuit when an excessive current is flowing. In action the switch is held in by a knuckle lever against a dead centre, which is "released" by the tripping device through the latch. Owing to the link action the switch is firmly locked in position when "on" and cannot be jarred from its contact even by excessive vibration.



The Ironclad Power Fuse Board is claimed to be particularly suited for motor purposes, the whole of the current-carrying parts being designed for use with heavy currents.

Tramway Plant.—We have received from the British Insulated & Helsby Cables (Ltd.), Prescot, Lancs., pamphlets illustrative of their apparatus for tramway work. These consist of the Prescot section insulator, combining the S.W.C. mechanical splicing ear with a novel form of air-gap section insulator. It is claimed that by the use of this insulator very smooth running is obtained, that there is no heating of the trolley wire by soldering, and that the insulators are easily renewable. It is also said to have the further advantage of being light (16 lb.) and to have a high insulation. The method of suspension allows the trolley wire to remain at normal level and the trolley wheel can thus run over it very easily.

The Prescot mechanical ear, manufactured by the same firm, can be detached or attached to the trolley wire in three minutes. If the insulator bolt breaks it does not fall and no screws are required for holding it together. As no heating is necessary for fixing this ear there is no weakness at the point of suspension from this cause. This firm are also sole licensees for the manufacture of the electrically-controlled switch frog, patented by C. H. Merz and S. G. Redman, which has been in successful operation on the Tyneside tramways for the last two years. Normally the tongue of the frog is set so that the driver coasts through on the straight track with his controller shut off. When he wishes to take his car round the branch tracks he puts on the controller, which is then in series with the frog solenoid, and the current taken from the section ahead operates the solenoid and moves the tongue of the frog.

Soldering Paste.—The British Insulated & Helsby Cables have brought out a new soldering paste which, it is claimed, will not corrode the most delicate work. The new paste, known as "Coraline Soldering Paste," is said to give off no spray, and when applied does not run off the work, nor does it dry.

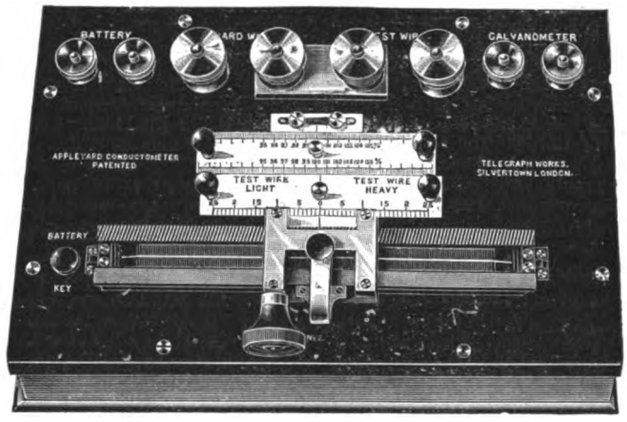
New Lamp Fittings.—The difficulty of finding some suitable place on which to rest a portable hand lamp when working in the interior of boilers or other confined space is well-known. To get over this difficulty the British Insulated & Helsby Cables have lately put on the market a magnetic lampholder which, directly the current is switched on, can be attached to any iron surface. The fitting is provided with a short length of flexible tubing to protect the leading-in wires. This firm also manufacture a portable hand lamp fitted with a brass case for use in collieries, mills, gasworks and other places of like description.

Electric Light Fittings.—We have received from the London Electric Fittings Co. a copy of their new catalogue.

The new catalogue of the Wandsworth Electrical Mfg. Co. contains illustrated particulars and prices of electrical fittings, switches, accessories, &c.

Electrical Measuring Instruments.—The Leeds & Northrup Co., Philadelphia (U.S.A.), have sent us a copy of their 1907 catalogue, which contains illustrated particulars and prices of a variety of electrical instruments.

Appleyard's Conductometer.—In testing copper wire and steel rods for conductivity it frequently happens that tests are required of a large number of samples of practically the same diameter, but since the diameter is liable not to be exactly the same in all cases a somewhat troublesome correction has to be introduced, instead of being able to take simply the resistance measurement of a certain length as a measure of the conductivity. This difficulty has been overcome by Mr. R. Appleyard in his "Conductometer." The instrument depends upon the Kelvin bridge principle but two adjustments are provided. One of these adjustments is set to compensate for differences in diameter, as found between the standard wire and the wire to be tested. When this adjustment has been made, an ordinary bridge adjustment is then carried out to obtain balance, and the conductivity can be read off directly in



THE APPLEYARD CONDUCTOMETER.

terms of Matthiessen's standard. Assuming that the differences in diameter are small, the errors involved are negligible. Results can be obtained at the rate of two or three a minute. The instrument is made by the India Rubber, Gutta Percha & Telegraph Works Co., Silvertown and London, and is listed in the Company's newly-issued catalogue.

Electric Heating and Cooking.—The Electrical Co. have issued pamphlet No. 242, containing illustrated particulars and prices of electric cooking and heating apparatus.

"Antioyl" Soap.—Those who take a practical interest in mechanical work, more particularly in motor cars, and make their own adjustments in preference to leaving such matters to other people, are well aware that it is a difficult matter to remove dirty oil from the hands. For this purpose "Antioyl" soap, of which we have received a sample from Messrs. F. S. Cleaver & Sons, the makers, will be found useful. It has the advantage that it can be used in the place of ordinary soap, is pleasant to the touch and has more than the usual softening effect on water.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from June 26 to July 2, with the ports of destination:—

Africa—Alexandria, £48; Durban, £305; East London, £90. *Argentina*—Buenos Ayres, £540. *Australasia*—Adelaide, £420; Auckland, £127; Fremantle, £300; Hobart, £15; Melbourne, £304; Perth, £70; Port Elizabeth, £44; Sydney, £992 (including £70 telegraph material); Wellington, £17. *Belgium*—Ostend, £188. *Brazil*—Rio Janeiro, £3,905 (including £3,846 telegraph material); Santos, £396 (including £133 telegraph material). *Burma*—Rangoon, £55. *Chili*—Antofagasta, £350 (including £320 telegraph material); Valparaiso, £159. *China*—Canton, £10; Shanghai, £1,083; Tientsin, £20 (telegraph material). *Denmark*—Copenhagen, £113. *France*—Boulogne, £48; Paris, £140. *Germany*—Bremen, £178. *Holland*—Amsterdam, £487; Flushing, £14; Rotterdam, £456 (telegraph material). *Hong Kong*, £2,685. *India*—Bombay, £689 (including £81 telegraph material); Calcutta, £282; Madras, £625. *Japan*—Kobe, £267; Nagasaki, £293; Yokohama, £231. *Malta*, £15. *Russia*—Libau, £50 (telegraph material). *Straits Settlements*—Penang, £231; Singapore, £90. *Sweden*—Gothenburg, £97 (including £45 telegraph material); Stockholm, £479 (including £320 telegraph cable). Total £16,910, against £16,968 in the corresponding week last year (June 27 to July 3).

COMPANIES STRUCK OFF THE REGISTER.—The following were, on June 21, removed from the register of joint stock companies:—Birmingham Telegraph Factory, Cross Electric Engineering & Mfg. Co., Electrical Engineering Corpn., Elmore's French Patent Copper Depositing Co., Fowler, Lancaster & Co., Lamina Accumulator (Elieson's British Patents) Synd., Medical Battery Co., Patent Engine & Power System Synd., Postal & Telegraph Employes Supply Corpn., Sheffield Telephone Exchange & Electric Light Co., Weybridge Electric Supply Co., Williamson Electrical & Engineering Co., Woodhouse & Rawson United.

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COMPANIES' MEETINGS AND REPORTS.

ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)—At the meeting on Wednesday it was reported that the growth of revenue which had been a marked feature of the business for some years past was well maintained. The gross revenue was £34,091, the gross profits £14,772 and the net profits £10,696. The accounts had been charged with £3,600 for debenture service (£2,500 interest and £1,100 sinking fund), compared with £2,281 in 1905. Including £5,458 brought forward, the total amount available for disposal is £16,154. The directors recommend a final dividend of 4½ per cent., making a total distribution of 7½ per cent. for the year; that £5,000 be placed to reserve (increasing this to £10,000), and that £3,655 be carried forward. The extension of the system south of the Tagus has been continued, and has been fully justified by the results. The directors have decided to further extend the system of underground cables in Lisbon and Oporto. Since the commencement of the present year there has been a continuous improvement in the business.

CITY OF WELLINGTON ELECTRIC LIGHT & POWER CO. (LTD.)—The report for 1906 states that the balance profit is £12,886 (including £2,306 brought forward), after paying debenture interest, preference dividend and expenses. Out of this balance an interim dividend at the rate of 8 per cent. for the half-year ended June 30, 1906, has been paid to the ordinary shareholders, absorbing £1,390. The directors now recommend payment of a final ordinary dividend at the rate of 22 per cent. for the half-year ended Dec. 31 (making 15 per cent. for year), and writing off £5,000 from goodwill. This will absorb £8,822, and leave £2,673 to be carried forward. In view of threatened opposition by Wellington Corporation, Mr. H. E. Salt (a director) visited Wellington at the end of last year to come to an understanding with the Corporation. The result was that the Corporation agreed to purchase the company's undertaking and to take over the management as from 31st inst.

ELECTRICAL POWER STORAGE CO. (LTD.)—The directors' report for the year ended May 31 states that the profit (including £425. 1s. 9d. brought forward) is £9,176. 4s. 9d. The directors have carried £1,000 to contingent fund and have written off £2,000 in respect of patents, goodwill, &c. They recommend a dividend of 6 per cent. on the paid-up ordinary shares which will absorb £5,389. 13s. 7d., and leave £786. 11s. 2d. to be carried forward. The buildings, plant, tools, &c., have been maintained in thorough repair and condition at a cost of £3,597. 6s., provided out of revenue. Notwithstanding the continuance of the severe competition, as well as the unprecedented rise in the price of raw materials, the company's business has increased during the year under review.

NEW GENERAL TRACTION CO. (LTD.)—The chairman (Baron E. B. d'Erlanger) stated at the meeting on Wednesday that the company had had to face a loss of £18,740. 18s. 1d. to carry through the very satisfactory arrangement they had succeeded in making between their Philadelphia undertaking and the Rapid Transit Co. of Philadelphia. Their principal interest was in the Philadelphia undertaking, and that was now leased to the Rapid Transit Co. The whole of the bonds which they held in the Philadelphia undertaking were guaranteed at the rate of 4½ per cent., and the shares were also guaranteed a dividend which, rising from 1 per cent., would reach, in the course of the next four years, 5 per cent. The Coventry tramways, in which they had a very large interest (about £770,000) were doing extremely well. The only concern which was causing any anxiety was the Norwich tramways, which, owing to the great depression, did not show any progress; on the contrary, they showed an appreciable decrease in takings. The Douglas Southern Co., which last year did exceeding well, was doing almost as well this year.

TYPEWRITING TELEGRAPH CORPN. (LTD.)—At the meeting last week the chairman (Mr. A. J. Parker) said that the new Liverpool Cotton Exchange had been fitted with a large number of Steljes recorders. The instruments had been in work for some months, and continued to give perfect satisfaction. The corporation had also sent out to Egypt, for demonstration before the Government authorities, some of the latest style of instruments (known as the teletyper), adapted to print messages in Arabic, and up to the present the results were satisfactory.

J. G. WHITE & CO. (LTD.)—At the meeting on Friday last Lord Arthur Butler said that the year's profits were nearly £5,000 in excess of those of the previous years, and the company had a large amount of satisfactory contract work in hand. During its existence the company had earned (up to Feb. 28, 1907) £142,859, or an average annual profit for 6½ years of nearly £22,000. The dividends distributed (including those now recommended) amounted for the preference shares to 45 per cent. of the subscribed capital, and for the ordinary shares to 39 per cent., no dividend having been paid on the ordinary shares for the first year of the company's trading. The average annual distribution on both classes of shares has been slightly over 7 per cent. per annum. During the same period the company had set aside (out of profits) to reserve £60,000, and would, if the present report be adopted, be in the happy position of carrying forward to next year £18,311. 12s. 5d., or more than sufficient to cover a full year's dividend on both classes of shares.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

HENDON ELECTRIC SUPPLY CO. (LTD.) (93,911).—Registered on June 27, capital £50,000 in £5 shares, to adopt an agreement with the Electric Supply Corpn. and Crompton & Co. and to carry on the business of an electric light and power company, &c. First directors: C. F. Tufnell, K. A. S. Monorieff and Col. H. Wood, C.B.

MISSENDEN & DISTRICT ELECTRIC LIGHT & POWER CO. (LTD.) (93,941.)—Reg. June 29, capital £1,000 in £1 shares, to supply electricity in the parishes of Great Missenden, Little Missenden and Lee (Bucks), and to carry on the business of electricians, engineers, producers and workers of and dealers in electricity, &c. First directors, G. Carrington, S. F. Beck and W. Clay. Reg. office, High-street, Amersham, Bucks.

MORRIS-HAWKINS (LTD.) (93,821.)—Reg. June 21, capital £20,000 in £1 shares (5,000 preference), to carry on the business of electricians, electrical and mechanical engineers, ironmongers, makers of electric tramcars, motor cars, dynamos, telephones, bells, electroliers, arc and other lamps, electric light fittings, heating and cooking apparatus, &c. First directors, T. Hawkins, W. M. Rolph and H. R. Beddoes. Reg. office, 9½, Union-court, Old Broad-street, London, E.C.

SWITCH ELECTRIC LAMPS (LTD.) (93,825.)—Reg. June 21, capital £15,000 in £1 shares, to take over, on the terms of an assignment made by Atkinson's Patents (Ltd.), certain patents and rights relating to a variable candle-power incandescent lamp, and to carry on the business of manufacturers of electric lamps and patent novelties, &c. Reg. office, 14, Devonshire-square, London, E.C.

MORTGAGES AND CHARGES.

BURGESS HILL & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—A debenture dated June 17, 1907, to secure £1,200, charged on company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, Mrs. E. L. Burrows.

OLIVER ARC LAMP (LTD.)—Particulars of £15,000 debentures, created by resolution of May 30, 1907, have been filed. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

D. SANTONI & CO. (1906) (LTD.)—Issue on June 22 of £440 debentures, part of series created May 31, 1907, to secure £2,750 charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £1,650.

SUPPLIES LIMITED.—Issue on June 17 of £200 5 per cent. debentures, part of series created April 17, 1907, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £800.

CITY NOTES.

MEMORANDA (July 4).—Bank rate 4 per cent. (since April 25, 1907). Price of silver 31 1/16d.—31½d. per oz. Consols 84⅛—84¼ for money, 84 5/16—84 7/16 for account; 2½ per cent. annuities 82½—83. Consols Pay Day, Aug. 1; Stocks and Shares Continuation Days, July 10 and 29; Ticket Days, July 11 and 30; Pay Days, July 12 and 31; Mining Share Carry-over Day, July 9.

BRITISH INSULATED & HELSBY CABLES (LTD.)—Warrants for interest to June 30, 1907, on the 4½ per cent. first mortgage debenture stock have been posted.

BRITISH WESTINGHOUSE ELECTRIC & MFG. CO. (LTD.)—On Tuesday Mr. Justice Neville made an order sanctioning the reduction of the capital from £3,250,000 to £1,875,000.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The directors have declared the following dividends on account of the distribution for the year ending Dec. 31, 1907: On the 6 per cent. preference shares, 6s. per share (being at the full rate of 6 per cent. per annum), and on the ordinary shares 5s. per share (at rate of 5 per cent.), both being for the half-year ended June 30. The above dividends will be subject to deduction of tax and are payable on and after the 17th inst.

CRYSELCO (LTD.)—We are informed that the annual meeting of shareholders of this company was held at the Kempston Works (Bedford) on 24th ult., when, after placing the usual amount to the reserve, a dividend of 10 per cent. was declared, and £3,216 19s. 9d. carried forward.

EDWARDS AIR PUMP SYND. (LTD.)—An interim dividend at the rate of 10 per cent. has been declared for first half of 1907.

LANCASHIRE DYNAMO & MOTOR CO. (LTD.)—This Company invites subscriptions to an issue of £50,000 5 per cent. first mortgage debentures.

MARCONI'S WIRELESS TELEGRAPH CO. (LTD.)—The following notice has been issued to the shareholders: "The Select Committee of the House of Commons appointed to consider the Radiotelegraphic Convention, signed at Berlin on Nov. 3, 1906, and to report what, from the point of view of national and public interests, would in their opinion be the effect of the adhesion or non-adhesion of this country to the Convention, have not yet presented their report. Your company's interests and policy are materially affected by this matter, and while it relies upon its contracts with the Government Departments, it is thought undesirable to make a full statement to the shareholders with regard to a question which is still under consideration by the Select Committee. The directors, therefore, in consultation with some of the largest shareholders, have decided to postpone the general meeting and issue of the report and balance-sheet until the intentions of His Majesty's Government with regard to this matter are known."

NATIONAL TELEPHONE CO. (LTD.)—The directors have resolved (subject to final audit) to recommend at the forthcoming general meeting the following dividends for the half-year ended June 30, after payment of the dividends on the preference shares, at the rate of 6 per cent. per annum on the preferred and deferred stock, less tax in all cases, carrying £130,000 to reserve and about £10,000 forward.

SIMPLEX CONDUITS (LTD.)—The directors have declared the usual dividend of 6 per cent. per annum on the preference shares for the six months ended June 30, and an interim dividend at the rate of 7½ per cent. for the same period on the ordinary shares.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	June 26	1,421	+ 12	14	5,359	- 257
Airdrie	,, 21	216	- 8	24	5,394	- 7
Anglo-Argentine	July 1	16,003	+ 3,422	26	428,235	+ 42,629
Ashton-under-Lyne Corp	June 29	388	+ 41	14	5,439	+ 568
Ayr Corporation	,, 29	318	- 9	7	1,942	- 140
Baker St. & Waterloo Ry.	,, 29	2,705	+ 1,286	16	38,505	+ 15,392
Barnsley	,, 21	213	+ 52	24	3,965	- 12
Barrow	,, 21	254	- 8	24	5,646	- 91
Bath Electric Trams, Ltd.	,, 26	838	- 20	26	19,201	- 56
Birkenhead Corporation	,, 30	1,071	- 34	...	...	...
Birmingham Corporation	,, 29	6,117	...	13	77,238	...
Birmingham & Mid.	,, 14	828	...	23	18,160	...
Blackburn Corporation	,, 26	1,060	- 42	‡13	14,777	+ 624
Blackpool Corporation	,, 27	1,090	- 127	12	11,118	- 1,709
Blackpool and Fleetwood	,, 29	716	- 157	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 30	2,345	+ 75	13	29,233	+ 871
Bournemouth Corporation	,, 26	1,571	- 58	¶12	20,583	- 121
Bradford Corporation	,, 29	4,605	- 89	13	60,056	- 319
Brighton Corporation	,, 30	882	- 138	13	11,453	- 1,155
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 28	5,029	- 277	20	98,143	- 4,278
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 29	1,217	+ 28	13	14,553	- 29
Burton Corporation	,, 30	288	- 28	12	3,704	- 262
Bury Corporation	,, 23	1,153	...	12	12,877	...
Calcutta Tramways Co.	,, 29	R39,264	- R2,807	25	₹1,266,031	+ R22,251
Camborne-Redruth	...	...	...	...	...	...
Cardiff Corporation	,, 29	2,140	+ 5	13	26,912	- 49
Cavehill	,, 21	104	+ 8	24	1,815	- 33
Central London Railway	,, 29	5,621	- 513	26	156,224	- 16,739
Charing C., Euston & H'stead	,, 29	2,715	...	1	2,715	...
Chatham & Dist. Lt. Rys.	,, 29	753	+ 110	¶25	17,433	+ 1,103
City & South London Rly.	,, 30	3,650	+ 1,024	26	78,100	+ 5,466
City of Birmingham	,, 21	2,898	...	24	66,911	...
Colchester Corporation	,, 26	221	- 20	...	...	...
Cork Electric Trams Co.	,, 27	503	- 55	26	11,291	- 406
Croydon Corporation	,, 28	1,450	- 116	‡13	18,320	- 1,346
Devonport & Dist. Trams	,, 21	469	+ 27	24	10,747	+ 68
Dover Corporation	,, 29	230	- 52	13	2,860	- 366
Dublin & Lucan Railway	,, 28	124	- 2	26	2,747	- 8
Dublin United	,, 28	6,519	+ 725	‡26	133 671	+ 9,055
Dudley Stourbridge	,, 21	817	- 16	24	19,990	- 343
Dundee Corporation	...	...	...	...	...	...
East Ham Council	,, 29	902	- 55	13	11,825	- 406
Exeter Corporation	,, 28	320	+ 15	13	4,050	+ 323
Falkirk and District	,, 26	273	...	...	...	...
Gateshead & Dist. Trams	,, 21	996	+ 77	24	23,903	+ 843
Glasgow Corporation	,, 29	18,284	+ 1,321	4	74,909	- 2,918
Glossop	,, 29	129	- 6	26	3,496	+ 54
Gravesend—Northfleet	,, 21	253	- 11	24	5,570	+ 48
Great Northern & City Rly.	,, 29	1,787	+ 87	26	47,134	+ 413
Gt. Northern, Piccadilly, &c	,, 29	4,430	...	26	102,669	...
Greenock & Port Glasgow	,, 21	681	- 128	24	15,518	- 149
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 21	317	+ 18	24	6 420	- 354
Hastings Elec. Trams Co.	,, 27	987	+ 228	26	22,595	...
Hong Kong	,, 29	$7,727	+ $863	13	$199,887	...
Huddersfield	...	...	...	...	...	...
Hull Corporation	,, 29	2,486	+ 176	13	30 860	+ 1,735
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 26	142	- 8	13	1,835	+ 147
Ipswich Corporation	,, 29	423	- 37	13	5,078	- 465
Isle of Thanet Co.	,, 29	796	- 61	39	13,789	+ 19
Jarrow	,, 21	128	...	24	2,816	...
Keighley Corporation	,, 27	168	+ 1	52	7,913	+ 554
Kidderminster & District	,, 21	119	+ 10	24	2,528	- 114
Kilmarnock Corporation	,, 29	158	+ 3	6	1,052	+ 18
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 27	1,275	+ 363	26	28,422	+ 6,182
Lancashire United	,, 26	1,295	+ 347	26	30,724	+ 8,421
Leamington	,, 21	163	- 45	24	3,579	- 287
Leeds Corporation	,, 29	6,555	+ 270	13	84,210	+ 3,403
Leicester Corporation	,, 29	2,360	- 106	26	57,274	- 137
Leith Corporation	,, 29	541	- 1	‡7	3,437	- 77
Lincoln Corporation	,, 22	113	...	...	...	...
Liverpool Overhead Rly.	,, 30	1,529	+ 1	26	37,168	+ 479
Liverpool Corporation	,, 20	11,187	+ 152	25	264,914	+ 3,579
*London County Council	,, 22	32,972	+ 5,590	12	369,801	+ 53,556
London United	,, 28	7,111	- 70	‡26	184,161	+ 2,643
Lowestoft	,, 29	253	+ 76	39	6,216	+ 885
Maidstone Corporation	,, 29	108	- 19	13	1,369	- 89
Manchester Corporation	,, 29	15,107	+ 1,369	13	189,170	+ 15,580
Mersey Railway	,, 29	2,085	+ 349	26	48,254	+ 2,923
Merthyr	,, 21	207	+ 23	24	4,979	+ 255
Metropolitan Dist. Railway	,, 30	8,181	+ 203	26	205,556	- 3,863
Metropolitan Elec. Trams	,, 21	5,107	+ 1,228	24	103 479	+ 23,408
Middleton	,, 21	332	- 25	24	8,212	- 84
Nelson Corporation	,, 29	144	- 1	14	2,021	+ 45
Newcastle-on-Tyne Corp.	,, 29	6,711	+ 277	13	85,149	+ 1,437
Newport (Mon.)	,, 29	639	+ 11	13	9,617	+ 1,392
Northampton Corporation	,, 28	412	- 22	‡13	5,540	- 203
Oldham, Ashton & Hyde	,, 21	568	+ 20	24	14,352	+ 732
Oldham Corporation	,, 30	1,880	+ 50	14	26,792	+ 1,758
Perth (N.B.) Corporation	,, 26	174	+ 18	6	971	+ 5
Perth (W.A.) Elec. Trams	,, 28	1,327	- 74	26	37,587	- 1,175
Peterborough	,, 21	119	- 14	24	2,772	- 56
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 29	2,232	+ 81	13	24,918	- 785
Potteries	,, 21	1,844	+ 133	24	45,014	+ 1,091
Preston Corporation	,, 26	768	- 2	13	9,770	+ 118
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 27	577	+ 91	‡13	7,161	+ 1,104
Rothesay	,, 21	288	- 103	24	2,737	- 318
Salford Corporation	July 1	4,726	+ 78	13	61,495	+ 1,121
Sheerness	June 19	64	+ 3	24	1,273	- 37
Sheffield Corporation	,, 30	5,424	+ 116	14	77,021	+ 3,269
Singapore Trams	,, 29	$9,018	+ $1,562	13	$126,040	+ $3,383

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	June 26	1,021	- 13	...	...	...
Southend Corporation	,, 26	407	- 30	13	4,427	- 254
South Metropolitan	,, 21	823	+ 406	24	17,756	+ 997
Southport Tramways	,, 21	308	- 40	24	6,411	- 486
South Staffs	,, 21	879	+ 98	24	21,448	+ 1,600
Stalyb'dge, Hyde, &c., Jt. Bd	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 30	1,826	+ 239	13	18,378	+ 63
Sunderland and District	,, 26	489	+ 53	26	11,040	+ 1,393
Swansea Trams	,, 21	865	+ 36	24	20,058	+ 500
Swindon Corporation	,, 26	120	- 3	...	...	...
Taunton	,, 21	41	- 5	24	987	- 77
Tynemouth and District	,, 21	273	+ 3	24	4,540	- 656
Tyneside Trams Co.	,, 26	1,385	+ 1	26	11,620	+ 612
Victoria, Elec. Supply Co. of	May 26	775	+ 126	9	8,373	+ 917
Wallasey District Council	June 29	886	+ 22	13	10,690	+ 208
Walsall Corporation	,, 29	520	...	26	12,573	- 522
Warrington Corporation	,, 27	441	+ 46	13	4,799	+ 171
West Ham Corporation	,, 27	2,450	+ 23	13	30,848	+ 1,000
Weston-super-Mare	,, 19	147	- 44	24	1,728	- 174
Wolverhampton Co.	,, 21	444	+ 52	24	10,629	+ 398
Wolverhampton Corpn.	,, 26	824	+ 9	23	10,190	...
*Worcester	,, 21	287	- 10	24	6,269	- 156
Wrexham	,, 21	105	+ 8	24	2,379	- 28
Yorkshire W.R. Trams	,, 30	1,103	+ 301	26	28,851	...
Yorkshire Woollen District	,, 21	990	- 79	24	22,824	+ 129

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Divi-dend	Name.	Price Wed., July 3.	Rate % Yield-ed.	Divi-dend Due.	Business Week to July 3. Highest.	Business Week to July 3. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8 —8½	4 14 0	Ap, Oct	8⅛	8⅛
5	2/9	† Do. 5½ per Cent. Cum Pref.	5¼—5	4 11 9	Ja, Jul	5 5/16	5 5/16
St.	6%	† Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5%	†Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	2 13/16—3 3/16	3 2 6	May ..	3 1/16	3
5	2/6	Do. 5 per Cent. Cum. Pref.	4¼—5	5 0 0	My, Nv	4 3/8	..
St.	4½%	† Do. 4½ per Cent. Db. Prov. Certs.	98 —100	4 10 0	Ja, Jul	9 7/8	..
St.	7%	British Columbia El. Ry. Df. Ord.	123 —125	5 4 0	Mr, Spt	124½	..
St.	5%	Do. Pref. Ord. Stock	105 —109	4 11 9	My, Nv	10	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	103 —107	4 13 6	Ja, Jul	105⅜	105½
St.	4½%	Do. 4½ per Cent. 1st Mort. Debs	99 —101⅜	4 8 0	Ap, Oct	101⅜	..
100	4½%	Do. Vancouver Power Debs.	103 —1 5	4 5 6	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4 1/16—4 5/16	8 9 6	Ap, Oct	4 3/16	4 1/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4 13/16—5 1/16	5 11 6	Ap, Oct	..	..
5	3/0	Do. "B"	4¾—5¼	5 14 0	April ..	..	..
St.	5%	† Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	110½	110
St.	5%	† Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	103½	..
St.	5%	†Buenos Ayres Elec. Trams. (1901) Ltd.	93 —98	5 2 0	Ja, Jul	98¼	..
100	5½%	†Buenos Ayres Grand National 5½ per Cent. Pref. Debs	98 —101	5 8 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7¼—7⅝	5 3 0	Mr, Spt	7 3/8	7⅜
100	2.6	† Do. 5 per Cent. Cum. Pref.	5 1/16—5⅜	4 9 0	Ja, Jul	..	..
1	4½%	† Do. 4½% 1st Deb. Stock (red.)	101 —105	4 5 6	Ja, Jul	102½	102
St.	..	Cape Electric Tram Shares	5/16—7/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db	96 —100	5 0 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	85 —90⅞	5 11 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	83 —93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 — 82	7 6 0	Ja, Jul	..	..
5	1/0	†Lisbon Elec. Trams. Ord.	1 1/8—1 1/16	3 15 0	July	..	..
100	0,7½	† Do. 6 per Cent. Cum. Pref.	1 1/8—1 1/16	4 10 0	Ja, Jul	..	..
St.	5%	† Do. 5 per Cent. Reg. Mort. Deb	95 — 98	5 2 0	Ja, Jul	..	..
St.	5%	†Madras Elec. Trams. 5% Deb. Stk.	96 —99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	103½	..
St	5%	†Perth E. Trams. 1st Mt. Db. Stock	100 — 104	4 13 0	Ja, Jul	..	..
.	$2	†Sao Paulo Tramway, Light & Power Co. $100 Stock	118 - 122	3 5 6	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92⅝—94⅞	5 6 6	Ju, Dec	93½	93
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4¾—5¼	5 14 0	Mr, Spt	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅛—8⅜	5 15 0	..	..	..
St.	4½%	† Do. 4½ per Cent. Deb. Stk. (red.)	£5 — 97	4 12 9	Ja, Jul	..	..
£	5,3	Calcutta Elec. Supply Ord.	7¼ 8¼	5 3 0	Ap, Oct	..	..
5	2/3	Do. £4 paid	6 — 7	..	..	..	..
50	5%	†City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	41 — 43	5 2 0	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2⅜	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	89½—90½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ 96½	5 3 6	Ja, Jul	..	..
St.	6%	†Indian Elec Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —106	5 13 0	Ja, Jul	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	3⅜ 3⅝	..	Ap, Oct	..	..
St.	6%	Madras E. S. Corp. 5 per Cent. Consln. Deb. St.	94 —97	5 3 0	Ap, Oct	..	..
1	1/6	Raud Electric	¾ - 1	..	..	..	..
1	0/6	River Plate Electricity Co. Ord.	2 - 2¼	..	April .	2⅜	..
1	1 2/5	Do. 6 per Cent. non-Cum. Pref.	—	6 0 0	May	5 5/16	5
St.	5%	† Do. 5 per Cent. Deb. Stock	93 —98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5¼	5 9 6	Ap, Oct	..	..
..	5%	†Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101⅞	4 19 0	Ja, Jul	99¼	..

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Divid end.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., July 3.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 3. High- est.	Low- est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 - 11	5 6 0	Mar, Sept,	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝-10⅛	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ..	1 ¼ - 10⅜	5 11 6	Feb, Aug	10½	..
St.	4¼ %	† Do. 4½ per Cent. Deb. Stock (red.) ..	99 - 100	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜- 5⅛	5 5 0	April, Oct	..	..
St.	4½ %	Do. Do. 1st Debs.	98 —100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞ - 8⅜	5 14 6	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅛ — ⅛	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co 4 Guar. Db. Stock	99 - 1 2	3 18 0	June, Dec	110⅛	100
5	2/6	Charing Cross (W. End & City) El. Sup. Co	3 - 2⅜	7 3 0	Feb, Aug	2⅜	3¼
5	2/3	Do 4½ per Cent. Pref.	4 — 4⅜	5 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 2 6	Jan, July	..	..
5	2/3	† Do. City Undertaking 4½ % Cm. Pref.	3⅝ - 4⅛	5 9 6	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3¼ - 4¼	5 6 0	March ..	..	..
St.	4¼ %	† Do. 4½ per Cent. Deb. Stock (red.) ...	104 — 104	4 6 6	June, Dec	105¾	..
10	7/0	City of London Electric Lighting Ord..	9⅛ 9⅜	6 3 0	Feb, Aug	9⅜	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼ - 12¼	4 18 0	Jan, July	..	..
St.	5%	* † Do. 5 per Cent. Deb. Stock (red.).....	120 —125	4 1 3	June, Dec	..	..
St.	4¼ %	† Do. 4½ per Cent. 2nd Deb. Stock (red.)	95 - 98	4 12 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	⅞—4⅛	5 0 0	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4⅞	5 4 11	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7¼ - 8⅜	5 17 6	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10⅜—11½	5 4 0	Mar, Sept	11	..
St.	4¼ %	† Do. 4½ Deb. Stock (all paid) (red.)...	1 4 —107	4 4 0	Jan, July	1 6¾	1 6¼
St.	4¼ %	Do. Second Deb. Stock Prov. Certs....	93 - 96	4 13 9	May, Nov	93⅜	..
5	3/6	Folkestone Electricity Supply Co. Ord	4⅜—5⅜	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅜	4 11 0	Mar, Sept	..	..
St.	4⅛ %	Do. 4⅛ 1st Deb. Stock (red).....	93 - 101	4 9 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ 7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ - 9⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜ - 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	97 - 100	4 0 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4 % Deb. Stock (red.)	101 103	3 17 9	April, Oct	..	..
3	2/4⅜	London Electric Supply Ord.	1⅞ - 2⅛	5 13 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅜—5⅛	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	98 - 100	4 3 8	Jan, July	..	..
5	4/0	Metropolitan Electric Sup. Ord.	5⅜ - 6⅛	6 8 0	April, Oct	..	..
5	2/3	† Do. 4½ per Cent. Cum. Pref.	4⅞ - 5⅛	4 8 0	Jan, July	..	..
St.	4½ %	† Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 —107	4 4 0	June, Dec	..	..
St.	3½ %	† Do. 3½ per Cent. Mrt. Deb. Stock (red.)	88 - 91	3 17 0	Jan, July	..	..
100	4½ %	Midland Elec. Corp. for P.D. 1st Mort. Db.	93 - 96⅞	4 13 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9¼—9⅝	4 16 2	Feb, Aug	..	..
100	4½ %	Do. 4½ per Cent. Deb.	101 - 103	4 8 3	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7 - 7⅛	5 13 3	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	⅛ - 1⅜	4 10 1	Feb, Aug	..	..
100	4%	Do. 4 per Cent, Mort. Deb. red. 1907.	99 - 100	4 0 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½ %	Do. 4½ per Cent. Deb.	99 —101	4 10 0	Jan, July	..	..
10	9/0	Notting Hill Electric Ord.....	12 - 13	5 15 0	March ..	..	..
5	4/6	Oxford Electric Ord.	6 - 6⅜	5 8 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 - 98	4 1 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8 - 8⅜	5 17 6	Feb, Aug	8⅜	8⅜
5	3/6	Do. 7 per Cent. Pref.	6⅜-7⅜	4 13 6	Feb, Aug	..	..
St.	3½ %	† Do. 3½ per Cent. Deb. Stock (red.) ...	86 -11	3 17 0	Jan, July	18⅜	..
5	..	Smithfield Markets Electric Sup. Ord...	1⅛-2⅛	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 — 77	5 4 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	1⅞ 2⅛	7 7 0	April ...	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝-¾	3 6 9	..	..	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.....	1⅛-1⅜	4 15 0	Feb, Aug	..	..
St.	4½ %	Do. 4½ 1st Db. Stk. Red.....	10? —103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1¼—2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent, Cum. Pref.	2 - 3	8 6 9	April, Oct	2⅛	2⅛
St.	4½ %	Do. 4½ per Cent. 1st Mort. Deb.....	94 - 97	4 12 9	April, Oct	9⅛	..
5	6/6	Westminster Elec. Sup. Ord.	9¼ 1⅜	6 3 0	Mar, Sept	..	..
5	2/3	† Do. 4½ per Cent. Cum. Pref.	1⅛ 1⅜	4 0 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4 % Perp. Db. St.	90 - 95	4 4 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜-⅝	5 14 0	April	..	..
1	0/6	† Do. 5 per Cent. Cum. Pref.....	⅜-⅝	5 3 0	Jan, July	..	..
St.	4½ %	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 - 99	4 11 0	April, Oct	..	..
St.	4½ %	B'ham & Midland Trams 4½ 1st Db Stk.	94 - 97	4 13 0	Jan, July	..	..
10	9½	Bristol Tramways & Carriage Ord.	14½ - 14⅞	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8⅜—9	4 8 11	..	..	..
St.	4%	† Do. 4 per Cent. Debs.	95 - 100	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅜—3⅛	..	June, Dec	3⅛	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6¾ - 7⅛	8 5 8	Feb, Aug	7⅛	6⅞
St.	5%	Do. 5 per Cent, Perpetual Debs.	103 - 106	4 14 3	April, Oct	104	103½
St.	4½ %	Do. 4½ per Cent. 2nd Deb. Stock	78 —81	5 11 0	May, Nov	79⅜	..
St.	4%	Central London Ordinary Stock..	72 - 75	5 6 9	Feb, Aug	75	72
St.	4%	Do. 4 per Cent. Pref. Stock	92 - 94	4 5 0	Feb, Aug	94	..
St.	4%	Do. Deferred Stock	53 - 56	7 2 8	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	103 - 106	3 15 6	Jan, July	105½	105
St.	4 %	Charing X. Euston & Hmpstd Per. Db Stk.	80 —13	4 16 6	Jan, July	11½	10
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ - 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 —101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ..	46 —48	4 3 3	Feb, Aug	47½	45
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ..	117 - 121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 - 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 - 118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent, Perpetual Debs.	1 2 - 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½ - 14½	4 2 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	13 - 14	4 5 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2 - 2⅛	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 —7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	82 - 85	4 14 6	Jan, July	84	85½
St.	4½ %	Hastings & Dist. Elec. Trams. Co. 4½ 1 b. St	98 —101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	12 - 13	6 18 6	Mar, Sept	..	..
10	6%	‡ † Do. 6 per Cent. Pref.....	0⅛ -11	5 9 1	Mar, Sept	..	..
St.	4½ %	‡ † Do. 4½ per Cent. Debs.	97 - 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 — 1¼	..	Mar, Sept	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock.....	66 - 71	5 12 6	Jan, July	..	..
St.	5%	† Lancs. Utd. Trams 5 % Prior Lien Db. St.	93 —96	5 4 0	Jan, July	94½	..
10	..	Liverpool Overhead Railway Ord.	1⅜—1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 - 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	88 —90	4 9 0	Jan, July	..	..
10	5 0	† London United Trams. 5% Cum. Pref. ...	7⅜-8⅜	5 14 3	Jan, July	8	7½
St.	4%	† Do. 4 per Cent. 1st Mort. Deb. Stock	85 - 89	4 11 0	Jan, July	85	..
St.	..	Mersey Con. Ord. Stock	2 —4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 — 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅜— ⅝	..	April....	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜— ⅝	5 3 0	Feb, Aug	..	..
St.	4½ %	† Do. 4½ per Cent. Deb. Stock	94 - 97	4 13 0	Jan, July	94	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜—1⅜	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	5⅜ - 6¼	6 8 0	April, Oct	3⅜	..
10	5%	Do. 5 per Cent. Cum. Pref.	6 —7⅛	6 13 3	Feb, Aug	6⅛	5
St.	4½ %	Do. 4½ per Cent. Deb. Stock	95 - 98	4 11 9	May, Nov	..	..
1	3/5½d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—1⅛	5 16 6	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock	80 — 84	4 15 3	Jan, July	..	..
100	5%	† Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	4 —?8	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London...	11 - 14	7 16 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 —1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅜—3⅝	..	..	..	..
St.	4½ %	† Do. 4½ per Cent. 1st Debs.	88 — 91	4 19 0	Jan, July	..	..

SHARE.	LAST DIVIDEND	NAME.	Price Wed., July 3.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 3. High- est.	Low- est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	3⅝—3⅞	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅞ ⅞	8 0 0	April, Oct	..	..
1	2/4⅜	Babcock & Wilcox Ord.....	3⅜— 3¾	5 3 0	April, Oct	3⅝	3⅜
1	0/7½	Do. Pref.....	1⅜—1⅝	4 0 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¼— ⅜	7 8 0	July, Feb	6⅜	..
5	3/0	Do. 6 per Cent. Pref.	5¼- 6½	4 16 0	Jan, July	..	..
St.	4½	† Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	..	..
St.	4½	British Thoms'n-Houst'n 4½ % 1st Mt. Db.	92 - 96	4 14 3	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref..	1 — 1½	..	Feb, Aug	1⅝	1⅜
St.	4¼	† Do. 4 per Cent. Mort. Deb. Stock	85 — 90	6 6 6	Jan, July	58½	..
2	..	Brush Electrical Engineering	¼ - ⅜	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	¾ - 1¼	4 16 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	84 — 91	4 19 0	Mar, Sept	..	..
St.	4½ %	† Do. Perpetual 2nd Deb. Stock	71 —74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Cum. Ord.	9⅜ 10⅛	7 2 6	Jan, July	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	5⅜ 5⅝	4 9 0	Jan, July	..	..
St.	4½ %	Do. 4½ per Cent. 1st Mort Debs. (red.)	104—107⅛	4 3 6	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅛—1⅛	5 12 6	May, Nov	1⅜	..
St.	4½ %	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 —102	4 8 0	Feb, Aug	..	..
1	1/2⅝	Chadburn's (Ship) Telegraph Ord.	1⅛ - 1⅜	‹ 0 0	March ..	..	..
1	0/7⅝	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	5 4 0	April, Oct	..	..
3	1/6	* Crompton & Co. (Nos. 1 to 54,000).....	1⅛ - 2⅛	3 12 9	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96% - 99%	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅛—1⅛	6 8 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 - 1¼	4 16 0	Sept	..	..
St.	4½ %	† Do. 4½ per Cent. Deb. Stock	100 - 103	4 7 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 1 d.)	1⅛ - 1⅜	9 8 0	Feb, Aug	1⅛	..
5	4/2	Do. (£5 paid)	2¼—2⅜	4 11 6	Feb, Aug	2⅜	..
St	4 %	† Do. 4 per Cent. Mort. Deb. Stock (id.)	83 —85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 —92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅛ - 1	10 0 0	Jan, July	⅜	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1½ 2⅛	..	May, Nov	2	1¾
St.	4½ %	Do. 4½ per cent. 1st Mort. Deb. (red.)	78 - 83	5 8 0	Jan, July	..	..
2	..	Electric Construction Co.....	⅜ ⅝	..	Jan, July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅛ - 1⅜	8 0 0	July	..	..
St.	..	Do. 4 per Cent. Perp. 1st Mort. Debs.	79 —83	4 18 3	..	..	..
10	5/0	† General Electric (1900) 5% Cum. Pref..	8 - 8⅛	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 - 96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅜ 12⅜	6 0 0	Feb, Aug	11⅜	..
5	2/3	Do. 4½ per Cent. Pref.	5 - 5⅛	4 2 0	Feb, Aug	..	..
St.	4½ %	Do. 4½ per Cent. 1st Mort. Deb. Stock	105⅜—107½	4 3 6	Mar, Sept	..	..
10	5/0	† India Rubber, Gutta Percha, &c., Wrks.	15 —16	6 5 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 - 99	4 1 0	April, Oct	..	..
1	1/2⅝	Richardsons, Westgarth & Co., Ltd. Ord.	⅜ - 1⅝	7 6 0	Nov	..	..
1	0/7⅛	Do. 6 per Cent. Cum. Pref.	⅛—1	6 0 0	May, Nov	..	..
St.	4½ %	† Do. 4½ per Cent. Perp. Deb. Stock ...	95 - 98	4 11 9	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	31⅛—32½	5 10 6	Mar, July	32¼	31¼
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	99 - 102	3 13 3	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2¼- 2⅜	6 6 6	..	2⅜	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜—1⅝	4 1 0	..	1⅝	1⅜
St.	5%	Do. 5 per Cent. non-Cum. Preferred	112 —115	4 7 0	..	113⅜	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 —104	3 17 0	June, Dec	..	..
10	4⅛ %	Do. 4⅛ per Cent. 2nd Mort. Deb. (red.)	1 2⅛ - 10⅜	4 5 0	June, Dec	..	..
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9⅛—10	5 0 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1¼—1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅛—3⅜	..	Apr, Oct	..	..
100	4⅜	Do. 4 per Cent. 1st Mort. Debs.....	77 - 81	4 18 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 —3½	—	June, Dec	..	..
100	5%	† Do. 5 per Cent. Debs. (red.)	86 —89	5 12 0	June, Dec	..	..
St.	15/0	Anglo-American	61 —63	6 3 0	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	107½—108½	5 11 0	F,My,Ag,N	108½	107½
St.	13⅜	Do. Deferred	10⅝—11⅜	4 9 0	F,My,Ag,N	11⅜	10⅝
St.	4%	‡ Commercial Cable 4 per Cent. Deb. Stk.	91 —93	4 5 0	Jn,Ap,Jy,O	92⅛	92⅛
10	5/0	Cuba Submarine Ord.....	7⅜-8¼	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent	15½—16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅛- 3⅜	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8¾- 9¼	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100%-103⅝	4 7 0	Jan, July	..	..
20	4/0	Direct United States Cable	16¼—16¾	5 15 6	Ja,Ap,Jy,O	16⅞	15½
100	4½ %	† Direct West India Cable 4½ % Rg. Db. (rd.)	98 —100	4 8 0	June, Dec	..	..
St.	£5/0	Eastern Ordinary	126 —129	5 1 0	Ja,Ap,Jy,O	128⅜	127
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 —91	3 17 0	Ja,Ap,Jy,O	90⅜	89½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103⅜—105½	3 16 0	May, Nov	..	..
10	6/6	Eastern Extension	13 - 13⅛	5 6 0	Ja,Ap,Jy,O	13⅜	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock	104 —106	3 15 6	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 —101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	104 —100¾	4 0 0	May, Nov	..	..
10	£/0	G.N. (of Copenhagen), ex Coupon 70.....	34 —36	6 19 0	Jan, July	..	..
100	4½%	† Halifax & Bermuda 4½% 1st Mt. Db. (red.	98 —100	4 10 0	June, Dec	..	..
25	£2/6	Indo-European	56 - 58	5 12 0	May, Nov	..	..
100	$1	† Mackay Companies Common	68 —70	5 14 0	Jan, July	..	..
100	$1	† Do. Preference	67 —69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	15/16—1	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Debs. (red.)	101½—102½	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 —10⅛	3 16 0	June, Dec	..	..
2	1/3	West Coast of America	1⅜ - 1⅝	3 12 9	May	1⅝	1⅜
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅛ ⅜	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅜ - 7⅞	7 12 0	May, Nov	7⅞	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅜ - 7⅛	..	May, Nov	..	..
100	5%	* † Do. 5 per Cent. Debs.	100 —103	4 17 6	Jan, July	..	..
10	3/0	† Western Telegraph	13⅞—14⅜	4 19 0	Mr,Jn,O,D	14⅜	13¾
St.	4%	† Do. 4 per Cent. Deb. Stock (red.).....	102 —105	3 17 6	June, Dec	..	..
		TELEPHONES.					
..	4%	† Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 —92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 —103	4 17 0	Mar, Sept	..	..
5	3/0	Chili Telephone	6⅞—7¼	5 11 0	August ..	7⅜	..
1	0/4⅛	Monte Video Telephone Ord.	⅞- 1⅛	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾—1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	108 —110	5 9 0	Feb, Aug	110⅜	108⅞
St.	4½%	Do. Def. Stock.....	100⅛—107½	5 2 0	Feb, Aug	107⅛	106⅜
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11½—13½	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛— 5⅝	4 10 6	Feb, Aug	5⅜	5⅛
St.	3½%	* † Do. Deb. Stock 3½ per Cent. (red.) ...	94 —96	3 13 0	June, Dec	95	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.)	99 - 102	3 18 6	Jan, July	100⅜	..
1	0/9⅜	Oriental	1⅛—1⅞	4 18 0	April, Oct	1⅜	1⅛
1	0/7⅛	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 10 0	April, Oct	1⅜	..
St.	4%	† Do. 4 per Cent. Red. Deb. Stock	95 —98	4 3 8	Jan, July	..	..
St.	4½%	† Telephone Co. of Egypt 4½ Db. Stk. (red.)	98 —101	4 9 0	Jan, July	..	..
1	0/9	United River Plate	⅞—1⅛	5 9 6	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 — 5⅜	4 11 0	June, Dec	5⅛	..
St.	5%	* Do. 5 per Cent. Deb. Stock (red.)	—	4 9 9	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	† Elec. & Gen. Investment 6% Cum. Pref.	5⅞—6⅜	6 6 3	Jan, July	..	..
10	6 2	† Globe Telegraph & Trust.....	10⅛—10¾	5 8 6	Ja,Ap,Jy,O	10⅞	10⅝
10	4/0	† Do. 6 per Cent. Pref.....	13⅝—13¾	4 6 6	Ja,Ap,Jy,O	13⅞	13⅝
10	6%	Submarine Cables Trust (Cert.).....	127 —130	4 12 0	April, Oct	129	..

In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

The Radio-Telegraphic Convention.

THE report of the Select Committee appointed to consider whether Great Britain should ratify the Radio-Telegraphic Convention has now been published, and is a somewhat lengthy document. In our last issue we gave the chief points of the report, and next week we may give a more lengthy abstract. Perhaps the most interesting part of the report is that dealing with the position of the Marconi Company. It is evident that the company had in mind the probability of compulsory intercommunication so far back as 1904, for in their agreement with the Post master-General in that year the Company undertook, if required by the Government, to accept the obligation to interchange messages with ships and shore stations in the United Kingdom equipped with other apparatus; but in giving this undertaking the Company introduced the words "without prejudice to the patent rights." The Marconi Company contend that an obligation of compulsory intercommunication between different systems under an international convention must result in an infringement of their patent rights, and they protected themselves accordingly.

The Committee are of opinion that the Marconi Company will benefit by the ratification, because a number of steamship lines will probably make use of Marconi apparatus under the new conditions, whereas at present they will not do so on account of the difficulty of messages being refused by one company or another. On the other hand, if the Convention were not ratified, and if the Marconi Company adhered to their policy of refusing to accept messages sent by apparatus other than their own, then the Governments ratifying the Convention would certainly have all Marconi apparatus removed from ships and stations under their jurisdiction. Although the Committee consider that the Marconi Company have exaggerated the case against ratification, they are reluctant to make any recommendation which would be injurious to the fair working of the Company's business, and they go so far as to recommend that if the business of the Company suffers, compensation should be paid from the date of the Convention coming into operation for a period of three years according to any falling off of business, so that the Company may adapt itself during this transition period to the new condition of things. Apart altogether from the position of the Marconi Company there were many points to consider. One of these was the importance of securing facilities for Lloyd's, ensuring the prompt transmission of reports of any maritime casualties. If the Convention were not ratified there might be retaliation of a kind to seriously affect this almost national British institution.

With regard to the simple question of ratification, the Committee had three courses to consider, namely, ratification, rejection and postponement. The Committee are of opinion that rejection would throw doubts upon the sincerity of Great Britain, considering that she took a prominent part in the Conference and that the Convention was modified in many important respects in order to meet her wishes. Further, it would create a direct and powerful motive for the erection of stations on foreign territory. Foreign ships and coast stations would seriously interfere with British stations, the development of our service would be much embarrassed, and the use of Marconi apparatus would be more restricted. With regard to postponement, no evidence was given in its

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favour, and such a policy would in no way diminish any of the unfortunate results following rejection. Moreover, if the Convention were brought into operation without reference to Great Britain, this country would have no influence in interpreting and enforcing the terms of the Convention. Further, Great Britain can withdraw, by giving 12 months' notice, if desirable. As to the third alternative—namely, ratification—the Committee considers that the Convention facilitates the use of wireless telegraphy, provides the means of preventing confusion, secures general freedom of communication, and will give free play to all systems, thus encouraging the general progress of invention in connection with wireless telegraphy. Among advantages which are important for our Navy and national defence, the Committee mention the facts that stations must not interfere with one another, that certain wave-lengths are reserved for naval use, that international sanction is obtained for such censorship arrangements as may be necessary, that the effect of the Convention will be to encourage the erection of stations in British territory, that the Convention has been framed with careful regard to the interests of our Colonies, and, lastly, that, although Great Britain can withdraw by giving a year's notice, no alteration can be made to her detriment without her consent.

Faults in Underground Cables.

It is not often that particulars of cable breakdowns are published, and for that reason the tabulated causes of failure given by Mr. C. E. Phelps, which will be found on another page of this issue, will be of interest to all cable users. This particular table refers to Baltimore, and records under different headings the cable failures which have occurred there during the last seven years. What is particularly striking is that, out of a total of 148 cases of faults, distributed over seven years, no less than 58 were occasioned by damage caused by picks or bars driven into the ground, whilst only three were attributed to defective cables. Altogether 55 per cent. of the total failures were attributed to mechanical damage and 20 per cent. to electrolysis. Such figures prove that very little improvement can be expected from the manufacturer's point of view, and that the methods adopted for laying and protecting the cables are of chief importance. It must, however, be noted that half of the cases of mechanical injury occurred during the years 1904 and 1905, when extensive street improvements were in progress. There is much to be said in favour of the author's suggestion that station engineers should make a point of publishing such records, and should place their experience at the disposal of each other for the general good.

Light Railways.

At the recent Engineering Conference in London a paper was read by Mr. W. Barrington on "Light Railway Policy," in which the author drew attention to the great development of light railways on the Continent, and expressed the opinion that sufficient attention was not paid to them in this country. This seems to be also the opinion of the Light Railway Commissioners, for in their annual report to the Board of Trade, an abstract of which appears elsewhere in our "Notes," they state that "Light railways are much needed in many parts of this country, and many of the lines proposed, but not constructed, are in fact necessary to admit of the progress, or even the maintenance, of existing trade interests." In fact, they consider that the prevention of depopulation in rural districts is largely bound up with the provision of better means of locomotion. The construction of many of the proposed lines seems to be prevented by financial difficulties, and in order to facilitate matters the Light Railway Commissioners suggest that the Light Railways Act of 1896 should be amended. For other reasons we advocated the amendment of this Act a few weeks ago, and it is quite evident that the measure now fails to meet the situation, however effective it may have been in the past. Now that the Light Railway Commissioners have found the Act ineffective we may hope that some Parliamentary action will be taken to render the construction of such lines more feasible, though tramways and motor omnibuses are now an important factor which cannot be neglected and will increasingly hamper the development of light railways.

Idle Currents.

The subject of "idle" currents appeals very strongly to engineers in charge of alternating-current supply systems, and this is especially the case where motor loads of low power factor are distributed over a large network. For dealing with these "idle" currents at Sheffield, Mr. Cridge described in his Paper, read before the Incorporated Municipal Electrical Association, an abstract of which appears elsewhere in this issue, the system of utilising synchronous motors which has already been adopted elsewhere in several cases with satisfactory results. It would certainly seem feasible to utilise, as synchronous motors, existing generating sets which, owing to their small size, have become practically useless for generating purposes, and this method would prove more particularly advantageous if such machines could be disposed of to large consumers, so that the cost of attention, &c., would be avoided. We have recently heard of a scheme for charging a lower rate for energy supplied to those consumers who would adopt such motors for driving their works, but owing to the extra trouble and expense involved in starting such machines, the offer would only appeal to consumers deriving their power from one large motor which could be run with but few stoppages.

Personal.—Dr. Rawson has been appointed Principal of Battersea Polytechnic, in succession to Mr. S. F. Wells, who leaves for Egypt in September.

University College School.—The King has graciously accepted the invitation of the Council to publicly open the new school buildings at Frognal, Hampstead, on Friday, July 26th.

Society of Chemical Industry.—This year's annual meeting of the society took place in Birmingham on Wednesday. It was decided to hold the next annual meeting at Newcastle-on-Tyne.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Panama—Buenaventura	Feb. 28, 1907 ..	Mar. 12, 1907
Buenaventura—Santa Elena..	Feb. 28, 1907 ..	Mar. 12, 1907
Faroe Islands—Shetlands....	July 8, 1907 ..	—
Trinidad—Demerara.....	July 9, 1907 ..	—

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Royal Assent.—The Royal Assent to the following new Acts of Parliament was declared on July 4th:—

West Riding Tramways, North-East London Railway, Folkestone, Sandgate & Hythe Tramways, West Yorkshire Tramways, Birmingham Corporation, Middlesbrough Corporation, Transporter Bridge and Metropolitan Railway (Pension Fund).

Institution of Mechanical Engineers.—The summer meeting of this Institution is to be held at Aberdeen from Tuesday, July 30th, to Friday, August 2nd. Among the Papers to be read are: "An Electrically-controlled Single-Lever Testing Machine," by Mr. C. E. Larard; and "Cableways used on Shipbuilding Berths," by Mr. J. M. Henderson.

Society of Arts.—The Society of Arts conversazione was held on Tuesday evening in the gardens of the Royal Botanic Society, Regent's Park. The rain which fell during a considerable portion of the evening reduced the attendance somewhat, but there were about 1,000 guests present. These were received by the chairman, Sir S. C. Bayley, and other members of the Council. In the grounds, which were tastefully illuminated for the occasion, a "Watteau" pastoral play, entitled "La Marquise," was performed by Mr. Patrick Kirwan's "Idyllic Players," and in a marquee was an exhibition of roses. A selection of music was performed by the string band of the Royal Marine Light Infantry (Portsmouth Division) and by the band of H.M. Coldstream Guards; whilst a concert and entertainment, under the direction of Mr. Patrick Kirwan, were given in the Club House twice during the evening.

Tramways and Light Railways Association.—The *Official Circular* for July deals chiefly with matters relating to the Association; the progress made by the Special committee on Brakes is reviewed; the final report presented to the Council by the Special committee on "Income-tax Assessment," and adopted by the Council, is given in full, together with six appendixes; also copy of a reply received from the Board of Inland Revenue intimating that Sir Henry Primrose, chairman of the Board, would consent to receive a deputation from the Association to discuss this report; further mention of the Postmaster-General's clause in regard to the use of tramway poles for the support of Government telegraph wires; a circular letter of the Association to its members, inquiring whether they would agree to be bound by arbitration on the question as to who shall bear the cost of inserting fuses and heat coils into the Postmaster-General's telegraphs, the arbitrator to be appointed by the Board of Trade, &c.; and Major Pringle's report to the Board of Trade on the accident which occurred on April 1st last on the Croydon & District Tramways.

Light Railways.—The annual reports of the Proceedings of the Board of Trade and of the Light Railway Commissioners under the Light Railways Act, 1896, for the year ended December 31, 1906, has been issued. Twenty-three fresh orders were submitted to the Board of Trade by the Commissioners for confirmation. Of these orders 11 were confirmed, in addition to 17 of the orders which were before the Board of Trade on December 31, 1905. The Commissioners point out that the Act has now been in force for 10 years, during which period 545 applications for orders have been received, 313 orders made, and 282 orders confirmed. The Commissioners in their report draw attention to certain points as follows:—

1. The large number of applications made to us in the early years, and the great falling off in recent years.

2. That although, up to the end of the year 1906, orders authorising the construction of about 1,730 miles had been confirmed by the Board of Trade, only about 550 miles had then been opened for traffic; and that the mileage of lines then open was much less in proportion to the mileage sanctioned in the case of lines constructed on their own land, than in the case of lines more of the nature of tramways.

3. That in other countries, where the mileage of main lines of railway in proportion to area and population is roughly the same as in this country, the mileage of Light Railways already constructed is considerable, while many additional lines are under construction or about to be constructed. The figures relating to France, Prussia, and Belgium are given in the Paper contributed by M. Colson, chief engineer of bridges and roads in France, to the International Railway Congress of 1905—viz., at the end of 1903, of Light Railways (a) in France 6,150 miles were in full working at an average cost of £4,500 per mile (earning £275 per mile per annum); (*b*) in Prussia, 3,730 miles at £4,180 per mile (earning £310 per mile per annum); and (*c*) in Belgium, 1,430 miles at £3,400 per mile (earning £320 per mile per annum); while in Great Britain only 186 miles had been constructed. The actual cost per mile of lines constructed in Great Britain was not given by M. Colson, and the figures are not available, but he quotes an average cost of £5,860 per mile.

The experience gained by the numerous local inquiries made by us during the past 10 years has satisfied us (a) that light railways are much needed in many parts of this country, and that many of the lines proposed, but not constructed, are in fact necessary to admit of the progress, or even the maintenance, of existing trade interests (including, in that expression, fishing, and the great industry of agriculture); and, further, (b) that improved means of access are requisite to assist in retaining the population on the land, to counteract the remoteness of rural districts, and also, in the neighbourhood of industrial centres, to cope with the difficulties as to housing and the supply of labour.

Proposals for new lines are now infrequent owing to the various difficulties in carrying them to a successful completion, and especially in regard to lines on their own land the cause of the falling off is largely due to the difficulty of raising the necessary capital, even when part of it is provided with the aid of the State and of local authorities.

We think that an improvement could be effected, enabling the construction of many much-needed lines, by an amendment of some of the provisions of the Light Railways Act, 1896; and by a reconsideration of the conditions under which financial or other assistance should be granted to such lines by the State, by local authorities, and by those more directly or indirectly benefited in each case.

Obituary.—We regret to record the death of Herr G. Winter, which occurred on June 19th. The deceased will best be remembered as the co-inventor of the Winter-Eichberg system of single-phase commutator motors. He was for a time with the Austrian firm of Kremenezky, Maier & Co., and afterwards he held a post with the Austrian Schuckert Co. He then joined the Osterreichischen Union E.-G., with whom he remained till they became amalgamated with the Allgemeine Elektricitäts Gesellschaft. Since then he has been in practice as a consulting engineer.

The death occurred at Hartfield Grove, Coleman's Hatch, Sussex, on Sunday last, after a very short illness, of Sir Spencer Walpole, K.C.B., in his 69th year. Sir Spencer entered the public service as far back as 1867, and, after occupying various positions, became Secretary to the Post Office in 1893. In that position he introduced many reforms and innovations. In 1899, at the age of 60, he retired from his direct association with the Post Office. Shortly after his retirement proposals were made for the construction and laying of an "all-Red" submarine cable in the Pacific from Canada to Australia, and the outcome of these proposals was the formation of the Pacific Cable Board, of which Sir Spencer was chairman till the time of his death. He was the author of the annual reports issued by the Board, in whose proceedings he took a very active part. His fame in literature was considerable, and he was a distinguished figure at the Athenæum Club. He was a son of Spencer Walpole, thrice Home Secretary under Lord Derby, his mother being a daughter of Spencer Perceval, the Prime Minister who was murdered in the lobby of the House of Commons. Sir Spencer's father was a prominent member of several Conservative Governments, and he may be said to have himself been born into the public service.

It is with sincere regret that we learn of the death of Mr. F. Moll, M.I.E.E., which occurred on the 3rd inst. at West Studdal, Dover, in his 62nd year. Mr. Moll, who was a graduate of Berlin University, joined the Electric & International Telegraph Co. in 1865 under the late Sir Henry Fischer. On the foundation in 1868 of the Indo-European Telegraph Co. he transferred his services to that company, taking charge of their London station, besides holding the chief accountancy to the company. Mr. Moll, in conjunction with the late Mr. W. S. Andrews, represented the Indo Company at the various International Telegraph Conferences, from that at St. Petersburg in 1875 to that at Budapest in 1896. His genial manner and upright character gained him many friends.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, July 13th.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

3 p.m. Visit to the Rotherhithe Tunnel Works, Shadwell.

SATURDAY, July 20th.

JUNIOR INSTITUTION OF ENGINEERS.

Visit to R.M.S. "Oruba" and the Tilbury Dock Pumping Plant, &c.

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ON THE LOSS OF ENERGY IN THE DIELECTRIC OF CONDENSERS AND CABLES.

BY DR. BRUNO MONASCH.

(*Concluded from page 463*).

Summary.—After dealing with the subject historically, the Author gives a method of measuring dielectric losses and discusses the sources of error to be avoided. He then considers the effect of different wave forms, frequency, change of temperature, &c., and gives measurements on various dielectrics and cables. Finally, the loss occurring in cables under working conditions is discussed, and quantitative figures are given.

III.—Quantitative Measurements.

Fig. 8 shows the arrangement used in all these tests. Throughout these, w_2 and w_3 or w_4 served for producing balance.

(*a*) *Condensers.*—In Table XI. I give the results of some of the tests made by this method on condensers.

The calculated values given in this table were found as follows: c_1 was ascertained by the equation $c_1 = c_2 \frac{w_4}{w_3}$. The angle ψ is the complement of the angle of phase difference between voltage and current. It is obtained from the data of the bridge by the equation $\tan \psi = nc_2 w_2$, the phase difference between the fundamental components of voltage and current being equal in the arms AD and AF of the bridge. The loss at 1,000 volts in watts per microfarad may be derived from equation (2′) by writing this latter in the form

$$A = n \,.\, nc_2 w_2 \,.\, c_1 E^2 = n \tan \psi \,.\, c_1 E^2, \quad . \quad . \quad (2'')$$

Putting herein $c_1 = 1$ mfd., $E = 1{,}000$ volts, the values given in the table are found. Whether this method of calculation is permissible depends upon two conditions—namely, that the loss at the same frequency is proportional to the square of the voltage and to the capacity. The first condition has already been proved to be fulfilled; the second will be shown to be so by the results of tests to be given later.

(*b*) *Cables.*—The 10 cables particularised in Table II. were tested at both the frequencies 86 and 50. The results of these measurements may be of interest, as results relating to cables with impregnated paper insulation are very scantily represented in the literature* hitherto available. Moreover, it may be remarked that, when testing pieces of cable only 5 metres in length at 1,100 to 1,500 volts, I was able by this method to obtain far more accurate results than those arrived at by the methods hitherto used at much higher voltages and on lengths of cable of 350 metres and more.

Tables XII., XIII., XIV. and XV. contain results found on the 10 cables given in Table II.

The remarks given in the column headed "connection" indicate that the conductors written at the left hand formed the high-tension coating, that is to say, they were connected to the point A of the bridge, the others and the sheathing being joined to the point D of the bridge; *e.g.*, "1, 2 and 3, Sh" means that the loss was measured between the conductors 1 and 2, forming the high-tension coating (joined to the point A), and conductor 3 and sheath, making the second coating. The capacities c_1 and c_2 are given in units of 10^{-3} mfd. The tests on cables II., VIII. and X. are given completely in the Tables XII., XIII. and XIV.; Table XV. contains an abstract of the tests made on the other seven cables—*i.e.*, the results of one measurement out of the test carried out on each of them.

First of all it may be mentioned that all these tests on cables, possessing three conductors or more, involved a means for checking the correctness of their results and thus for recognising the arrangement to be sufficiently free from the errors alluded to in the first part of this Paper. As is known, the charge Q_i of a conductor belonging to a system of conductors charged to potentials V_0, V_1, . . . V_i, . . . may be expressed by the equation

$$Q_i = c_{i0}(V_i - V_0) + c_{i1}(V_i - V_1) + \ldots$$

The quantities c_{i0}, c_{i1}..., the so-called "partial capacities" occurring herein, prove to be negatively equal to the induction-coefficients q_{i0}, q_{i1}... in Maxwell's equation

$$Q_i = q_{i0}V_0 + q_{i1}V_1 + \ldots$$

In the case of a symmetrically constructed cable with three conductors there are only two different values of partial capacities—viz., that between two conductors which may be denoted by c_{12} and that between each conductor and the sheathing, c_{10}. Now, in the tests the conductors were arranged in three different groupings. The effective capacity—*i.e.*, the ratio between the charge on each of the coatings of the condenser in question and the P.D. of the two coatings, is easily calculated to be (*a*) $c_{10} + 2c_{12}$, if one coating is represented by one conductor, the other by the two other conductors and the sheathing; (*b*) $2c_{10} + 2c_{12}$ if two conductors form one coating, and the third with the sheathing the other one; (*c*) $3c_{10}$ if all the three conductors are used as one coating and the sheathing the other one. As these effective capacities are also measured in the tests, three equations are thus obtained, each of which must comply with the values of c_{12} and c_{10} calculated from the two others. If this is found to be so, the measurements must have been correct—*i.e.*, all the errors have been made negligible.

The agreement is a perfect one. In Table XII., for instance, there results from the measurements in the groupings (*a*) and (*b*) $c_{10} = 0{\cdot}70_8$, $c_{12} = 0{\cdot}23_8$; from (*a*) and (*c*) $c_{12} = 0{\cdot}23_8$; from (*b*) and (*c*) $c_{12} = 0{\cdot}23_8$; from (*c*) $c_{10} = 0{\cdot}70_6$.

Now, as regards the loss in the cables, the tables show its quantity to be small throughout. Cable III. exhibits the smallest loss of them all by far; its loss is but very little greater than that in flint glass (*cf.* Table XI.). In contradistinction to the nine other (paper-insulated) cables, each conductor of cable III. was covered by a layer of rubber, 2–3 mm. in thickness, the remaining space within the sheathing being filled in with impregnated jute.

For comparing the loss found in the different measurements on the same cable, ψ, or here also w_2, may be considered. As already proved, the constancy of the product $c_2 w_2$ shows the proportionality of the loss to the capacity; c_2 having been kept constant in the tests given in Tables XII., XIII. and XIV., the proportionality in question can be concluded from the constancy of w_2. As the tables show, this proportionality is fulfilled in a very approximate way, as completely at least as can be expected taking into account the dissimilarity of stratification of the dielectric in the different parts of the cable-section. At least a very near proportionality of the loss to the capacity therefore can be accepted.

The last point to be considered is the connection of the loss in the cables to the frequency. Only in the case of cables VIII., IX. and X. are the results obtained at the two different frequencies strictly comparable with each other, since only these tests were made under the same circumstances and shortly after one another. It was not possible to carry out the seven other tests similarly. The values of ψ, found at both the frequencies in the tests on cables VIII., IX., X., prove to be equal to less than 2 per cent. A similar coincidence is noticeable in all the other cables except cable I. Here the product $n \tan \psi$ will be found to be nearly equal at both the frequencies. What this means is seen from equation (2″). If the product $n \tan \psi$ remains unchanged, the loss is independent of the frequency; with respect to the loss the dielectric of cable I. therefore behaves like an ohmic resistance. This, together with the comparatively high loss, makes it probable that cable I. owes its loss principally to leakage in the ordinary meaning of the word. In all the other cables, however, ψ had nearly the same value at both the frequencies, that is to say, the loss at equal capacity and voltage is proportional to the frequency.

Hence there results a rather simple relation for the loss, valid enough within the interval of frequencies used for technical purposes. Denoting by ν the number of periods per second, and by c the capacity of the cable, we may write

$$A = k \,.\, \nu \,.\, c \,.\, E^2, \text{ where } k = 2\pi \tan \psi.$$

For a given dielectric the phase-difference ψ, therefore, may be considered as a constant, $2\pi \tan \psi$ would be the loss taking place in a condenser of capacity 1 during a cycle at the voltage 1.

* P. Humann, *l.c.* Discussion on Mr. Mordey's Paper, "Capacity in Alternate-Current Working," read before the Institution of Electrical Engineers, London, *The Electrician*, Vol. XLVI., p. 512, 1901. Ch. V. Drysdale, *The Electrician*, Vol. XLVI., p. 890, 1901.

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Table XI.

—	Frequency $n/2\pi$.	E.	c_2 in mfd.	w_3.	w_4.	w_2.	Δw_2.	c_1 in mfd.	tan ψ.	ψ.	Loss at 1,000 volts in watt per mfd.
Mica Condenser, Siemens & Halske	85·6	..	$2·02 \times 10^{-3}$	103·0	500	6,600	250	$9·81 \times 10^{-3}$	$0·00717_5$	0°24′ 40″	$3·86_0$
Flint-glass Leyden jar.....	86·1	1,500	$1·51_9 \times 10^{-3}$	302·1	200	4,500	330	$1·00_6 \times 10^{-3}$	$0·00369_7$	0°12′ 40″	$1·99_9$
Eleven Grisson condenser plates..	,,	,,	,,	577·8	500	12,200	330	$1·31_4 \times 10^{-3}$	$0·0100_2$	0°34′ 30″	$5·42_2$
,, ,, ,, *.	50·1	1,200	,,	572·4	,,	23,600	1,000	$1·32_7 \times 10^{-3}$	$0·0112_9$	0°38′ 50″	$3·55_2$

* It is possible that some of the plates were not the same in the two measurements, the results obtained, therefore, being not strictly comparable with each other.

Table XII.—*Cable II.—Length 5·3 Metres.*

Connection.	$n/2\pi = 86·1$									$n/2\pi = 50·7$.								
	E.	w_3.	w_4.	c_2.	w_2.	Δw_2.	c_1.	tan ψ.	ψ.	E.	w_3.	w_4.	c_2.	w_2.	Δw_2.	c_1.	tan ψ.	ψ.
1 and 2, 3, Sh. ..	1,500	259·6	200	$1·51_9$	19,500	370	$1·17_0$	0·01602	0°55′ 5″	1,100	500	387·6	$1·51_9$	37,800	200	$1·17_6$	0·01829	1°2′ 52″
2 ,, 3, 1, Sh. ..	,,	256·5	,,	,,	19,700	,,	$1·18_4$	0·01619	0°55 39″	,,	,,	391·4	,,	37,800	,,	$1·18_8$	0·01829	1°2′ 52″
3 ,, 1, 2, Sh. ..	,,	254·6	,,	,,	19,700	,,	$1·19_3$	0·01619	0°55′ 39″	,,	,,	394·5	,,	37,600	,,	$1·19_8$	0·01819	1°2′ 52″
1, 2 ,, 3, Sh. ..	,,	161·8	,,	,,	19,700	,,	$1·87_8$	0·01619	0°55′ 39″	,,	401·7	500·0	,,	37,800	,,	$1·89_0$	0·01829	1°2′ 52″
2, 3 ,, 1, Sh. ..	,,	160·1	,,	,,	19,700	,,	$1·89_7$	0·01619	0°55′ 39″	,,	398·3	,,	,,	38,100	,,	$1·90_7$	0 01844	1°3′ 22″
3, 1 ,, 2, Sh. ..	,,	160·8	,,	,,	19,700	,,	$1·89_0$	0·01619	0°55′ 39″	..	..	..	..	..	..	..	..	..
1, 2, 3 ,, Sh. ..	,,	143·3	,,	,,	19,700	,,	$2·12_0$	0·01619	0°55′ 39″	,,	356·6	,,	,,	37,300	,,	$2·12_9$	0·01805	1°2′ 3″

Table XIII.—*Cable VIII.*

	$n/2\pi = 86·1$.									$n/2\pi = 50·1$.								
1 and 2, Sh. ..	1,200	348·3	500	$1·51_9$	19,800	300	$2·18_1$	0·016271	0°55′ 56″	1,200	346·2	500·0	$1·51_9$	34,800	200	$2·19_4$	0·016640	0°57′ 12″
2 ,, 1, Sh. ..	,,	349·7	,,	,,	19,800	,,	$2·17_2$	0·016271	0°55′ 56″	,,	347·1	,,	,,	34,700	,,	$2·18_8$	0·016592	0°57′ 2″
1, 2 ,, Sh. ..	,,	271·3	,,	,,	19,000	,,	$2·79_9$	0·015613	0°53′ 40″	,,	270·0	,,	,,	33,200	,,	$2·81_3$	0·015875	0°54′ 34″

Table XIV.—*Cable X.*

	$n/2\pi = 86·1$.									$n/2\pi = 50·1$.								
1 and 2, 3, Sh. ..	1,500	266·2	500	$1·51_9$	18,700	270	$2·85_3$	0·015367	0°52′ 49″	..	..	..	..	..	..	..	..	..
2 ,, 3, 1, Sh. ..	,,	267·2	,,	,,	18,900	,,	$2·84_2$	0·015531	0°53′ 23″	..	..	..	..	..	..	..	..	..
3 ,, 1, 2, Sh. ..	,,	270·6	,,	,,	18,900	,,	$2·80_7$	0·015531	0°53′ 23″	..	..	..	..	..	..	..	..	..
1, 2 ,, 3, Sh. ..	,,	163·2	,,	,,	18,700	,,	$4·65_4$	0·015367	0°52′ 49″	..	..	..	..	..	..	..	..	..
2, 3 ,, 1, Sh. ..	,,	163·3	,,	,,	18,700	,,	$4·65_0$	0·015367	0°52′ 49″	1,450	161·2	500	$1·51_9$	31,300	300	$4·71_2$	0·014966	0°51′ 27″
3, 1 ,, 2, Sh. ..	,,	163·8	,,	,,	18,700	,,	$4·63_7$	0·015367	0°52′ 49″	..	..	..	..	..	..	..	..	..
1, 2, 3 ,, Sh. ..	,,	139·6	,,	,,	18,600	,,	$5·44_1$	0·015285	0°52′ 32″	1,450	137·7	500	$1·51_9$	31,300	300	$5·51_5$	0·014966	0°51′27″

Table XV.

Cable.	Connection.	$n/2\pi = 86$.			$n/2\pi = 50$.		
		c_1.	tan ψ.	ψ.	c_1.	tan ψ.	ψ.
I.....	3 and 1, 2, Sh.	$0·85_1$	0·02301	1°19′ 5″	$0·86_6$	0·03920	2°14′ 41″
III.	3, 1 ,, 2, Sh.	$1·17_4$	0·003821	0°13′ 8″	$1·17_4$	0·005081	0°17′ 28″
IV.	1, 2 ,, 3, Sh.	$3·50_9$	0·007190	0°24′ 43″	$3·51_9$	0·009515	0°32′ 48″
V.	1, 2, 3 ,, Sh.	$4·35_7$	0·007231	0°24′ 52″	$4·35_8$	0·007985	0°27′ 27″
VI.	3 ,, 1, 2, Sh.	$2·89_8$	0·009779	0°33′ 37″	$2·90_2$	0·010065	0°34′ 36″
VII.....	1, 2 ,, Sh.	$2·85_7$	0·010765	0°37′ 0″	$2·86_9$	0·011763	0°40′ 26″
IX	3 ,, 4, 1, 2 Sh.	$2·82_4$	0·014956	0°51′ 25″	$2·83_6$	0·015109	0°51′ 56″

IV.—Loss in Cables under Working Conditions.

1. In all the measurements on cables here described, the conductors of the cable, including the sheathing, were so arranged as to possess only two different values of potential in every moment. This does not take place, of course, when the cable is working; but the loss arising by any mode of working may be easily calculated from the results of the tests. The course to be taken for this purpose may be recognised in the following way:—

A condenser exhibiting a loss may be considered in which the P.D. E_t, existing at every moment between its coatings, has an angle of lag $(90 - \psi)$ with respect to the current I_t. Denoting by I_{ct} the momentary value of the charging current —*i.e.*, of that component of the current possessing a lead of a quarter of a period, as compared with the P.D., we find the energy contained in the electric field of the condenser at the time t to be:—

$$W_{et} = \int_0^t E_t I_{ct} dt, \text{ supposing } t = 0 \text{ at the moment the P.D. is zero.}$$

Since $E_t = E_{max.} \sin nt$ and $I_{ct} = I_{max.} \cos \psi \cos nt$, where $E_{max.}$ and $I_{max.}$ denote the amplitudes of the respective quantities, we obtain

$$W_{et} = \frac{1}{2n} E_{max.} I_{max.} \cos \psi \sin 2nt, \text{ and the mean value of the}$$

electric energy $W_e = \frac{1}{4n} E_{max.} I_{max.} \cos \psi$.

Comparing herewith the work wasted in the condenser during a period

$$\frac{2\pi}{n} A = \frac{1}{2} E_{max.} I_{max.} \sin \psi \frac{2\pi}{n},$$

we determine the ratio $\frac{\frac{2\pi}{n} A}{W_e} = 4\pi \tan \psi$. . . . . (3)

This is, except for the factor 2, the quantity which we have already proved as keeping the same value for a given dielectric at all voltages, capacities and frequencies. The constancy at different frequencies, however, here need not be considered, and only the loss at the same frequency may be regarded as a constant fraction of the mean electric energy.

For finding the loss which takes place in the cable when working under given conditions, only the amount of energy contained in the electric field in the case in question need be determined. This amount is given by the formula $W_{et} = \frac{1}{2} \Sigma Q_i V_i$, in which Q_i is the charge on the conductor at potential V_i. I will only give the results arrived at by this method of calculation in two cases of special interest without giving details of calculation.

(*a*) In the case of a symmetrically constructed cable with three conductors carrying three-phase alternating current, the neutral point of the system and the sheathing of the cable

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being connected to earth, then the electric energy is found to be constant and to amount to $W_e = \frac{3}{2}(c_{10} + 3c_{12})E^2$ if by E is denoted the effective voltage of each of the phases.

Here it would have been possible also to find the loss directly from the results of the tests by taking into consideration its proportionality to the capacity and to the square of the voltage. But the method of calculation already explained possesses the advantage of enabling us to ascertain the loss in other cases in which a capacity, as defined by a constant ratio between charge and voltage, is no longer present.

(*b*) As a case of practical interest, for instance, that of a three-phase-current cable may be mentioned, in which one of the phases is connected to earth. The mean electric energy is then $W_e = \frac{3}{2}(2c_{10} + 5c_{12})E^2$, E having the same meaning as before. The loss is therefore nearly twice as large if a phase is earthed than if the neutral point is connected to earth.

Cable II. may serve as a numerical example of the method of calculation just discussed. Its three-phase current capacity —*i.e.*, the constant ratio between charge and potential of each conductor existing if the neutral point is earthed—is $c_d = c_{10} + 3c_{12} = 0{\cdot}274$ mfd. per kilometre. In this case (*cf.* case *a*) the loss taking place at 50·7 periods per second, at a pressure of 11,000 volts for each phase, supposed to be the same along the whole cable, is found by equation (3) to be

$$A = 2n \tan \psi W_e = 3n \tan \psi c_d E^2 = 580{\cdot}17 \text{ watts per kilometre.}$$

If 100 km. of this cable were continually acted upon by a pressure of 11,000 volts, during a year the energy wasted would amount to 508,228·92 kw.-hours.

2. There should also be some interest in the question as to how the loss in the dielectric influences the phenomena occurring when alternating currents are flowing through long cable lines.* In order to inquire into this question and to recognise the action of the loss as clearly as possible, I have made calculations as to a cable at no load—*i.e.*, with open circuit—for lengths of 50, 100, 150 and 200 km. For this purpose I took the case of a cable given in the book just referred to (p. 78, Table V., No. 7) and introduced into the calculation the loss found in cable No. II., which I experimentally tested, and the data of which very nearly coincide with those of the cable dealt with in the book. In Table XVI. the results of this calculation are compared with those given in the book, obtained without taking account of the loss. The notation is the same as in the book. As may be seen by the table, the quantities c, γ, I_l are but slightly altered by the loss: c, the ratio of the voltage at the central-station end and that at the far end of the cable, is somewhat increased, the increase of voltage from central station to the far end, therefore, is somewhat reduced; γ, the phase angle of lead of the voltage at the central-station end, as compared with that at the far end, is somewhat increased; I_l, the current in amperes taken by the cable at the central-station end, is first slightly increased, but is reduced for greater distances; ϕ_l, the angle of lead of the current with respect to the voltage at the central-station end, is reduced by the loss.

The most interesting result, indeed, is that in regard to A_l, the power taken up by the cable at the central-station end in kilowatts per phase at a pressure of each phase of 10,000 volts. ΔA_l is the difference of the waste of power A_l when the loss is taken into account and when it is disregarded respectively; it represents fairly approximately the loss in the dielectric. It will be seen to increase somewhat more rapidly than in proportion to the length, owing to the increase of voltage from the central-station end to the far end of the cable. By considering the values of A_l the loss in the dielectric will be noticed at shorter lengths to afford by far the greater part of the power wasted in the cable at no load; at 50 km. still it amounts to nearly twice the copper loss. This latter, however, becomes more and more prominent at greater lengths, so that the loss in the dielectric only comes to half the copper loss at 100 km., one-fifth of it at 150 km. and one-tenth at 200 km.

Table XVI.

—	——	50 km.	100 km.	150 km.	200 km.
c	Without loss	0·99195	0·96866	0·93388	0·89368
	With ,,	0·99216	0·96978	0·93636	0·89815
γ	Without ,,	0° 53′ 27″	3° 37′ 14″	8° 21′ 28″	15° 21′ 1″
	With ,,	0° 54′ 0″	3° 39′ 23″	8° 25′ 51″	15° 27′ 35″
I_l	Without ,,	32·849	66·727	102·44	140·13
	With ,,	32·885	66·763	102 39	139·82
ϕ_l	Without ,,	89° 20′ 25″	87° 30′ 38″	84° 15′ 59″	79° 23′ 53″
	With ,,	88° 19′ 2″	86° 27′ 40″	83° 11′ 56″	78° 18′ 50″
A_l	Without ,,	3·782	28·983	102·340	257·814
	With ,,	9·657	41·210	121·248	283·201
ΔA_l	..	5·875	12·227	18·908	25·387

* *Cf.* G. Roessler, "Die Fernleitung von Wechselströmen." Berlin, Springer, 1905.

Summary.

1. In all the dielectrics tested (various kinds of glass, ebonite, dielectric of the Grisson condenser plates, impregnated paper, rubber, impregnated jute) the square law is obeyed with perfect accuracy as soon as the voltage alone is varied.

2. Apparent digressions from the square-law result as soon as another quantity by which the loss is influenced, for instance, the temperature, is varied; in the dielectrics glass and ebonite, tested in this respect, the loss increases appreciably even with a small rise of temperature. In the cables tested, however, this departure from the square law caused by rise of temperature originating in the loss itself does not take place except above the working voltage, the loss thus increasing strictly in proportion to the square of the voltage in these cables also.

3. A further apparent digression from the square-law is exhibited by the loss in a condenser at high voltages if it allows point discharges to take place. In this case the loss caused by the point discharges, increasing much more quickly than the square of the voltage, soon grows so large at high voltages that in comparison with it the amount of energy wasted in the dielectric itself is almost inappreciable.

4. The energy-loss in the dielectric is proportional to the capacity and may be considered as proportional to the frequency through the range of frequencies used for technical purposes.

5. Although only dielectrics with comparatively small loss were selected, the amount of the loss exhibits rather considerable differences in the different materials tested. Especially in glass great variety in the loss was found with different kinds. The smallest loss of all the solid dielectrics tested, except paraffin, was observed in flint-glass, while the loss in the cable insulated with rubber and impregnated jute was but slightly greater.

6. Owing to strict compliance with the square law, the quantity by which the loss is measured in the method here used remains the same at all voltages, and there is, therefore, no reason for undertaking the measurements at high voltages. Since exact measurements of loss can be made at comparatively low voltages for capacities of 0·001 mfd. and upwards the method presents a suitable means for determining the energy loss in dielectrics. As to cables, especially, far more accurate measurements can be made on pieces of a few metres in length at 1,100-1,500 volts than by the methods used hitherto on lengths of several hundred metres and at much higher voltages. The method, therefore, appears to be very well suited for technical measurements of loss in cables, and moreover, it might replace advantageously the insulation test on alternating-current cables, as it provides all the effects required by an insulation test on such cables and is much more to the point than the methods used hitherto for this purpose.

7. In extensive high-tension cable networks the amount of energy wasted in the dielectric is by no means negligible. In the case of short or medium lengths it affords by far the greater part of the no-load loss, and only in very long uninterrupted cable lines can it be neglected in comparison with the copper loss.

Wireless Telegraphy.—It is reported that a number of Royal Marines are to be selected for training as wireless telegraphy operators in the Nore Division of the Home Fleet and the Fifth Cruiser Squadron. If found satisfactory they will eventually be transferred to the wireless telegraphy branch of the Royal Navy.

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SWITCHBOARDS FOR TESTING WORK.

BY LEONARD SOLOMON.

Summary.—The Author considers the design of switchboards used for testing purposes, and describes the switchboard at present in use at the Central Technical College.

The design of a switchboard for use in a laboratory of a technical school or the test-room of a central station must necessarily differ vastly from that of a central station main board; for not only must it be possible to connect any number of the experimental circuits in series or parallel, and put any source of power on to these circuits, but also every likelihood of making short-circuits must be completely removed.

The difficulties in the design of a board that has to fulfil the requirements as stated above are such that it becomes necessary to weigh up the advantages and disadvantages of the various types of switchboard in vogue, and to see if their design can be adapted.

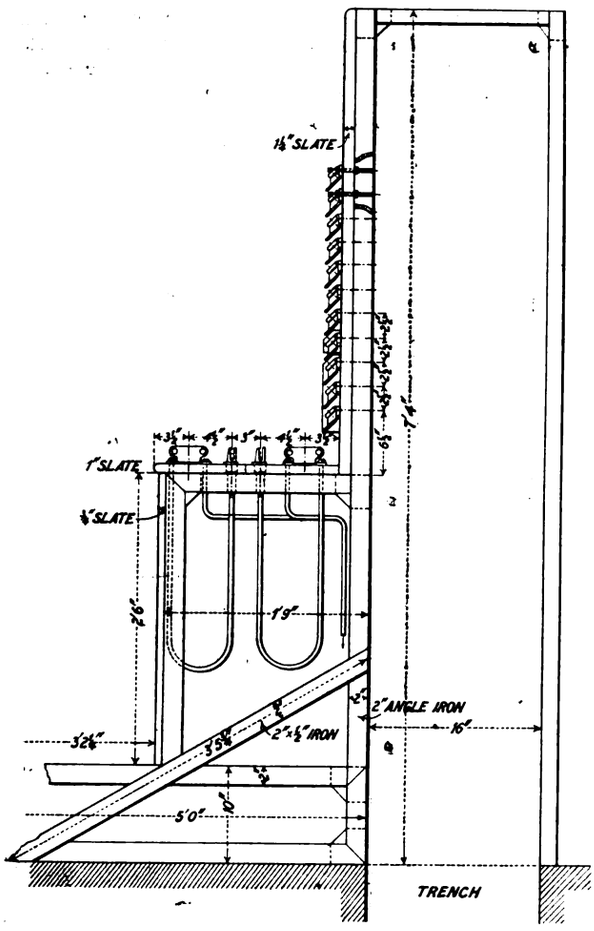

FIG. 1.—SIDE ELEVATION OF SWITCHBOARD.

The three types of board usually seen in practice are (*a*) the "switch" board, (*b*) the "plug" board, and (*c*) the "telephone" board.

(*a*) The switchboard type, which consists of a board containing (1) a number of 'bus bars fed from the various machines through separate switches, (2) a number of feeding or distributing bars connected to the various circuits through switches, is obviously not suitable for technical schools; for although by having a separate switch on each circuit of the board short-circuiting between circuits or opposite poles would be minimised, the number of switches required to enable the operator to connect any number of circuits in series or parallel would be so numerous as to be absolutely prohibitive.

(*b*) The plug board consists of a board on which the 'bus bars are fixed in a horizontal direction, the distributing bars in a vertical direction and crossing the 'bus bars without making any electrical connection with them. In order to throw any circuit on to the 'bus bars, plugs are screwed through the pair of distributing bars (to which the circuit is connected) to the positive and negative 'bus bars respectively. While with such a system only a limited number of plugs would be required, nothing would be easier than to plug one circuit on to more than one pair of live 'bus bars with a disastrous result to board or plug or both.

(*c*) In the telephone type of board the machines are connected to a number of sockets, and separate plugs for each circuit take the place of the distributing bars in the plug board. In this type the difficulties in the two former types of board are overcome, but only a very small current can be obtained, or the plugs become of abnormal size; further the necessary tangled crossing of flexibles is most undesirable.

Of these three systems the only type that can be made suitable for all purposes is a modification of the last form, and an improved type of telephone board has actually been adapted in the manner shown in Figs. 1, 2 and 6 to meet all the requirements of the ordinary electrical laboratory.

This board was originally designed by Mr. William Cramp for the Central Technical College, South Kensington, and was constructed by Messrs. Reyrolle, of Hebburn-on-Tyne. It has now been in use for about five years, and I believe that there have been no instances of short-circuiting taking place through the ignorance of students during this period. Further, it has been found to answer so well the purposes for which it was designed that it has already been copied for use at Newcastle and District Electric Power Supply by Mr. Fawsett; by the Professor of Electricity at the Armstrong Institute, Dr. Thornton; and by Mr. Leek, of Devonport. It will be seen by reference to the front-view and end-elevation given (Figs. 1 and 6) that insulated horizontal bars on vertical panels take the place of the telephone board sockets, while flexibles and plugs arranged on front horizontal panels form the circuit connections. Each bar will carry easily 200 amperes and each circuit flexible about 100 amperes. The apparatus which replaces the ordinary telephone plug is of a special design, and a drawing of one of these is shown in Fig. 2. The rounding of the inside corners at the bottom of the insulated handle is to prevent the nicking of the flexible cable where it leaves the plug.

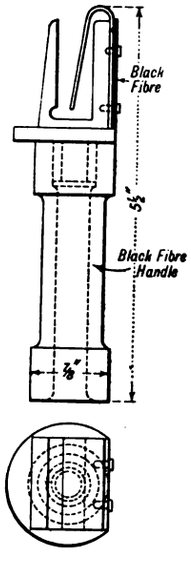

FIG. 2.—SPRING PLUG.

The panels of the Central Technical College board are eight in number, and of 1¼ in. slate enamelled on the front and all edges. Four of these are vertical, the other four being horizontal and resting upon supports in front of the vertical panels. The two smaller vertical panels, each 2 ft. wide and of opposite polarity (seen to the left in Fig. 6), are for lighting purposes and for charging the batteries; while the other two vertical panels, each 4 ft. wide and of opposite polarity, have mounted upon them the horizontal 'bus bars above referred to.

The sources of power for lighting and experimental purposes are 12 in number, viz.: the town's mains, a 40 kw. Bruce Peebles compound-wound dynamo, a lighting battery of 100 cells, an experimental battery of 100 cells, a second smaller experimental battery of 20 cells, and seven small machines. From the cells connections have to be brought to the smaller charging panels.

With so many sources of power any student engaged in a series of experiments can, if desirable, monopolise one of the above sources without being disturbed by any other member in the laboratory; and on the other hand, by arrangements to be presently detailed, any number of circuits may be placed in parallel on one machine.

To accommodate all these machines each of the large vertical panels is fitted with 14 horizontal gun-metal bars, each connected to its source of supply through aluminium fuses seen at the centre of the board. Between consecutive gun-metal bars

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runs a projecting bar of hard black fibre to prevent the possibility of short-circuits by accidental contact made across two bars of like polarity, but with a difference of potential between them, and for similar reasons between panels of opposite polarity is fixed another bar of hard black fibre. In order to procure a supply of power at voltages of 50, 100, 150 and 200, from the experimental battery, connections are made in the following manner to four pairs of bars, which we will assume for our purpose are Nos. 1, 2, 3 and 4 :—

No. of bar.	Positive.	Negative.
1st pair	1st cell	25th
2nd ,, ...	25th ,, ...	50th
3rd ,, ...	50th ,, ...	75th
4th ,, ...	75th ,, ...	100th

Nos. 2, 3 and 4 positive are connected to Nos. 1, 2 and 3 negative, so that 50 volts can be obtained across 1 + and 1 −, 2 + and 2 −, 3 + and 3 −, 4 + and 4 − ; 100 volts across 1 + and 2 −, 2 + and 3 −, 3 + and 4 − ; 150 volts across, 1 + and 3 −, 2 + and 4 − ; and 200 volts across, 1 + and 4 −, by which

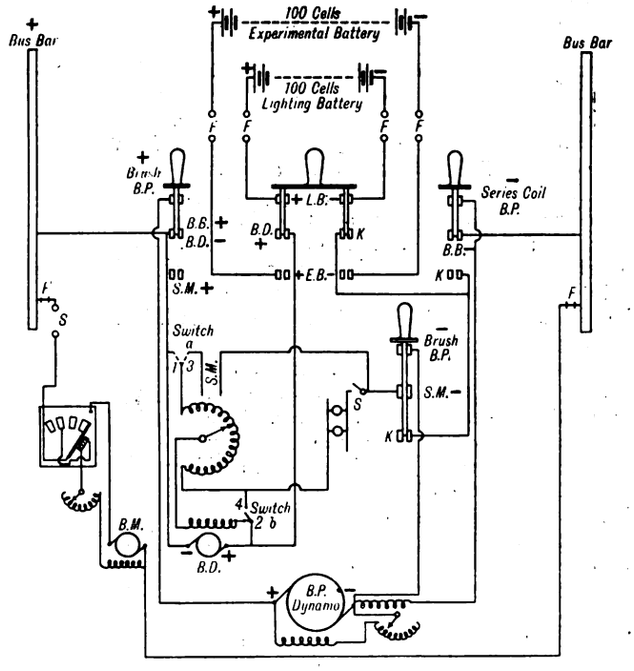

Fig. 3.—Diagram of Connections of Central Technical College Switchboard.

means it is possible to balance the load fairly evenly between the different sets of 25 cells.

The remaining pairs of bars are allotted to the town mains, lighting battery, Bruce Peebles dynamo, small experimental battery and the various machines, each pair being clearly labelled to avoid any mistake in making the connections. There were also two or three idle bars originally provided on each board as spares.

The four horizontal panels in front of these machine panels form the circuit board. Each panel carries 12 plugs and damper fuses, which are connected to flexible leads as shown in Fig. 1. When not in use these plugs rest in specially made holes in the horizontal panels, while the flexibles depend therefrom in U loops between the plugs and fuses, as shown.

From the circuit fuses cables pass along trenches in the floor to the distributing centres, each plug and fuse being distinctly labelled.

Owing to the length of the bars the crossing of leads is completely avoided and all danger from short circuit between positive and negative panels is removed, since in no case is the length of cable sufficient to allow it to cross to the panel of opposite polarity. To avoid sharp bends in the flexible cable the horizontal machine bars are set at an angle to the board face, as is clearly seen in the illustration.

There are also provided independent flexibles with plugs at both ends by which means any two bars may if necessary be connected in series, so that different combinations can be made with the different machines ; but in no case are students allowed to handle these unless in the presence of some capable instructor, as it is naturally possible to short-circuit the machines with them.

As a point of additional interest I may mention the two sets of smaller panels to the left of the main board. These panels contain the necessary charging booster-motor starting switch, the main cut-outs, the lighting bus bars, and a multiple way voltmeter switch so arranged that at any moment it is possible to read the voltage across the town mains, lighting battery, or other special terminals. The horizontal slate panels on the front support the resistances for the booster dynamo and Bruce Peebles dynamo fields, which are regulated by a small handle projecting from the panels.

Three Crompton cut-outs are seen at the top of the vertical panels. These are set for a maximum current of 90 amperes and are placed in series with the experimental battery, one at each end and one in the centre. Such an arrangement is necessary on account of the subdivision of this set of cells.

Below the cut-outs are two S.P. change-over switches and a D.P. change-over switch. These, together with the special switch in the right-hand lower corner and two tumblers, are all that are necessary for the following functions :—

1. Charging the experimental battery or the lighting battery from either town mains, or dynamo, through the booster.
2. While using the dynamo as above yet throwing in the compounding coils for other circuits.
3. Discharging for lighting purposes from either battery.
4. Lighting from either town mains or dynamo independently of or in parallel with the charging circuit.
5. Use of booster as above either by independent or automatic excitation.
6. Discharging the cells through the booster for lighting purposes.

It will be seen that to carry out all these variations with so few switches involved no little scheming, and as such an arrangement may be useful to other engineers a few details will not be out of place.

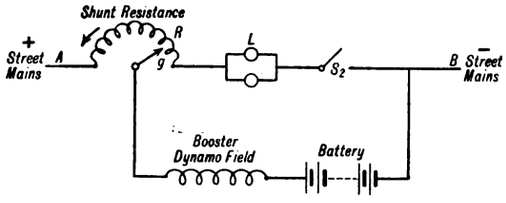

Fig. 4.—Diagram of Connections showing Booster Dynamo self-exciting.

The system of boosting is not unlike that of Highfield, but it is not absolutely automatic ; its principle is explained in the following paragraphs.

Suppose that the lighting battery is being charged from the Bruce Peebles dynamo, then the three switches at the top of the switchboard diagram (Fig. 3) will be closed in the positions shown. From the same diagram it will also be evident that it is quite possible to run the booster dynamo either self or separately excited. Considering, first of all, the former case, the switches *a* and *b* must be closed respectively to 1 and 2.

Since the two points A and B (Fig. 4) are connected to the main, there is always between them a fairly constant P.D. of 200 volts.

If the battery voltage be greater than this, switch S_2 is opened, so that the current flows through the booster dynamo field in the direction denoted by the arrow. The charging current is regulated at the commencement of the charge by means of the shunt regulator R.

As the voltage of the battery increases, so grows the P.D. across the two ends of the dynamo field ; and hence there is an increase of current or exciting ampere-turns, by which means the booster dynamo is still capable of charging the battery against the increased back E.M.F. of the latter.

Should the battery voltage fall below that of the dynamo, it is obvious that the current through the field (of the booster) would be reversed.

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This difficulty is overcome in the following ingenious manner, due to Mr. T. Mather, F.R.S.

Switch S_3 is closed, thus making a second complete circuit between A and B, consisting of the shunt regulator in series with two lamps wired in parallel; the regulator is then adjusted to such a point g that the drop of potential across Ag is greater than the difference between the battery terminal voltage and that of the mains. The charging will then proceed automatically until the battery voltage exceeds 200, when, owing to the waste of electrical energy in the lamp circuit, switch S_2 is opened and the regulator again adjusted as explained above.

Taking the second case where the booster dynamo is separately excited, the two switches a and b (Fig. 3) must be closed across 3 and 4 respectively, when again the process of charging is similar in every way to that previously explained, except that now it is not automatic. Should it be necessary to charge the battery from the street mains, the only alterations made are in the position of the two single pole switches at the top of the diagram, Fig. 3, which must now be closed on to the bottom contacts; a study of the diagram (Fig. 3) will also make clear the use of the other connections.

It only remains to add a few remarks as to the construction of the platform and the ease with which the board can be at any time extended (a great advantage when one contemplates the speed at which a technical school grows).

The flooring of the platform is constructed of glass laid in insulating cement on sunk iron frames, so that the operator is protected from any chance of shock; the hand rails also are both insulated from the board and from earth.

The framework supporting the horizontal panels is drilled so that at any future time it may take projecting brackets forming the supports of a panel of half the width of that at present installed, capable of carrying 24 circuits. The platform is built of ample width to allow of this extension horizontally.

A vertical panel may also be added above those already existing, since the instruments are not supported by terminals or screws passing through the panel, but by means of the framework behind.

The whole board and platform can in a very short time be removed to any part of the laboratory, since it is nowhere permanently fixed. The framework at the back is arranged so that it can be closed by Bostwick patent gates.

It might be mentioned that exclusive of instruments the total cost of the board was only about £150, which is quite a low figure when one considers the number of main circuits and distributing circuits that are provided for.

There is just one point which might be criticised and pointed out as a defect in the arrangement of the board—viz., that the two large vertical panels are not strictly positive and negative in that the four small bottom bars are also used for alternating current; but after all, against this must be weighed the economy in cost, an item of no small value in the eyes of a technical school committee. This defect, however, would suggest the advisability of separating the alternating and continuous-current machines, by adopting distinct distributing panels in any future board.

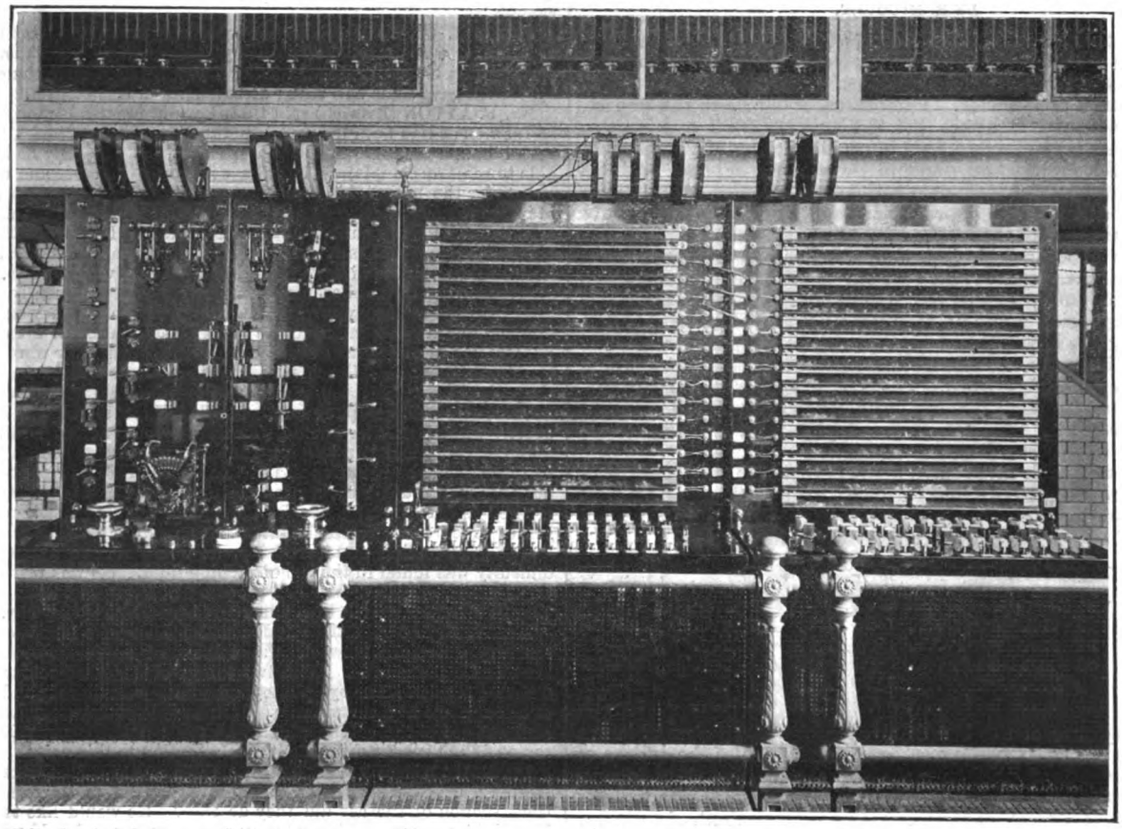

FIG. 6.—SWITCHBOARD AT THE CENTRAL TECHNICAL COLLEGE

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Electric Blasting Apparatus and Explosives." By Wm. Maurice. (London: "The Electrician" Printing and Publishing Co.) 8s. 6d. net.

"The Electric Tramcar Handbook." By W. A. Agnew. Fourth Edition. (London: H. Alabaster, Gatehouse & Co.) 2s. 6d. net.

"Science Abstracts." June, 1907. Vol. X. Part 6. Section A. Physics; Section B. Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

"Fortschritte der Elektrotechnik." (Zwanzigster Jahrgang). By Karl Strecker. 1907. Part III. (Berlin: Julius Springer.) 9m.

"The Protection of Buildings from Lightning." By Alfred Hands. (London: J. W. Gray & Son.)

"Patents and Designs." Critical Notes, by Ernest Lunge and Bernhard Dukes, on Mr. Lloyd-George's Bill as Amended. (London: Stevens & Sons.) 1s.

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TWELFTH ANNUAL CONVENTION OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

Friday, June 28, 1907.

The President, in calling upon Mr. R. McCourt to read his Paper on "The Value of Photometry in Central Station Practice," which had won the I.M.E.A. Travelling Studentship, said the Council had been very pleased to find the Paper of such high merit. In addition to giving the award, the Council had decided, as a further encouragement to students to come forward with Papers, and on account of the high order of merit of this particular Paper, that it should be read at the Convention.

THE VALUE OF PHOTOMETRY IN CENTRAL STATION PRACTICE.*

BY R. MCCOURT.

The Author draws attention to the fact that photometry has not received the attention it deserves from electric supply station engineers, and even now a large proportion of central station test-rooms do not possess a photometer. Photometrical laws and the importance of a standard of light are then dealt with.

As regards lamp testing, in 1905 it was decided by Mr. Wilkinson, in view of the great harm done to the electric lighting business by the large number of inefficient and wrongly-graded lamps on the market and as a measure of protection to the consumer, to institute with the assistance of the local contractors a system of testing and certification of all incandescent lamps. For this purpose a lamp specification was prepared and sent out to all lamp manufacturers and they were informed that only lamps complying with the terms of that specification would be certified for use in Harrogate. The local contractors have worked loyally with the department in this matter and no lamps are sold by them now other than those which have been tested and certified. The consequence is that the department now have passing through their hands from 20,000 to 30,000 lamps per annum. The procedure adopted is in two steps: (1) Wattage tests; (2) candle-power tests.

The following table gives the limits within which the lamps must fall to ensure being passed and certified. The certification is completed by stamping on the glass bulb with etching fluid the word "certified" and the initials of the electricity department.

	—100 volts—		—200 volts—		
	Total watts.	Watts per c.p.	Total watts.	Watts per c.p.	Limits of c.p.
5 c.p.	26	4·2	28	4·5	from 4—6·5
8 c.p.	34	4·0	36	4·25	,, 7—9
16 c.p.	66	3·75	68	4·0	,, 14—18
25 c.p.	100	3·75	108	4·0	,, 22—28
32 c.p.	130	3·75	140	4·0	,, 28—36

As an evidence of the beneficial effect upon the class of lamps supplied to the consumers since the introduction of the system of testing and certification of lamps, the following figures are significant. They show the number of lamps received to be tested, the number passed, and the percentage of passed lamps in the month of January, 1906 and 1907.

	Jan. 1906.	Jan. 1907.
Lamps received	2,704	1,746
Lamps passed	2,320	1,595
Per cent. of passes	85·7%	91·3%

A point worthy of attention in the design of photometer benches was brought forward in a recent Paper—viz, the advisability of replacing the straight photometer bench by two benches set at an angle, the photometer head being fixed at the apex and the angle of the benches being such that the rays from both lamps would fall directly on their respective screens, thus eliminating error. The operator would sit between the benches, thus not only would each bench be nearer his hands, but the lamps would be behind him.

The author concludes by describing the use of Mr. Haydn Harrison's portable photometer for accurate tests in the streets on arc lamps, glow lamps and gas lamps.

DISCUSSION.

Mr. G. WILKINSON (Harrogate) opened the discussion, and thought the Paper was particularly applicable at the present time, because there had recently been published a specification for filaments of carbon lamps accepted by manufacturers. It was possible to purchase lamps alleged to coincide with such specification, but there was no organisation for the testing of such lamps in quantities, and the lines set forth by Mr. McCourt would enable station engineers in smaller towns to introduce an inexpensive method of lamp checking in their consumers' interests. Before the method was introduced at Harrogate there was danger of a slump in the electric lighting, because such wretched quality lamps had been sent in by the makers, chiefly from the Continent, and also because extraordinary efforts were being made by the gas company, due to the improvements in the gas mantle. Up till that time they had been suppliers of electricity, and as long as this was produced at a fair profit they considered their responsibilities were at an end. It was soon seen, however, that they ought to take some cognisance as to the lamps used. There was a very considerable margin found on the street photometer described, largely due to the fact that in this photometer they were dealing with such peculiarly limited surfaces. If something could be done to strengthen the standard of light, they would get closer results. He mentioned this as a suggestion to photometer makers. A brilliant illumination was required on the screen to get closer readings.

Prof. CRAPPER (Sheffield) considered that there was no more important part of the work in lighting stations than that of attending to the quality and standardisation of light. He had read an article a short time ago which compared the testing room of the ordinary electric lighting department very unfavourably with the test rooms of the telegraph companies.

Mr. A. J. CRIDGE (Sheffield), remarking upon the statement that photometry was a matter of individual judgment, referred to a Paper by Dr. Fleming before the Institution of Electrical Engineers some few years ago which gave some surprising divergencies in this respect.

Mr. F. AYTON (Ipswich) said that they did practically the same thing in Ipswich as had been described in the Paper. They had a large number of lamps on maintenance in Ipswich, and not only had they been able to remove complaints, but the consumers had become advertising agents for the undertaking, as they were satisfied. Another advantage of introducing a proper means of testing and standardising lamps was in connection with the pairing of metallic filament lamps. Although they ordered lamps from the makers for that purpose, and assumed they would send them properly paired, they did not find that was the case. Another great advantage of the photometer was that they were frequently called upon to advise as to the best way in which to light a house. They ought to give more study, in his opinion, to the proper illumination of interiors. The photometer was of great assistance in this, because they were able to tell the consumers what the effect of various shades was. In the case of shop lighting, again, the use of proper reflectors was of the greatest importance, and the photometer enabled them to tell the shopkeeper exactly what result he would get in the way of reflected light. He had found some difficulty in keeping the voltage constant whilst testing, so he took one of the batteries off the 'bus bars and used it for that purpose, but that rather upset the station when it might be wanted for charging. If they had to instal a special battery for the photometer room, it was rather expensive for a small station. In regard to the labelling of the lamps after testing and certifying, he would like to ask whether any difficulty was found in the use of etching fluid. He was rather afraid to introduce it, and they had had prepared at Ipswich a little label about ¼ in. in diameter, which they stuck just beneath the lamp cap.

Mr. A. B. MOUNTAIN (Huddersfield) drew attention to the extraordinary difference between the colours of an incandescent electric lamp and a gas mantle. With two things of different colours they got different results. The eye photographed at a certain rate and the waves of colour came at a certain rate. If these did not correspond, an enlarged idea was got of the colour which had the quicker waves. He thought some of the younger men might give attention to this point.

Mr. R. HAMMOND remarked that there was a difficulty in regard to lording it over the customers in the way they did in Harrogate. Under what section of the act did they do this? He would like to know how Mr. Wilkinson was at liberty to say a consumer could only use a certain type of lamp. He would like to mention that notwithstanding the excellent tests made, they succeeded in passing some very poor lamps at Harrogate. The table given by Mr. McCourt showed that a 32 c.p. lamp was allowed 12½ per cent. difference either way, making 25 per cent. allowance. The lamps should be started on their career in a more perfect condition.

Mr. C. C. ATCHISON (Rochdale) said Harrogate had given him some kind assistance in connection with photometry. Engineers were now keeping in touch with their consumers and doing what they could to retain those consumers and also to obtain fresh ones. He had only been a short time in touch with this class of work, but already he had retained several consumers whom he would otherwise have lost, as he was able to show them what sort of lamps they had been using. He cited the example of one man who was using a 32 c.p. lamp giving only 18 c.p., and another with a 16 c.p. lamp was getting only 6 c.p. In connection with the marking of lamps, he had not been successful in getting a fluid that would etch properly. It usually wiped off very soon. As a last resource he was going to try sand blasting, which he thought would last better. In connection with street lamps, he got within 9 yds. of an ordinary gas mantle before it came on his scale.

Mr. HAYDN HARRISON thought that the most interesting point in photometry was the degree of accuracy in carrying out the work of lamp testing for consumers. If they worked within 10 per cent. they could test a good many more lamps at less cost. As they knew, they were generally not quibbling over 10 per cent., but over 50 per cent. It required practice to get results of value with the ordinary photometer; but with the flicker head photometer, anyone would be able to eliminate the flicker within 4 or 5 per cent. The distance at which the photometer could be used depended, of course, upon the standard in the photometer. The first he had designed were intended for measuring street lamps. A large number of people now found they wanted to measure interior illumination.

*Abstract.

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Messrs. Elliott Bros. had, therefore, put in two standards, including one for 10 candle-ft. down to 0·1 candle-ft.

Mr. C. FURNESS (Blackpool) said that they did free testing of lamps in batches of not less than 12 at a time. Any bad lamps they smashed and did not return. Lamps over 5½ watts per candle-power and below 10 c.p. for a 16 c.p. lamp were destroyed. If the commercial prosperity of the electrical industry were to depend upon the standard of light, it was not, he thought, a good outlook. In his opinion, metallic filament lamps would do away with all the trouble. The consumer fixed his standard of light, and if he was content to have 8 c.p. when he could have 16 c.p., it was his look-out. Their business was to sell electricity. In Blackpool they settled disputed accounts with the photometer. If a consumer questioned his account they sent out their portable photometer and soon satisfied him—and smashed the lamp (laughter). In regard to public street lighting, photometry was very important in giving them records of what the gas lamps were doing, and also the flame arcs, rectified arcs and ordinary arcs, and, when any question arose, always provided figures to settle the matter.

Mr. J. K. BRYDGES (Eastbourne) said he had used both the grease spot and the flicker head photometers. He found that the personal error must be taken into greater consideration with the grease spot than with the flicker head. Mention had been made of the difficulty in pairing metallic filament lamps. The readings could, in his opinion, be taken much more carefully with an ammeter than with a photometer. He was very pleased to think they satisfied their consumers so easily at Blackpool. He found the best thing to do was to put in a standardised wattmeter. It was the meter they had to consider and not the candle-power of the lamps when dealing with a disputed account. The fluctuation of voltage was not of so much account if the standard lamp and the lamp to be tested were of the same power. He did not think they should condemn lamps on results given by the pentane standard. He also thought it was a drastic method to smash contractors' lamps that did not come up to the standard, and that the contractors ought to have the opportunity of making their own tests.

Mr. R. McCOURT, in reply, said as regards the limits within which the lamps were passed, if they had erred in that matter they had erred in very good company, because in the Engineering Standards Committee's specification it was specified that individual lamps must come within 12½ per cent. of the standard. The last six dozen Osram lamps they had tested very carefully, and had found it was almost necessary for another Engineering Standards specification. The actual candle-power of the 32 c.p. lamps varied from 17 to 36, and the watts from 29 to 36; and the 50 c.p. lamps from 27 to 44, and the watts from 36 to 48. The G.E. Co. stated that in future they intended to supply the lamps rated according to watts and not to candle-power. He thought, therefore, they had still more need for the specification. He had not mentioned street lighting, but would like to give some figures taken with the Harrison photometer, with a 50 c.p. Osram lamp as against a 3 ft. incandescent gas lamp. At 14 ft. from post the result was: Osram lamp, 0·29 candle-ft.; gas lamp, 0·18. Working out the figures, they found the Osram lamp was giving 54 c.p. and gas lamp 36 c.p. The month previous, with the same two lamps, the Osram lamp was giving 54·5 c.p. and the gas lamp was giving 25·2 c.p. Evidently the mantle had been renewed in the meantime. He had worked out these figures (taking the Osram lamp at 52 watts) at 3d. per unit, a high price for street lighting, and gas at 2s. 10d. per 1,000, as charged in Harrogate. This gave a saving in favour of electricity of 17·6 per cent. They did not legally prescribe a form of lamp—it was a kind of moral persuasion. In reply to Mr. Hammond, they did not deal with the consumer, but with the local contractors, who had signed an undertaking that they would only sell lamps in Harrogate certified by the electricity department. The average householder in Harrogate was very keen to see he was only supplied with lamps certified by the department.

The last paper to be read at the Convention was on :—

SOME NOTES ON ALTERNATING-CURRENT DISTRIBUTION.*

BY A. J. CRIDGE,
Assistant Electrical Engineer, Sheffield.

The author first gives an account of the theoretical considerations involved in a supply of alternating current, such as power factor, losses, &c. An interesting point to which attention is drawn is that the power factor of an alternating-current motor is increased by reducing the voltage. Some experiments made on a motor generator used for a direct-current supply in Sheffield are given in Table I. Readings were first taken with the machine on the 200 volt circuit. It was then switched over on to the 50 volt winding of an auto-coil used for starting it. The figures show that the power factor, which at 200 volts was 0·35, at 50 volts became 0·9. On adopting this system of running the machine on low voltage a reduction in the units consumed each week was the result.

Table I.—*Test of 120 H.P. Induction Motor Driving Direct-Current Generator in Sheaf-street Station.*

Volts.		Amperes.		Kilowatts.		K.W. total.	Power factor.	Time.	Remarks.
A.	B.	A.	B.	A.	B.				
								a.m.	
210	209	33	32	6·0	6·1	12·1	0·889	11:10	50 volts on stator.
210	209	55	55	10·4	10·2	20·6	0·894	11:20	50 ,, ,,
209	210	130	130	10·0	9·0	19·0	0·35	11:30	200 ,, ,,
								p.m.	
210	212	48	48	9·0	9·2	18·2	0·9	4:45	50 ,, ,,
212	212	35	35	6·6	6·6	13·2	0·89	4:55	50 ,, ,,

The author then gives a table and curves (Figs. 1 and 2) showing how the power factor at the Neepsend station varies during each day, and an average value during the months of the year. From Fig. 1 it is evident that any device for improving the power factor is only required in the daytime.

He then describes the machine about to be installed on the Sheffield system to relieve the plant and mains of the excessive amount of idle current which sometimes flows in them. This machine will be situated at the old generating station at Sheaf-street, and will serve to keep the trunk mains from Neepsend loaded at a power factor approximately equal to unity. It will be of 600 kilo-volt-amperes capacity, and, in order to keep the starting current low, it will be started by a small induction motor, and switched into parallel on attaining synchronous speed in the same manner as an ordinary generator. A power factor meter is to be provided, so that the effect which the machine is producing may be read at intervals.

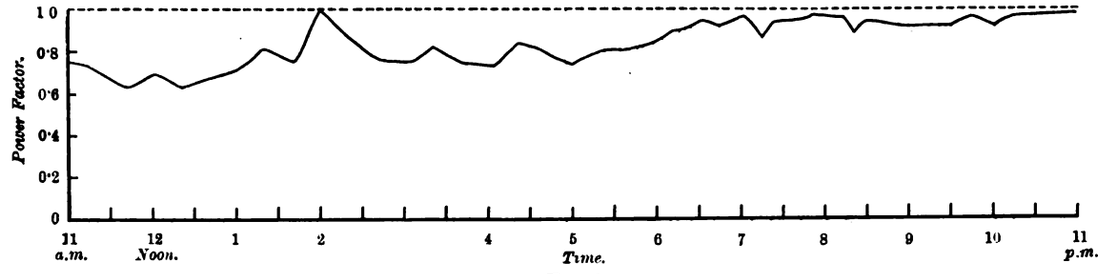

FIG. 1.

The cost of the machine, with the necessary switchgear and accessories, will be about £800, and its consumption of electricity will be some 32 units per hour. This will be taken up in overcoming the friction, copper, and iron losses of the machine, as it will have no mechanical work to do. The cost of this power may be taken at ¼d. per unit—for distribution expenses are nil in the station—and, taking an average run of 15 hours a day for 300 days in the year, the amount will be £150 per annum. Cost of switching and attendance will be quite small, as no extra help will be needed beyond the present staff employed in the station. Capital charges at 6 per cent. are £48, and with sundry amounts for exigencies it would appear that the cost of running the machine for a year would not exceed £200.

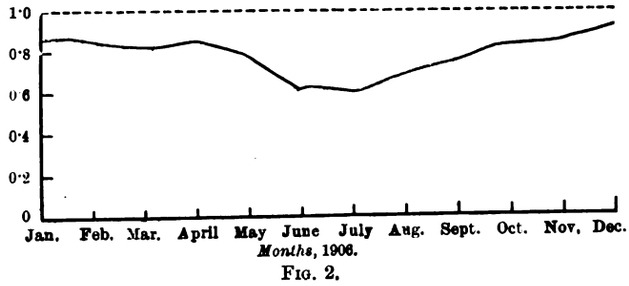

FIG. 2.

For this sum, plant and mains to the extent of 420 kilowatts will be liberated. Extra plant to this amount would cost £5,000 without buildings or mains, and the capital charges alone would be £300. These approximate figures serve to give some idea of the improvement it is hoped to effect by the installation of the machine.

*Abstract.

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The provision of another similar machine to be situated in a suitable sub-station in the power district previously mentioned was at first contemplated, but it was thought wiser to proceed with the motor at Sheaf-street as a commencement. There seems reason to hope that in the near future static condensers, energised by step-up transformers, will be available for the purpose indicated. These, although dearer in first cost, will absorb less power to a sufficient extent to make them commercially preferable, while the effect, in respect of reducing the wattless current and of limiting the fall of pressure due to weakening of the fields of the alternators, will be equally good. It is also claimed for this class of apparatus that the dangers which occasionally arise from resonance on opening the circuit and from the presence of harmonics of a high order in the alternator wave are practically eliminated, and that the wave form is caused to be much more nearly sinusoidal.

During the early part of last year the experiment was tried of running a 300 k.w. Parsons turbo-generator at Sheaf-street as a synchronous motor, and over-exciting its field, and the greater carrying capacity gained for the mains was sufficiently marked to warrant the highest hopes for the success of the project which has been briefly outlined above.

DISCUSSION.

Mr. F. LANGLEY (Sheffield) said that Mr. Cridge had given the amount of loss in the synchronous motor as 32 units per hour, and worked out the cost for a year. But although using 32 units per hour on one pair of trunk mains 4,200 yds. long from Neepsend to Sheffield, some units per hour would be saved in cable losses, and the real loss would be only some 16 or 17 units per hour. There was another advantage in having the synchronous motor running: where there were variations of load, the flywheel would take up these. Of course, against that, when they began putting down synchronous motors there would be some further cost for attention. He thought, however, the attention required would be quite small. If Mr. Acland could leave the Tirrill regulator for 18 hours without looking at it, the synchronous motor could be run with simply an attendant being sent to put it on and to shut it down. It was a move in the right direction to do away with the wattless current.

Mr. C. H. YEAMAN (Hanley) said it had occurred to him that in some of the older stations where plant was being discarded as being too small it might be possible to adapt those machines for the purpose of supplying idle currents. He had found that small units which were no longer of use for generating purposes could be adapted for use as motors by consumers. His own experience was that motors on a small scale did not affect the lighting.

Mr. C. TURNBULL (Tynemouth) stated that if the frequency remained constant the speed would not change, and a flywheel would have no effect. The Paper dealt particularly with Sheffield, and in considering it they must remember that at Sheffield the pressure was 2,000 volts, and hence wattless current had a proportionately greater effect. With a higher pressure and less current, the troubles were not quite so great. His own impression was that engineers talked too much about the great value of the load factor. It had a value, but they had to confess that the supply of large quantities of current was of much greater importance than having a good load factor. If the load factor were everything isolated plants would be able to compete with the main power stations very well. They had to face the fact that current could be generated in large quantities at extremely cheap rates even if the load factor were not so high. Mr. Cridge had spoken of "wattless" current and "useful" current. In his opinion, they wanted the word "wattful" instead of "useful."

Mr. R. McCOURT (Harrogate) said that it seemed to him that a condenser, if it could be suitably put down at each motor on the mains, would be a simpler way of dealing with the problem than putting down a synchronous motor.

Mr. S. L. PEARCE (Manchester) thought that all engineers supplying three-phase alternating currents would sooner or later have to consider the possibility of dealing with the very low power factors which obtained in the works of large consumers. They were not in quite so bad a position at Manchester as Mr. Fedden was at Sheffield. The lowest power factor on record at Manchester from a large works was in the neighbourhood of 0·7. Fortunately, those works were only about ½ mile from one of the distributing sub-stations, and they quite easily compensated by over-exciting the synchronous motor-generators.

Mr. W. J. U. SOWTER (Bray) mentioned that when he was at Coventry they found it necessary to run with 25 per cent. more plant owing to the low power factor.

Mr. A. A. DAY (Bolton) said they had had no trouble with their three-phase plant. They could keep their power factor very nearly unity, and had always been accustomed to over-excite their synchronous machines.

Mr. A. J. CRIDGE, in reply to Mr. Yeaman and Mr. Turnbull, said the flywheels on the synchronous motors came into effect only when the speed varied. If the load or the wattless current varied, the call on the synchronous motor varied, and the flywheel prevented it getting out of step.

The PRESIDENT said there was one point worth noting, and that was that they could put in too many synchronous motors and get a bad leading current. One of the big companies in London, supplying a great many sub-stations, with a great many synchronous motors, had real trouble from the exactly opposite cause from what they had at Sheffield.

On Friday afternoon visits were paid to the power stations of the Sheffield Corporation, and the Convention was brought to a close.

THE DEVELOPMENT OF ELECTRICITY IN THE IRON AND STEEL INDUSTRIES.*

BY D. SELBY BIGGE.

Summary.—In this Paper the Author first considers the advantages and financial gains which may be expected by adopting electrical driving in rolling mills, especially where use is made of the blast-furnace waste gases. Considerable attention has been paid to this subject on the Continent; and the Author describes the equipment of the Hildegarde Works at Trzynietz.

The rolling mills of this country, in view of complete electrification schemes, may be divided into two classes:—

Firstly, those which have blast furnaces adjacent;

Secondly, those which have not.

The cost of power production, or, alternatively, the price at which one can purchase current, is a dominant factor in the determination of the savings to be realised by the electrification of rolling mill plants. Owing to the great advance which has been made in the construction of gas blowing engines during the last three years many blast furnace owners have adopted this method in place of steam blowing engines, thus utilising from the blast furnaces a large amount of waste gas available for the production of electric power by means of gas engines, or, alternatively, if the supply of waste gas is plentiful, by means of high-pressure condensing steam turbines receiving their steam from boilers fired by the waste gases from the blast furnaces.

In such cases as the above the cost of power production will be found to be very low, and should in no case exceed 0·25d. a unit, while in certain cases, with modern plant and under favourable conditions, the cost of production has been brought down considerably below this figure.

In the second category of rolling mills—*i.e.* those which have no blast furnaces attached, or those which for certain reasons are unable to avail themselves to a sufficient extent of their waste gases for power production purposes—it becomes necessary either to produce their own electricity in the most economical form, from coal, or else to purchase it from the power company.

In powers of, say, 1,500 kw. and upwards, it is possible with the most modern plant to produce electricity at rates from 0·32d. a unit and upwards, varying proportionately with local conditions and the price of coal, but in no case should the cost exceed 0·45d. per unit.

The financial gains and advantages to be derived from such electric rolling-mill equipments and complete electrification schemes may be tabulated as follows: (1) For rolling-mills in Class I.—*i.e.*, with blast furnaces attached. The possibility, now that the electric reversing-mill problem has been solved, of entirely dispensing with all coal-fired boilers and their attendant charges for firemen, conveyance of coal, removal of ashes, repairs and insurance costs, &c., the electric power for operating the complete rolling-mill plant and auxiliaries being primarily derived from the waste gases of the blast furnaces. (2) For rolling mills under Class II. with no blast furnaces attached. The entire removal of boiler plant as above in the case of a cheap outside power supply, or the great reduction in the number of boilers required for working the mills, and the generation of the power in any convenient spot within reasonable distance of the works, with high-tension mains to the rolling-mill balancer converters. (3) Increased output, the rolling-mill motors being made to run at any desired speed direct coupled to the rolls, the speed of rolling being controlled only by considerations such as the rapid handling of the material and the mechanical strength of rolls and housings. (4) Extreme simplicity of the direct-coupled electric reversing mill, the whole operations of rolling, reversing and speed regulation being controlled by one lever. (5) Decreased cost of upkeep, as, owing to the use of electric motors with their continuous rotary action and regular torque, the breakages of coupling boxes, standards, pinions and necks are reduced to a minimum. (6) Absolute control over rolling-mill costs and power absorbed at any stage of all rolling operations, by the use of electric recording and automatic instruments, such exact control having been impossible in the case of steam. (7) Gain in space formerly occupied by ranges of boilers, coal bunkers, railway sidings, &c., which in some overcrowded works, or where land is of high value, is an item of considerable importance. (8) The great reduction in power used in connection with reversing rolling mills, owing to the method of utilising a balancing converter upon the Ilgner principle, the energy absorbed by the converter, which is derived direct from the central generating station or mains, being about one-tenth of the maximum value or torque upon the mill, even when the load fluctuates on the mill between 0 and 10,000 H.P. (9) In the event of new mills being laid down, the ease with which the rolling-mill motors can be applied direct to the rolls without the necessity of large and costly foundations, as is the case at present with heavy reciprocating steam rolling-mill engines.

* Abstract of a Paper read at the recent annual meeting of the Iron and Steel Institute.

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(10) The very large reduction, in the majority of cases, of the power cost per ton of steel rolled, owing to the foregoing considerations. Less than 20 kw.-hours are used per ton of blooms rolled, which, in the case of mills having blast furnaces adjacent or waste gases available, and producing electricity at 0·25d. per unit, works out at under 5d. a ton.

The foregoing are the main advantages which present themselves to the author, but to steelworks engineers several subsidiary advantages may become apparent. With few exceptions, far greater attention has been given to this subject on the Continent than in this country, and it is undoubtedly high time that we in Great Britain fully realised this fact and, having studied the subject more closely, acted upon the result of our investigations.

Taking the case of a steelworks which, in addition to having a range of blast furnaces, has also its own collieries within a radius of 5 or 6 miles (or even more) of the works, it is possible, by taking full advantage of the power which can be obtained from the blast-furnace waste gases, to supply, from this source alone, the whole of the electric current requisite in the working of the collieries, as well as all the power applications which have to be dealt with in the steelworks and rolling mills themselves.

It is in connection with the high-powered reversing-mill engines that the greatest saving of all will be effected. Even the best steam rolling-mill engine, owing to its intermittency of working and rapid reversals, as exemplified in the case of cogging-mill engines, is necessarily a heavy consumer of steam. In some cases the exhaust steam from these wasteful engines has been utilised in low-pressure turbines, upon the regenerative principle, this until now being the best solution of a bad job. Since the successful application of electricity to reversing mills, this can only be now considered as but a half measure, and one that does not touch the root of the evil—viz., the rolling-mill engines and their attendant ranges of boilers, &c.

Having touched upon the salient points to be borne in mind in connection with complete electrification schemes for steelworks and rolling mills, the actual methods by means of which these results are arrived at will now be dealt with, and this cannot be better done than by taking as an example the actual case of the Hildegardehütte at Trzynietz in Austrian Silesia.

This reversing mill was started on July 27th last, and has been running ever since.

The Hildegarde Works were formerly owned by the Archduke Frederic of Austria, and within the last few years were purchased by a company. On assuming possession the new owners set themselves to reconstruct the works in the best possible manner, and electricity was chosen as a means of bringing the plant up to a state of modern efficiency. Apart from the reversing and continuous rotation rolling-mills, there were, as is the case in all other steelworks, a large number of auxiliary steam engines of moderate powers, and these alone, while presenting no great difficulties in the way of adaptation to the new and improved conditions, showed very considerable returns on the necessary capital expenditure. The company, however, looked further than this, and wished to consider the driving of the rolling mills, keeping in mind the possibility of concentrating the whole of the power required for the works in one large central power station.

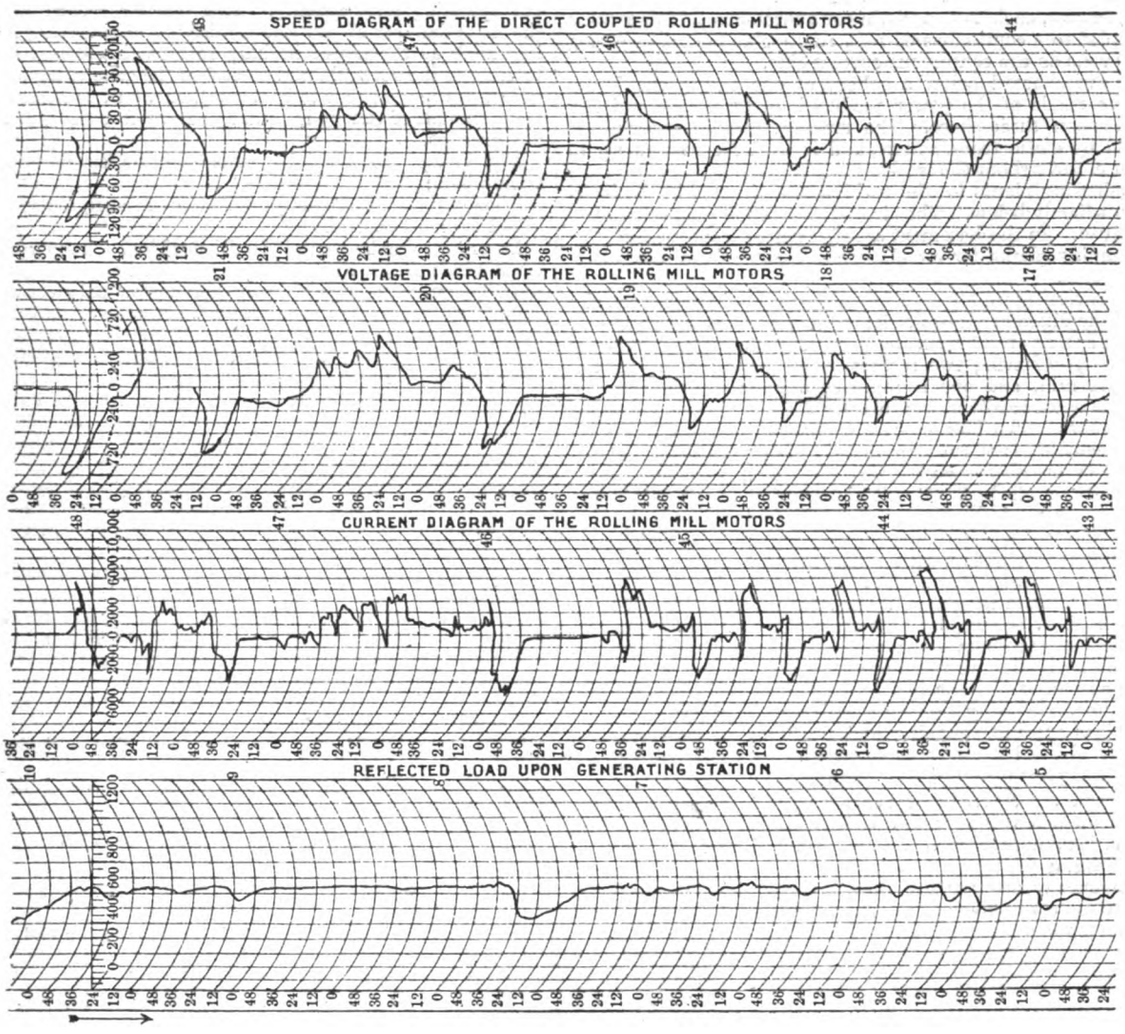
SPEED DIAGRAM OF THE DIRECT COUPLED ROLLING MILL MOTORS
VOLTAGE DIAGRAM OF THE ROLLING MILL MOTORS
CURRENT DIAGRAM OF THE ROLLING MILL MOTORS
REFLECTED LOAD UPON GENERATING STATION

FIG. 1.—DIAGRAMS TAKEN WHEN ROLLING BARS.

It was decided for several reasons to adopt a steam turbine station. Originally 54 boilers were required to raise steam for the whole works, and since the conversion of the works to electric driving up to the present time this figure has been reduced to 17 boilers. It must be borne in mind, however, that some of these remaining boilers are required to provide steam for the steam engines still in use, and it is expected that this number will be considerably reduced when these engines are dispensed with. Eight boilers are actually required to steam the electric power station, all fired with gases from the blast furnaces, and thus the whole of the power production is obtained on highly economical modern lines.

At the present time the plant driven is as follows: One reversing rolling mill, 10,350 H.P. maximum; one non-reversing mill, 750 H.P. normal; and 800 motors varying from 5 to 70 H.P.

In addition to the above must be included the electric lighting of the works.

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Further extensions are about to be made—viz., two continuous rotation rolling mills, each 750 H.P. normal capacity, together with sundry pumping plants and other auxiliary plant about the works. When these are completed the whole of the power items, with the exception of the blowing engines, will derive their power from the one electric power-generating station.

In the station are installed the following plants:—

One Parsons type three-phase turbo-generating plant, the turbine being constructed by the Ersten Brunner Co., and the alternator by Messrs. Brown, Boveri, having an output of 3,000 kv.-amperes, 50 cycles, 3,000 volts, at 1,500 revs. per min, or giving, with a power factor of 0·8, an output of 2,500 kw.

On the opposite side of the house are placed in line two turbo-alternators by the Allgemeine Elektricitäts Gesellschaft, of Berlin, each having a capacity of 1,250 kv.-amperes, or 1,000 kw. on a power factor of 0·8.

In the station there are also two motor-generators for electric lighting purposes, each set consisting of a three-phase high-tension motor coupled to a continuous-current multipolar generator giving 220 to 230 volts on the continuous-current side.

A main switchboard below a gallery at one end of the house controls the whole of the power produced on both high and low medium tension three-phase. The medium tension three-phase is obtained by static transformers, and is used for motors up to about 40 H.P. throughout the works.

The condensing plants for the turbines are situated in the basement, immediately below. The air and circulating pumps are electrically driven. In the basement are also placed three electrically-driven pumping plants for circulating the water from the blast-furnace tuyeres.

The non-reversing mill is rope-driven by three-phase motors. On account of the different classes of its work it was deemed necessary to have two speeds on the mill, and these are obtained in an unusual manner—viz., by having two motors, one running at a speed of 210 revs. per min., and one running at a speed of 160 revs. per min., both coupled together, and driving the mill from one end by means of ropes. The idea of having two motors was to obtain economical conditions of running on both the fixed speeds. Intermittent speeds are also arranged for. The motors are three-phase, and are run direct off the 3,000 volt high-tension circuit. Only one of the motors is used at a time, a change-over switch transferring the load to one or the other, depending on the speed required.

Proceeding to the item which constitutes the main interest of this Paper—viz., the reversing mill: The duty of the mill is to roll ingots of a maximum weight of 2 tons, having dimensions 16½ in. square plus 18 in. square, by approximately 5 ft. 6 in. in length, cogging these ingots down to suitable billets for rails, girders, &c., and proceeding further to roll them into girders and rails. The maximum size of H girder rolled in the mill is 18 in. deep by 7 in. wide, and the usual heavy sections of rails are also rolled. The mill thus combines cogging, roughing and finishing in one operation, and the time allowed for the complete rolling of the largest girder section from ingots is from 5½ to 6 minutes.

Three continuous-current motors are coupled to the shaft. These motors are for 330 volts, 120 revolutions normal, 1,200 normal to 3,000 B.H.P. maximum, to which must be added an extra overload capacity, bringing the total capacity to a maximum of 10,350 B.H.P. For convenience of manufacture, the shaft carrying the armatures of the three motors is divided into three, with rigid couplings fixed between the motors.

There is also a flywheel balancing plant, consisting of one three-phase motor, coupled through two flywheels to two continuous-current generators. This balancer is on the Ilgner system, and is the crux of the whole situation, forming the medium whereby the excessive peaks caused by rolling and reversing are reduced to a mean, straight and comparatively low load-line demand from the power station.

The three-phase motor in the centre derives its energy from the 3,000 volt circuit. The capacity is 393 amperes, 3,000 volts, 50 cycles, running at a speed of 370 to 310 revolutions. The armatures of the two continuous-current dynamos on the balancing set are connected in series with each other, and directly in series with the three armatures of the rolling-mill motors. Thus there is no interruption or break whatever in that portion of the circuit carrying the large main currents.

The two flywheels forming the intermediate buffers between the motor of the Ilgner set and the two continuous-current generators are each 13 ft. in diameter, and weigh 26 tons each. Water-cooled brakes are provided on the flywheel peripheries for stopping the set, when required, in a short time.

There is also a plant consisting of three machines coupled together, forming the starting and excitation machines. The centre machine is a three-phase motor which receives its energy from the high-tension circuit at 3,000 volts. The maximum capacity of this machine is 150 H.P. when running at a speed of 585 revolutions per minute. The machine on one side consists of the continuous-current dynamo for exciting the shunt of both the mill motors and Ilgner generators, while the machine on the other side provides current for the excitation of a special compound winding upon the three rolling-mill motors. Automatic liquid rheostats insert resistance into the rotor of the three-phase motor driving the balancing set, thereby dropping the speed of the set and permitting the two heavy flywheels to give off their energy.

The author emphasises the fact that, in the case of the electric drive, even when the attendant leaves the full current on his motors, the increase in speed is practically negligible at the moment when the billet leaves the rolls. This is on account of the fact that the motors are provided with a compound winding, which has the effect of preventing any great variation in the speed between no-load and full load.

If the motor driver pulls out his controlling lever when the ingot is still in the rolls, as he should do, the mill then comes to rest immediately the ingot leaves the rolls. If he delays to do this, he has the ready means of braking the motor in an instant by reversing the operating lever quickly. This braking, incidentally, is one of the main features of the electric driving of reversing rolling mills, inasmuch as the act of braking returns the energy developed in braking to the network, and so assists the generating station. This advantage may appear to be a small one, but, as a matter of fact, a large amount of energy is actually returned to the system in every-day practice.

Fig. 1 gives the actual diagrams taken on the electric drive when rolling bars.

The author in his Paper gives details of the Ilgner system and the Ward Leonard control.

In order to make himself familiar with the many varying conditions which obtain at different works, he has, during the past few months, visited a large number of the principal steel works in this country as well as on the Continent. In many cases the reduction in working costs which can be effected are enormous, and would in themselves represent a dividend by no means negligible upon the total capital of the firms in question.

If steel makers in this country are to maintain their position when prevailing prices are at a low rate, they cannot afford to let matters of such moment pass unnoticed, and the author would urge upon them the most minute consideration to this important subject. The first reversing rolling mill just described has only been in operation about nine months, and already the continental steelworks owners and engineers have lost no time in availing themselves of this new innovation.

Two electric reversing rolling mills of 10,000 H.P. each have been started up at the Resicza Ironworks in Hungary, while another electric reversing-mill of 15,000 H.P. is being erected at the Rombacher Ironworks, near Metz, and yet another is to be installed at the Hüstener Works, Hüsten. It will therefore be apparent from the rapidity with which the matter has been taken up on the Continent what very great importance is attached to the subject.

Indeed, in the author's opinion, the day of the electric rolling mill has come, and it has come to stay. The preliminary electric rolling mill equipments to which he has alluded are but the first stepping stones to a complete revolution in the methods of rolling iron and steel.

ELECTRIC BAGGAGE TRUCKS.

For carrying baggage and mails between trains and the baggage and mail-rooms of stations, the Pennsylvania Railroad Co. has recently built three electrically propelled trucks. Two are in service in the Broad-street Station, Philadelphia, and the third is in Altoona.

Although similar in general appearance, the three trucks are not alike. They are regarded as still in the experimental stage, and monthly reports of operation are compiled with a view to developing the best type for general use. The following description applies to the particular truck which has been found to be most serviceable up to the present time.

In general appearance, the truck is similar to the hand-drawn type universally used throughout the country. It is operated by one man, who walks ahead of it and steers it with a tongue or handle, in the same way that he would if it were not electrically propelled.

Power is taken from a storage battery contained in a box secured to the under side of the platform near the middle. It consists of 14 Willar cells, and has a capacity of 136 ampere hours. The batteries are charged for about eight hours daily at the rate of 17 amperes.

Each of the rear wheels is driven by a Westinghouse type AA, four-pole series-wound, 20-volt motor. Double reduction gearing is used between the motor and rear wheel, and each motor is provided with a solenoid brake of the multiple disc type on the end of its shaft. These brakes form an essential element in securing safe operation; for the truck cannot start of itself even if it is on an incline, and if it is in motion it stops promptly and automatically as soon as the power is shut off.

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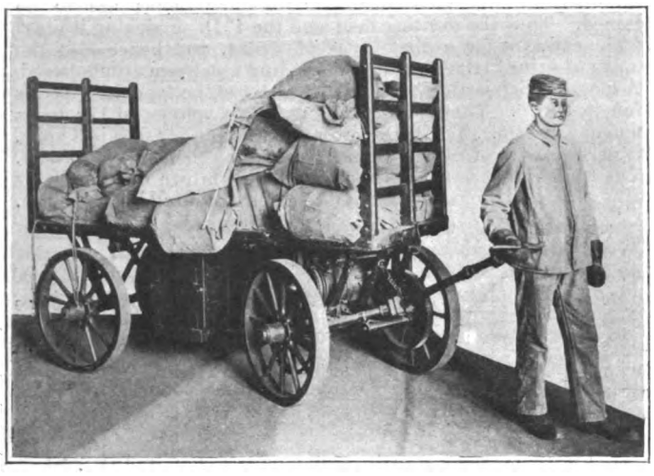
Control of the motor is made as simple as possible. Only two speeds forward and two backward are provided. These are approximately four and six miles per hour for the loaded truck, and on the crowded platforms they have been found fast enough.

The two motors are operated in series and on the low speed a wire resistance is inserted. The motor current is controlled by two single-pole solenoid switches; one for the low and the other for the high speed. The solenoid switches are enclosed in a box directly in front of the storage batteries, and current for operating them is controlled by contacts in a small box on the outer end of the tongue or handle.

The contact box is of metal, cylindrical in form, and operated by a rod which slides axially through it. The rod is provided at one end with a ring, which is readily grasped by the operator. A slight movement of the rod starts the truck forward at low speed; further movement of the rod gives the high speed. The rod is returned to the off position by a spring, so that the instant the ring is released the truck stops. It cannot be started by any accidental knock, but only by an intentional pull on the ring. The pole changing switch for running the truck backward or forward is located in the box with the solenoid switches and operated by a small lever under the front of the platform. The tongue or handle is connected by reach rods to pivoted bell cranks carrying the two front wheels in a way similar to that generally used upon automobiles.



View of Truck with Mail Bags.

This truck has been in operation about six months, and has won the confidence and approval of the men who use it. One man is enabled to handle the immense loads of baggage and mail quickly and without the usual tugging and pulling by several men.

THE NEW DOUBLE-CIRCUIT SINGLE-PHASE MOTOR OF THE FELTEN & GUILLEAUME-LAHMEYER WORKS.*

BY M. OSNOS.

A great deal of activity has recently been displayed in connection with single-phase commutator motors, but in spite of the numerous proposals that have been put forward, only a few types seem to have found application in practice. Among these latter is the motor developed by the Felten & Guilleaume-Lahmeyer Works, which possesses certain advantages over other types, and which has successfully withstood exhaustive and searching tests.

The motor is suitable both for continuous running, as, *e.g.*, for driving presses, pumps, machine tools, &c., and for intermittent work—as a crane, railway or lift motor. It is well adapted for use as a railway motor, since—as will be seen below—it may be given either a series or a shunt characteristic, and the transition from the one arrangement to the other may be effected by a simple single-pole switch (hand or automatic), and without any break in the circuit. Such a type of motor is particularly valuable on railways with steep gradients, since when working as a shunt motor it may be employed for regenerative control when running downhill, at the same time acting as a reliable electric brake.

Experiments carried out on the Homburg–Saalburg line with a car equipped with two 25 H.P. motors of this kind have shown that during the descent the energy returned to the line amounted to 50 per cent. of that absorbed in ascending.

The means employed for passing from the series to the shunt characteristic consist, in addition to the single-pole switch already mentioned, of a few additional windings on the stator, which form some 3 to 5 per cent. of the main stator winding.

In the present article the motor will not be considered as a railway, but only as a *lift* motor.

The conditions which should be fulfilled by a good lift motor are: (1) Large starting torque; (2) small starting current for a given P.D. of supply; (3) small value of volt-amperes per metre-kilogramme of starting torque; (4) sparkless running; (5) high power factor; (6) noiseless running, especially if the motor is to be used in a hotel; (7) constancy of speed at all loads when once the motor has reached its normal speed; the motor must thus possess a shunt characteristic under normal conditions of running.

Keeping the above requirements in view, we shall consider in how far the existing typical forms of single-phase commutator motor are suitable, and shall investigate the nature of a motor best adapted to fulfil the above conditions. The motors which we shall pass in review are the compensated shunt motor, the Atkinson repulsion motor, the series motor with neutralised armature reaction, and the compensated series motor.

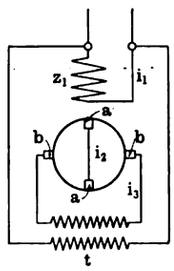


Fig. 1.—Compensated Shunt Motor.

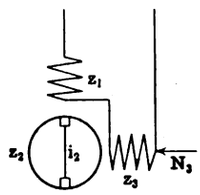


Fig. 2.—Repulsion Motor. (Atkinson's System.)

(*a*) Compensated shunt motor (Fig. 1). Let z be the symbol for number of turns, i for current and N for magnetic flux, the values of these three quantities in the different parts of the motor being indicated by suitable suffixes, as shown in Fig. 1, where N_1 and N_2 have directions along the line of the short circuit brushes *aa*, while N_3 coincides with the direction of the exciting brushes *bb*. Of the total flux N_1, due to the stator ampere-turns $i_1 z_1$, only a fraction $v_1 N_1$ enters the rotor, where $v_1 < 1$. The total torque T exerted by the motor may be regarded as the resultant of three torques—viz.:—

the torque T_1 between $v_1 N_1$ and $i_3 z_2$.
" " T_2 " N_2 " $i_3 z_2$,
and " " T_3 " N_3 " $i_2 z_2$,

so that $T = T_1 + T_2 + T_3$. If the magnetic reluctance has the same value along the two axes *a* and *b*, we have $\frac{N_2}{N_3} = \frac{i_2 z_2}{i_3 z_2}$, and $N_2 i_3 z_2 = N_3 i_2 z_2$, so that T_2 is numerically equal to T_3. It is not difficult to show that T_2 and T_3, while numerically equal, are of opposite sign.

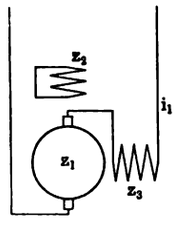


Fig. 3.—Compensated Series Motor.

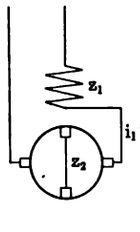


Fig. 4.—Compensated Series Motor.

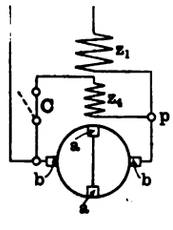


Fig. 5.—Double Circuit Motor.

Hence, $T = T_1$. If δ denote the phase difference between N_1 and i_3, we have

$$T = K v_1 N_1 i_3 z_2 \cos\delta \quad \ldots\ldots\ (1),$$

where K is a constant which depends, among other things, on the windings.

Now since the P.D. across the stator is nearly in phase with that across the brushes *b*, it follows that the value of δ will depend on the time constants $\left(\frac{\text{inductance}}{\text{resistance}}\right)$ of the two circuits. But the time constant of the stator circuit is nearly constant, while that of the rotor varies with the speed. If, therefore, the motor be designed so as to make the value of δ small under normal running conditions, the value of δ at starting will be large and the starting torque poor. For this reason the motor is unsuitable for lift work.

(*b*) Atkinson's repulsion motor (Fig. 2). If $N = v_3 N_3$ (where $v_3 < 1$) denote that part of the flux N_3 which enters the rotor, the torque is

* Abstracted from the *Elektrotechnische Zeitschrift*.

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given by $T=KNi_2z_2\cos\delta$, and since it may be shown that $i_2z_2=v_1i_1z_1\cos\delta$, we have

$$T=Kv_1v_3\,i_1z_1N_3\cos^2\delta \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

In this type of motor δ is nearly constant (assuming the effects of the short circuit currents and saturation to be negligible). But in lift motors whose output does not generally exceed 7 H.P., δ is not very small. Further, at the usual frequencies of 40 and 50 the motor would be built with a six-pole field, so that the values of v_1 and v_3 would also be small. Hence the motor possesses poor starting qualities.

(*c*) Compensated series-wound motor (Fig. 3). Since the flux N entering the rotor is in this case always in phase with i_1z_1, the torque is given by

$$T=Kv_1i_1z_1N_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

On comparing this with (2) we see that the factors v_3 and $\cos^2\delta$ have dropped out, and the motor will, other things being equal, give a considerably larger torque than Atkinson's motor.

(*d*). Compensated series-wound motor (Fig. 4). In this case we have

$$T=Kv_1N_1i_1z_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4),$$

and the torque is identical with that given by the ordinary series-wound motor.

From the above it appears that the ideal lift motor should combine the starting qualities of the compensated series motor with the running qualities of the compensated shunt motor shown in Fig. 1. The normal speed of this latter motor is not far removed from the speed of synchronism, at which a rotating field—resulting in a high power factor and good commutation—is produced.

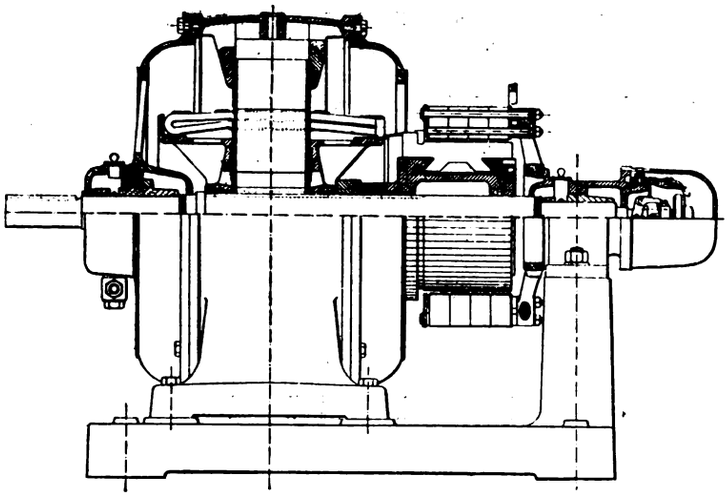

FIG. 6.—LONGITUDINAL SECTION OF DOUBLE CIRCUIT MOTOR. Scale 1 : 12.

Such a combination of the features characteristic of the motors shown in Figs. 1 and 4 has been attained in the new motor of the Felten & Guilleaume-Lahmeyer Works, the general arrangement of which is shown diagrammatically in Fig. 5. This motor possesses a stator winding, z_1, connected in series with the exciting brushes *b* and short-circuited working brushes *a*, arranged along the direction of the stator winding axis. In addition, there is provided a supplementary winding, z_4, having the same magnetic axis as the stator winding, and this may, by means of the switch C, be connected across the exciting brushes *b*. At starting, C is left open, and the motor starts as a series motor with a powerful torque; when a certain speed has been reached C is closed, and the motor becomes a constant-speed machine. As compared with the motor of Fig. 1 the new motor possesses the following advantage: In the motor of Fig. 1 the current between the brushes *b* has to be supplied entirely by the transformer *t*. In the new motor, on the other hand, the winding z_4—which we shall term the *transformer winding*—supplies only the *difference* between the exciting current and the stator current. The motor may be so proportioned as to make the stator current equal to the exciting current at normal load, in which case the transformer winding will take no current at all at normal load, and will only become active when the load rises above or falls below the normal. For this reason the transformer winding may be made very small, occupying but little space.

The starting torque of a single-phase commutator motor depends, for a given P.D. of supply, on the ratio $\frac{\text{exciting ampere-turns}}{\text{working ampere-turns}}$, and the question arises as to the value of this ratio which corresponds to the maximum value of the starting torque. Experiments carried out on this point have not led to concordant results. Now the author has succeeded, by purely theoretical reasoning, in establishing the general result that in the case of motors in which the working and exciting currents are in phase or nearly in phase with each other, maximum starting torque is obtained by designing the motor so that the volt-amperes used up for excitation equal $\frac{1}{3}$ of the volt-amperes corresponding to magnetic leakage.

In the case of lift motors it is, however, not in general desirable that the motor should exert the greatest possible starting torque, as the acceleration would be too rapid, and the starting jerky. A starting torque equal to 2·5 times the normal running torque is in most cases sufficient, and this, in the type of motor under consideration, is generally much below the greatest possible torque. A matter of much greater importance is to keep the volt-amperes per metre-kilogramme of starting torque as small as possible. The value of this quantity is again dependent on the ratio $\frac{\text{exciting ampere-turns}}{\text{working ampere-turns}}$, and the most favourable ratio is connected with the magnetic leakage of the motor. The author has found that the minimum value of the volt-amperes/metre-kilogrammes is obtained by making the exciting volt-amperes equal to the leakage volt amperes, and this conclusion has been amply verified by experiments.

It is a somewhat remarkable fact that the transformer winding z_4 (Fig. 5) is, for a given rotor winding, quite independent of the voltage for which the stator is to be wound. This is due to the fact that, in accordance with what has been said, the exciting field in the direction of the brushes *b* stands in a constant ratio to the stator field in the direction of the working brushes *a* if the best results as regards volt-amperes/metre-kilogrammes are to be obtained. Thus the exciting field and the P.D. producing it must remain constant for a given type of motor, and hence also the number of turns in the transformer winding must remain unaltered.

A longitudinal section of a 6·5 H.P. motor of the type described is given in Fig. 6. The motor is designed for a voltage of 120 and a frequency of 45·5. The P.D. across the exciting brushes is 6 volts. The performance of the motor is illustrated by the curves of Fig. 7.

The transformer winding is automatically thrown into circuit by means of a centrifugal device at the commutator end of the shaft,

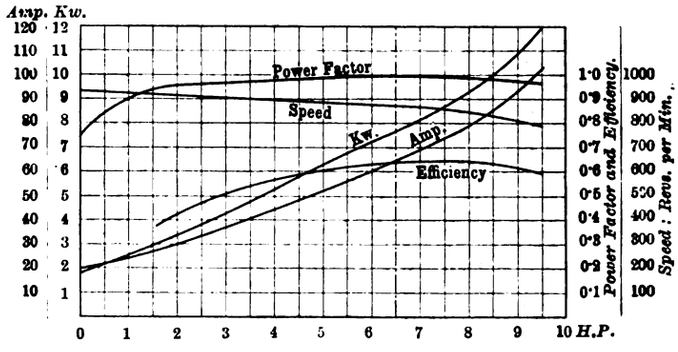

FIG. 7.—CHARACTERISTIC CURVES OF THE DOUBLE CIRCUIT MOTOR.

and the spring of the centrifugal device is so adjusted as to close the circuit of the transformer winding at the instant when no current will pass through it.

The motors are designed so as to be capable of direct connection to the mains at starting, without the use of any resistances. Their starting torque is 2·5 times the normal full-load torque, and the starting current is not much greater than twice the normal current.

THE OSCILLATORY DISCHARGE IN IRON WIRES.*

BY A. BATTELLI AND L. MAGRI.

1. One of the most important questions suggested by the study of oscillatory discharges concerns the form of the discharge when the field produced by it is occupied by a magnetisable substance such as iron.

It is certain by this time that iron easily follows the oscillations of the field, even when their period is as short as that of the Hertzian oscillations (10^{-8} sec.). Now if the iron is placed in the magnetic field of any oscillatory discharge it must exert some kind of influence upon that discharge itself. But this influence will be quite different according to whether the discharge passes through a long iron wire stretched in a straight line or through a solenoid, or a coil of copper wire with an iron core.

For in the first case the lines of induction are almost altogether outside the iron wire, and the change produced by it in the magnetic field (and, therefore, also in the inductance and the natural period of the circuit) is not great. Yet the influence of the iron upon the form of the discharge will be very perceptible, for the high value of the magnetic permeability brings it about that the

* Translated from the *Physikalische Zeitschrift*, May 1st, 1907.

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Foucault currents in the wire become strong enough to make the surface layer traversed by the discharge very thin. In this manner the resistance becomes very high, and the damping becomes very pronounced.

But when the iron forms the core of a copper wire coil traversed by the current, the lines of magnetic induction are largely confined to the iron, and the magnetic energy of the circuit (and, therefore, also the inductance and period) are sensibly affected. In this case, also, the Foucault currents in the iron tend to confine the magnetised layer to the surface, and since both the parasitic currents and the work of magnetisation absorb a considerable amount of energy, the damping of the discharge is increased in this case also.

The theoretical investigations already made in this connection are the well-known treatments concerning the passage of sinusoidal currents through a wire of constant permeability μ, and Barton's studies, which also deal with the damping, but always assume μ to be constant. The experimental results may be summarised as follows: Trowbridge could only trace in thin wires an increase of period consequent upon high values of the magnetic permeability; Emden found the same increase under conditions which he does not describe in detail; Klemencic, and later Broca and Turchini, determined μ for rapid oscillations by calorimetric measurements and obtained concordant values. Saint John did the same by very accurate measurements of the wave-length of electric oscillations in iron wires, but found values for μ which are much larger than those found by Klemencic before him, and again by Broca and Turchini afterwards.

But all the physicists mentioned only concerned themselves with the rate of change of the field, without regard to the magnetising force, and their results are, therefore, not comparable with each other.

It is necessary to take this fundamental condition into account, and this has not been properly done hitherto. Since in the case of slowly-changing fields the value of μ changes with the magnetising force, there is no reason to doubt that similar changes must also take place in rapidly alternating fields. We must, therefore, learn to understand what significance the permeability has for an electric discharge. Neither the calorimetric methods, nor the measurements of frequency as carried out by Trowbridge and Emden, nor measurements of wave-lengths will yield us anything but a mean value, and even that only in rough approximation. We can also say beforehand that this mean value depends essentially upon the maximum intensity of the discharge current and the thickness of the wire.

This accounts for the differences in the results obtained by these investigators in spite of the greatest care.

2. This led us to make new experiments in order to analyse the oscillatory discharge in iron wires by measuring the period. In view of the difficulties introduced by damping we took every imaginable precaution. We used thick wires, and constructed our apparatus with such precision that we could discover the difference of period in iron as against copper, which had escaped Trowbridge.

Our arrangement was the same as that used in 1902. We first used the same two air condensers, having a capacity of 14,175 cm. when parallel, and of 3,568 cm. when in cascade.

The discharge circuit consisted of a well-annealed iron wire 0·9178 cm. in mean diameter, bent into a circle 296 cm. in diameter. This wire was mounted on a wooden cross with four ebonite blocks, and was mounted in free air at a distance from the walls of the room. The wire was 929 cm. long, with a gap in the circle 1 cm. wide. Such a wire, if possessing unit permeability, would have an inductance of 11,355 cm. for $n=0$.

The connections between this discharge circuit, the condenser and the spark micrometer were made by those brass tubes possessing an aggregate inductance of 1,693 cm.

With these conditions we succeeded in observing for every spark five complete oscillations, or four in the case of the slower ones, which was very favourable.

Wherever possible we made two measurements with each plate, at the images of the upper and lower electrode respectively. This was not possible in the cases where the elementary sparks proceeded from different parts of the electrode. Sometimes one electrode gives clear images and the other electrode blurred ones, so that it is not always possible to measure both simultaneously.

In Tables I. and II. we reproduce two series from our diary.

For calculating the mean value each measurement was credited with the number of periods counted.

The values obtained with iron in the discharge circuit, and especially those in Table I., cann t claim the accuracy attainable with copper circuits, for the damping diminishes the number of elementary sparks, and thus considerably increases the length of the images on the plate. At the shorter periods especially the small displacements of the spark on the electrode seriously mar the accuracy of the measurements, and the difference in the brightness of successive sparks composing a discharge becomes so great that the negatives show great variations of intensity in different parts. Besides, the sparks may be actually more irregular than those obtained with non-magnetic material of low resistance. Thus in

Table I.

C = 3,568 cm. Spark-gap 2·5 mm.

No. of plate.	Periods measured.	Result.	No. of plate.	Periods measured.	Result.
1	5	0·000001580	9	7	0·000001424
3	4	1317	9	4	1406
4	5	1335	10	8	1522
4	5	1428	10	4	1465
5	6	1481	10A	6	1465
5	5	1506	10A	6	1363
6	6	1470	12	7	1460
6	5	1469	12	7	1454
7	8	1453	13	5	1554
7	4	1478	13	5	1492

Mean: $0{\cdot}000001455 \pm 0{\cdot}000000006$.

Table II.

C = 14,175 cm. Spark-gap 2·5 mm.

No. of plate.	Periods measured.	Result.	No. of plate.	Periods measured.	Result.
15	4	0·000002953	17	4	0·000002927
15	5	2888	18	4	2820
16	3	2955	18	4	2835
16	5	2887	19	4	2916
17	4	2856			

Mean: $0{\cdot}00000289 \pm 0{\cdot}000000008$.

Table I. we have discrepancies of 10 per cent., whereas in Table II. they are only 2·5 per cent.

Having experimentally measured the period we may easily calculate the value of μ by the relations

$$\left(\frac{T_\mu}{T}\right)^2 L' = L'_\mu, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$L'_\mu - L' = l\left(A + \sqrt{\frac{\mu\sigma_1}{2\pi p r^2}}\right) - l\left(A + \sqrt{\frac{\sigma}{2\pi p r^2}}\right). \quad . \quad (2)$$

In these two equations T_μ is the experimental value of the period with the iron circle, T the period in a geometrically identical copper circle, L′ the inductance of the whole circuit comprising the copper circle, L'_μ the observed value of the inductance with the iron circle, σ_1 the resistivity of the iron, σ that of copper, r the radius of the wire, l its length, and p the frequency multiplied by 2π.

In these formulæ it is implicitly assumed:—(i.) That the effect of damping upon the duration of the oscillations may be neglected. (ii.) That the frequency is great enough to admit equation (2) instead of the corresponding series. (iii.) That the damping is small enough to allow of Barton's correction being neglected.

In examining the photographs we must take into account that the number of elementary sparks which leave a sufficient impression upon the plate is smaller than the number of sparklets which really compose the discharge.

Taking this into account, the photographs show that the damping of the discharge is sensibly greater than it would be with copper, but not sufficiently so to perceptibly increase the value of the period. This is corroborated by the following fact: Assuming for R and L the values given by known data for μ between 100 and 600, and using these to calculate $R^2/4L^2$, this shows itself to be barely a few 10,000ths of the value of 1/LC, and may, therefore, be safely neglected.

As regards the applicability of the usual formulæ, we must remember that in our periods we always had $n > 10^{-6}$, and hence

$$\sqrt{\frac{8\pi^2 n_\mu r^2}{\sigma}} > 3\sqrt{\mu}.$$

However small μ may become, it always, in these experiments, exceeds the limit above which these formulæ are valid.

Finally, as regards the correction calculated by Barton, it must be remembered that the maximum value of k here attained was always less than 0·1. Hence the correction for the resistance is less than 5 per cent. The inductance correction, which is here specially interesting, is of the order of 20 cm., and this is also negligible in comparison with 10,000.

In these first two series the values for T were calculated from the dimensions of the circuit. For L^1 the values were those corrected according to Rayleigh.

The results were:—

	First series.		Second series.
T_μ	$1{\cdot}455 \times 10^{-6}$	.....	$2{\cdot}89 \times 10^{-6}$
T.....	$1{\cdot}404 \times 10^{-6}$	.....	$2{\cdot}80 \times 10^{-6}$

It is evident that the influence of magnetic permeability is very slight, but it is certainly greater than the errors of observation.

3. We eventually carried out a third series of measurements on this subject, using a glass plate condenser with a capacity of

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98,100 cm. and a discharge circuit of iron wire 2·44 mm. thick, bent into a square of 200 cm. side.

This time we considered it advisable to compare the period obtained with the iron wire with that obtained with a geometrically identical copper wire. In this way we meant to avoid the uncertainty liable to affect the condenser capacity owing to glass being the dielectric. In any case, the agreement between measurement and calculation was good in the case of the copper wire, especially considering that the value resulting from the measurement of the capacity is surely greater than what would correspond to such short periods.

The arrangement was nearly the same as that used in the earlier experiments. The discharge circuit consisted of a spark micrometer, the square of iron or copper wire, and the three brass tubes joining the various parts of the circuit with each other and with the condenser and representing an inductance of 1,232 cm.

Although both the copper and the iron wire had been drawn through the same machine, their diameters were slightly different, the copper wire being 2·47 mm. and the iron wire 2·44 mm. in diameter.

The copper wire showed for $n=0$ an inductance of 10,980 cm. Had it possessed exactly the diameter of the iron wire, its inductance would have been 11,004 cm. The difference of 24 cm. can be safely neglected in these measurements.

We here quote the results obtained with the copper wire :—

Calculated Values for T.
0·00000704
0·00000705
0·00000703
0·00000709
Mean..... 0·00000705

It will be seen that when the discharge circuit consists of non-magnetic material, the measurement of the period is very exact.

The value for the inductance of the copper wire, corrected according to Lord Rayleigh's formula for T = 0·00000705, becomes 10,688 cm.; on adding another 1,232 cm. for the connections the theoretical value of the inductance for this period becomes 11,920 cm. If we now calculate the value of T from the measured capacity of the condenser, we get for T the value 0·00000716, which agrees well with the experimental value, but is slightly larger, as might have been expected.

We now replaced the copper wire by the iron wire, and obtained the following results:—

Calculated Values for T.
0·00000815
0·00000772
0·00000805
0·00000762
0·00000765
0·00000775
Mean value... 0·00000782

On every plate we had an image of seven half-periods, and each image occupied a length of 4 cm. The conditions for measuring the period were, therefore, favourable. The deviations from the mean value above must, therefore, not be ascribed to inaccuracies in the measurement of these images. They are a proof that the maximum field intensity changed from one case to another, and that even with such rapid oscillations the phenomena of magnetic saturation of iron come into play.

4. We may now summarise the results of our measurements of μ, and confront them with the maximum field intensities. This field H at the surface of the wire is, as we know, given in absolute electromagnetic C.G.S. units by the equation

$$H = \frac{2I}{r} = \frac{4\pi CV}{T\mu r},$$

Where I is the greatest amptitude of the current, C the capacity, V the discharge potential, and r the radius of the wire. The discharge potential was in our experiments 30 electrostatic units. We therefore had the following values :

Series.	Period.	Maximum field.	Permeability.
I.	$1·455 \times 10^{-6}$	65	600
II.	$2·89 \times 10^{-6}$	180	240
III.	$7·82 \times 10^{-6}$	340	70

This table clearly shows that with increasing H the phenomena of magnetic saturation come into play, and the mean magnetic permeability of the iron becomes decidedly less.

The table also shows distinctly that the value of μ does not depend essentially upon its frequency, since it assumes its greatest value for the shortest period. On the other hand, it depends essentially upon the field H. This suffices to explain the different results obtained by various experimenters.

5. To recapitulate, these researches prove—(i.) That iron behaves as a magnetic material of high susceptibility, even at very high frequencies (about 10^7 per second). (ii.) That the permeability changes with the magnetising field. (iii.) That the variability of μ with the field invalidates the usual formulæ for the inductance and resistance.

In view of the variation of μ with H, the duration of the successive oscillations composing the discharge can hardly remain the same throughout the discharge. But the measurements carried out under the conditions described, though they indicate some such irregularity, are not sufficiently accurate to determine the difference between two successive periods.

THE WATER POWERS OF PERU: THEIR DEVELOPMENT AND POSSIBLE APPLICATIONS.*

Summary.—The purpose of this article is to describe the amounts and relative locations of the water powers of Southern Peru, the feasibility of their development, the present and prospective demand for power in the locality, and the possible application of electricity to old and new industries, the Tambo Valley and Lake Titicaca being the sources of supply, and the towns of Mollendo and Arequipa the markets for consumption, of the power produced.

The present developments of the southern Peruvian water-power, reports Mr. Guarini, professor of physical and electrical science at the "Escuela de Artes y Oficios" of Lima (Peru), are insignificant, being limited to a 1,000 H.P. installation furnishing light and power to Arequipa, and a very modest private lighting plant in the Tambo Valley.

At Mollendo there is to-day no power plant of any description. The Peruvian Corporation is about to instal a steam plant to furnish power for industrial purposes and harbour work during the day and for public lighting at night. The high cost of fuel and the uninterrupted demand for power during the 24 hours, however, make the advantages of a water-power installation apparent.

In the immediate vicinity of Mollendo, in the Tambo Valley, there are a number of small streams capable of developing several hundred horse-power, which can be easily utilised and transmitted electrically. The utilisation of the city's water supply to operate a wheel before entering the distributing mains suggests an alternative source of power. Mollendo gets its water from the mountains at an elevation of 2,800 metres above sea-level, whence it is conveyed a distance of 140 km. through pipes 20 cm. in diameter at a rate of 20 litres per second. Allowing for all losses the theoretical available power would be 320 H.P. But the line is sectioned off at different levels to supply intermediate towns, and even if it were not the water pressure would be excessive.

The power problem would consequently have to be solved by either of the following methods:—(1) By installing a water-wheel and alternator at the mouth of each reservoir, by which means 250 H.P. could be delivered in this manner at Mollendo. (2) By building two reservoirs at Mollendo, at different levels; the lower one to be used as the supply reservoir proper for distribution, and the other as a water-power storage basin, which would empty into the lower reservoir during lighting hours.

According to Mr. Guarini, the Tambo Valley abounds in small water powers which could be easily developed to supply power to run the machinery in the sugar mills that dot the valley during the day, and to light the many estates and farms at night.

At Arequipa the "Sociedad Electrica de Arequipa" owns and operates a hydro-electric central station at a place called Charcani, about 11 km. from the town, the motive power for which is supplied by the Chile River, with a maximum capacity of 1,000 H.P. Mr. Guarini says that Arequipa to-day uses 10 arc lamps and 4,391 incandescent lamps of different ratings. But the lighting is most unsatisfactory, and the streets are frequently in darkness.

The Sociedad Electrica de Arequipa, it must be admitted, is now installing an additional 500 H.P. equipment, which should suffice for present requirements, although, as a matter of fact, an entirely new hydro-electric plant would be advisable in order to bring the light and power service up to the standard expected in a first-class city of the importance of Arequipa.

Another source of supply, Prof. Guarini writes, should be the Chile River, which is easily capable of furnishing all the motive power necessary for the purpose, representing, as it does, a colossal hydraulic force hitherto overlooked.

Mr. Habich, director of the Technical School of Lima, in an article puplished in the *Bulletin* of the Mines of Peru, in its issue of July 31, 1901, pointed out that Peru, with its rivers descending from elevations of 3,000, 4,000 and 5,000 metres, possessed incalculable sources of power, and showed that the Rimac River alone was capable of developing at least 100,000 H.P.

Returning to the River Chile itself, and basing calculations from

* Abstracted from the *Engineering Magazine*.

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a point a little above the location of the present station at Charcani, about 3,000 metres above sea level, Mr. Guarini estimates that this stream carries a volume of water of 6 cubic metres per second, equal to a theoretical force of 240,000 H.P. By properly damming the Chile between Charcani and sea level it would be easy to develop a minimum effective power of 100,000 to 120,000 H.P. The suitable development of this power would give a supply of electrical energy sufficient for the electrification of the railroads of southern Peru.

The next and by far the most important source of water power supply of Peru is Lake Titicaca, lying 3,800 metres above the level of the sea, with a surface area of 6,600 sq. km., and an average depth of 20 metres. But Lake Titicaca lies in a hollow, surrounded on all sides by an unbroken ridge of mountains, ranging from 250 to 800 metres in height, presenting a formidable engineering problem which can be overcome by only two solutions: either tunnelling through the mountain or pumping the water up and over the lowest practicable eminence.

The distance from Lake Titicaca to the Pacific Ocean, as the crow flies, is 250 km. According to surveys the shortest practicable tunnel that could be bored through this natural barrier to the nearest valley would be between 35 and 40 miles long; this, while entailing an enormous cost, would greatly shorten the transmission line.

An alternative plan is to pump the water over the side of the mountains, on certain assumptions.

Prof. Guarini shows that after allowing 1,914,667 H.P. for losses from all sources in the turbines, generators, &c. (which is extremely liberal), a net surplus of 2,000,000 H.P. of electrical energy would be left available for sale.

The market for this supply of power would be in its application to the electrification of present steam roads and the operation of new electric properties, mining and agricultural industries, public and private lighting, the manufacture of carbide of calcium at the coal mines, the operation of overhead conveying cables which are in general use in Peru, and for heating, household and general power purposes.

AUTOMATIC CALLING DEVICE FOR A WIRELESS TELEGRAPH STATION.*

BY W. R. CARROLL.

The author gives an account of his automatic calling device in use at Yerba Buena Island, San Francisco Bay. The station communicates regularly with the Navy's wireless stations at Mare Island on San Pablo Bay 20 miles away and with Farallone Islands 35 miles at sea beyond the Golden Gate. The transmiting apparatus is similar to that in use at all modern wireless stations. The receiving devices include a coherer system with tape recording apparatus, an electrolytic receiver with high-resistance double-head telephone receivers and a magnetic detector so arranged that it can be left attached to the transmitting aerial at all times even when sending. By this arrangement it becomes possible for the receiving station to "break" the sending station, just as is true on land-lines, and to secure at once a repetition of lost signals instead of waiting until the sending has ceased as is done with all other receivers.

The auto-sender is shown in the accompanying diagram. There are four transmitting or type wheels and a half-wheel or aerial control wheel as it may be called. The calling wheels bear the call letters of the different stations, TG being Mare Island and TH Farallones. The wheels V and V-MK are for sending out a continuous train of V signals for the adjustment of another station. All of these wheels and the half-wheel are on a common shaft which also carries the drive wheel of a set of gears which propels the travelling iron core of the magnetic detector, and the whole is belted to a small motor. The speed of the motor is controlled by a slide rheostat, and a telephone hook switch in the circuit serves to set the mechanism moving when the telephone is taken up for receiving or whenever it is desired to start the automatic sending. Underneath the lever of the sending key K is an armature and an old pair of relay magnets having a resistance of 75 ohms, which, actuated by a shunt circuit from the main battery, serve to manipulate the key whenever the circuit is closed at one of the contact points *d* by the flat spring *g* when the latter is pushed into contact by the teeth on the rim of the type wheel. A condenser or a lamp, *e*, of suitable resistance is shunted across this make-and break to obviate the spark and render the signals sharp and clear. This form of make-and-break is well adapted for telegraphic work. The switch G connects to the wheel desired or it opens the circuit entirely for hand sending with key K.

The half-wheel is not fastened rigidly to the shaft but is held by means of a compression spring under a nut on the end of the shaft. If it is desired to send V signals or call continuously, when the detector is used the aerial switch A is moved to the point *c* and the back arm catches on a stop pin, *c'*, on the half-wheel, thereby stopping it and placing the aerial in permanent contact with the detector D. If the detector is not to be used the back arm is placed on a stop pin, *ab'*, just an instant after the spring brush *s* has slipped off the segment and the aerial is no longer in contact with the half-wheel. The contact *xy* at the spring brush *x* at the opposite side of the half-wheel serves to keep open or close the magnet circuit as the segment revolves. When the switch A is on either *a* or *b* and the half-wheel is free to revolve it closes the magnet circuit just an instant after the aerial spring S flies open, and when the segment moves around and again engages the aerial in contact the magnet circuit is broken and the transmitting signals cease.

The signals on each half of the wheels TG and TH are composed of the letters three time repeated and signal TI, the last being the call letter of Yerba Buena station. When the control wheel is in motion the magnet circuit is broken one-half of the time. By this arrangement the calls are not continuous but intermittent, and during the interval the coherer or electrolytic receiver is thrown in circuit and the station called may reply and business then proceed in the usual way. If it is desired to call continuously the back arm is placed in contact with pin *b*.

When the V or test signals are sent out signed MK, as occurs once in each revolution of the wheel occupying about one-half minute, the receiving station is aware that the sending station is using the magnetic detector and that it can "break" and interrupt the signals when enough test signals have been received to have secured the desired adjustment. Should the sending station operator be called away to some other duty he switches over to the plain V wheel and allows it to continue sending for some prearranged time as agreed upon for adjusting purposes.

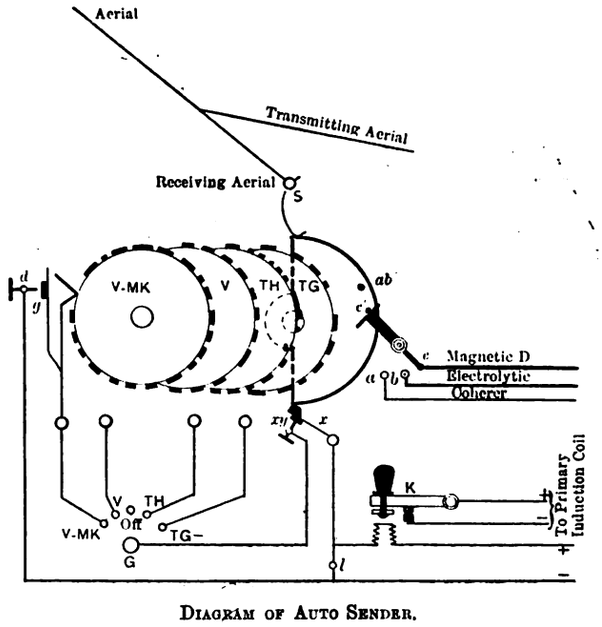

DIAGRAM OF AUTO SENDER.

In order to have type wheels for any call letter desired, a wheel is made with changeable teeth. With floating (ship) wireless stations coming in contact every day with new stations this arrangement would be quite useful. The type wheel and make-and-break as used in this device are what is known as the Omnigraph transmitter and are made by the Omnigraph Co. of New York.

Improvements in Electric Glow Lamps.—An invention lately patented by the Deutsche Gasglühlicht Aktiengesellschaft relates to tungsten filament glow lamps, and consists in employing carbon suspenders in place of the suspenders of metal or the refractory metallic oxides which have hitherto been generally used for this purpose. As carbon possesses the property of good radiation for heat rays this support remains comparatively cool, even near the point of contact, and can, therefore, be made very thin. Carbon suspenders have been found to be unsatisfactory for osmium lamps owing to the formation of osmium carbon compounds, but this objection is not present when tungsten is used. The suspender is attached to the filament by means of a suitable cement, the carbon being made of such thinness that it will allow sufficient movement in the lamp filament when switching on and off, and rupture of the filaments is thus prevented.

* Abstracted from the *Electrical World*.

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ETHICS IN ELECTRICAL ENGINEERING.

Following the example of the Institution of Electrical Engineers, whose Council issued certain rules in reference to professional etiquette in 1902, the American Institute of Electrical Engineers is now considering a code of ethics drawn up by Messrs. C. P. STEINMETZ, H. W. BUCK and S. S. WHEELER. The distinction between etiquette and ethics appears to be that professional etiquette is more concerned with the making of money, or at least with the obtaining of work, and ethics are concerned with broader principles. This much may be gathered if we can take the respective documents as a criterion. The Council of the Institution of Electrical Engineers concerned itself principally with the question of advertising, or soliciting work, on the part of consulting engineers, and the receipt of commissions for services rendered. The Committee of the American Institute have entirely neglected the question of advertising, but have considered in quite an elaborate way the principles which should underlie the work of all their members, whether consultants or not. These principles are discussed under six headings.

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Under the first heading—namely, General Principles—it is laid down that association should be avoided with any questionable projects, even if the engineer is only concerned with their engineering features, and considerable stress is laid upon the question of standardisation. Paragraph 5, which deals with this point, reads as follows: "The electrical engineer should incline toward and not away from standards of all kinds, since standardisation is peculiarly essential to the general progress of the profession. This applies to construction, measurement and expression or nomenclature, as well as to conduct or ethics. Even the tendency to give individuality by providing special construction may sometimes be avoided with advantage."

No doubt standardisation is in many ways essential to progress, but it is probably more essential to the progress of the manufacturer than to the progress of the profession. We are inclined to think that rather too much stress is here laid upon standardisation. No doubt standard plant should be used as far as possible, but a slavish following of standardisation is apt to stifle progress resulting from new ideas. In fact, for that reason consulting engineers are apt to hamper progress, because if they have the welfare of their clients at heart they cannot recommend anything in the nature of a serious experiment: standard practice must be adhered to unless the client is willing to take the risk.

In section B the Committee consider the relations of the electrical engineer to his employer or client, and deal with the acceptance of commission, financial interest in apparatus specified, &c., and the general responsibility of the engineer.

In section C the somewhat difficult question of the ownership of records of work is considered, as follows: "If in executing his work, the electrical engineer uses data or information which are not common and public property, but which he receives, directly or indirectly, from his employer, or if the problem solved by the engineer is met in the pursuit of his work for his employer, and is not of such a character that his attention would have been directed to it regardless of his relations to his employer, the products of his work, in the form of inventions, plans, designs, &c., are not his private property, but the property of his employer, though the engineer may be entitled to special remuneration for such inventions, &c." This clause would apply to assistants, but its application appears to be difficult. If an assistant reaps no reward by exerting his ingenuity, he will not feel much stimulation. On the other hand, it is very difficult to draw the line in some cases between what originates from the employer and that originating from the assistant. The question, therefore, seems to be essentially one of those which should be treated fairly and liberally by the employer as each case arises.

In section D the Committee deal with the relations of the electrical engineer to the general public, and lay down rules to the effect that controversies on questions of engineering should never be carried on in the public press, but should be confined to the technical press and the engineering societies. To those who write to *The Times* on such matters this rule will not be acceptable, though, doubtless, the Committee would make exceptions in the case of letters written to the daily press correcting the mistakes that are so frequently made. In the next section the relations of the electrical engineer to the engineering fraternity are considered, and there is a clause to the effect that an electrical engineer in responsible charge should not permit other engineers or non-technical persons to overrule his electrical engineering decisions. This opinion will appeal to all engineers, and particularly to those who carry out work for municipal committees. The heroic course of resignation is undoubtedly the one to follow if such overruling is persisted in, but it is not every engineer who is prepared to take such a course.

Finally, the Committee give definitions of "electrician," "electrical engineer" and "consulting electrical engineer." In these days, when every plumber is apt to designate himself an electrical engineer, it is interesting to note that this title should be applied only to graduates from the electrical engineering schools of Universities of recognised standing, and to such men as possess an equivalent knowledge of electrical engineering. The title of "consulting electrical engineer" is to be applied only to those electrical engineers who possess such knowledge and experience in electrical engineering as would qualify them to full membership in the American Institute of Electrical Engineers.

Such codes of ethics, like the code of professional etiquette issued by our Institution, are useful as a guide to those who wish to be guided by high principles, but there is one weak point in their conception. It is always a case of "those who will may heed," but if they will not, what is the penalty? There are only two professions at the present time—namely, those of Law and Medicine—that are strong enough to enforce any code of etiquette. An engineering institution may influence, but it cannot do more; for the result depends very largely upon the ignorance of the general public rather than upon the observance of professional etiquette by the engineer. The general public knows nothing of professional etiquette, and is more likely than not to break down any rules drawn up for its observance.

REVIEWS.

(Copies of the undermentioned work can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Conduction of Electricity Through Gases. By J. J. Thomson, D.Sc., LL.D., Ph.D., F.R.S. 2nd edition. (Cambridge: University Press.) Pp. VIII.+678. 16s.

Gaseous conduction is one of the romances of science. Not that it is treated romantically in the book before us. On the contrary, the reserved and somewhat forbidding style handed down from Maxwell to his distinguished successor is carefully maintained. But even a perfectly unemotional treatment cannot obscure the underlying enthusiasm which undoubtedly animates our Cambridge school of physicists, a school whose recent work may well be expected to live for ever in the annals of physical research.

When we remember that the solution of the problem of gaseous conduction belongs almost exclusively to the present century, that that century is only six years old, and that the first edition of this work appeared in 1903, it is not surprising that the second edition should present many new features. Among these the discussion of ionisation by rays emitted by radioactive bodies still occupies considerable space, though a large portion of the purely radioactive phenomena, being fully covered by Rutherford's treatise on "Radioactivity," is omitted in the present edition. The kernel of the book may be found in the short summary of the theory on p. 471. In this sum-

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mary, as, indeed, throughout the book, the word "corpuscle" is used for what everybody else calls an "electron." It is, as the author himself acknowledges, simply a case of paternal affection, and is certainly excusable in view of all the father has done for his offspring.

"A gas is ionised when cathode rays—*i.e.*, rapidly-moving corpuscles—pass through it; these cathode rays, when their velocity is accelerated or retarded, give out Röntgen rays, and these rays also ionise gases through which they pass. When a current of electricity passes through a gas it is carried by moving corpuscles and positive ions, the velocity of these depending on the strength of the electric field. The moving corpuscles are cathode rays; these ionise the gas directly by striking against the molecules, and indirectly by means of the Röntgen rays which are produced when the cathode rays come into collision with the molecules of the gas; the Röntgen rays produced in this way constitute Wiedemann's entladungsstrahlen (discharge rays). Thus, when there are any corpuscles present to begin with, an electric field, by setting these in motion with sufficient velocity, may produce a new supply of corpuscles, and these, again, may produce another generation of corpuscles, and so on. It will be noticed that the collisions are the source of the ionisation, not only when this is produced directly by the impact of cathode rays, but also when it is due to the Röntgen rays, for it is by the collisions that the Röntgen rays originate. Thus when an electric force acts upon a gas in which there are corpuscles, these corpuscles will be the parents of others, and on this account the number of corpuscles will increase; on the other hand, the recombination of corpuscles with positive ions to form neutral systems, and with uncharged molecules to form massive negative ions, will reduce the number of free corpuscles; if the rate of recombination exceeds the rate of production, any corpuscles originally present in the gas will tend to disappear, and the gas will cease to conduct electricity, while if the rate of production exceeds the rate of recombination the number of corpuscles will increase and the gas will become a better and better conductor; in order that it should remain in a steady state the rate of recombination must equal the rate of production."

In Johannes Stark's "Elektricität in Gasen"—the only treatise which can be at all compared with the present work—the doctrine of ionisation by "ionic shock" is developed in a manner very similar to the above, but without considering the ionising effect of the Röntgen rays produced by the collisions themselves. That is a new and valuable point, but the first sentence quoted above is somewhat loosely worded. The acceleration and retardation of electrons does produce radiation—it is the only thing that does—but the rays are not recognisable as Röntgen rays unless the change of velocity is very sudden. And since it is easier to produce a sudden stoppage than an equally sudden start, we are practically reduced to collisions for our source of Röntgen rays.

Chapters specially redolent of the atmosphere of the Cavendish Laboratory are those on the power of the elements in general to emit ionising radiation (Le Bon's "Dematerialisation of Matter"), ionisation due to chemical action, and on the properties of moving electrified bodies.

In the chapter on the "Electric Arc," which is of special interest to the engineer, the author develops the theory that the discharge is primarily due to the cathode. Hot carbon emits electrons to the extent of several trillion per second from every square centimetre of surface. This itself constitutes a current of about 1 ampere. The main function of the positive carbon is to provide heavy positive ions which, by their constant bombardment, maintain the negative carbon at the white heat necessary to liberate the electrodes. Hence, you may have an arc with a cold anode, but not with a cold cathode. But the latter may be heated by an independent source. The characteristic of non-arcing metals is that they easily transport heat away from where it is most required. Chemical combination diminishes the P.D. between the terminals, as in Mrs. Ayrton's hissing arc, by furnishing an independent source of heat in the form of chemical energy.

The book will be welcomed as a standard and up-to-date work of reference on all matters connected with gaseous discharge.

ON A METHOD OF PLOTTING THE HYSTERESIS LOOP FOR IRON WITH AN APPLICATION TO A TRANSFORMER.*

BY DR. GISBERT KAPP.

Let ϕ_o be the flux in megalines produced by a continuous current of I_o amperes through n turns of winding under an E.M.F. of e volts; then

$$e = RI_o.$$

If now e be suddenly reversed, then I will pass from its initial value $-I_o$ through zero to the final value $+I_o$. Any intermediate value of the current must obviously satisfy the equation

$$e = \frac{n}{100}\frac{d\phi}{dt} + RI. \quad \ldots\ldots\ldots \quad (1)$$

By observing t and I a time-current curve may be plotted, and from this curve and the known values of e and n the hysteresis loop giving ϕ as a function of I may be drawn. The arrangement of the test is shown in Fig. 1.

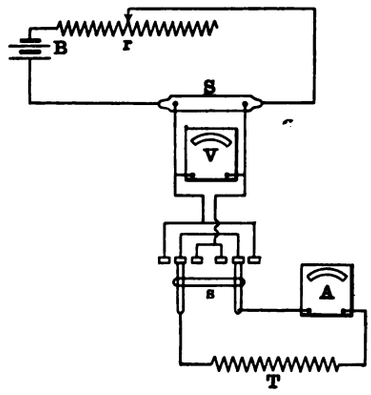

FIG. 1.

B is a source of current capable of giving from 50 to 100 times the magnetising current I_o, which is passed through the transformer coil T. This current is taken off on the heavy shunt resistance S, between whose terminals the E.M.F. e is maintained and indicated on the voltmeter V. A is an ammeter with central zero and s a reversing switch. Care must be taken to have the contacts of this switch in good order, so that its resistance may be exactly the same in either position. S may conveniently be the shunt belonging to V, so that this instrument indicates the main current given by B, and A should be of sufficiently low resistance to reduce the loss of E.M.F. between S and T as much as possible.

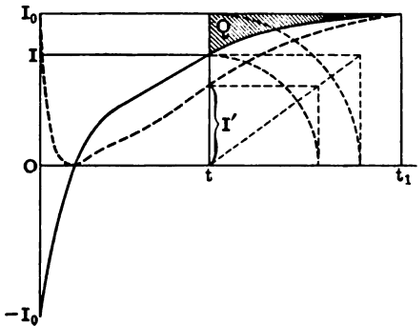

FIG. 2.

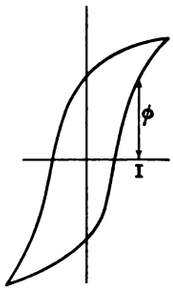

FIG. 3.

To make the test, regulate r so that A indicates the desired magnetising current I_o and note the E.M.F. e. Then knock s sharply over, starting at the same time a stop-watch and noting the current indicated by A as a function of the time. The movement of the needle for values of I lying between $-I_o$ and zero is fairly quick, so that in this region single observations can only be taken by stopping the watch at the moment that the pointer passes a predetermined point on the scale. After the zero has been passed the movement becomes sufficiently slow for a continuous series of coordinate values of current and time to be noted. For transformers of similar type the speed of the needle is approximately proportional to the two-third power of the output. Thus, if with a 10 kw. trans-

* Original communication accepted by the Council of the Institution of Electrical Engineers for publication in the *Proceedings*.

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former zero is reached in 4 seconds, it would be reached in about 6½ seconds with a 20 kw. and in about 16 seconds with an 80 kw. transformer. The shape of the time-current curve is of the character shown in Fig. 2. If there were no hysteresis loss, it would be a true logarithmic curve, but owing to the influence of hysteresis there is a depression in the upper part as shown.

From (1) we have

$$\frac{100}{n}(e-\mathrm{R}i)=\frac{d\phi}{dt}$$

$$\frac{100\mathrm{R}}{n}(i_o dt-i dt)=d\phi,$$

$$\frac{100\mathrm{R}}{n}(i_o-i)dt=d\phi.$$

Now i_o-i is the length of the ordinate between the curve and the $+i_o$ line, so that $\int(i_o-i)dt$ is the area enclosed between the curve and this line. Integrating between the limits $-\phi_o$ and $+\phi_o$, to which correspond the times 0 and t_1, we find

$$2\phi_o=\frac{100\mathrm{R}}{n}\mathrm{Q}_o, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

if by Q^o we denote the whole area between the curve and its asymptote.

Integrating between the limits $-\phi_o$ and $+\phi$, to which correspond the times 0 and t, we find

$$\phi_o+\phi=\frac{100\mathrm{R}}{n}(\mathrm{Q}_o-\mathrm{Q}). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

By combining (2) and (3) we get

$$\phi=\frac{100\mathrm{R}}{n}\left(\frac{\mathrm{Q}_o}{2}-\mathrm{Q}\right),$$

$$\phi=\frac{100e}{ni_o}\left(\frac{\mathrm{Q}_o}{2}-\mathrm{Q}\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

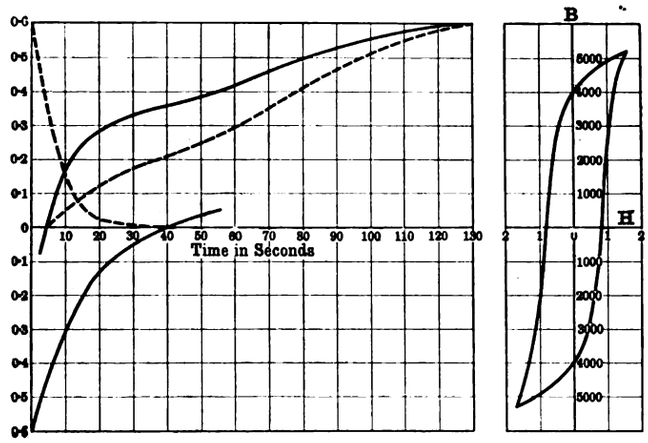

FIG. 4.

Q is the shaded area in Fig. 2. Having fixed on a value of i, we find by planimeter the corresponding area Q, and from (4) the corresponding value of the flux ϕ.

It is thus easy to find by means of a planimeter corresponding values of i and ϕ, and to plot these as shown in Fig. 3. The hysteretic energy per cycle is obviously

$$\mathrm{E}=\frac{n}{100}\times \text{area of loop.}$$

If there are no joints in the carcase, and its cross-sectional dimensions are such as to make the induction the same in any part, the true B-H loop can, of course, be plotted, and the permeability as a function of the induction may also be found. In most cases, however, a knowledge of the exact shape of the B-H loop and of the permeability is of secondary importance; what we require is a knowledge of the hysteretic loss in the whole transformer, and this may be found graphically from Fig. 2 without even drawing Fig. 3.

The hysteretic energy absorbed by the carcase in one half-cycle is obviously the difference between

$$e\int_o^{t_1} i\,dt,$$

the total energy supplied, and

$$\mathrm{R}\int_o^{t_1} i^2 dt,$$

the energy lost in copper heat. The latter quantity may be expressed in the form

$$\mathrm{R}i_o\int_o^{t_1} i\frac{i}{i_o}dt \text{ or } e\int_o^{t_1} i'dt,$$

where $i'=i\frac{i}{i_o}$ can be determined graphically by the construction shown by dotted lines in Fig. 2. The hysteretic energy for one half-cycle is, therefore,

$$\frac{\mathrm{E}}{2}=e\int_o^{t_1}(i-i')dt \text{ watt seconds.}$$

The integral is the area (expressed in coulombs) between the original time-current curve and the new i' curve shown in a dotted line. The area is to be taken with reference to the sign of the current; that is to say, negative up to the point $i=0$ and positive for $i>0$. By planimetering the two areas and deducting that which is negative, we find

$$\mathrm{Q}_h=\int_o^{t_1}(i-i')dt,$$

$$\mathrm{E}=2e\mathrm{Q}_h.$$

This construction applies to any transformer, whether it has joints or not, and whether the induction is the same throughout the magnetic path or not.

By way of illustration I give in Fig. 4 one of the time-current curves taken on a Westinghouse transformer of the shell type. The

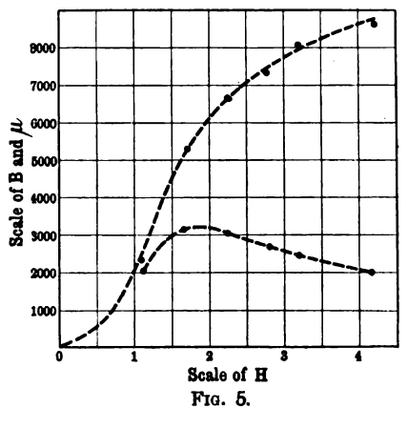

FIG. 5.

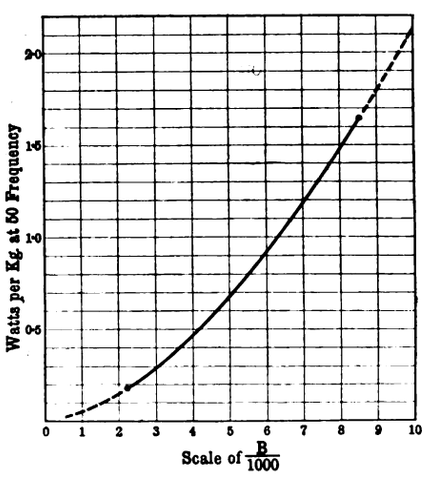

FIG. 6.

cross-sectional area of magnetic circuits is, in this case, constant throughout the path, namely, 200 sq. cm., its length is 53·8 cm., and as there are no butt joints (the carcase is built up with overlapping plates) it was possible in this case to find the true shape of the hysteretic loop. This is drawn to the right of the time-current curve. In the test to which Fig. 4 refers n was 120, $\mathrm{R}=0{\cdot}1$, $e=0{\cdot}06$, $i_o=0{\cdot}6$.

To obtain greater accuracy in the planimetric measurements, the i and i' curves up to zero are drawn to a time scale magnified tenfold. Tests were also made with values of i_o ranging from 0·4 to 1·5, A corresponding to values of B from 2,300 to 8,600 respectively. From these tests the conjugate values of H, B, and μ are plotted in Fig. 5, whilst Fig. 6 gives the curve of hysteretic loss per kilogramme of iron at 50 frequency.

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UNDERGROUND TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY*.

BY C. E. PHELPS.

The faults in underground cables naturally classify themselves as follows: (1) Defects in the cable itself; (2) Injury received during installation; (3) Faulty workmanship; (4) Mechanical injury; (5) Electrolytic action; (6) Certain external injuries, the cause of which may not be conclusively established.

And to these six may be added the injuries which occur to cables not strictly underground, but which are above the surface of the ground on poles, &c., making connection with aerial conductors.

Referring to the other six classes of faults, the first three should be sufficiently provided against in the contract for the cable and in the character of conduit construction, that they may be developed on the breakdown test which is invariably applied to a completed cable before putting it into continuous service. This test usually requires that at least double the ordinary working voltage shall be applied to the insulation of the cable; that is, between conductors and ground, for various periods of time depending upon the judgment of the purchaser and acquiescence of the contractor. The test should never be pushed to a point where the insulation is liable to be pin-holed by the strain of the test voltage, and experience has generally pointed to the continuance of the test voltage for from one to two minutes' duration, instead of 30 or more minutes which have often been specified. Under this test the defect should be developed, and the obligation should, by contract, be imposed upon the contractor to make it good. If it should have been caused by any defect in the conduit construction the cable contractor would, of course, be blameless. The other faults are of purely external cause.

In order to illustrate this feature more prominently, below is given a tabulated record of cable faults in Baltimore for the seven years ending December 31, 1906, together with the lengths of cable in use in each year. This tabulation includes all classes of cables, both high and low tension, and telephone cables, &c.

In considering the tabulations of cable faults, these data must be understood to show actual existing and not sporadic conditions; that not only do they cover a considerable period of time, but they cover also a time during which progress in this particular branch of the art was undergoing great changes. A part of the time may even be taken as experimental. In addition to this, the data for the years 1904 and 1905, shown in these tables, will suffer in its application to a normal situation by reason of the apparently high percentage of faults developed on account of mechanical injury.

Out of a total of 80 faults by mechanical injury for seven years, exactly one-half, or 40 of them, occurred during the years 1904 and 1905, although in 1906 there were but four, while the amount of cable in use was much greater. This disproportion is easily explained by pointing out that during 1904 and 1905 all street improvements consequent upon the fire of February, 1904, were carried out. Street lines and grades were changed, necessitating a similar change in conduits and of cables within them. A great many men were employed upon all sorts of work, and naturally the underground system had to stand its share of damage.

In studying the list of cable faults you will see that, barring the sole element of human frailty, all the faults may be to a large extent anticipated, and in a large measure avoided. By analysing these failures, you will find some definite reason for each of them to which a remedy can be applied, but I do not intend to convey the impression that a cable system can be developed which will never be fault-proof.

I can perhaps illustrate the conclusion which I desire to convey to you. Suppose, say, 20 important companies on this continent engaged in the same character of electrical business were to keep accurate records of the performance of their underground equipment under actual operation, with clear explanation of the conditions surrounding and the effect of each cable fault; and suppose that all these 20 separate sets of data were available to each one of the companies concerned, so that each would have, in addition to its own data, those concerning the cable performance of 19 other companies. Suppose now you had these data in hand, what would be the result? You would eagerly search out those of the companies which showed few faults where you were subjected to many of the same kind, and you would get in touch with them and learn in what particular they had succeeded where you had failed. In the same way you would be called upon to explain your successful methods to certain others who had failed where you had succeeded. This is a process which seems so easy, so simple, and so inexpensive when the great benefits that would accrue are considered, that it seems surprising it is not an almost universal custom. I cannot refrain from backing up this statement by saying that this spirit of co-operation and co-ordination is one of the important elements which has maintained the preeminence of the Bell Telephone Co. in its particular field of operation, judging solely by results from the point of view of an outside but interested observer.

With regard to mechanical injury, the author drew attention to the case of manholes. He had seen inside the manholes of an important underground system where the cables were so run through the manholes that it was impossible for a workman to get to the floor of the holes without using these cables as a step ladder. This was the case, not in a single manhole, but in many of them. Apparently the manholes were built simply because every other underground system had them, and they exhibited utter disregard of their permanent use by the cable equipment for which they were built.

Class.	Nature of damage.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	Total.	% of whole.
1	Defective cable	..	1	..	..	..	2	..	3	2
2–3	Damage during installation	..	..	..	3	7	4	10	24	16
4	Damage by picks, bars, &c.	..	2	6	6	13	27	4	58	
4	Flood	..	..	..	1	..	1	..	2	55
4	Gas explosions	1	..	..	..	1	..	..	2	
4	Rats	..	..	..	..	..	..	5	5	
4	By workmen in manholes	..	..	..	2	3	4	4	13	
5	Electrolytic action	1	..	2	15	5	4	4	31	20
6	Cables above ground	..	1	1	..	..	..	..	2	1·5
7	Unknown	..	..	..	..	..	7	1	8	5·5
	Total	2	4	9	27	29	49	28	148	100·0
Feet of cable in operation at end of each year		106,779	236,266	470,154	708,152	853,948	1,246,443	1,535,294	..	..
Fault per 1,000 ft. of cable		0·018	0·017	0·019	0·038	0·034	0·039	0·018	..	..

* Abstract of a paper read before the American Institute of Electrical Engineers.

THE FACULTY OF COMMERCE AT THE UNIVERSITY OF BIRMINGHAM.

We have received a memorandum, signed by Prof. W. J. Ashley, Dean; Prof. A. W. Kirkaldy, Secretary of the Board; and Messrs. N. Chamberlain, G. H. Claughton, F. D. Docker, A. H. Gibson, E. Hickman, W. E. Hipkins, J. S. Taylor and T. S. Walker, giving a précis of the objects of the faculty of commerce recently created by the University of Birmingham. After stating that the members of the Board have had opportunities of judging of the practical value of the course of special training suggested, the memorandum deals with the objects the Board has in view.

The establishment of a Faculty of Commerce in the University of Birmingham is the first attempt in this country to systematise the preliminary teaching requisite for the higher positions of commercial and financial responsibility, and to raise such teaching to a university standard.

This object must commend itself to everyone conversant with the requirements of modern business. In the *departmental* administration of large concerns, technical skill is so evidently called for, that expe of with the highest available training are employed in subordinate positions of authority. Yet this country has hitherto neglected the training rts *general* managers, who not only engage and superintend these experts, advance them for proved competency, or dismiss them for inefficiency, but, at the same time, have the responsibility of buying materials to the best advantage, deciding as to the extension or replacement of plant, assuring the disposal of the output, and planning financial policy. Every director of an industrial company has doubtless experienced the difficulty of filling the position of executive head of a commercial concern. In some cases, departmental managers are thought capable of assimilating the knowledge necessary outside their own special branch, or, more frequently, clever clerks acquire some technical insight into departmental work; and, when a vacancy occurs in the post of managing director or general manager, it is filled by promotion from one or other of these sources. Not infrequently the results are disastrous; for the training of the departmental expert is often found to unfit him for general management; while the promoted clerk is entirely in the hands of the departmental experts whom he has not sufficient knowledge to control.

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In banks and other financial institutions the like difficulty exists in an equal degree; for the strict discipline necessary in the subordinate grades of service does not tend to develop the sound and quick judgment that is required in positions of control.

It is not pretended that the training of the University will impart a knowledge which only experience can give, but it is suggested that the curriculum is such as to specially prepare the mind for the impress of that experience; in other words, to offer to business men assistants who are something more than raw material.

The aim of the faculty in relation to commerce is to devise such a system of training as, combined with a liberal education, shall be a suitable preparation for the proposed career. The course extends over three years, and embraces the study of subjects specially selected to bring out the broader qualities necessary in men who aspire some day to fill positions of great responsibility. The expectation of those interested in the development of the new section of the University is that it will do for commerce preliminary work similar to that which is undertaken for the Army by the Royal Military Academy and Royal Military College, and that its graduates will enter upon their careers not only with the advantage of a liberal education, but also with an intelligent understanding of the commercial and economic sides of business in general, and an initiatory training in methods and functions appropriate to their intended pursuits. Such graduates should take positions in the world of commerce akin to those of cadets from Woolwich and Sandhurst in the army; and should be fitted, after assimilating the lessons of their practical experience, to qualify themselves for the higher posts in the branches of manufacture and trade with which they may become identified.

The Advisory Board feels that, on national grounds as well as on grounds of immediate self-interest, it can ask for active recognition from everyone interested in the country's material prosperity.

CORRESPONDENCE.

ALUMINIUM FUSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the recent Paper on Fuses by Dr. G. J. Meyer, read before the German Institution of Electrical Engineers,* the Author makes the following statement: "Schwartz and James, as the result of their investigations, state that the formation of a skin of oxide militates against the employment of aluminium. This view cannot be accepted."

He goes on to state that with thick wires the heat generated by the normal fusing current in the fluid core is sufficient to destroy the oxide sheath, while with thin wires under 1 mm. diameter this is not the case, and for rupture a current somewhat higher than the normal fusing current is necessary. This excess current is comparatively small and is definite, so that the use of aluminium wire within the limits of dimensions used commercially is quite permissible.

The statement referred to above is based on a report in the *Elektrotechnische Zeitschrift*, 1906, p. 416, of a series of articles by us on "Zinc and Aluminium Fuses," which appeared in your journal† in connection with our Paper on "Low-tension Thermal Cut-outs."

Our statement was as follows: "Aluminium wire, as we have previously shown, particularly when of small diameter, is unreliable as a fuse owing to the molten metal being held up by the skin of oxide."

The cause of this unreliability is twofold: Firstly, owing to the fact that the aluminium core in small wires fuses within the oxide sheath with about 50 per cent. of the current that is required to produce the rupture of the fuse. The rupture is brought about by an alteration in the cross-sectional area of the fluid core due to draining to the lower part of the fuse, and this will be influenced by the length and gauge of the wire employed and as to whether it is horizontal or vertical.

Secondly, owing to the fact that if an aluminium wire is subjected to a current sufficient to fuse but not to rupture it, and the current be then reduced, the metal will remain molten with quite a small percentage of the current originally necessary to produce fusion, and it is frequently a difficult matter to get the metal to solidify again, as the fuse ruptures while the current is being reduced. This is no doubt due to a contraction effect on solidification.

The above applies only to aluminium wires and strip of small dimensions, as we have already pointed out; for larger strip the oxide sheath does not seem to have an appreciable prejudicial effect on the constancy of the fusing current.

Aluminium is further highly electro-positive to copper or brass and in damp situations corrosion occurs at the contacts unless special precautions are taken. These are difficult for small wires.

We cannot see any advantages in the use of small aluminium wires *vice* copper, and therefore wish to reiterate our opinion as to their unsuitability.—We are, &c.,

School of Technology, Manchester, July 11. ALFRED SCHWARTZ. W. H. N. JAMES.

* "Theoretisches und Practisches über Abschmelzsicherungen" *E.T.Z.*, April 25, 1907.

† *The Electrician* November 17, 1905, p. 184.

UNDAMPED OSCILLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I ask you at this time, following upon the continued discussion of the production of continuous wave trains of high frequency, or so-called "undamped oscillations," to supplement my former statements on this subject by publishing the following, which is taken from your own columns of September 22, 1899, p. 779, where you give an abstract of my vice-presidential address at the Columbus (Ohio) meeting of the American Association for the Advancement of Science? The statement, of course, is very brief, as it occurred in a Paper devoted to a general review rather than to a special subject, but I think it is much to the point in this connection:—

There is much room for experimental work in this fascinating field. There is needed for it the means for the production either of a continuous electric discharge at from 60,000 to 100,000 volts, or a high-frequency apparatus capable of giving an unbroken wave train—that is, a succession of high-period waves of current without breaks or intermissions. The ordinary high-frequency apparatus for obtaining discharges of high potential from alternating currents gives only a rapid succession of discharges, each consisting of a few rapidly dampened oscillations. These discharges occupy but a small fraction of the total time. This is very different from a continuous sustained wave train, with the successive waves of equal amplitude following each other without break. Such sustained waves would, doubtless, be of use in research, especially in vacuum-tube work, and they would, of course, convey much more energy than the usual broken or interrupted discharge known as a high-frequency discharge.

Some six or seven years ago I endeavoured, while working upon the subject of high frequency, to fill the gap. The result was an apparatus which, with its modifications, deserves more study and experiment than I have been able to give to it. A brief description may not be out of place: A large inductance coil, with a heavy iron-wire bundle for a core, a coil of relatively few turns, with no iron core, and a condenser of variable capacity were connected in series across the mains of a 500 volt electric circuit. The smaller coreless coil and the condenser were arranged to be shunted by an adjustable spark-gap with polished ball terminals. By simply closing for a moment the spark-gap so as to form a low-resistance shunt around the condenser and the small coil, and afterwards slowly separating the balls, the local circuit of the condenser, small coreless coil and shunting gap became the seat of sustained oscillations, the frequency of which depends upon the relation of inductance and capacity in the local circuit. The energy supplied is that of a continuous current through the large inductance coil with the heavy core. The action of the apparatus is easily comprehended by a little study. The oscillating current in the local circuit may be made to induce much higher potentials in a secondary circuit inductively related thereto. In this case the turns of the secondary in relation to the primary are, as usual, such as to step up the potential. In other words, the potential developed in the secondary is determined by the transforming ratio.

This quotation not only supplies a gap in the history of "undamped oscillations," so-called, but it serves as a complete answer to certain criticisms which were made that my experiments did not involve anything very different from the ordinary high-frequency apparatus. Inasmuch as this publication was made before others had entered the field, and shows that the subject was a live one in my mind in 1899, its republication now would not seem to be out of place.—I am, &c.,

West Lynn, Mass., June 18. ELIHU THOMSON.

TIRRILL VOLTAGE REGULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of June 28th (p. 414), under the head of "Voltage Regulators," reference is made to the "Tirrill Regulator," as described in Mr. Acland's Paper before the I.M.E.A. in terms which might convey the impression that this device, as an automatic regulator, lacks reliability.

We should like to point out that some two thousand or more of these regulators are now in successful operation, and it has been the experience of those who have used them that

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they are entirely automatic, thoroughly reliable, and require only the care and attention usually given to central station apparatus.

If the operation of a regulator in any particular instance has been found to be so unreliable as to necessitate constant watching, we are confident that an investigation of the conditions will prove either that it has not received proper care and attention or that it is working under conditions for which it is not suited.

If we are given complete and accurate information regarding the conditions under which a regulator is required to operate, and it receives reasonable and proper care, we will guarantee its operation to be entirely automatic and thoroughly reliable.

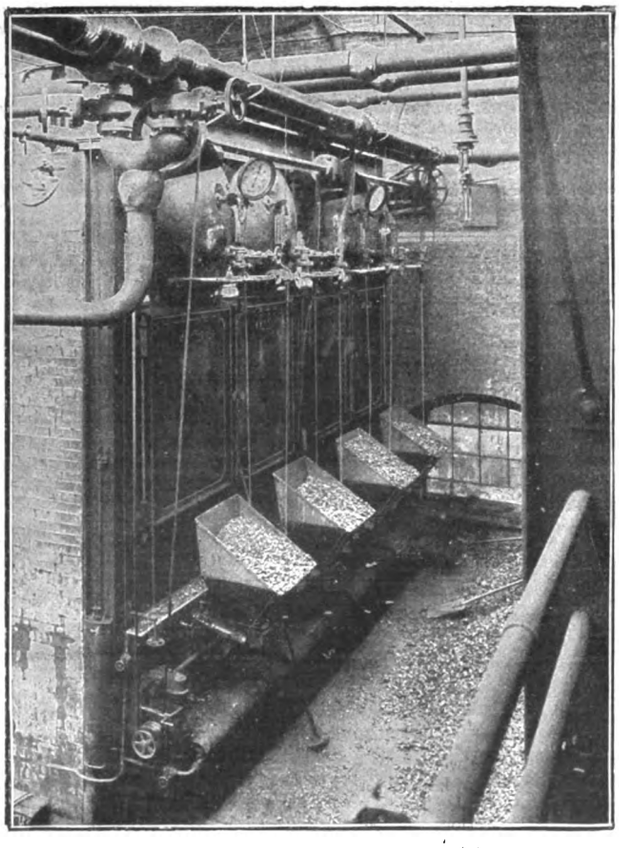
With reference to the material for the relay contacts, a great deal of data has already been accumulated regarding the behaviour of various metals under different conditions, and we confidently expect in the very near future to be able to predetermine what material is best suited for any particular set of conditions.

Regarding the suggestion of operating the contacts "in vacuo," the difficulties of applying this idea in a practical form are such as to have discouraged its adoption.—We are, &c.,

THE BRITISH THOMSON-HOUSTON CO. (Ltd.),
Rugby, July 3. J. S. Conover, Managing Engineer.

BENNIS STOKERS AT WIMBLEDON.

In 1903 Mr. H. Tomlinson Lee, resident engineer to Wimbledon Corporation, and also the Corporation's consulting engineer, designed important extensions at the electricity generating station, and



FIRST BATTERY OF BENNIS STOKERS SET TO WORK IN FEBRUARY, 1905.

amongst the plant specified was a battery of four of the well-known Bennis stokers. These were duly installed and set to work in February, 1905. A second battery of six succeeding in 1906 thus offering most convincing testimony to the satisfaction resulting from the first installation. In the course of an interview recently accorded to a correspondent, Mr. Tomlinson Lee furnished some interesting particulars regarding the economies of mechanical over hand firing at Wimbledon. The following figures give the cost per unit of current generated with hand firing for the last three months of 1904, compared with mechanical firing for the last three months of 1906:—

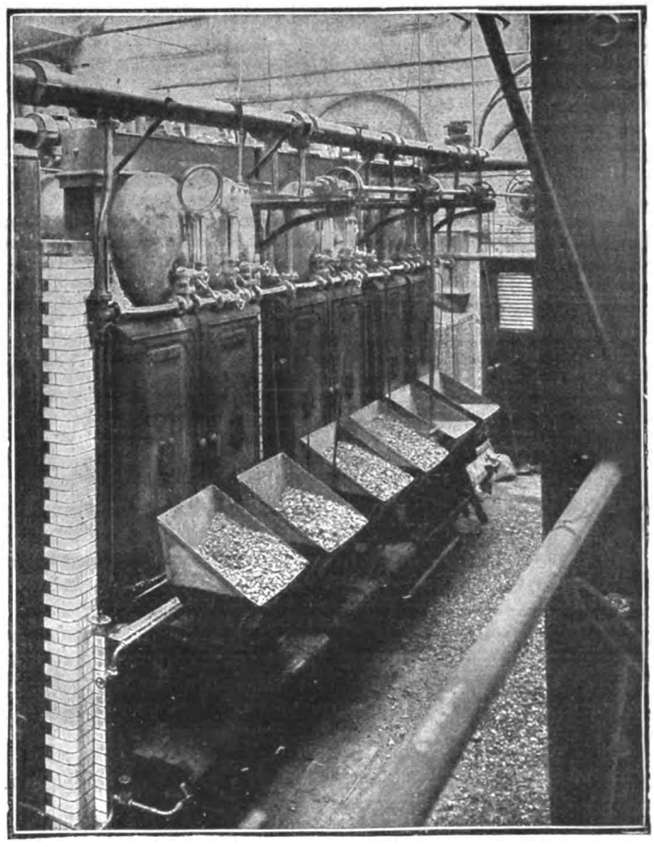
Costs per unit generated.	1904.		1906.
October	0·737d.	.....	0·539d.
November	0·749d.	.....	0·540d.
December	0·670d.	.....	0·593d.
Average per unit	0·718d.	.....	0·557d.

Difference 0·161d. per unit.

For the quarter ended December, 1906, 725,624 units were generated; these at 0·161d. = £495. 2s. 1d.

These figures go to show that the saving effected was at the rate of £1,980. 8s. 4d. per annum. Derbyshire coal from the Mapperley colliery is used at Wimbledon.

In the course of the interview some interesting particulars concerning the Wimbledon station were furnished by Mr. Lee, from



SECOND BATTERY OF BENNIS STOKERS, INSTALLED IN 1906.

which we gather that, notwithstanding the large increase in the number of consumers connected to the mains between March, 1906, and March, 1907 (no less than 540 new consumers in one year), the connections from March 31, 1907, to June 12 (11 weeks) added another 120 consumers connected, making the total at June 12, 2,671. This is all the more creditable from the fact that Wimbledon is a purely residential borough, the energy supplied for power being practically nil, if the amount required for sewage pumping purposes is left out of consideration. The whole of the sewage pumping is operated electrically.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

In *The Electrician* for July 5 we extracted from the "Manchester Guardian" a version which our contemporary had published of the report of the Select Committee of the House of Commons on the Radio-Telegraphic Convention. We have now received the complete report ordered by the House of Commons to be printed on July 8. This report runs into 26 closely-printed foolscap pages, and comprises some introductory remarks and a dissertation on the scientific history of radio-telegraphy, setting out the principal systems in use in all parts of the world (these include Marconi, De Forest, Fessenden, Lodge-Muirhead, Telefunken, Rochfort, Branly-Popp, Poulsen, Shoemaker and Massie). A political history of the subject follows, dealing with the development of the invention, and this again is followed by notes on the Convention and its objects, its bearing upon imperial, naval and commercial interests, and a review of the position of the Marconi Co.,

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following in all essentials the account which appeared in our last issue, p. 489. This résumé is succeeded by a series of observations on the subjects of the rejection, the postponement, and the ratification of the Convention.

The statement published in *The Electrician* for July 5, p. 457, that the adoption of the report was carried in Committee by five votes to four, was correct. The Ayes were: Mr. Adkins, Mr. Sydney Buxton, Sir Wm. Holland, Mr. Lambert and Sir Gilbert Parker; the Noes were: Mr. Gwynne, Mr. Arthur Lee, Mr. Macpherson and Sir Edward Sassoon. Sir Dickson-Poynder's vote, as chairman, was not recorded. The only member of the Committee who did not vote was Mr. Enoch Edwards, who had not been present at any sitting of the Committee after the first sitting on March 13.

Telegraph (Money) Bill.—Standing Committee B of the House of Commons met on Monday to consider this bill, which was introduced by Mr. Sydney Buxton to enable the Post Office to raise £6,000,000 under the Telegraph Acts. Mr. Buxton moved the insertion of words to make it clear that the money was to be spent entirely on the development of the Post Office telephone system and this was agreed to without a division.

Mr. Harold Cox then moved a reduction from £6,000,000 to £3,000,000. The amendment was rejected by 19 votes to 3, and the bill was reported to the House.

Aberdeen Corporation Electricity Bill.—On Tuesday a Committee of the House of Commons found the preamble of this bill proved, subject to the promoters coming under an obligation that Aberdeen County Council should have the right to acquire the whole or any part of the undertaking within the County Council area; that in the event of the County Council taking over the whole or part of the undertaking in their area, the County Council should be entitled to a supply in bulk from the Corporation; and that stringent provisions were put in the bill regarding care of the roads. The bill gives the Corporation power to supply electricity in parishes outside the city boundary.

London United Tramways Bill.—On Tuesday the preamble of this bill was declared to be proved, and it was ordered to be reported for third reading.

Miscellaneous Bills.—On Monday in the House of Lords the *North Metropolitan Electric Power Supply Bill* was read a second time, and the *Great Northern and City Railway Bill* a third time. In the House of Commons the *Electric Supply Corporation Bill* was read a second time.

The *Central London Railway* Bill was read a second time in the House of Lords on Wednesday.

The *Rawtenstall Corporation* Bill was read a third time and passed in the House of Lords on Thursday last.

A bill to confirm certain provisional orders, including the *Newark Provisional Electric Lighting Order* was passed by an Unopposed Committee of the House of Commons on Thursday last, and allowed to go forward for third reading.

LEGAL INTELLIGENCE.

United Motor Industries (Ltd.) v. Vandervell & Co.

In the King's Bench (London), on Monday, Mr. Justice Walton and a special jury heard an action brought by the United Motor Industries (Ltd.) against C. A. Vandervell & Co., for damages for breach of an expressed and implied agreement, and sought an injunction restraining defendants from further violating the agreement. Defendants, whilst admitting the act which constituted the alleged breach, repudiated that the agreement was contained by implication and denied liability.

Mr. MONTAGUE LUSH, K.C., for plaintiffs, said in 1901 plaintiffs were selling dry batteries which they had been getting from Paris, but they were at that time informed that defendants were making a useful ignition battery. Up to that time the dry battery had been used, and defendants' accumulators were the commencement of the ignition accumulators which had become so popular. Plaintiffs approached defendants as plaintiffs were desirous of building up a business in ignition accumulators. Their idea was to identify them with some name by which they would become known to the public and by which it would be known that they could be got from the United Motor Industries (Ltd.). They negotiated with defendants to make the accumulators and sell them exclusively to them, they, on their part, to build up a large business by extensive advertising. The accumulators were to be known as "The Castle," plaintiffs selecting that name because their works were situated in Castle-street, London. The negotiations eventuated in a written agreement, dated Oct. 12, 1902, whereby plaintiffs guaranteed during 1903 to take out not less than 1,000 accumulators for defendants, who were to make them in a special form with a specially designed plate. Defendants, on the other hand, were not to supply the same accumulators to any other firm, or to supply accumulators of similar capacity to persons at a price less than they sold the "Castle" accumulators to plaintiffs. Defendants were, however, to be at liberty to make and sell accumulators providing they did not sell them as the "Castle." The United Motor Industries (Ltd.), on their part, undertook to sell no accumulators as the "Castle" except those manufactured by defendants as long as the quality was sustained and deliveries were adequate, and defendants undertook not to divulge that the "Castle" accumulators were made by them. The word "Castle" was registered by the plaintiff company as the trade mark. "Castle" accumulators acquired a good reputation in the trade. Defendants made and sold another accumulator known as the "C. A. V." That, although the written agreement extended over a single year only, defendants continued to make and supply plaintiffs with the "Castle" accumulator, and recognised and acknowledged that its terms were still binding upon the two firms, would be shown by correspondence. Defendants, however, admitted that they supplied plaintiffs under the agreement during 1903, but asserted that since that year they had simply sold accumulators to the plaintiffs in the ordinary way of business, affixing the word "Castle" at plaintiffs' verbal request. In other words, they said that the obligation upon them not to divulge that they were the manufacturers lasted for one year only, and that afterwards they had liberty to do exactly what they pleased. For five years the plaintiffs had been advertising "Castle" accumulators, and, having bound the defendants down not to divulge that they were the manufacturers, the business, he contended, was theirs, and they were entitled to the benefit of the care they had taken and the money they had expended in building it up. On April 30, 1907, defendants advertised that they were the manufacturers of the "Castle" accumulator, as sold by plaintiffs, that they were no longer supplying that firm and that the same accumulator would be sold by them as the "C.A.V." accumulator. That, counsel contended, was a flagrant breach of the undertaking.

Evidence having been given in support of plaintiffs' case.

Mr. HAMILTON, K.C., for defendants, said that the point for Court was whether the transactions which took place between the parties after 1903 were attended by the restrictive term that the defendants were not to disclose the fact that they were the manufacturers of "Castle" accumulators. Plaintiffs asked them to say that there was a renewal of the agreement, although there was not one word said about renewal, and although the two parties were dealing with one another simply in the ordinary way of maker and customer. The friendly relations between the parties which began in 1902 continued to the end of 1906, when Mr. Smith, manager for plaintiffs, learned that Messrs. Vandervell were selling, as they were entitled to do, their own goods and had secured a contract to supply the Daimler Co. with coils. Plaintiffs thereupon commenced to manufacture their own accumulators at their works in Coventry and to sell them under the name of "Castle." That in itself was a breach of agreement of 1902 if it still existed. In course of time Messrs. Vandervell found this out and asked plaintiffs what they were to understand by it. For answer, they were informed that plaintiffs, rightly or wrongly, felt there was a competitor springing up against them in this branch of their business. Having been cast adrift like that, and having acquiesced in it, because Messrs. Vandervell recognised that there was no agreement binding upon them at the time, defendants proceeded to advertise their own accumulators.

Mr. Justice WALTON, in summing up on Wednesday, said, that plaintiffs contended that all orders given after 1903 were given subject to the terms of the agreement of 1902, that the defendants should not divulge that the accumulators were made by them; defendants, on the other hand, said that all they undertook was not to disclose the fact so long as their business relations continued harmonious. The jury, before finding a verdict for plaintiffs, must be satisfied that there was an agreement, not necessarily in words, and certainly not in writing, but which was understood by both parties that defendants bound themselves not to disclose at any time that the accumulators supplied after 1903 were made by them. If they thought the evidence was sufficient to establish such an agreement, then the defendants were liable, because after the business relations ceased they advertised the fact that they were makers of the "Castle" accumulators.

The jury found that there was such an implied agreement, and found for plaintiffs, assessing the damages at one farthing.

Yesterday Mr. LUSH, K.C., claimed to be entitled, on the finding of the jury, to an injunction restraining defendants from further advertising themselves as the makers of the "Castle" accumulators, with costs.

Mr. HAMILTON, K.C., contended that the jury's verdict meant that the action never ought to have been brought. It was not brought to vindicate any real wrong. He asked his lordship to deprive plaintiffs of their costs, to require them to pay defendants' costs and to refuse to grant the injunction.

His LORDSHIP reserved judgment.

Birkenhead Corporation v. Mersey Railway Co.

In the House of Lords (before the Lord Chancellor and Lords Ashbourne, Macnaghten, James of Hereford, and Atkinson) this action was heard on the 8th and 9th inst., and was an appeal by Birkenhead Corporation from an order of the Court of Appeal of Dec. 14, 1906, which, on the respondents giving certain undertakings, discharged an order of Mr. Justice Warrington of March 8, 1906. The respondents, the Mersey Railway Co., own a railway under the river Mersey from Liverpool to Birkenhead, and they started and maintained a service of motor omnibuses at Birkenhead between Claughton, a residential part of the town, and their central station, in connection with the running of their trains at a six minutes' interval. These omnibuses, besides taking passengers to and from the station, picked up persons along the route, and carried them to places other than their own station. The fares varied according to distance travelled, and were not limited to journeys to and from the station, but included fares between intermediate points. It was established that the omnibus service was worked bona fide for the purpose of obtaining traffic on the railway and was not intended to be an independent omnibus service. The defendants' special act contained no express power to carry on the business of omnibus proprietors. The Birkenhead Corporation owned the ferry across the Mersey and a system of electric tramways which were convenient to passengers using the ferry but not for the railway. They objected to the motor omnibuses, and brought action in the Chancery Division for an injunction to restrain defendants from continuing them, on the ground that in so doing they were acting in excess of their statutory

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powers. Respondents pleaded that these omnibuses were part of their system and auxiliary and incidental to their ordinary business of conveying passengers by their line. Mr. Justice Warrrington held that the motor omnibus service was ultra vires, and granted an injunction. The Court of Appeal, while agreeing with the learned judge that the system as worked was ultra vires, thought that if defendants would give an undertaking to cease to hold themselves out as carriers of passengers otherwise than to or from the station, the omnibuses could be brought within their contention, and therefore not ultra vires. The undertaking was given to the satisfaction of the Court, but the Corporation were not satisfied and brought the matter to the House of Lords.

The LORD CHANCELLOR, in moving that the appeal should be allowed, said respondent company had been running a number of omnibuses in the town, and they justified doing so on the ground that this omnibus service was incidental to and consequential upon their railway system. It had been laid down in that House that a business which in itself would be ultra vires might be within the statutory powers of a railway company if it could fairly be considered as being auxiliary and incidental to its undertaking as a railway. This service of omnibuses, however, in his opinion, was not fairly incidental to the respondent's railway enterprise and was within the rule laid down in "Attorney-General *v.* London County Council, 1902, sec. 165"—the case of the halfpenny omnibuses over the London bridges—where it was held that the powers of their tramway undertaking did not authorise the London County Council to run "feeding" omnibuses to and from the tramway termini. In substance this undertaking was one to enable the railway company to compete with the electric trams and a ferry owned by the appellents in taking passengers across from Birkenhead to Liverpool.

Lord ASHBOURNE concurred.

Lord MACNAGHTEN agreed, and pointed out that the respondents' proper course if they wished to continue the running of this omnibus service was to apply to Parliament for further powers.

Lord JAMES OF HEREFORD and Lord ATKINSON concurred in the appeal being allowed, with costs.

Judgment of Mr. Justice Warrington restored.

Lynch v. Macartney, McElroy & Co. (Ltd)

The Master of the Rolls, Sir Gorell Barnes and Lord Justice Kennedy on Tuesday heard the application of the defendants for judgment or new trial on appeal from verdict and judgment in the trial before Mr. Justice Bigham and a common jury.

The action was brought by Mr. J. J. Lynch, mechanical and electrical engineer, for damages for an alleged libel published in the "Malta Chronicle," and the proceedings were reported in *The Electrician* for May 3. Plaintiff was awarded £250 damages.

Mr. HUGH FRASER, for the appellants, now contended that the words complained of could not reasonably be construed as containing an imputation upon plaintiff. There was no ill-feeling between the parties, and their relations were perfectly friendly. Plaintiff was not even cross-examined on the question of spite or anything of that kind. Mr. M'Call in opening the case for the plaintiff had made statements which were not substantiated, and the jury were probably misled by them. One such statement was that plaintiff had applied to defendants for a reference and that it was refused. The judge recommended the jury to find small though not contemptuous damages if they thought the advertisement conveyed the impression that plaintiff's engagement had been determined in circumstances which were not creditable to him, and after the verdict he intimated that in view of the smallness of the circulation of the paper and the fact that the plaintiff had suffered no direct pecuniary loss, the damages were too large, and that if it had been left to him he should have awarded £50.

Mr. LUSH, K.C., also addressing the Court on behalf of the appellants, said Mr. Lynch had himself, in a letter to them, asked when he could be "relieved of his duties," and all they had done, without the least malice or ill will, was to use his own language. They might be liable for the incautious use of a phrase which might convey an injurious imputation; but the reason for the advertisement was that the defendants had lost £1,000 through natives in Malta foisting orders upon officials. They had no chance in the Malta courts and that was why the notice was published. The idea of attacking Mr. Lynch was not present to their mind at all.

Mr. M'CALL, K.C., on behalf of the plaintiff, submitted that the verdict was right and that the question of injurious imputation was solely one for them. With regard to the damages he was prepared in the Court below to reduce them with a view to ending the litigation, but the defendants did not consent.

Their Lordships reserved judgment.

The Liabilities of Tramway Owners.

At Manchester Assizes last week, before Mr. Justice A. T. Lawrence and a special jury, Mr. John Lancaster sued Manchester Corporation for damages for personal injuries. It was stated that on Feb. 11 plaintiff boarded a car at the corner of King-street. He had reached the top of the stairs, and as a means of steadying himself he got hold of the door-handle on the upper deck, when the car gave a sudden violent jerk, causing him to lose his grasp, and he was thrown into the roadway. He had been confined to bed for three weeks and said he had not yet fully recovered, and was unable to attend to business as effectively as before.

Mr. SHEE, K.C. (for plaintiff), contended that there was negligence on the part of the driver in starting the car and proceeding at an excessive speed over the points before passengers had taken their seats. There was negligence on the part of the Corporation also in having a car which was unprovided with a rail sufficiently high to form a protection.

Mr. A. M. FOWLER, civil engineer, said he considered the curve at which the accident happened too sharp for heavy cars.

Mr. LANGDON, K.C., for the Corporation, said the charges of negligence affected the entire tramway undertaking. If the jury found there had been negligence they would condemn the working of the Manchester tramways in all material aspects. Negligence was alleged first as to the car. The hand-rail, it was stated, was not an adequate protection. But it was the same as on the other cars in the city—cars which had worked, under the sanction of the Board of Trade, without any accident of this kind happening. It was a standard type of car, the best the makers could devise. The rails had been passed by the Board of Trade. Plaintiff, he suggested, having ascended the stairs, loosed his hold of the rail and seized the door-handle, which gave way under the pull, and so he lost his balance.

Mr. G. R. BLACKBURN, superintendent of the rolling-stock department of the tramways, said the line was properly laid and the curve in Cross-street was the same as on other parts of the system, and not dangerous.

In summing up, the JUDGE asked the jury to say whether the plaintiff's fall was caused by a sudden jerk, which might have been avoided by ordinary care on the part of the driver, or whether it arose from the plaintiff's own negligence in clutching the door-handle instead of the hand-rail.

The jury found for plaintiff, damages £650, and added a recommendation as to careful driving over points.

Judgment was entered for the amount stated, and his Lordship certified for a special jury.

Whitaker v. Favell and Another.

At Nottingham Assizes on Monday, the Commissioner (Lord Coleridge) heard a claim by Mr. A. E. Whitaker, electrical engineer, Nottingham, for £500 from Mr. W. W. Favell, Rood-lane, London, and the Nottingham Gas & Electric Fittings Co. (Ltd.), as damages in respect of breach of warranty in connection with the supply of coils of wire for an electrical installation. There was a counterclaim for £32. 6s. 8d. for goods supplied.

Mr. T. H. WALKER, for plaintiff, said in April last year Messrs. Allsopp accepted plaintiff's tender to instal electric light at the Bentinck Hotel, Nottingham, and plaintiff placed with Messrs. Favell orders for supply of wire and other materials. During the progress of the work defendant (who had carried on business under the names of the Nottingham Gas & Electric Stores and S. Haynes & Co.) transferred the business to the other defendants. The wiring was finished on Oct. 3. When it was submitted to the Corporation test defects in the form of leakage, &c., were found in the cables. The resistance of the insulation was found to be much less than stated on the guarantee attached to the coils. The owners of the hotel claimed from plaintiff £96. 14s. for damage and loss of business.

PLAINTIFF said he did not test the wire when he received it, as that was not usual, and there was nothing in its appearance to suggest that it was unsuited for his work. He did not use any wire at the hotel other than that obtained from defendants. It was possible for the cable to be damaged in being pulled out of the tube. The installation had now temporarily passed the test.

Mr. H. TALBOT, borough electrical engineer to the Corporation, and Mr. F. H. COMFORT, mains superintendent of Nottingham Corporation Electricity department, confirmed the opinion that the wire was useless for the purpose for which it was used. Other evidence was also called in support of plaintiff's case.

For the defence, Mr. A. NEILSON submitted that the wiring was badly done—that the wire could not have been bad in itself, as large quantities had been made and sold without any complaint.

Mr. J. T. MAYFIELD said there was nothing in the external appearance of the cable, which had been tested in London, to suggest that it had been damaged. He had himself tested coils of the same grade and make of wire and found them satisfactory.

His LORDSHIP, in giving judgment, said he was driven to the conclusion that the fault was in the article supplied, and not in the manner in which it was dealt with by plaintiff or in the condition of the place where the installation was made. Judgment for plaintiff for £71 13s. 8d., and on the counterclaim for defendant for the amount claimed.

Bland v. Graham.

At Newcastle Assizes on Saturday, before Mr. Justice Grantham, Bland Bros. (Ltd.), electrical engineers, Newcastle-on-Tyne, sued J. H. Graham (Ltd.), for £132, balance of account for installing the electric light at the Turk's Head Hotel, Newcastle. The defence was that the work done was defective, and that it had cost defendants £99 to remedy it. Defendants contended that they were entitled to reduce the account by £99, and they also counterclaimed £65 for alleged loss of business.

Mr. BLAND stated that the work was done in accordance with specifications, and no complaints were made from the end of 1903 until well on in 1904. He suggested that the defects were due to defendants putting hot-water pipes against the wires.

Mr. Justice GRANTHAM held that plaintiffs ought not to be mulcted in damages where the deficiencies arose through alterations required by defendants. He doubted whether he ought to make any deductions at all, and he would be doing full justice to defendants if he allowed them £20 for work which had to be re-done. He found for plaintiffs for £112 on their claim and also on the counterclaim.

London Electron Works v. Wagner.—In the High Court on Saturday, before Mr. Justice Phillimore, judgment was entered, in default of defence, for plaintiff in the case of the London Electron Works (Ltd.) *v.* Wagner. Plaintiffs, the employers of defendant, sought an injunction restraining him from disclosing trade information and from carrying on business himself within a certain time of the termination of his engagement. The injunction was granted with costs.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A lecturer in electricity and physics is required in September next at the City of Birmingham Municipal Technical School. Commencing salary £140. Particulars from the secretary (Mr. George Mellor), Suffolk-street, Birmingham. See also an advertisement.

The Commissioners of the Port of Calcutta require assistant to the Superintendent of Machinery, with thorough mechanical and electrical engineering training. Salary Rs.450 per month, rising to Rs.550, with free quarters, or Rs.100 per month in lieu thereof. Applications to the Agent for the Commissioners, 17, Victoria-street, London, S.W., by July 18.

A first-class draughtsman, used to h.t. switch gear, is wanted in London district. See an advertisement.

There are vacancies for two premium pupils at Bedford Corporation electricity works. Particulars from the borough electrical engineer (Mr. R. W. L. Philips, A M.I.E.E.), Cauldwell-road, Bedford. See also an advertisement.

A professor of civil engineering (Rs.500 per month) and a professor of mechanical engineering (Rs.500 per month, rising to Rs.1,000, with a pension) are required at the College of Engineering, Madras. Applications to the Secretary, Public Department, India Office, London, S.W., by July 31.

The Yorkshire Electric Power Co., Thornhill, near Dewsbury, have vacancies for junior assistant engineers on 18 months' engagement. Small salary during last six months.

An experienced engineer is wanted for Brentry Inebriate Reformatory, Bristol. Salary £100. Forms of application from the Resident Superintendent. Applications by July 20.

Dr. S. G. Rawson, F.I.C. (director of education for Worcestershire, and formerly principal of Huddersfield Technical College and lecturer at Liverpool University), has been appointed principal of Battersea (London) Polytechnic, in succession to Mr. Sidney H. Wells, Wh.Sc., who, as announced on p. 514 of our issue of Jan. 18 last, has been appointed Director-General of the Department of Agriculture and Technical Education for Egypt.

EDUCATIONAL NOTICES.

City and Guilds of London Institute.—The entrance examinations of the Institute's Colleges are held in September. Particulars of the entrance examinations, scholarships, fees and courses of study may be obtained from the respective colleges or from the head offices of the Institute, Gresham College, Basinghall-street, E.C. The City and Guilds Central Technical College, Exhibition-road, W., is a college for higher technical instruction for day students not under 16 preparing to become civil, mechanical, or electrical engineers, chemical and other manufacturers or teachers. The College is a school of the University of London and the Faculty of Engineering. The City and Guilds Technical College, Finsbury, is a college for intermediate instruction for day students preparing to enter the engineering and chemical industries, and for evening students.

King's College, London.—The Michaelmas term of the faculty of engineering and applied science commences on Wednesday, Oct. 2. A list of the teaching staff appears in an advertisement. Evening classes are held for civil, mechanical and electrical engineering, workshop practice, drawing, metallurgy, mathematics, physics and all science subjects. Prospectuses and further information can be obtained from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

University College of North Wales.—A systematic course of instruction in electrical instruments and practical electricity for students proposing to enter the electrical engineering profession commences in October next. The course extends over two sessions. The physical laboratory at the college is very well equipped. Prospectuses, &c., from Mr. J. E. Lloyd, M.A., secretary and registrar.

Technical College, Finsbury.—The drawings executed by the Students of this College during last session will be on view at the College, Leonard-street, Finsbury, London, each afternoon from Monday. July 15, to Friday, July 19, from 2 to 5 o'clock.

Accrington.—Steam tramcars having been discarded, it is expected that a through service of electric cars between Blackburn and Accrington will soon come into operation.

Acton.—In future the Council's charges for electricity supply will be to private consumers for lighting 5d. per unit; for shops, public buildings and places of worship 4d.; for heating 1d., and for power a maximum demand system of 2½d. for the first hour and 1d. after, with the alternative of a 1¾d. flat rate. The charges have been hitherto a flat rate of 5d. per unit for lighting, less 10 per cent. off demands over 1,000 units per quarter, and 3d. per unit for first two hours and 1d. after for power.

Ashton-in-Makerfield.—Supply of electricity in bulk for street lighting is to be taken from St. Helens Council at 2d. per unit.

Australasia.—Kalgoorlie (W.A.) Council recently rejected by five votes to four a resolution that no further Bastian meters should be purchased unless specially authorised by the Council

Councillor Potts said the meters caused dissatisfaction, and the staff had attributed this to not having the right quality of oil.

Councillor Clemenger said a Bastian and a mechanical meter had been fitted up in the Council chamber, and the results had been the same. The solid fact remained that "in Kalgoorlie no more units were paid for than were generated."

The borough electrical engineer (Mr. D. Curle Smith) said the average complaints were 1¾ per cent. per month, and he knew no meter which would cause fewer complaints nor any mechanical meter that would register an 8 c.p. light.

Councillor Rickarby said his meter was all right until January last, but it was found subsequently to register about 40 per cent. too much. He thought it was because the meters were exposed to the intense heat of the climate.

The electrical engineer was instructed to prepare a report on the advisability of protecting the meters.

Barnes.—The District Council on Tuesday adopted the recommendation of the Lighting committee that two boilers at the electricity works be equipped with mechanical stokers, and that tenders be invited for the work.

The committee reported that the electrical engineer (Mr. C. S. Davidson) estimated that by using the mechanical stokers with a cheaper class of fuel a saving of 15 per cent. would be effected, or a saving of £345 on the estimated fuel bill for 1907-8 (£2,300).

Bath.—The Council last week adopted the recommendation of the Electric Lighting committee that Mr. Schenk be notified that unless the agreement for the sale of the Council's electricity undertaking be executed by July 22 steps will be taken to rescind the resolution of the Council authorising the agreement to be made.

Battersea (London).—The fees charged by the Thames Conservancy for the privilege of using suction and discharge pipes in the river for the purposes of the Council's electricity works condensing plant, were, according to the original assessment, to commence in 1902 at £50 per annum and rise annually to a maximum of £100 in 1906. As the result of strong representations by the borough electrical engineer, however, the fees have been fixed at £50 per annum until 1911.

Beeston.—The Council have asked for an extension of time allowed for carrying out the provisions of their 1902 electric lighting order.

Bosnia.—The Government have granted a concession for the utilisation of the Trebinjcica river in the generation of electrical energy. The water is to be conducted through a tunnel about 7 miles in length to Ragusa, where the fall will be about 800 ft. The concession has been granted for 50 cubic metres of water per second, and the electrical station will ultimately have a capacity of 120,000 H.P. It is said that chemical factories are to be erected in the district.

Brandon (Co. Durham).—The Council have instructed the surveyor to obtain tenders for the electric lighting of the only portion of the Council's area not yet lighted electrically.

Brighton.—At the Council meeting on Thursday, Ald. Carden, in moving the confirmation of the proceedings of the Lighting committee (whose accounts were abstracted in our last issue), said

The committee regretted the deficit of £10,233, which was shown on the past year's working, but the engineer's report explained that owing to their having had two stations working during the twelve months the deficit was inevitable. The first three months of the current year bore out so far the engineer's estimate that a saving of about £11,000 would be effected on the present year. He (Ald. Carden) still believed the policy of doing all the generation at Southwick was a good one and that in a year or two they would have got rid of the smoke nuisance in the town without any expense to the ratepayers.

The committee recommended that securities in which the reserve fund was invested should be realised and the proceeds with the uninvested portion of the fund would discharge the deficit.

Ald. Sendall and Councillor Sone adversely criticised the committee and proposed that the Council's consulting engineer (Mr. Arthur Wright) prepare a report as to whether he approved of taking the whole of the generating to Southwick.

Councillor Griffith gave every credit to the committee for their hard work. He complained, however, of the committee's having left the Council under the supposition that the estimate for the first half of the past year of the amount required from the rates would answer all purposes.

Councillor Black said while the cost of production had been as high as ever the average price for private supply of current had gone down steadily during the past three years. At his own Hove establishment he was charged 5½d. per unit, but the supply to his Brighton shop usually cost 2¾d. or 3d. per unit.

Councillor Martin said they could not compete with gas unless they supplied electric energy as cheaply as gas.

Ald. Carden said consumers ought to be grateful that the prices for current charged in Brighton were 50 per cent. lower than other towns on

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the South Coast, but the committee got little credit for it. It was unfair to insinuate that the Lighting committee had not considered the question whether they should call on the rates for this year's deficit. It was thoroughly considered some time ago and decided against. The cost of lighting the ordinary street lamps was £2. 13s. 7d. each by electricity and £3. 8s. 9d. by gas.

The committee's proceedings were confirmed.

Carmarthen.—The Council on Wednesday discussed a motion that the consideration of Messrs. Saunders' electric lighting scheme should be deferred until after November next.

Mr. H. E. Blagdon Richards pointed out that it would be dishonourable to shelve the matter when the contractors had already laid out considerable sums of money.

The Council conceded certain points raised by the contractors, which practically amounted to a decision in favour of the scheme.

China.—The port of *Shanghai* has become recognised as the greatest commercial distributing centre of the Far East, and gives the Celestials a good idea of foreign methods in regard to electricity and other modern developments. More than half the foreign trade of China belongs to Shanghai, which, although only existent for about 60 years, ranks as the eighth shipping port of the world. The tramways of Shanghai represent about 25 miles of route, the concession being in the hands of a British firm, who will transfer the system on completion to a syndicate of British capitalists. The introduction of electric tramways into the city has created a demand for many other modern improvements, and the ancient landmarks are fast disappearing. An interesting report on the trade of Shanghai for 1906 has just been issued.

At *Ningpo* a large cotton mill has recently been erected for the Whofoong Spinning Mill Co. The capital is Chinese and the management Japanese, the whole of the machinery being of British manufacture, and representing 11,000 spindles, which is to be largely increased. The mill is lighted and driven throughout by electricity, and as there is power to spare it is proposed that the company should undertake the lighting of some portions of the native city as well as of the camp where foreigners reside.

Cotton Mill Driving.—On the occasion of the visit of a large party of members of the Lancashire section of the British Association of Managers of Textile Works to the Acme Cotton Spinning Co.'s mill at Pendlebury on Thursday last, the most interesting feature was found to be the electric driving, which was explained by Mr. C. D. Taite, manager and engineer of the Lancashire Electric Power Co.

Current is transmitted from the company's station to a sub-station in the mill building, where the voltage is reduced from 10,000 to 400. The power is controlled separately on each shafting by independent motors. An exhibition was given of the ease and rapidity with which full power can be obtained, and the visitors remarked on the lightness of the shaftings and the flexible couplings to the motors. Mr. Taite said that in the transformation of the current 98 per cent. of efficiency was obtained. The processes of ring and mule spinning are nearly equally divided on the 80,000 spindles in the mill. An electrically driven centrifugal pump, used to operate fire sprinklers, and stated to be the only one of its kind erected in the country, was also shown, and the manager of the mill, Mr. James Whitehead, said it had proved admirable under stringent fire-insurance tests.

Crewe.—The Council have applied for permission to borrow £3,000 for extensions of the electricity undertaking.

Croydon.—The electric mains are to be extended in Norbury and Addiscombe at a cost of £345. The estimated number of lamps for which the extensions are required is 2,600 and the estimated revenue £642 per annum.

Dewsbury.—Mr. A. P. Dryburgh has resigned his position of borough electrical engineer at Dewsbury.

Dunfermline.—Mr. Matthew Buchan (of Buchan & Partners) has reported to the Council to the effect that if the Corporation desire to have a satisfactory supply of electricity for lighting purposes in the burgh, they must either take current in bulk from the Fife Electric Power Co., and convert it in a sub-station and distribute it as direct current, or generate the current themselves. Unless they could get the company to withdraw their active opposition for both lighting and power, there is, he fears, no hope of their successfully competing with the company. It is of vital importance that a state of harmony should exist between the Corporation and the company, and a friendly working agreement be entered into, but this, Mr. Buchan thinks, can only be obtained by taking supply in bulk from the company. By so doing, less capital expenditure would be involved, and the best financial results would be obtainable.

Edinburgh.—At the Council meeting on Tuesday treasurer Harrison, in his report on the finances of the city for the year ending May, referred to the surplus on last year's working of the electricity undertaking, amounting to £10,075.

Mr. Harrison said the plain facts regarding the electric lighting accounts were that between 1895, when the account opened, and May, 1907, £942,594 had been spent on electric lighting, and there had been laid aside as sinking fund £232,227, and in reserve fund £93,204, and, pending the report asked for from Sir Alexander Kennedy and Mr. Newington, he could not see how the surplus could be appropriated except in contributing to the reserve fund and to relief of rates.

The question of the disposal of the surplus for the past year was remitted to the Electric Lighting committee, who are to report to next Council meeting.

Electricity in Mining.—At the meeting of the New Hillgrove (N.S.W.) Proprietary Mines (Ltd.) the chairman (Mr. J. Coltman) stated that their manager (Mr. Paterson) foreseeing the difficulties which would arise from the anticipated fuel shortage, had for some time had under consideration the question of an electrical installation, and on his recommendation the board had authorised the construction of a transmission line from the Styx River, about 19 miles from the mine, and every effort was being made to get electric energy for power available at the mine at the earliest possible date. The board were informed that the water supply from the Styx River, even in a record dry summer, would be more than sufficient to generate all power required by the company.

Exeter.—At the City Council meeting on Wednesday Mr. Varwell moved the adoption of the Finance committee's report recommending an increase in the salary of the city electrical engineer (Mr. H D. Munro) from £350 to £400 per annum. Mr. Varwell said that Mr. Munro's duties had been practically doubled since the salary was fixed at £350 three or four years ago, and the electricity undertakings had been maintained in an efficient manner. The report was adopted.

Exhibitions.—The Board of Trade have received a description and photograph of the permanent exhibition of machinery in motion at São Paulo, and can acquaint British manufacturers with the conditions for exhibiting. Further information can be obtained from the Director of Industry and Commerce, Palace of Agriculture, São Paulo, Brazil. It is necessary to have an agent in S Paulo or Santos to receive the machinery, clear it at the Custom House, attend to the erection, &c.

Loughborough Corporation electricity department will hold an exhibition in the Town Hall, Loughborough, during the week commencing Sept. 16. Space and d.c. 220 v. current will be provided free of charge. Further information can be obtained from the borough electrical engineer (Mr. W. H. Allen). See an advertisement.

An electrical exhibition, under the auspices of the Corporation, will be opened in the Public Hall, Devonport, on Sept. 18. Electrical energy will be supplied to exhibitors at 1d. per unit. Further information from the borough electrical engineer, Mr. J. W. Spark. See also advertisement.

Felixstowe.—At the Council meeting last week the Lighting committee reported that they had received offers from two makers of flame arc lamps to fit up five each of their lamps for a month's free trial on the Promenade, and to replace the present arc lamps at the end of that period if requested. The committee has ordered the lamps to be arranged in two circuits and a record to be taken of the current consumed.

Feltham (Middlesex).—At the last meeting of the Council the chairman said he understood that the Twickenham and Teddington Electric Supply Co. had no authority to transfer their powers for supply in Feltham. The whole question of electric supply in Feltham has been referred to a committee.

Flue Gas Losses.—The calculation of flue gas losses is, with ordinary methods, a lengthy and complicated process. Mr. O. L. Peard points out that with the aid of his calculating apparatus (described in patent No 23,363 of 1904) definite results can be arrived at in a few seconds. It is claimed for Mr. Peard's calculator that it affords a simple means of arriving at conclusions which would otherwise entail tedious and complicated technical calculations.

Glasgow.—At the meeting of the Corporation on Thursday last a recommendation that, before determining upon the offers received for the supply of turbine engines for Pinkston power station, two members of the staff of the tramways department should be authorised to visit Zurich and other towns on the continent, and inspect turbines in operation. What they required was a 3,000 kw. turbine. The committee had been informed that the Zoelly turbine, which was made at Zurich, was simple and required less coal consumption than the turbines for which they had received offers. The recommendation was adopted and Mr. W. W. Lackie, city electrical engineer, was added to the deputation.

Gloucester.—At the last Council meeting Mr. Clark called attention to the charge made by the electricity department for current for the tramways. He understood current was supplied at 1d. per unit and yet cost the Electricity committee over 1½d. Ald. Fielding undertook to have the matter adjudicated upon by an expert.

Grassington (Yorks.)—At a public meeting on Tuesday a scheme for the electric lighting of the town, prepared by Messrs. Grace & Sutcliffe, electrical engineers, Keighley, was discussed. It was unanimously decided to adopt the scheme and to canvass the town to ascertain the number of lamps required.

Gravesend.—Northfleet Council have declined to release Gravesend Corporation from their obligation, under agreement between the Councils, to supply current in Northfleet by Aug. 11.

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Hammersmith (London).—The Finance committee have asked the borough electrical engineer to report upon the advisability of lighting electrically all the streets in which mains are laid. This step has been taken in consequence of the increased price of gas.

Hastings.—The electric mains are being extended to Clive Vale at an estimated cost of £1,507.

Inquest.—The West Middlesex coroner (Dr. Gordon Hogg) held an inquiry last week into the circumstances attending the death of William Rose at the G.W. Railway Co.'s Old Oak Common electricity sub station.

GEO. SPITAL (superintendent of the inspection chamber) said deceased was engaged in cleaning insulators. One half of the insulators had to be done at a time, the other half keeping the light going. The last time he saw deceased the latter was cleaning insulators on the "dead" side. Witness's attention was drawn to a flash of sparks, and he saw deceased on one of the live conductors. Why he went there witness could not say. Artificial respiration was tried, but death ensued in a few minutes.

An employé named POWELL gave evidence showing that deceased made contact between the live and dead conductors with his hand.

Mr. ROGER SMITH (chief electrical engineer to the company) said deceased was a good workman, always busy and eager. There was a sign on the live insulators that there had been a contact. It appeared that in his eagerness he left insulators which he could not reach to clean, and then got on to the other rail and started cleaning on the live side. To do this, however, he would have to get to the other side of the doorway, which was screened by an iron bar screen. The other men would have their backs turned to him, and deceased could only be seen by a man working by his side.

The jury returned a verdict of accidental death, and were of opinion that there was negligence on the part of the company in the cleaning of the insulators, and that better protection should be given to the men, and especially to men inexperienced in the work.

Japan.—The value of the imports of electric lighting apparatus into *Yokohama* in 1906 was £30,332, compared with £39,182 in 1905, and the value of electric motors was £79,805 in 1906, compared with £167,799. It is estimated that one-half this machinery and apparatus comes from the United Kingdom, one-third from the United States and one-ninth from Germany. Electric light wires and cables were imported into Yokohama in the same period to the value of £60,018, compared with £66,970.

At *Hakodate* the dock company has recently greatly improved and extended its plant. The whole of the lighting of the docks and works is electrical, and, while steam is used for the punching and shearing machines and hammers, electric driving is employed for all the remainder of the machinery. Most of the machines are of British manufacture. Considerable extensions are about to be made to the buildings and their equipment.

Johnstone (N.B.)—The Strathclyde Electricity Co. propose to apply for a provisional electric lighting order for Johnstone.

Kirkcaldy.—The Tramways Committee stated at the Council meeting on Monday that, in consequence of the opinion expressed by Col. Von. Donop on the subject, they did not propose to adopt the use of trailer cars.

Leeds-Guiseley Tramway.—Rawdon, Yeadon and Guiseley Councils have decided to agree to the terms proposed by Leeds Tramways committee for the construction of a tramway from Horsforth to Guiseley, via Rawdon and Yeadon, and will collectively contribute to the cost £400 per annum for 11 years.

Leek.—The Council adopted last week the recommendation of the Electricity committee to accede to an application from Messrs. Brough, Nicholson & Hall for a supply of current for power not exceeding 50 H.P. during the time of heavy load and to lay a new cable at an estimated cost of £330.

Lincoln.—At the City Council meeting last week it was decided that the tramways be now taken over from the contractors.

Llansamlet (Glam.)—The Parish Council have decided to apply for a provisional order and to engage an expert to advise on the subject of electricity supply.

Local Government Loan Procedure.—Erith council last week decided to ask Mr. Jas. Rowlands, M.P., to support Mr. T. Summerbell, M.P., in moving a reduction of the vote on the estimates of the L.G. Board in order to obtain a discussion on the Board's procedure in regard to loans for electricity supply.

London County Council—At the meeting on Tuesday the Highways Committee submitted a report recommending the erection of a central car repairing depot, estimated to cost £51,400 for building and £16,000 for tools. Consideration of the report was deferred, and a further report as to site &c., is to be prepared.

London County Council Tramways.—On Friday last Islington Council decided, on the recommendation of the Works Committee, not to continue to oppose the proposal for a tramway in Pemberton-gardens, which the County Council consider desirable for the use of cars travelling between Holloway-road and the car-shed in Caledonian-park.

Longton.—Mr. H. Shelford Bidwell held an unopposed L.G. Board inquiry last week into the application of the Council for permission to borrow £2,000 for additional steam plant for the electricity department.

Mardy (Rhondda).—The Mardy Electric Light Co have secured a further seven years contract for supplying current for public and private lighting. A flat rate of 4½d. per unit has been fixed for shops.

Marylebone (London).—The Finance committee recommend the Council to carry out the original proposal to borrow £1,400,000 required for the electricity undertaking from the L.C.C. at 4 per cent. A firm of financiers have informed the committee that they could not find the money at 3⅞ per cent.

Morecambe.—The Council decided on Monday to give notice of intention to acquire the undertaking of the local horse tramway company and to convert the system to electric traction. Mr. Gardner, manager of Chester Corporation tramways, estimates the cost of purchase and conversion at £46,093. It would be necessary to spend a further £10,000 on additional plant for the electricity works.

Municipal Telephony.—It is stated that the National Telephone Co. and the Post Office have arrived at an agreement with regard to the purchase of Swansea municipal telephone undertaking by the company, and that there is now no obstacle to the immediate transfer of the system.

New Romney.—Foote & Milne intend to apply for a provisional order for this district.

Northallerton.—Northallerton Electric Lighting Co. have informed the Council of their willingness to consider an offer for the purchase of the undertaking, and the Council have referred the matter to a committee.

Parcel Carrying on Tramcars.—Leeds Tramways traffic sub-committee decided on Monday not to recommend the adoption of a system of parcel carrying on the Corporation's tramcars.

Portsmouth.—Mr. F. H. Tulloch recently held a L.G. Board inquiry into the application of the Corporation for permission to borrow £17,688 for electricity supply. Mr. Foale, borough electrical engineer, gave evidence as to the progress of the undertaking. A local ratepayers' association opposed.

Presentation.—The manager of Dartford Council tramways (Mr. A. D. Murdoch) has been presented with a smoker's cabinet by the staff, on the occasion of his resignation of his post to proceed to South Melbourne (Victoria) to represent J. G. White & Co.

Provisional Order Revocation.—The Board of Trade have revoked the Lower Bebington Electric Lighting Order, 1902.

Sheffield.—At the Council meeting on Wednesday Ald. Styring (the Lord Mayor) tendered his resignation as chairman of the Electric Lighting committee, in consequence of criticism of the accounts of the electricity department, which he did not consider had been conducted in a fair and reasonable manner.

A long discussion followed, in which many members disclaimed any personal feeling in the matter, and also expressed the wish that the Alderman would withdraw his resignation.

Ultimately Ald. STYRING said the suggestion should receive his careful consideration.

Councillor PADLEY moved that the Electric Lighting committee's recommendation to increase the salary of the city electrical engineer, Mr. S. E. Fedden, from £800 to £900 a year should be referred back.

The LORD MAYOR said Mr. Fedden's salary was increased four years ago, when the income of the undertaking was £47,200. Now it was £69,400. When the undertaking was purchased the income was only a quarter of what it was to-day, and yet the then manager received from the company a salary of £1,000. Mr. Fedden was producing electrical energy on more favourable lines than in any place in this country. The works now in hand amounted to £250,000.

Ald. SENIOR said they had to thank Mr. Fedden for producing current at Neepsend cheaper than anybody else in Europe.

Ald. Padley's amendment was carried.

Councillor KING asked how it was that only £1,348 was debited for salaries in the electric light department when the salary of manager, deputy-manager and secretary alone amounted to £1,425.

A printed reply showed that the salaries were apportioned between the electric light and trading departments.

Sir WILLIAM CLEGG moved the adoption of the minutes of the Tramways committee, and said the gross income was £279,585, an increase of £20,856, and the expenditure £169,418, an increase of £11,349. The net profit was £45,696, increase £9,100.

Ald. HUGHES said the special committee which reported on tramway finance recommended that the accumulated surplus should be £30,000, but it stood at considerably less than that sum, and he did not consider it good finance to relieve the rates out of the accumulated surplus.

The committee's minutes were ultimately adopted.

South American Telegraphs.—The Argentine "Boletin" of June 11 contains a copy of a contract entered into by the Argentine Government, whereby the Central & South American Telegraph Co. are authorised to construct a land telegraph line from Buenos Ayres to Mendoza via Mercedes, Junin, Rufino, Villa Mercedes and San Luis, with a branch from Junin to Pergamino, San Nicolas and Rosario.

South Lancashire Tramways.—The clerk to Irlam Council has been instructed to communicate with Manchester and Warrington

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Councils and with the South Lancashire Electric Tramways Co. with a view to securing the establishment by the company of an electric tramway service through the district and connecting with Manchester and Warrington. This would form a connecting link between Manchester and Liverpool.

Southwark (London).—About 12 months ago a number of "Excello" arc lamps were purchased and fixed in the Walworth-road to afford members of the Council the means of judging the quality of the lamp. In view of the satisfaction the new lamp has given the Works committee report that they have decided to "convert" the remaining arc lamps, and 80 "Excello" lamps are to be purchased and fitted at an estimated cost of £800.

Spain.—The electric tramways in *Cadiz* have proved a great success, and the extension of the lines to Chiclana, Tarifa and Algeciras is now under consideration, the main difficulty being the obtaining of permission for the construction of a bridge at San Fernando in place of the present bridge of boats. The existing tramways are largely patronised by the working classes both for holiday and workaday traffic

It is notable throughout Spain that while in regard to many matters modern methods have still to be introduced, there is a notable exception in the case of electric lighting and electric tramways. Thanks to foreign enterprise, most Spanish cities, and many of the smaller districts, are blessed with both electric lighting and electric tramways.

During the last few years a large number of small installations of electric light and power have been introduced into country towns, and many others are in course of erection, combining a flour mill with an electric light supply, the same generating machinery operating the power load by day and the lighting load by night. Most of these mill installations are worked by producer gas from plant of German make, the fuel used being chiefly Belmez anthracite, though charcoal and the refuse of the olive can also be used.

Sunderland.—Mr. H. Ross Hooper held a L.G. Board inquiry on Tuesday into the application of the Corporation for permission to borrow £58,967 for the electricity department.

The Telephone.—Mr. Ellis Lever, of Colwyn Bay, has recently referred in the "Manchester Guardian" to an interesting letter written by his son to that journal in 1879-80 on the subject of the then newly-invented telephone of Edison.

Mr. Lever's son Charles was a pioneer in electric lighting, and at his own and his father's expense lighted the council chamber of the Fisheries Exhibition at South Kensington and the Tropical Department of the Crystal Palace at Sydenham in the early eighties of last century by means of the "Lever" electric arc lamp, which we well remember. Mr. Charles Lever's first experiments were in the electric lighting of his father's residence at Culcheth Hall, Bowdon, Cheshire, to which many thousands of visitors were attracted. Mr. Lever died suddenly in January, 1890, at the early age of 27, and his father writes us to say that it was his letter to "The Times" which led to a Cabinet Minister stating in Parliament that the telephone was nothing more nor less than a "scientific toy." "The Times" of Jan. 6, 1890, also *The Electrician*, contained biographical notices of Mr. Lever and his inventions, and Mr. Lever, senior, states that there is scarcely any use to which electricity has since been applied that this young engineer had not predicted in 1879-80. The telephone—that "scientific toy"—is now to be acquired by the State for several millions sterling.

Thetford.—The Council have asked C. Burrell & Sons to submit terms for supplying electricity in the district.

Victorian Railways Electrification.—We are informed by Messrs. Merz & McLellan that Mr. Charles Merz will be leaving England for a short visit to Australia on Sept. 13.

Village Lighting.—Easebourne (Sussex) Parish Council discussed on Tuesday the question of street lighting, and the chairman (Mr. H. B. Gadsdon) quoted the views of an expert that there was enough water power running to waste at North Mill to light the whole of Midhurst and Easebourne electrically. Further discussion of the subject was adjourned.

Warrington.—The Corporation are applying for an electric lighting order for parishes in the Warrington Rural Council's area.

Watford.—The Council has received from the L.G. Board sanction to borrow £8,151 for extensions to the electricity undertaking. The loan originally applied for was £13,500.

Wednesbury.—The Council decided last week to obtain from the British Westinghouse Co. two 240 H.P. engines and dynamos, to enable them to generate their own current. Supply is at present taken in bulk from the Midland Electric Corpn. for power distribution.

West Ham.—The Electric Lighting committee recommend the Highways committee to adopt single light 50 c.p. Osram lamps in streets other than tramway routes in which cables are already laid. The Lighting committee offer to provide these lamps at £2. 12s. 6d. per annum, inclusive, the Highways committee providing columns and lanterns.

Wexford.—A notification by Foote & Milne's of intention to apply for a provisonal electric lighting order for the district before Dec. 21 has been submitted to the Council.

Woolwich.—London County Council have granted a loan of £16,394 to the Borough Council for the electricity department out of £18,282 applied for.

The Borough Council have been notified that, in view of the unsatisfactory financial condition of the electricity undertaking, the Finance committee of the L.C.C. have been reluctant to recommend the loan, and they will require to be satisfied before considering further applications for loans for electric lighting that the additional expenditure is absolutely necessary and unavoidable.

Workhouse Lighting.—Hammersmith (London) Guardians have decided to request the Finance committee to ascertain the probable cost to the Guardians of producing their own electric light and power. The supply for the workhouse and infirmary last year cost £670.

Yardley.—At their meeting on Tuesday the Council decided to apply to the Board of Trade for an extension from 12 to 18 months of the time allowed for the transfer of the Council's powers under their 1904 electric lighting order to Birmingham Corporation.

Yarmouth.—Mr. H. Ross Hooper held an unopposed inquiry last week into the application by the Council for sanction to borrow £8,235, including £3,000 for steam plant for the tramway department, £2,800 for mains, £1,200 for meters and £1,235 for excess expenditure. Previous sanctions had been pooled and amounted to £92,500, and excess expenditure was £1,235.

The inspector recommended that meters should be purchased out of revenue. With regard to the excess loan the Local Government Board, he said, usually wanted all sanctions accounted for separately, but he proposed that a period of not more than 10 years should be allowed for repayment of the excess expenditure portion of the loan. The undertaking seemed to be doing very well.

Borough Polytechnic Sports.—The annual sports were held on Saturday last under unexpectedly favourable weather conditions at Dulwich. 38 events, contested by juveniles and adults, were decided, to the discourse of popular music.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Accrington.—The accounts of the electricity department for the year ended March show capital expenditure £53,045, increase £7,556.

Revenue was £6,848, including £3,544 for current supplied to private consumers for lighting, £1,707 for power and £1,239 for public lighting. Total expenses were £3,557. Gross profit was £3,291. Interest on loans required £1,233, Parliamentary expenses £30, sinking fund and repayment of loans £2,028, leaving net profit 7s. 3d., compared with a loss of £444 on the previous year. The average price received for current for all purposes was 1·92d. (against 2·92d.). There are 363 consumers (against 331) and 207 motors in use (against 55). 964,298 units were generated. There was a great increase in the supply for power (485,078 units, against 115,268), and the units supplied for lighting were 295,916 (262,421), for use at the destructors 23,299 (20,636). The total maximum demand was 758 kw. (304 kw.).

Bermondsey (London).—During the year ended March 31 the capital expended by the electricity department was £13,026. 10d. 1d., making the total expenditure £133,921. 8s. 4d.

The income from sale of current during the year was £10,521. 15s. 3d., and after paying expenses there was a balance of £7,191. 19s. Of this amount £6,950 was carried to net revenue, and after paying interest and sinking fund there was a balance of £590. 13s. 5d. 1,906,489 units were sold, including 1,402,395 to private consumers.

Burnley.—The accounts of the tramways department for the year ended March show a total capital expenditure of £185,826. 16s. 10d.

The total income was £62,803. 10s. 2d., including £62,075. 19s. 2d. from passenger receipts and £622. 16s. for parcels. Total working expenses were £41,291. 4s. 4d., leaving gross profit £21,512. 5s. 10d. After paying interest and sinking fund (£10,688. 16s.) and rent of leased lines, £8,766. 10s. 4d. was placed to reserve for renewals and depreciation. 11,967,488 passengers were carried, an increase of 874,794 over 1906. 1,205,830 car-miles were run, an increase of 8,058. The fare per passenger averaged 1·31d. (the same as 1906). Traffic receipts per car-mile were 12·48d., against 11·61d., and working expenses were 65·86 per cent. of the receipts. 2,525,135 units of electrical energy were consumed, equal to 2·08d. per car mile.

Glasgow.—The accounts of the Corporation tramways department for the year ended May 31 show capital expenditure £3,104,061, increase £139,614, of which permanent way works accounted for £74,707, electrical equipment of line £51,242, power station and sub-station plant £2,534, workshop tools and sundry plant £1,737, cars £5,488, and other rolling stock £3,126.

Revenue was £895,842 (against £820,939 in previous year), £887,382 (£813,769) from traffics, £2,250 (£1,766) rents, and £5,735 (£5,033) electrical energy sold to the Fairfield Shipbuilding Co. Total working expenses were £485,256 (£456,269). Gross profit was £410,586 (against £364,670), added to interest on surplus revenue £3,511 (£4,745). Interest on capital required £63,769 (£54,787), sinking fund £49,777 (£48,327), income tax £9,932 (£12,423), parliamentary expenses £6,977 (£2,858), payment to common good £35,000 (£25,000), rental of leased lines, &c.. £9,953 (£9,716). £168,408 (£159,886) has been placed to depreciation and permanent way renewals fund, £45,000 (£10,000) to special depreciation fund for buildings and plant, and £25,279 (£36,418) to general reserve. 28,578,613 units were generated and 1,545,940 (h.t.) sold to

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electricity department, 27,007,118 was transmitted to sub-stations and 98,928 (l.t.) also sold to electricity department, the total issued for traction load from sub-station d.c. 'bus bars being 22,487,336 units. 20,350,367 (18,886,910) car-miles were run and 224,063,098 (208,059,833) passengers carried. The maximum load on power station was 9,486 kw. and the total load factor 35·6. The total revenue per car-mile was 10.565d. (against 10·432d.), working expenses per car-mile 5·353d. (5·451d.), or including power works cost 5·721d. (5·797d.). The average fare per passenger was 0·95d. There are 780 cars in stock.

The Tramways committee's report says £63,778 has been spent during the year on upkeep of track, and in addition £83,377 has been laid aside out of the year's revenue for renewal of track, calculated at £500 per mile of single track, repairs of buildings (£5,608) has been charged against revenue and £9,887 has been set aside to meet depreciation for the year, besides a further £25,000 out of the net surplus for the year.

It has been decided to instal two 3,000 kw. turbo-generator sets at Pinkston station. Total cost of repairs of power plant and sundry machinery during the year was £3,729, and £19,528 was charged against revenue to meet depreciation.

Manchester.—The accounts of the electricity department for the year ended March last show capital expenditure £2,388,373, an increase of £71,246 on the year, of which £50,807 was for purchase and laying of mains, £3,066 for meters, and £6,247 for motors, the remainder being chiefly for distributing stations (buildings and machinery).

Revenue was £346.545 (against £329,199), expenses were £184,801 (£181,117), leaving gross profit £161,744 (£148,081). Interest required £65,958 (£65,333), sinking fund £64,045 (£61,217), instalment of loan £5,474 (£5,326), reserve fund £1,096 (£593), leaving net profit £26,268 (£16,219). Of this £2,353 has been appropriated for payment of wages of permanent employés engaged on capital account (for which borrowing powers are not granted), and the remainder (£23,915) is carried to reserve. 63,056,914 (55,025,966) units were generated, 22,686,508 (18,255,313) supplied to private consumers, 91,938 (94,613) to public lamps, and 24,786,457 (22,267,858) for traction. The total maximum supply demanded was 25,180 kw. (21,928 kw.). The average price obtained per unit was 1·73d. (1·93d.).

The city electrical engineer (Mr. S. L. Pearce) states that at *Dickinson-street* a fourth 500 kw. motor converter has been added to the sub-station plant, and in consequence of the decision to transfer the Dickinson-street load to Stuart-street station during the summer contracts have been entered into with Bruce Peebles & Co. for three 1,500 kw. motor-converter sets, and with the British Westinghouse Co. for additional h. and l.t. switch gear. Coal consumption has been 4·51 lb. per unit generated (against 4·64 lb. in previous year).

In reference to *Bloom-street station* Mr. Pearce says the keys of the flywheels of two of the Musgrave engines have worked loose and the makers are to rebuild the wheels of all four sets solid on the shafts. The capacity of the Harris-Anderson feed-water filter has been extended from 8,000 to 13,000 gallons per hour capacity. On the first year's working of the filter a saving of £398 has been effected by recovering the air-pump discharge water instead of running it to waste. Coal consumption was 3·37 lb. (3·47 lb.) per unit generated.

In regard to *Stuart-street station* the report states that to cope with the anticipated demands a contract has been entered into with Willans & Robinson for a 6,000 kw. turbo-alternator, comprising Willans turbine, Siemens alternator and Richardson-Westgarth condensing plant, and Ferranti Limited are supplying additional h.t. switch gear. It is anticipated that this new plant will be in operation by the end of this year. Fuel consumption was 2·77 lb. (3·22 lb.) per unit.

The serious explosion in the Victoria-street mains last September (as the result of the failure of an old service joint), taken in conjunction with the Fountain-street disaster a few years ago, has led to serious consideration being given to the advisability of using a substitute for bitumen. 649 new consumers have been connected (an increase of 39 over the previous year), equal to 62,372 8 c.p. lamps, and the motor connections are equal to 124,762 8 c.p. lamps, or a combined increase of 8,027 H.P. (against 4,810 H.P.). Motors on hire number 764 = 3,394 H.P. (increase 1,057 H.P. over last year's connections). 566,803 yds. of mains are laid, an increase of 33,761 yds., after deducting 2,171 yds. taken up and converted. Total generation costs were 0·496d. (0·511d.) at Dickinson-street (coal 0·237d., against 0·234d.); 0·320d. (0·309d.) at Bloom-street (coal 0·175d., against 0·168d.); 0·242d. (0·269d.) at Stuart-street (coal 0·137d., against 0·158d.); and distribution (all stations) cost 0 108d. (0·127d.).

Sheffield.—The accounts of the electricity supply department for the year ended March show capital expenditure £860,242, an increase of £21,206 on the year, of which £17,739 was for purchase and laying of mains, £1,772 for transformers, motors, &c., and £1,505 for meters and fees for certifying same.

Revenue was £69,469, including sales of current by meter at the average price of 2·36d. per unit, £66,442, rentals of meters, &c., £1,302, sales, repairs, &c., of other apparatus £1,673, and rents receivable £53. Total expenditure was £19,359. Gross profit was £49,883 and balance from last account £18,977. Interest required £29,092, sinking fund £19,236 and renewals fund £5,000, leaving £16,533 to carry forward, of which £2,556 is the net profit for the year. 8,540,629 units were generated, of which 6,778,555 were supplied to private consumers by meter and 202,519 were used on works. The total maximum supply demanded was 5,500 kw.

Taunton.—The accounts of the electricity department for the year ended March show capital expenditure £1,047, making the total £68,226.

Revenue was £9,187. Expenses were £4,700. Gross profit (including sundry receipts) was £4,579, of which, after meeting interest (£1,792) and stock redemption (2,220), £350 has been transferred to reserve, and the balance (£28) carried forward. 877,215 (against 806,850) units were generated, 164,206 (145,390) supplied to public lamps, 86,883 (76,857) for traction, 360,850 (333,560) to private consumers by meter and 980 (860) by contract. The total maximum supply demanded was 544 kw. (524 kw.).

Wigan.—The accounts of the electricity department for the year ended March show capital expenditure £179,178, an increase of £3,486.

Revenue was £26,683 (against £23,050) in respect of the *Wigan* station, expenses being £12,993 (£9,914), leaving gross profit £13,689 (£13,136). From *Pemberton* station the total revenue was £6,053 (£3,533), and total expenses £5,025 (£4,429), leaving gross profit £1,028 (£895). After meeting capital charges the net profit on the Wigan works was £4,502 (£4,567), and the deficit on the Pemberton works £2,015 (£3,837), or a net profit of £2,487 (£730) on the joint undertaking.

Capital expenditure on the tramways was £515,212, increase £24,137. Revenue was £62,469 (£53,352) and expenses £50,152 (£35,400), including £14,807 (£9,569) for current. 11,269,947 passengers were carried and 1,452,458 car-miles run, the total revenue per car-mile being 9·97d. and per mile of track £2,375.

The borough electrical and tramways engineer and manager (Mr. Jas. Slevin) states that the capital cost of the tramways is over £16,000 per mile, which is twice that of similar undertakings. This he attributes partly to the fact that large amounts spent on track, in wages and for materials, have been passed by the Streets committee and not brought before the Tramways committee (and much of which has gone towards street improvements), and partly to the sum paid for the undertaking, and for reconstruction of narrow-gauge tracks. In this respect the undertaking is crippled, sinking fund and interest requiring this year £28,710, and the loss on the year is £16,302, making with last year's balance debit (£2,170) a total deficit of £18,563. Mr. Slevin calls attention to the fact that the present low fares were not adopted on his advice, and he recommends a revision of fares.

Wishaw.—The capital of the electricity undertaking was increased during the year ended April 30 from £11,621 to £18,291.

The year's revenue was £2,191. Expenses were £1,640. Gross profit was £550, and as £1,144 had to be provided for interest and sinking fund, the deficit was £593. 186,076 units were purchased (at prices varying from 1·1d. to 1·3d. per unit) from the Clyde Valley Power Co. 50,000 units were supplied to public lamps and 124,893 to private consumers. The maximum load was 160 kw.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The *Metropolitan Water Board* want tenders by 10 a.m. July 24 for supply of two 25 kw. generators, motors, four triple-expansion marine type engines, three hydraulic turbines, 10 water-tube boilers, mechanical stokers, coal conveyor, ash hoist, pumps, valves, economisers, pipes, &c. Specification, &c., from the Engineer, Southwark Bridge-road, S.E.

Newcastle-upon-Tyne Tramways committee require tenders by noon Aug. 8 for supply of points, crossings, rails, &c., in connection with renewal and extension of a three-road double-turnout junction of the tramways. Forms, &c., from the City Engineer, Town Hall, Newcastle, on and after 17th inst.

Manchester Tramways Committee want tenders by 5 p.m. July 15 for supply of steel girder rails, fishplates, tie-bars, bolts and nuts, steel poles, span wire brackets and rail bonds and for special track work. Specifications from Mr. J. M. M'Elroy, 55, Piccadilly, Manchester.

The Electricity committee of *Stepney* (London) Borough Council invite tenders for supply, delivery and erection at their electricity works of a testing switchboard, motor-generator and transformer; also a three-pole distribution board and earthing panel. Tenders to 27, Osborn-street, Whitechapel, E., by noon July 22.

The Storthes Hall Asylum sub-committee of *West Riding* County Council want tenders by 10:30 a.m. July 22 for supply, erection, &c., of two engines and dynamos, wiring, fittings, lamps, electric bells, telephones, fire alarms, recording clocks, &c. Particulars from Mr. J. Vickers-Edwards, County Hall, Wakefield.

Bristol Docks committee want tenders by 10 a.m. July 26 for supply, erection, &c., of 10 2 ton electric waggon capstans, and two 10 ton, two 8 ton and 16 30 cwt. movable electric jib cranes for the new Royal Edward Dock, Avonmouth. Specifications from the engineer, Cumberland Basin, Bristol.

Cardiff Guardians require tenders by 10 a.m. July 16 for alteration of telephone service at Cardiff and Ely workhouses and provision of telephones, wiring, switchboard, &c. Forms from the Clerk, Queen's-chambers, Cardiff.

Wednesbury Corporation want tenders by mid-day July 23 for supply of balancer boosters and for alterations and extensions of accumulators. Specification, &c., from Mr. W. Fennell, Camp-street, Wednesbury.

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Beckenham Urban District Council want tenders by 4 p.m. July 22 for meters. Specifications, &c., from the Resident Engineer, electricity station, Church Fields-road, Beckenham.

London County Council invite tenders by 11 a.m. July 16 for 78 tramway feeder pillars and overhead electrical equipment for 2,400 yds. of double track for the Council's tramways in Woolwich.

London County Council also want tenders by 11 a.m. July 16 for oil tanks, filters, &c., for their generating station, East Greenwich. Forms from County Hall, Spring-gardens, S.W.

Leeds Sewerage Committee want tenders by July 15 for supply and erection of a 34 kw., 110 volt c.c. steam dynamo. Particulars from Mr. Geo. A. Hart, Municipal Buildings, Leeds.

Croydon Electricity committee invite tenders for supply of flame arc lamps and transformers and lowering gear for same. Particulars from the Borough Electrical Engineer.

Wallasey Tramways committee want tenders by July 16 for supply of points and crossings. Particulars from Mr. W. H. Travers, Egremont, Cheshire.

Willesden Council want tenders by 10 a.m. July 22 for supply of stoneware conduits. Specifications, &c., from the Electrical Engineer.

Tenders will be received at the office of the Deputy Postmaster-General, Adelaide, until noon, Jan. 8 next, for the supply and delivery at Adelaide, of one common battery switchboard and 3,000 subscriber's telephones, in accordance with specification No. 166. Tenderers must state the country in which the articles tendered for have been made or produced, and in the case of manufactured articles, where the material has been made or produced. Specifications can be seen, and forms of tender obtained, at the General Post Offices, Adelaide, Melbourne, Sydney and Brisbane; also at the Commonwealth Office in London, 72, Victoria-street, S.W. A deposit of 5 per cent. of the amount of tenders is required up to £1,000 and 2½ per cent. on additional amounts.

TENDERS RECEIVED AND ACCEPTED.

Salford Council have accepted the tenders of Tandem Smelting Synd. for magnolia antifriction metal; Lancaster & Tonge, Malleable Steel Castings Co., and Richard Johnson, Clapham & Morris, for mechanical car accessories; Bailey & Jones, brake blocks; Geo. Hill & Co., overhead equipment, insulating materials, ears, frogs, pull-offs, &c.; United Asbestos Co., asbestos powder, corrugated brass joint rings, boiler gauge and sight feed glasses, &c.; W. T. Glover & Co., cable and cable accessories; General Electric Co., c.c. house meters, cut-outs, casing and capping, and steel insulated screwed tubing; Veritys Limited, electric motors; Ferranti Limited, house meters; W. T. Henley's Co., rubber strip and black tarred tape; Hall & Pickles, iron and steel bars, plates, &c.; and Chas. Macintosh & Co., cables.

Stalybridge, Hyde, Mossley & Dukinfield Tramways and Electricity Board have accepted the tenders of Tinkers, Shenton & Co. for three boilers; A. F. Ammon, spring washers; J. Carter & Sons, brake blocks; Edison & Swan Co., 16 c.p. lamps; Morton & Edwards, trolley wheels, &c; Vacuum Oil Co., lubricating oil and manganesite paste; Brooke & Sons, asbestos yarn, &c.; and F. Wild & Co., cylinder oil.

London County Council have accepted the tenders of the British Electric Transformer Co. and the Electric Construction Co., amounting to £178 and £95, for an electric transformer and an additional motor for the New Cross sub-station.

West Ham Council have placed orders with the Fuller Electrical Co. for slow speed and squirrel cage two-phase motors, and with the Burroughs Adding & Registering Machine Co. for one of their machines at £85 for the tramways department.

Woolwich Council have placed orders with Heathman & Co. for arc lamp trimmer's ladder at £20, and with Kaye, Son & Co. and W. Cory, Son & Co. for coal for the electricity works.

Croydon Corporation have extended W. Cory, Son & Co.'s contract for coal for the electricity department for a further eight months at present rates.

Bruce Peebles & Co. have received an order from Glasgow Corporation for a 1,000 kw. Peebles-La Cour motor-converter, to operate on a 25 cycle circuit.

Portsmouth Council have accepted the tenders of W. W. Learmonth for extensions of electricity works buildings at £3,564 and Willans & Robinson for a turbo-alternator, &c., at £5,553.

Stockport Council have accepted the tenders of Bertram Thomas for switches at £105 and Eckstein, Heap & Co. for Elliott's ampere meters at £77.

Grimsby Corporation have accepted the tender of the Lahmeyer Electrical Co. for supply of lead-covered cable during the ensuing two years at £1,194. 14s. 9d.

Grossmith & Co. have the contract for the electric lighting of the King's Theatre, Portsmouth.

BUSINESS NOTICES.

With the view of increasing the company's business facilities, the Harris Patent Feed-water Filter (Ltd.) have decided to centralise their engineering and drawing-office department (hitherto at 2, Hamilton-street, Greenock), and their laboratory (hitherto at the London office, 82, Victoria-street), at Bank-chambers, 24, Grainger-street West, Newcastle-on-Tyne, which will be the company's head office as from July 9 instant. The Scottish office from that date will be at Mail Office Buildings, 102-114, Union-street, Glasgow. Telegrams: "Windtight Newcastle" and "Shute Glasgow." Telephones: 3220 Central, Newcastle, and 956 Royal, Glasgow.

The business of the New Century Arc Light Co. (Ltd.), including patents, goodwill, plant, stock, &c., which was offered for sale by tender, has been purchased by Messrs. Broom & Taylor, engineers of the company, who have been associated with the business since its formation, and who will carry it on without interruption as the New Century Arc Light Co.

Mr. A. G. Cuthbert, who formerly represented Messrs. Crompton & Co in Ireland, has been placed in charge of their Manchester district, at the office, Woodall's-buildings, 42, Deansgate.

A. H. Gibbings and F. Chauntler, consulting engineers, Egerton Park, Rock Ferry, Cheshire, have dissolved partnership. Debts by Mr. Gibbings, who continues as Gibbings & Chauntler.

Andrews & Co., 198A, St. Vincent-street, Glasgow, have been appointed agents in Scotland for T. Harding Churton & Co.'s alternating-current motors.

On June 30 Mr. Hy. G. Bradlee became a partner in the firm of Stone & Webster, electrical engineers, of Boston, Mass, U.S.A.

British Insulated & Helsby Cables (Ltd.) have opened a branch office at 17, Crow-street, Dublin, with Mr. F. H. Jones in charge.

The partnership between C. Willis, H. Willis and W. James, electrical engineers, 4, Ryley's-gardens, and Manchester-buildings, Tithebarn-street, Liverpool, has been dissolved. Mr. H Willis continues, trading as C. & H. Willis & Co.

Messrs. McPhail & Simpson (Ltd.) inform us that they have purchased the business of McPhail & Simpson's Dry Steam Patents Co., Ltd., with goodwill, patents, machinery, plant and tools, but not the liabilities or outstanding accounts. The business will, as heretofore, be conducted under the personal management of Mr. McPhail.

Brockie-Pell Arc Lamp (Ltd.)—The creditors of this company have been notified that, in order to preserve the assets of the company and to protect the interests of the creditors and shareholders, Mr. R. Warner, F.C.A., and Mr. Duncan Watson, M.I.E.E., have been appointed receivers for the debenture-holders. It is proposed that the present company shall go into voluntary liquidation with a view to reconstruction. In the opinion of the directors and the receivers the assets of the company are ample to pay the whole of the debentures and debts in full, and to leave a fair surplus for shareholders.

BANKRUPTCIES, LIQUIDATIONS, &c.

Arthur H. Dodd & Horace John A. Whateley (trading as the Garrick Electrical Co.), Bilston, have been adjudicated bankrupt.

In the bankruptcy of R. S. Blackburn, electrical engineer, Osborne-street and Ribstone Works, Hebden Bridge, the public examination will take place on July 26, at Church Institute, Manchester-road, Burnley. The official receiver has issued his statement of the debtor's affairs, in which the causes of failure are stated to be sickness and heavy expenses and pressure by creditors. According to the account filed by debtor, the deficit on June 4, 1906, was £624. 10s. 7½d. and the loss in business since £200; household expenses since the same date were £100; reduction of stock from cost price to probable realisable price, £126. 1s. 4d. Total, £1,050 12s.

A meeting will be held on Aug. 8 at Town Hall-chambers, Fargate, Sheffield, to receive an account of the winding up of the Light Cure & Electro-Therapeutic Institute (Ltd.).

A meeting will be held at 21, Spring-gardens, Manchester, on Aug. 2 to receive an account of the winding up of the Atmospheric Electrical Purification Co. (Ltd.).

Plant for Sale.—A new 10 kw. 100 ampere homo-polar type plating generator, without commutator, is advertised for sale, price £50.

Some electric lighting plant, consisting of 3½ H.P. Hornsby engine coupled to a Canning dynamo (giving 85 amperes at 65 volts), with switchboard, &c., is advertised for sale by the Rev. J. R. Mills, D.D., the Vicarage, Gedney, Lincs.

Mr. Frank G. Bowen, auctioneer, 67A, Aldersgate-street, London, E.C., advertises in another column a Schuckert's projector for sale.

A 2 H.P., 110 volt alternating motor (2,320 revs. per min.) is advertised for sale.

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A large 30 panel h.t. c.c. switchboard and high-class instruments and rheostats are advertised for sale in one or more lots.

Business for Sale.—Old-established electrical and general manufacturing works in London are advertised for sale as a going concern.

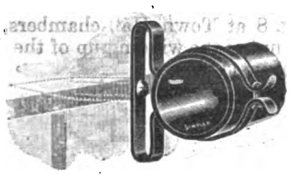
Crystopal.—Kent's Crystopal tiling was put on the market about eight years ago, and is being largely used in places where opal tiling is unsuitable, owing to the way in which it is liable to crack. The chief feature about Crystopal is the patent backing material which is used. This backing is composed principally of bitumen and asphalt, and acts as a cushion between the glass and the cement. The object of the backing is to allow for the necessary expansion and contraction due to changes of temperature, so that Crystopal may be used in situations exposed to considerable heat or cold. Owing to its high reflecting powers Crystopal is very suitable for indoor work, and it has been used at Buckingham Palace, Marylebone power station, Newcastle-on-Tyne tramway power station, Wimbledon electricity works and a number of other power stations, where it is said to have proved very satisfactory. The tiles will withstand a considerable amount of hard treatment, and it is a simple matter to replace one if at any time necessary. A standard bend of 1½ in. radius has been adopted for all angles, as this is proved by experience to give the most satisfactory results. The adoption of this standard bend enables the fixing of the tiles to be more easily carried out, but, if required, curves of any radius can be constructed. The makers of Crystopal are Messrs. George Kent, of High Holborn, London.

New Flash-light for Photographers.—A demonstration was recently given of the "Jupiter" photographic arc lamp at Belgrave-chambers, Westminster, by Mr. A. Strauss-Collin, of Bush-lane House, Cannon-street, London, E.C. In the lamp adapted for a flash light three carbons are used and fixed horizontally in one straight line, so that two arcs are obtained. The points of the carbons are adjusted so that they just make contact, and when by means of a pneumatic ball release a momentary closing of the circuit is made, an intense light, which is stated to be of 5,000 c.p., is obtained. The current taken momentarily is 40 amperes, but, if required, the arcs may be struck by hand regulation and the current varied to any extent by means of an adjustable resistance. The duration of the flash can be regulated from about $\frac{1}{10}$ to $\frac{1}{100}$ of a second, and at these exposures correctly exposed negatives can be obtained in any room. The chief feature of lamp is the excellent diffusion of light, which is obtained by means of a large gauze screen placed in front of the flash, which takes place inside a large white reflector. For providing light for focussing purposes eight 32 c.p. frosted glow lamps are used. At the present time there are about 400 of these arc lamps in use by Continental photographers, but none have yet been supplied in this country.

Kryptol and Mirella.—We have received an announcement that the Kryptol G.m.b.H., of Bremen, and the Mirella G.m.b.H., of Laasphe-i-W., both manufacturers of electric heating apparatus, will establish a joint sales department at Bremen. Until the issue of a catalogue embodying both systems the current catalogues of both companies hold good. The sole agents in the United Kingdom and the Colonies for "Kryptol" are Messrs. W. F. Dennis & Co., 49, Queen Victoria-street, London, E.C.

CATALOGUES, &c.

Surface Wiring in "Simplex."—It is, of course, bad practice to erect conduits and fittings in direct contact with damp walls, or in places where steam is constantly present, as condensation takes place and the conduits are thus continually subjected to drip, which damages the exterior and causes condensation within the conduit. The obvious way to avoid this trouble is to fix conduits some distance from the wall. This is, of course, quite practicable, but is, all the same, a matter of some difficulty, and to overcome this difficulty and to make it as easy to erect conduit on damp walls, as elsewhere, Simplex Conduits (Ltd.) have devised a new spring clip which not only makes the erection of conduit in damp places easy, but entails little additional expense in the work. The clip is shown in the accompanying illustration. It is manufactured from a stout steel strip of a springy nature, and is drilled with a ⅛ in. hole to take a screw, the tips of the spring being provided with holes to take a split pin, thus preventing all possibility of the conduit slipping out after erection. There are several advantages in the use of these clips in surface wiring work in damp situations, not the least of which is the rapidity and ease with which the clips can be fixed to the walls without adopting the ordinary method of plugging. Being made of hardened steel, the clips do not fracture when driven into cement-faced, common-brick or patent fireproof walls.



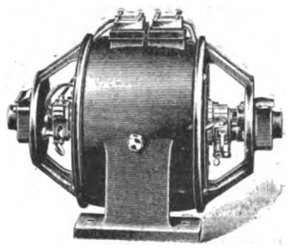
"Simplex" Clip for Surface Wiring in Damp Places.

Controllers and Resistances for Tramway-type Cranes, &c.—A well-illustrated catalogue of standard tramway-type controllers and resistances for cranes, hoists and various forms of lifting machinery has been issued by Thomas Broadbent & Sons, Huddersfield. The firm specialise in this line, and are, consequently, well equipped for quick delivery. The resistances are of substantial construction and liberally rated.

Fans.—The Electrical Co. have ready a sheet list showing electric fans for continuous, alternating and three-phase current.

Anti Friction Metal.—Messrs. Andrew Barclay, Sons & Co., of Kilmarnock, N.B., are distributing a card containing a lot of useful information concerning their Lion Babbitt anti-friction metal, of which they are sole makers. It is claimed that this metal is not an ordinary alloy, but is specially made by a double-alloying process.

Continuous-Current Transformers.—The Crypto Electrical Co. have ready for distribution particulars of a completely new type of continuous-to-continuous transformer for charging ignition and car-lighting accumulators. The transformer can be wound on the primary side for any voltage up to 250, and has an output on the secondary side of 15 volts 7 amperes. The accompanying illustration gives a good view of the machine.



"Crypto" C.C. Transformer.

Fibre Conduit.—The Key Engineering Co., of 4, Queen Victoria-street, London, and 38, Deansgate, Manchester, have ready a "Fibre Conduit Picture Book," the pictures comprising a set of 23 illustrations of fibre conduit, methods of laying in different positions and a large amount of general information concerning this conduit will be found in the booklet.

Marine Type Motors.—A list of totally-enclosed marine type motors, fitted with ball bearings, is issued by Royce Limited, Manchester. A good example of these machines is shown in the list.

Electric Capstans.—A list of electric capstans for direct and alternating (one, two and three-phase) current, direct acting and geared, manufactured by Hillairet Huguet, has been issued by Monté-Callow & Co., who are sole British agents for these machines. The pamphlet now issued gives detailed particulars of the mechanical and electrical construction of these machines, methods of lubrication and other interesting particulars.

Rheostats.—The Adams Mfg. Co. have a list ready of automatic starting rheostats designed to meet cases where it is desired that an alternating-current motor of the induction type, either two or three-phase, shall be started and stopped from a distance by means of a pilot circuit, or where it is desired to control the motor by means of the level of the water in a tank, or by the variation of pressure in the reservoir of an air compressor.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during June, 1907, and (*b*) during the current year from Jan. 1 to June 30, with the increases or decreases compared with the corresponding periods of 1906:—

Electrical machinery, (*a*) £48,382 (increase £9,099), (*b*) £293,458 (increase £21,074); telegraph and telephone cables, (*a*) £8,152 (decrease £3,764), (*b*) £151,074 (increase £69,322); telegraph and telephone apparatus, (*a*) £23,824 (decrease £4,371), (*b*) £130,274 (decrease £50,437); other electrical wires and cables: rubber insulated, (*a*) £3,593 (increase £1,002), (*b*) £45,005 (increase £9,095); with other insulations, (*a*) £6,150 (increase £1,428), (*b*) £40,895 (decrease £5); other electrical goods and apparatus, (*a*) £43,561 (increase £10,340), (*b*) £264,984 (increase £23,269). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £85,280 (increase £4,635), (*b*) £632,232 (increase £51,244).

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from July 3 to 9, with the ports of destination:—

Africa—Alexandria, £561; Benguella, £150; Cape Town, £427 (including £427 telegraph material); Delagoa Bay, £576; Durban, £769; Kilindini, £48; Port Elizabeth, £20. *Argentina*—Buenos Ayres, £175. *Australasia*—Adelaide, £320; Auckland, £20; Fremantle, £357; Melbourne, £182; Perth, £361; Sydney, £866 (including £126 telegraph material); Wellington, £661. *Belgium*—Ostend, £153. *Brazil*—Rio Janeiro, £164. *Burma*—Rangoon, £60 (telegraph material). *Canada*—Halifax, £26; Montreal, £55; Toronto, £49. *Ceylon*—Colombo, £324. *Chili*—Antofagasta, £1,381. *China*—Shanghai, £637 (including £85 telegraph material), *Denmark*—Copenhagen, £44. *France*—Boulogne, £100. *Germany*—Bremen, £8; Hamburg, £47. *Gibraltar*, £101. *Holland*—Rottterdam, £388. *Hong Kong*, £377. *India*—Bombay, £330; Calcutta, £1,011 (including £65 telegraph material); Karachi, £235; Madras, £357. *Japan*—Kobe, £48; Tokyo, £604; Yokohama, £541.

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Malta, £14. *Roumania*—Galatz, £15. *Siam*—Bangkok, £91. *Straits Settlements*—Singapore, £472 (including £302 telegraph material). *Sweden*—Gothenburg, £265 (telegraph cable); Stockholm, £291 telegraph cable). *U.S.A.*—New York, £540 (telegraph cable). *W. Indies*—Port Swettenham, £813 (including £510 telegraph material). *Zanzibar*, £500 (telegraph material). Total £16,006, against £19,366 in the corresponding week last year (July 4 to 10).

According to official returns for June, 1907, the value of electrical goods and apparatus (other than machinery and telegraph and telephone wire) exported from the United Kingdom was £364,987, compared with £102,610 in the corresponding month of 1906 and with £246,168 for June, 1905, an increase of £262,377 compared with 1906 and of £118,819 compared with 1905. For the six months of 1907 the total value of these goods was £1,132,966, compared with £1,061,098 for 1906 and with £1,047,725 in 1905, showing increases of £71,868 and £85,241 compared with 1906 and 1905 respectively. The value of electrical machinery exported in June, 1907, was £71,857, compared with £77,675 in June, 1906, and £49,666 in June, 1905, a decrease of £5,815 compared with June, 1906, and an increase of £22,191 over June, 1905. The total value of electrical machinery for the six months ended June 30, 1907, was £452,933, compared with £438,261 in 1906 and £324,249 in 1905, increases of £14,672 and £128,682 respectively.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

April 16, 1907.

8,804 LAWRENCE. Mechanism for operating the points of tramways.
8,838 RÜHL. Electro-mechanical toys.
8,841 ALLGEMEINE ELEKTRICITÄS-GES. Incandescence bodies suitable for lighting and heating purposes. (Date applied for, 17/4/06.)*†
8,846 ARTHOR. Controlling systems for electric railways.
8,850 FRICKER & MORDEY. Electricity meters.
8,851 MAVOR & MAVOR & COULSON. Multiphase electric induction motors.
8,865 PINK. Working electric lamp signs.

April 17, 1907.

8,874 HAHN. Alternating current vapour apparatus.
8,881 PARSONS. Inter-communication telephone systems.
8,903 DAVIS. Electric lamp.
8,913 BUMPSTEAD & GOVER. Electric switches or circuit breakers.*
8,947 ALLGEMEINE ELEKTRICITÄTS-GES. Incandescence bodies specially adapted for lighting purposes. (Date applied for, 19/4/06.)*†
8,948 ALLGEMEINE ELEKTRICITÄTS-GES. Electric motor-controlling devices. (Date applied for, 18/4/06.)*†
8,951 DAVY. Distribution of electricity.

April 18, 1907.

13,949A/06 FERRANTI. Electric furnaces. (Date applied for, 18/6/06.)
8,953 DAWE. Brake mechanism for electric winding appliances.
8,954 DAWE. Electric winding appliances.
8,984 HOOKHAM & HOLDEN. Electricity meter.
8,999 CREED & COULSON. Machines or apparatus for reproducing in ordinary characters telegraphic or other messages or intelligence in the form of perforations in a tape.
9,009 & 9,010 RITCHIE. Telautographs.*
9,017 TALTSCH. Reflectors for electric and other lamps. (Date applied for, 20/4/06.)*†
9,028 & 9,051 AMALGAMATED RADIO-TELEGRAPH CO. (Hans Rosenthal, Germany.) Oscillatory circuits of radio-telegraph systems.*
9,029 BORGNET. Electrolytic apparatus.*
9,040 METZ. Tramway and railway rails.
9,042 & 9,043 MALEY. Track brakes for rail or tramcars.
9,055 B.T.-H. Co. (Allgemeine Elektricitäts-Ges., Germany.) Electro-magnetic driving and switching mechanism.

April 19, 1907.

27,932A/06 DEMOLDER. Railway and tramway axle boxes. (Date applied for, 7/12/06.)
9,066 DAY & MARSLAND. Trolley rope holders for electric cars.
9,143 ISARIA-ZÄHLERWERKE G.M.B.H. Electricity meters. (Date applied for, 27/4/06.)*†
9,172 INGRAM & HUNT. Arc lamps.
9,176 LAND-UND SEEKABELWERKE ART.-GES. Safety cable. (Date applied for, 3/8/06.)*†

April 20, 1907.

19,461A/06 THOMAS. Systems of electrical distribution in which vapour electric devices are employed. (Date applied for, 1/9/05, comprised in application No. 19,461, 31/8/06.)*†
9,234 B.T.-H. Co. & HOLDEN. Electric measuring instruments.
9,235 B.T.-H. Co. (G.E. Co., U.S.) Machines for use in the manufacture of incandescent electric lamps.
9,240 MOLLER. Electric timepieces.*

April 22, 1907.

9,270 CUMMINS. Automatic electromagnetic sanding gear and foot sanding gear for use on electric railways and tramway vehicles.
9,279 WOODARD & FIELD. Tide or wave power motors.*
9,288 HOLDEN & ELPHINSTONE. Commutators and distributors for electric ignition apparatus.
9,294 HOLDEN & ELPHINSTONE. Automatic electric switches.
9,301 MARTYN. Devices for supporting the insulation of cables.
9,304 JEWELL. Means for utilising tides or currents for the purpose of obtaining power.
9,333 GRAHAM. Telephonic apparatus.
9,337 NORTH & POHL. Electrolytic electricity meters.
9,345 ELLIOTT. Electric pendant lamps.*
9,355 ALLGEMEINE ELEKTRICITÄTS-GES. Bearing for the upper end of the shaft of an electric motor meter. (Date applied for, 14/9/06.)*†
9,361 FORSBERG & LJUNGSTRÖM. Means for controlling the speed of the vane series of fluid-driven turbines. (Date applied for, 23/4/06.)*†

April 23, 1907.

9,390 SIMPSON. Electric vehicle or locomotive brakes.
9,397 PONT. Manufacture of insulating or non-conducting materials.
9,434 MAINPRIZE. Combination electric fuse and switch.
9,461 DE TÖRLEY & BENKÖ. Operating primary batteries.
9,463 NORTH & POHL. Electrolytic electricity meters.
9,477 LAKE. (Hite, U.S.) Primary batteries.*
9,483 TRIQUET & BARROLLIER. Incandescent electric lamps.*
9,491 ALLGEMEINE ELEKTRICITÄTS-GES. Electric motor controllers. (Date applied for, 27/4/06.)*†
9,498 SUCHOSTAWER. Arc lamps.
9,499 DEUTSCHE BECK-BOGENLAMPEN GES.M.B.H. & HEINRICH BECK. Current-loop for arc lamps. (Date applied for, 21/12/06.)*†

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

876 MASCORD. Application and distribution of electro-motive power particularly for use in starting machinery and for such and similar purposes.
1,714 GRAHAM. Supplying electric current to telephonic apparatus.
1,716 FINLAY & FINLAY. Batteries of electrolytic cells.
3,590 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current electric motors.
4,094 NEWMAN. Elastic fluid turbines.
4,654B EVERSON. Illuminating signs. (Date applied for, 27/4/06.)
8,345A DE MARÇAY. Charging accumulators. (Date applied for, 24/1/06, included in No. 8,345/06.)
8,430 CHITTY. Cooling and ventilating dynamo-electric machines.
8,499 JUSTICE. (Deutsche Gasglülicht A.G., Auerges.) Glow lamps.
8,523 JOHNSON & PHILLIPS, TUNLEY & BURN. Starters and regulators for electro-motors.
8,605 TOURTEL & HATFIELD. Electrically-wound clocks.
8,717 VERITYS LIMITED & DALZIEL. Supplying and controlling the voltage of electric currents.
8,787 BARONIO, MUIRHEAD & EDGAR. Telegraphy.
8,891 STELJES. Electric apparatus for making and breaking electric circuits and as a motor.
8,909 PRINGLE. Indicating the pressure between railway or tramway trolley poles or like collectors and the conductors with which they are in contact.
8,935 B.T.-H. Co. (G.E. Co., U.S.) Electric controllers.
9,068 FAIRWEATHER. (International Telegraphic Call Co.) Selective signalling mechanism.
9,090 CHITTY. Cooling or ventilation of dynamo-electric machines and the like.
9,103 GREENWOOD & BROWN. Electrically propelled vehicles.
9,117 ATELIERS THOMSON-HOUSTON (ANCIENS ETABLISSEMENTS POSTEL VINAY). Magneto-electric generators. (Date applied for, 17/4/05.)
9,142 ABERDEEN ELECTRICAL ENGINEERING CO. & BOTTING. Electrical wire conduit surface outlet box.
9,268 BACON. Electro-magnetic transmitting mechanism for governors.
9,346 JUSTICE. (Deutsche Gasglülicht Akt.-Ges. Auerges.) Pocket electric lamps.
9,348 DAWSON & BUCKHAM. Switches for electrical signalling apparatus.
9,349 JUST, HANAMAN, LANDESBERGER, SALZMAN & FIRM VEREINIGTE ELECTRICITÄTS AKT.-GES. Cement joints for incandescent electric lamp filaments.
9,351 RICHARD. Galvanometers.
9,594 LAKE. (Ingersoll Rand Co.) Electro-pneumatic channellers.
9,606 MURDOCK. Electric rotary converters.
9,781 & 9,788 STONE. Space telegraphy. (Date applied for, 20/6/05.)†
9,784 GROTE & ELY. Arc lamps.
9,789 PEARD. Electric fusible cut-outs.
9,794 MORGAN CRUCIBLE CO. & SPEIRS. Brushes for dynamo-electric machinery.
9,858 JACOBY. Alternating-current commutator motors.
9,951 JOHNSON. (De Vara.) Electro-automatic mechanisms for displaying advertisements.
10,020 B.T.-H. Co. (G.E. Co., U.S.) Fluid-pressure brake systems.
10,249A KITSEE. Translating systems for electric telegraphy. (Date applied for, 2/5/06.)
10,404 LEIDL. Construction of masts for wireless telegraphy and other purposes.
10,462 MERRITT. Prepayment mechanism for hire purchase of electric installations.
10,467 STEWART. Automatic switch for preventing excessive current.

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10,565 LAKE. (Stromberg-Carlson Telephone Mfg. Co.) Telephone exchange systems.
10,630 DIXON. Controlling gear for electric cranes and like hoisting
13,032 CRIPPS. Electric heating and cooking apparatus.
13,078 WALKER. End connections for conductors on field magnets of alternate-current generators.
13,450 COLLIE. Trolley poles of electrical tramcars.
13,600 SCHATTNER. Electric fusable cut-outs.
13,972 COWPER-COLES. Electrodeposition of copper.
15,915 NERNST & STOCKEM. Incandescence lamps.
15,985 B.T.-H. Co. (G.E. Co., U.S.) Electric resistance devices.
16,162 JANDUS ARC LAMP & ELECTRIC CO., JONES & DRAKE. Arc lamps.
16,681 ELECTRIC & ORDNANCE ACCESSORIES, HANCOCK & HALL. Centrifugal fans.
16,820 HIGHFIELD. Direct-current electric supply systems.
17,562 WARWICK MACHINERY CO. (G.E. Co., U.S.) Bucke's for elastic fluid turbines.
17,790 FOSTER. Blading apparatus of steam and other fluid turbines and pumps.
17,845 WARWICK MACHINERY CO. (G.E. Co., U.S.) Governing mechanisms for turbines.
17,957 BOREL & DÉNÉRÉAZ. Electric accumulators. (Date applied for, 11/8/05.)

COMPANIES' MEETINGS AND REPORTS.

Electrical Power Storage Co. (Ltd.)

The eighteenth ordinary general meeting was held yesterday, under the presidency of Mr. J. IRVING COURTENAY.

The SECRETARY (Mr. Malcolm Leggett) read the notice calling the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, the directors congratulate the shareholders on the results of the year's working. You will see that, after payment of debenture interest, the profit is £8,751. 3s., which, with £425. 1s. 9d. carried forward, makes £9,176. 4s. 9d. Out of this the directors have placed £1,000 to credit of contingent fund, which now amounts to £10,000, which we consider is ample for any requirements that may fall on this special fund, and, as at present advised, they do not intend to further increase it. In addition, £2,000 has been written off patents goodwill account. They recommend a similar dividend to that of the last four years—namely, 6 per cent.—absorbing £5,389. 13s. 7d., leaving £786. 11s. 2d. to be carried forward. During the year £3,597. 6s. has been spent on renewals, repair and maintenance of buildings, plant and tools, and £2,381. 3s. 10d. on purchase of new plant, including £600 as the first instalment on new suction gas plant to provide power for the works. We hope a reduction in the cost of manufacture will be made when we get the benefit of the full installation of this cheap form of power, instead of relying, as we do at present, partly on steam and partly on electric power supplied by the borough council. The original debentures of the company (£30,000), of which only £28,400 were issued, matured and were paid off on 30th ult. £10,000 (part of an authorised new issue of £30,000) has been issued, which the directors consider will be sufficient for the present.

In the remarks I addressed to you last year I intimated that there were signs that the extreme depression in our particular branch of the electrical industry was passing away. This forecast, I am pleased to say, has been fulfilled, and we have not only had a record in the amount of turnover, but also the actual weight of batteries turned out from our works has exceeded that in any previous year of the company's existence. Unfortunately, however, the enormous rise in price of raw materials chiefly consumed in our manufactures—namely, lead and lead oxides—has told very heavily against us, and the increasing keenness of competition has prevented our raising prices to an extent fully justified by this rise in raw materials, so that, notwithstanding the increased turnover, we are only able to show a profit slightly in excess of last year. I may say that during the past year we have paid for pig lead on an average 22 per cent. more per ton than in the previous financial year. The increase in output has been spread over all the various types of batteries manufactured by the company, including those for central stations, house lighting, telegraphs, telephones, electrically-propelled vehicles, and small types. During the year we have completed batteries for the following large central stations: Marylebone two batteries (these batteries have certainly the largest output of any batteries installed in the metropolitan area, if not in the whole country), Carlisle, Birmingham (three batteries), Devonport, Oxford and Chelsea. We shall continue to push the sale of the batteries in all directions, and by strict economy in the cost of manufacture, and at the same time maintaining a high standard of excellence, we hope to counteract to some extent the disturbing influences already alluded to. There is nothing novel to report in the direction of what I may term "revolutionary" storage batteries. We are ever on the watch to test and examine new inventions in this connection, but inventors are sometimes shy in submitting their discoveries to stringent tests. I now move the adoption of the report and accounts and the dividend set out therein.

Mr. FREDERICK GREEN seconded the resolution, which was carried unanimously.

The retiring director (Mr. F. Green) and the retiring auditors (Messrs. James Meston & Co.) were then re-elected, and a cordial vote of thanks to the chairman, directors and staff terminated the proceedings.

CHILI TELEPHONE CO. (LTD.)—The report of the directors for the year ended March 31 last states that the company's plant suffered severely in the earthquake disaster in Chili last August, and repairs and reconstruction have greatly increased expenditure. The aggregate number of subscribers at all centres at the end of the year was 7,115, as compared with 7,270 at the beginning—a loss of 155 on the year. The net income in Chili from all sources was $520,938, compared with $589,536 in 1905-6, a decrease of $68,598. Converted into sterling at 14·01d., the average rate of exchange for the year, the figures represent £30,414, a decrease of £7,021 compared with the previous year. The liquid assets and liabilities in Chili on March 31 were valued at 12¾d., the current rate of exchange, compared with 15¼d. on corresponding date of the previous year. The balance to credit of revenue, including £2,653 brought forward, is £29,892, and £9,564 has been carried to reserve. The directors recommend a final dividend of 5s. per share, tax free (making 8s. for the year), leaving £2,727 to be carried forward. The total mileage shows an increase of 305 miles 353 yards on the year, bringing the total to 12,678 miles 746 yards.

ELECTRIC CONSTRUCTION CO. (LTD.)—The report of the directors for the year 1906 states that the very severe competition has continued to prevail throughout the year in the electrical manufacturing industry. The increased price of copper and other materials has also been prejudicial, a corresponding increase in the price of electrical plant not having been obtainable, particularly during the first half of the financial year. In consequence, the directors regret that the year's operations, after payment of £10,250 for debenture interest and crediting £5,000 as formerly to depreciation, show a loss of £1,442. 2s. 10d. This has been deducted from the surplus of £1,650. 16s. 2d, brought forward, leaving a balance to be carried forward of £208. 13s. 4d.

During the year several important contracts have been completed at home and abroad. The volume of business in hand is greater than at this time last year, and includes important orders from the Admiralty, London County Council, Wolverhampton Corporation and others. Prices have also improved. The directors, therefore, take a hopeful view of the outlook, reasonable selling prices being alone necessary to restore the company's prosperity.

HARPER ELECTRIC PIANO CO.—The first ordinary meeting was held on Thursday last, Mr. W. E. Garstin presiding. According to the official report of the proceedings, the chairman said the amount of £4,174 against trade debtors shown in the balance sheet was due to the fact that a large portion of the business was done on the deferred payment system; but careful provision had been made against bad debts. Sales last year had been satisfactory, and a new invention, the electric horizontal grand piano, was on view at Earl's Court. The net profit was £699, from which an interim preference dividend had been paid, while from the balance of £467 the directors recommended the payment of a final preference dividend, making 10 per cent. for the year, and leaving £217 to carry forward. The directors contemplated an issue of 5,000 first mortgage debentures at 5 per cent.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

BIRMINGHAM ELECTRICAL CASE CO. (LTD.) (93,998).—Registered July 3, capital £1,000 in £1 shares, to acquire the business of E. Bennett, electrical case maker and cabinet maker, at 109, Unett-street, Birmingham, or elsewhere. First directors P. T. Thompson, F. E. Bill and E. Bennett (all permanent). E. Bennett, managing director. Reg. office, 109, Unett-street, Birmingham.

BRITISH CARBIDE FACTORIES (LTD.) (93,999).—Registered July 3, capital £15,000 in £1 shares, to exploit chemical and electro-chemical processes, and carry on the business of manufacturers of and dealers in carbide of calcium or any electro-chemical products and apparatus and electrical or other plant, &c. First directors H. Compton, A. Howard and A. Akers. Reg. office, 178, Tower Bridge-road, London, S.E.

BRITISH ELECTRIC DETONATOR (LTD.)—Reg. July 3, capital £6,000 in £1 shares, to acquire rights, &c., connected with the business of manufacturers of fuse heads for detonators for explosives, and to carry on the business of manufacturers and wholesale and retail dealers in fuse heads or electric fuses for blasting purposes, &c. S. Salisbury is life governing director. Reg. office, 2, Albert-street, Manchester.

BROADSTONE (LTD.) (93,905).—Reg. June 27, capital £1,000 in £1 shares, to acquire assets and undertaking of the Fleetwood and District Electric Light & Power Synd. (Ltd), to take a transfer of the Fleetwood electric-lighting order 1890, and to carry on the business of an electric light and power company generally. First directors, W. C. Johnson and E. G. Vecqueray. Reg. office, 107, Cannon-street, London, E.C.

CABLERIE DU NORD (LTD.) (93,978).—Registered July 2, capital £5,000 in £1 shares, to take the business of rope manufacturers and boiler coverers, carried on at Armentieres, France, as William Kenyon & Sons, and to carry on the same, and the business of manufacturers of and dealers in ropes, cables (including electric cables), belts, bandings, twines, cords, tapes and braids. First directors G. H. Kenyon, Edwin Kenyon, W. Kenyon, A. Kenyon, Ernest Kenyon and A. Fihey. Reg. office, Chapelfield Works, Dunkinfield.

ELECTRICAL SECURITIES TRUST (LTD.) (6,567.)—Registered in Edinburgh on July 3, capital £200,000 in £1 shares, to carry on the business of an investment trust company. First directors, A. Shepherd, J. Bowhill, J. Guild, R. S. Portheim and A. W. Tait. Qualification, 100 shares. Remuneration, £550 per annum, divisible. Reg. office, 43, Charlotte-square, Edinburgh.

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HUDSON ECONOMISER CO. (1907) (LTD.) (93,788).—Reg. June 19, capital £5,000 in £1 shares, to acquire business and assets of the Hudson Economiser Co. (Ltd.), and to carry on the business of engineers, &c. First directors are C. A. Hunton, H. C. Brown and J. Kitchin. Reg. office, 2, Bishopsgate-street Without, London, E.C.

NORTH EASTERN ELECTRICAL STORES (LTD.) (94,048).—Reg. July 5, capital £1,000 in £1 shares, to acquire the business of manufacturers and dealers in electric lamps and bulbs, bells, batteries, motors, dynamos, accumulators, stores, engines and apparatus, electricians, engineers, &c., formerly carried on by the Northern Electrical Supplies Stores(Ltd.), and recently by F. H. Potts, at 92, Northumberland-street, Newcastle-on-Tyne. First directors, F. H. Potts and A. F. Hawdon. Reg. office, 93, Northumberland-street, Newcastle-on-Tyne.

WRIGHT & WOOD (LTD.) (93,878.)—Reg. June 25, capital £12,000 in £1 shares (3,000 preference), to carry on the business of manufacturing electrical and mechanical engineers, iron and brassfounders, metal workers, cable makers, rubber manufacturers, makers of and dealers in electric, telegraphic, telephonic and other apparatus, &c. H. H. Wright and H. R. Wood are permanent governing directors.

STATUTORY RETURNS.

BARNSLEY & DISTRICT ELECTRIC TRACTION CO. (LTD.)—Return to May 6 gives capital as £50,000 in 5,000 ordinary and 5,000 preference shares of £5 each, of which 4,007 and 4,000 preference have been taken up. £40,035 has been received. Mortgages and charges, £20,000.

BRECKNELL, MUNRO & ROGERS (LTD.)—In return to May 20 capital is £30,000 in 2,000 preference shares of £5 each and 20,000 ordinary shares of £1 each, of which 958 preference and 14,829 ordinary have been taken up. £1 per share has been called up on 767 ordinary and £5 per share on 958 preference shares, and £5,557 has been received. 14,062 ordinary shares are considered as fully paid. Mortgages and charges, nil.

BRITISH INSULATED AND HELSBY CABLES (LTD.)—In return to April 1 capital is £1,000,000 in 100,000 preference and 100,000 ordinary shares of £5 each, all of which have been taken up. £5 per share has been called up on 74,470 preference and 40,065 ordinary shares, and £572,675 has been received. £427,325 is considered as paid on 25,530 preference and 59,935 ordinary. Mortgages and charges, £500,000.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD)—Capital in return to April 8 is £100,000 in £5 shares, of which 15,000 have been taken up. £75,000 has been received. Mortgages and charges, £70,000.

CHISLEHURST ELECTRIC SUPPLY CO. (LTD.)—According to return to April 8 capital is £15,000 in £5 shares, all of which have been taken up and paid for in full. Mortgages and charges, £10,000.

LANCASHIRE DYNAMO & MOTOR CO. (LTD.)—The capital in return to April 22 is £150,000 in 1,000 ordinary and 500 preference shares of £100 each, of which 850 ordinary and 470 preference have been taken up. £100 per share has been called up and £132,000 has been received. Mortgages and charges, nil.

LONDON UNITED TRAMWAYS (LTD.).—The capital in return to March 18 as £2,500,000 in 125,000 preference and 125,000 ordinary shares of £10 each, of which 125,000 preference and 100,000 ordinary shares have been taken up. £10 per share has been called up on 89,000 preference, £8 per share on 39,993 ordinary, and £10 per share on seven ordinary shares, and £1,210,014 has been received. £960,000 is considered as paid on 36,000 preference and 60,000 ordinary shares. Mortgages and charges, £1,331,000.

OKONITE CO. (LTD.)—Return to April 12 gives capital as £120,000 in 32,000 preference and 16,000 ordinary shares of £2. 10s. each, all of which have been taken up. £2. 10s. per share has been called up on 100 ordinary and 110 preference shares, and £525 has been received. £119,475 is considered as paid on the remainder. Mortgages and charges £50,400, of which £33,300 is in the hands of trustees for the company.

ORIENTAL TELEPHONE & ELECTRIC CO. (LTD.)—Return to May 8 gives capital as £300,000 in 200,000 ordinary and 100,000 preference shares of £1 each, of which 179,313 ordinary and 50,000 preference have been taken up. £1 per share has been called up on 7,816 ordinary and 50,000 preference, and £57,828 10s. has been received, including £12. 10s. paid on 50 ordinary shares forfeited. 171,497 shares are considered as fully paid. Mortgages and charges, £100,000.

PERTH ELECTRIC TRAMWAYS (LTD.)—Return to May 16 gives capital as £200,000 in 100,000 ordinary and 100,000 preference shares of £1 each, all of which have been taken up and paid for in full. Mortgages and charges, £229,237.

PETERBOROUGH ELECTRIC TRACTION CO. (LTD.)—Return to April 2 gives capital as £60,000 in £5 shares (6,000 preference) of which 4,400 preference and 4,000 ordinary have been taken up. £5 per share has been called up and £42,000 has been received. Mortgages and charges £21,000.

WINDERMERE & DISTRICT ELECTRICITY SUPPLY CO. (LTD.) Return to April 13 gives capital as £50,000, in 5,000 preference and 5,000 ordinary shares of £5 each, of which 5,000 preference and 3,000 ordinary have been taken up. £5 per share has been called up on 3,040 preference and 1,730 ordinary and £23,850 has been received. £16,150 is considered as paid on 1,960 preference and 1,270 ordinary. Mortgages and charges, £16,800.

WYCOMBE (BOROUGH) ELECTRIC LIGHT & POWER CO. (LTD.)—The capital in return to April 17 is £50,000 in £5 shares, of which 8,000 have been taken up. £40,000 has been received. Mortgages and charges, £10,000.

MORTGAGES AND CHARGES.

BROCKIE-PELL ARC LAMP CO. (LTD.)—Issue on June 25 of £6,000 6 per cent. debentures, to secure £8,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. No previous issue of same series.

CONTROLS LIMITED.—£750 debentures, dated June 27, charged on the company's property, present and future, including uncalled capital, have been registered. No trustees.

ELECTRICAL POWER STORAGE CO. (LTD.)—Issue on July 1 of £1,600 5 per cent. debentures, part of series to secure £30,000, charged on company's undertaking and property. present and future, including uncalled capital. No trustees. Previously issued of same series, £8,400.

FRANK SUTER & CO. (LTD.)—£1,600 5 per cent. debentures have been registered, created and dated June 20, charged on company's undertaking and property, present and future, including uncalled capital. No trustees.

HELIS CELL & ACCUMULATOR CO. (LTD.)—A debenture dated June 24, to secure £650, charged on the company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, R. A. Draper.

LANCASHIRE DYNAMO & MOTOR CO. (LTD.)—The trust deed dated June 24 (securing £75,000 debentures and increasing the interest from 4½ to 5 per cent.) has been registered. Property charged, company's undertakings and other assets, present and future, except uncalled capital. Trustees, E. F. Sheppard and A. Tongue.

MEVAGISSEY ELECTRIC SUPPLY CO. (LTD.)—£1,300 5 per cent. debentures have been registered, charged on company's undertaking and property, present and future, including part of uncalled capital. No trustees.

WHITE, JACOBY & CO. (LTD.)—Re-issue on June 20 of £1,080 and on June 28 of £100 5½ per cent. debentures, part of series to secure £1,500, charged on the company's property present and future, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (July 11).—Bank rate 4 per cent. (since April 25, 1907), Price of silver 31 1/16d. per oz. Consols 84—84⅛ for money, 84⅛—84¼ for account; 2½ per cent. annuities 82¼—82¾. Consols Pay Day, Aug. 1; Stocks and Shares Continuation Days, July 29 and Aug. 13; Ticket Day, July 30; Pay Days, July 12 and 31; Mining Share Carry-over Day, July 26.

BOURNEMOUTH & POOLE ELECTRICITY SUPPLY CO. (LTD.)—The directors have authorised payment of interim dividends on the 4½ per cent. preference shares and the 6 per cent. second preference shares of the company, less tax, for the half-year to June 30, and have declared an interim dividend at the rate of 5 per cent. on the ordinary shares, less tax, all payable Aug. 15.

BUENOS AYRES GRAND NATIONAL TRAMWAYS CO. (LTD.)—The directors recommend a final dividend at the rate of 3s. per share, less tax (making 5 per cent. for the year), on the cumulative preference shares, payable July 25.

COMPANIES TO BE STRUCK OFF THE REGISTER.—A notice dated July 2 announces that the following, among other companies, will be removed from the Register unless cause is shown to the contrary in three months:—

Brighton & Shoreham Tramways Co., Britannia Electric Carriage Synd., Electric Heating Corpn., Mfg. Electric Co., Miniature Arc Lamps, Perfect Dry Seat Synd., Suspended Electric Railway Co., Suspended Railway Contractors, Zea Arc Lamp Synd.

The Herculite & Electrical Mfg. Co. will be struck off the Register in three months from June 21, unless cause to the contrary is shown.

DIRECT UNITED STATES CABLE CO. (LTD.)—The directors have resolved to recommend a final dividend of 4s. per share, with a bonus of 2s. 6d. per share, both free of tax, payable on and after the 31st inst., making with the three interim dividends already paid a total distribution of 4¾ per cent. for the year ended June 30, and to place £15,000 to reserve fund and carry forward about £2,515. The transfer books will be closed from July 12 to 26 inclusive.

NEWCASTLE-ON-TYNE ELECTRIC SUPPLY CO. (LTD.)—An interim dividend of 2½ per cent. on the preference and ordinary shares of this company has been declared.

RIVER PLATE TELEPHONE CO. (LTD.)—The directors have resolved to recommend a final dividend of 5 per cent. on the ordinary shares, making 8 per cent. for the year.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have granted a quotation to £195,000 £100 5 per cent. mortgage debentures of the *Electric Traction Co. of Hong Kong (Ltd.)* and ordered 2,000 additional £5 fully-paid ordinary shares of the *British Aluminium Co. (Ltd.)* to be quoted. The Committee have been asked to grant quotations to a further issue of 10,000 £1 fully-paid ordinary shares of *Vickers, Sons & Maxim (Ltd.)* and £75,000 4½ per cent. irredeemable debenture stock of the *Kent Electric Power Co.*, to appoint a special settling day in 325,000 £1 fully paid shares of the *Electric Traction Co. of Hong Kong (Ltd.)* and to appoint a special settling day in and grant a quotation to scrip (fully and partly paid) for £200,000 4½ per cent. perpetual consolidated mortgage debenture stock of the *Shawinigan Water & Power Co.*

SUN ELECTRICAL CO, (LTD. & REDUCED).—A petition for the confirmation of a resolution reducing the capital of this company from £50,000 to £15,400 will be heard by Mr. Justice Swinfen Eady on July 30.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 3	1,571	+ 96	‡5	6,930	- 160
Airdrie	June 28	231	- 4	25	5,625	- 11
Anglo-Argentine	July 8	16,505	+ 1,687	27	444,740	+ 44,316
Ashton-under-Lyne Corp	,, 6	399	+ 16	15	5,838	+ 584
Ayr Corporation	,, 6	351	- 60	8	2,293	- 209
Baker St. & Waterloo Ry.	,, 6	2,785	+ 1,339	1	2,785	+ 1,330
Barnsley	June 28	152	- 1	25	4,117	- 13
Barrow	,, 28	291	+ 3	25	5,937	- 88
Bath Electric Trams, Ltd.	July 3	782	- 152	27	19,983	- 209
Birkenhead Corporation	,, 7	1,080	- 29	1	1,080	- 29
Birmingham Corporation	,, 6	6,056	...	14	83,294	...
Birmingham & Mid.	June 21	818	...	24	18,978	...
Blackburn Corporation	July 6	1,080	- 51	§14	15,857	+ 580
Blackpool Corporation	,, 4	1,409	+ 100	13	12,528	- 1,577
Blackpool and Fleetwood	,, 6	885	- 65	1	885	- 65
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 7	2,293	+ 26	14	31,577	+ 898
Bournemouth Corporation	,, 3	1,591	- 85	¶13	22,175	- 209
Bradford Corporation	,, 6	4,691	- 18	14	64,747	- 337
Brighton Corporation	,, 7	937	- 172	14	12,390	- 1,328
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 5	5,122	- 490	21	103,265	- 4,768
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams.	...	...	...	...	...	...
Burnley Corporation	,, 6	1,352	+ 26	14	15,910	- 3
Burton Corporation	,, 7	291	- 40	14	3,995	- 302
Bury Corporation	June 30	1,152	...	13	14,029	...
Calcutta Tramways Co.	July 6	R47,752	- R2,728	26	R1,313,813	+ R24,979
Camborne-Redruth	,, 6	152	+ 30	27	3,142	+ 16
Cardiff Corporation	...	...	...	...	...	...
Cavehill	June 28	71	- 30	25	1,886	- 63
Central London Railway	July 6	5,836	- 295	1	5,836	- 295
Charing C., Euston & H'stead	,, 6	2,660	...	1	2,660	...
Chatham & Dist. Lt. Rys.	,, 4	834	+ 103	1	834	+ 103
City & South London Rly.	,, 7	3,260	+ 790	1	3,260	+ 790
City of Birmingham	June 28	2,854	...	25	69,765	...
Colchester Corporation	July 3	218	- 7	1	218	- 7
Cork Electric Trams Co.	,, 4	610	- 5	27	11,901	- 411
Croydon Corporation	,, 5	1,444	- 198	14	19,973	- 1,544
Devonport & Dist. Trams.	June 28	487	+ 43	25	11,234	+ 111
Dover Corporation	July 6	242	- 62	14	3,102	- 428
Dublin & Lucan Railway	,, 5	76	- 22	‡1	76	- 22
Dublin United	June 28	6,519	+ 725	26	136,214	+ 9,902
Dudley Stourbridge	,, 28	830	- 51	25	20,820	- 393
Dundee Corporation	July 3	1,145	+ 58	7	7,926	+ 30
East Ham Council	,, 6	943	- 39	14	12,768	- 415
Exeter Corporation	,, 5	330	+ 20	14	4,381	+ 343
Falkirk and District	,, 3	303	...	1	303	...
Gateshead & Dist. Trams.	June 28	1,245	+ 15	25	25,148	+ 858
Glasgow Corporation	July 6	17,206	+ 180	5	92,115	- 2,738
Glossop	,, 6	136	- 11	27	3,632	+ 43
Gravesend—Northfleet	June 28	256	- 9	25	5,826	+ 39
Great Northern & City Rly.	July 6	1,748	+ 31	1	1,748	+ 34
Gt. Northern, Piccadilly, &c.	,, 6	4,440	+ 10	1	4,440	+ 10
Greenock & Port Glasgow	June 28	755	+ 32	25	16,273	- 117
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 28	318	- 44	25	6 738	- 398
Hastings Elec. Trams Co.	July 4	1,037	+ 261	1	1,037	+ 261
Hong Kong	,, 6	$8,014	+ $982	14	$207,901	...
Huddersfield	,, 6	1,532	- 12	14	22,123	+ 699
Hull Corporation	,, 6	2,478	+ 143	14	33,338	+ 1,879
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 3	136	- 7	14	1,971	+ 140
Ipswich Corporation	,, 6	418	- 30	14	5,526	- 479
Isle of Thanet Co.	,, 6	888	- 212	40	14,677	- 193
Jarrow	June 28	161	...	25	2,977	...
Keighley Corporation	July 4	163	+ 7	1	163	+ 7
Kidderminster & District	June 28	155	+ 21	25	2,683	- 93
Kilmarnock Corporation	July 6	153	- 15	7	1,206	+ 3
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 4	1,318	+ 336	27	29,751	+ 6,519
Lancashire United	,, 3	1,320	+ 254	27	32,044	+ 8,677
Leamington	June 28	157	- 78	25	3,736	- 365
Leeds Corporation	July 6	6,960	+ 64	14	91,170	+ 3,968
Leicester Corporation	,, 6	2,192	- 132	1	2,192	- 132
Leith Corporation	,, 6	593	+ 2	†8	4,030	- 74
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 7	1,611	+ 48	1	1,611	+ 48
Liverpool Corporation	June 29	11,296	+ 106	26	276,210	+ 3,685
*London County Council	,, 29	31,696	+ 5 348	13	401,397	+ 58,904
London United	July 5	7,232	- 261	†27	161,393	+ 2,382
Lowestoft	,, 6	230	+ 22	40	6,476	+ 907
Maidstone Corporation	...	...	...	...	...	...
Manchester Corporation	,, 6	14,936	+ 545	14	204,106	+ 15,856
Mersey Railway	,, 6	1,907	+ 276	1	1,907	+ 276
Merthyr	June 28	207	+ 10	25	5,686	+ 265
Metropolitan Dist. Railway	July 7	8,214	+ 104	1	8,214	+ 102
Metropolitan Elec. Trams.	June 28	5,114	+ 1,438	25	108,593	+ 24,846
Middleton	,, 28	360	- 32	25	8,572	- 116
Nelson Corporation	July 6	124	- 43	15	2,145	+ 2
Newcastle-on-Tyne Corp.	,, 6	3,810	+ 15	14	58,958	+ 1,451
Newport (Mon.)	,, 7	669	+ 9	14	10,286	+ 1,406
Northampton Corporation	,, 5	460	- 73	‡14	6,000	- 276
Oldham, Ashton & Hyde	June 28	611	+ 26	25	14,963	+ 758
Oldham Corporation	July 7	1,887	+ 6	15	28,679	+ 1,764
Perth (N.B.) Corporation	,, 3	170	+ 15	7	1,145	+ 21
Perth (W.A.) Elec. Trams.	,, 5	1,303	- 101	27	38,890	- 1,270
Peterborough	June 28	117	- 16	25	2,889	- 72
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	July 6	2,072	- 379	14	27,020	- 1,163
Potteries	June 28	1,919	+ 95	25	46,933	+ 1,186
Preston Corporation	...	...	...	...	...	...
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	July 4	599	+ 86	†14	8,060	+ 1,189
Rothesay	June 28	275	- 37	25	3,012	- 355
Salford Corporation	July 8	4,690	- 158	14	66,185	+ 975
Sheerness	June 26	59	- 1	25	1,332	- 38
Sheffield Corporation	July 7	5,537	+ 42	15	82,558	+ 3,310
Singapore Trams	,, 6	$9,201	+ $1,923	14	$135,241	+ $25,306

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	July 3	441	- 16	14	4,869	- 269
South Metropolitan	June 28	814	+ 388	25	18,570	+ 1,385
Southport Tramways	,, 28	326	- 23	25	6,737	- 479
South Staffs	,, 28	868	+ 52	25	22,316	+ 1,652
Stalyb'dge, Hyde, &c., Jt. Bd	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	July 7	1,409	- 148	14	19,787	- 86
Sunderland and District	,, 3	503	+ 100	27	11,543	+ 1,493
Swansea Trams	June 28	899	+ 51	25	20,957	+ 551
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 28	42	- 4	25	1,029	- 81
Tynemouth and District	,, 28	430	- 77	25	4,970	- 733
Tyneside Trams Co.	July 3	689	+ 22	27	12,309	+ 635
Victoria, Elec. Supply Co. of	...	...	...	...	...	...
Wallasey District Council	,, 6	855	- 52	14	11,545	+ 155
Walsall Corporation	,, 6	552	+ 24	27	13,125	- 499
Warrington Corporation	...	...	...	...	...	...
West Ham Corporation	,, 4	2,393	- 60	14	33,241	+ 939
Weston-super-Mare	June 26	170	- 68	25	1,898	- 242
Wolverhampton Co.	,, 28	446	+ 26	25	11,073	+ 424
Wolverhampton Corpn	July 3	853	+ 2	24	11,313	...
*Worcester	June 28	299	- 9	25	6,568	- 165
Wrexham	,, 28	113	- 6	25	2,492	- 34
Yorkshire W.R. Trams	July 9	1,155	+ 269	27	30,006	...
Yorkshire Woollen District	June 28	976	+ 70	25	23,800	+ 199

(a) These comparisions are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., July 10.	Rate % Yielded.	Dividend Due.	Business Week to July 10. High-est.	Business Week to July 10. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8 —8½	4 14 0	Ap, Oct	8⅝	8½
5	2/9	† Do. 5½ per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	6 5/16	5 31/32
St.	6⅞	† Do. Permanent 6⅞ Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5⅞	†Auckland Elec. Trams. 5⅞ Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	2 15/16—3 3/16	3 2 6	May ..	3 3/32	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	My, Nv	4 13/16	..
St.	4½	† Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	99	95
St.	7⅞	British Columbia El. Ry. Df. Ord.	120 —125	5 4 0	Mr, Spt	124½	..
St.	⅞	Do. Pref. Ord. Stock	107 —111	4 10 0	My, Nv	110½	..
St.	5⅞	Do. 5⅞ Cum. Perp. Pref. Stock	103 —107	4 13 6	Ja, Jul	..	..
40	4½⅞	Do. 4½ per Cent. 1st Mort. Debs.	99 —102	4 8 0	Ap, Oct	..	..
100	4½⅞	Do. Vancouver Power Debs.	103 —1 5	4 5 6	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4 1/16—4 5/16	8 9 6	Ap, Oct	4 1/16	4 1/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4¾—5¼	5 14 0	Ap, Oct	..	..
5	3/0	Do. "B"	4¾—5¼	5 14 0	April ..	..	..
St.	5⅞	† Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5⅞	† Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	..	..
St.	5⅞	†Buenos Ayres Elec. Trams. (1901) Ltd.	93 —98	5 2 0	Ja, Jul	..	..
100	5½⅞	†Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 —103	5 7 0	Ja, Jul	..	..
100	6⅞	Do. 6 per Cent. 1st Deb. Bonds.	100 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7¼—7¾	5 3 0	Mr, Spt	7⅞	..
100	2/6	† Do. 5 per Cent. Cum. Pref.	5¼—5¾	4 7 0	Ja, Jul	5 5/16	5½
1	4½⅞	† Do. 4½⅞ 1st Deb. Stock (red.)	101 —103	4 5 0	Ja, Jul	1'3	..
Sh.	.	Cape Electric Tram Shares	3/16—7/16	..	..	..	..
..	5⅞	Colombo Tr. & Ltg. 5⅞ 1st Mt. Db.	96 —100	5 0 0	My, Nv	..	..
1	5⅞	Havana Elec. Ry. Con. Mt. 5⅞ $1,000 50 year Coup. Bds.	85 —90	5 11 0	Fb, Aug	..	..
100	5⅞	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	91	..
5	6⅞	Do. 6 per Cent. "B" Ditto	78 —82	7 6 0	Ja, Jul	..	..
5	1/0	†Lisbon Elec. Trams. Ord.	1⅛—1⅛	3 15 0	July	..	..
100	0,7⅛	† Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	4 10 0	Ja, Jul	..	..
St.	5⅞	† Do. 5 per Cent. Reg. Mort. Deb.	95 - 98	5 2 0	Ja, Jul	..	..
St.	5⅞	†Madras Elec. Trams. 5⅞ Deb. Stk.	96 —99	5 1 0	Ja, Jul	..	..
St.	4½⅞	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	..	..
St	⅛	†Perth E. Trams. 1st Mt. Db. Stock	100 —104	4 15 0	Ja, Jul	..	..
..	$2	†Sao Paulo Tramway, Light & Power Co. $100 Stock	117 - 121	3 6 0	..	..	..
..	5⅞	Do. 5 per Cent. 1st Mt. $500 Db	92⅞—94⅞	5 6 6	Ju, Dec	93⅜	93½
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6⅞ Cu. Pr.	4¾—5½	5 14 0	Mr, Spt	..	..
10	3/1½	Bombay E. S. & T. 6⅞ Cm. Pf. £8 pd.	7⅝—8⅜	5 15 0	..	8⅛	..
St.	4½⅞	† Do. 4½ per Cent. Deb. Stk. (red.)	95 —97	4 12 9	Ja, Jul	96½	95⅞
5	5/3	Calcutta Elec. Supply Ord.	6¾ 7⅛	5 10 6	Ap, Oct	7 1/16	7⅛
5	2/3	Do. £4 paid	6½—7⅛	..	..	6⅞	..
50	5⅞	†City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 —53	4 14 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½—2¾	..	Fb, Aug	..	..
St.	5⅞	† Do. 5 per Cent. Deb Stock	8 1/2—9½	5 11 6	Ja, Jul	..	..
St.	5⅞	†Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½—96½	5 3 6	Ja, Jul	..	..
St.	6⅞	†Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —106	5 13 0	Ja, Jul	..	..
1	0/3⅜	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	31/32—32/32	..	Ap, Oct	..	..
St.	5⅞	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	95½	95
1	1/6	Rand Electric	—	..	..	..	..
1	0/6	River Plate Electricity Co. Ord.	5/8—3/4	..	April ..	11/16	11/16
1	1 2/5	Do. 6 per Cent. non-Cum. Pref.	1—1	6 0 0	May	1	..
St.	5⅞	† Do. 5 per Cent. Deb. Stock	96 —98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6⅞ Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	1/16	..
..	5⅞	†Shawinigan Water & Power 5 per Cent. Deb., Scrip	99 —101⅞	4 19 0	Ja, Jul	100	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 10.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 10. Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 – 11	0 6 0	Mar, Sept,	10⅞	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅜ – 10½	4 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1 ⅛ – 10⅜	5 11 6	Feb, Aug	..	..
St.	4½/	† Do. 4½ per Cent. Deb. Stock (red.) ..	99 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 – 100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅜ – 8⅜	5 14 6	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅛ – ⅞	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	99 – 102	3 18 0	June, Dec	100	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3½ – 4	6 5 0	Feb, Aug	3⅞	..
5	2/3	Do 4½ per Cent. Pref.	4 – 4½	5 0 0	Feb, Aug	3⅞	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 – 98	4 1 6	Jan, July	97½	97
5	2/3	† Do. City Undertaking 4½% Cm. Pref.	3⅜ – 4⅜	5 9 6	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3½ – 4½	5 6 0	March ..	..	..
St.	4½%	*†Do. 4½ per Cent. Deb. Stock (red.) ..	102 – 105	4 5 9	June, Dec	104	103⅜
10	7/0	City of London Electric Lighting Ord...	9½ 9⅝	6 3 0	Feb, Aug	9⅝	9½
10	6/0	Do. 6 per Cent. Cum. Pref.	11½ – 12½	4 18 0	Jan, July	..	..
St.	5%	*†Do. 5 per Cent. Deb. Stock (red.),.....	128½ – 129½	4 1 0	June, Dec	..	..
St.	4½%	† Do. 4½ per Cent. 2nd Deb. Stock (red.)	95 – 98	4 12 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.	3⅜ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅝ – 4⅞	5 4 11	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	7½	7¼
10	6 0	Do. 6 per Cent. Cum. Pref.	10⅜ – 11½	5 4 0	Mar, Sept	11	..
St.	4½%	† Do. 4½ Deb. Stock (all paid) (red.)...	105 – 109	4 2 9	Jan, July	107	106⅝
St.	4½%	Do. Second Deb. Stock Prov. Certs....	98 – 100	4 13 9	May, Nov	99⅛	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜ – 5⅜	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	99 – 101	4 9 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ – 7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8⅜ – 9⅛	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ – 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 – 99	4 1 0	..	..	..
St.	4%	Kensington. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	101 – 103	3 17 9	April, Oct	..	..
3	2/4½	London Electric Supply Ord.	1⅜ – 1½	5 6 8	Mar, Sept	⅜	..
5	3/0	Do. 6 per Cent. Pref.	4⅞ – 5½	5 14 0	Mar, Sept	1⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	98 – 96	4 3 8	Jan, July	..	..
5	4/0	Metropolitan Electric Sup. Ord.	5⅜ – 6⅛	6 8 0	April, Oct	..	..
f	2/3	† Do. 4½ per Cent. Cum. Pref.	4⅝ – 5⅛	4 5 6	Jan, July	..	..
St.	4½%	† Do. 4½ per Cent. Deb. Stock 1st Mort.	1 3 – 107	4 4 0	June, Dec	..	..
St.	3½%	† Do. 3½ per Cent. Mrt. Deb. Stock (red.)	86 – 91	3 17 0	Jan, July	..	..
100	4½	†Midland Elec. Corp. for P.D. 1st Mort. Db.	96 – (8%	4 11 9	June, Dec	96½	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9½ – 9¾	4 16 2	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	101 – 103	4 8 3	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	7 – 7⅛	5 13 3	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛ – 5⅛	4 13 0	Feb, Aug	..	..
100	4%	† Do. 4 per Cent. Mort. Deb. red. 1907.	97 – (8	4 2 11	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	† Do. 4½ per Cent. Deb.	97 – (9	4 11 10	Jan, July	..	..
10	9/0	Notting Hill Electric Ord.....	12 – 13	5 15 0	March ..	..	..
5	4/6	Oxford Electric Ord.	(3 (4	5 12 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	96 – 98	4 1 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord	8 – (8	5 17 6	Feb, Aug	8⅜	8 5/16
5	3/6	Do. 7 per Cent. Pref.	6⅜ – 7⅛	4 13 0	Feb, Aug	..	..
St.	3½%	† Do. 3½ per Cent. Deb. Stock (red.) ...	(6 – (1	3 17 0	Jan, July	(9	..
5	..	Smithfield Markets Electric Sup. Ord...	1 – 2	..	Feb	1	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	78 – 77	5 4 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	1⅜ – 2⅛	7 7 0	April	2 1/16	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜ – ½	3 6 9	..	..	..
1	0/8½	Do. 7 per Cent. Cum. Pref.....	1⅜ – 1⅝	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 – 103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1¾ – 2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
f	6/6	Westminster Elec. Sup. Ord.	9½ 9⅝	6 3 0	Mar, Sept	..	..
5	2/3	† Do. 4½ per Cent. Cum. Pref.	(8 – (8	4 0 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	90 – (5	4 4 0	Jan, July	92	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ – ⅞	5 14 0	April	..	..
1	0/6	† Do. 5 per Cent. Cum. Pref.....	⅝ – ¾	5 8 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	April, Oct	..	..
St.	4½%	†B'ham & Midland Trams 4½ 1st Db Stk.	94 – 97	4 13 0	Jan, July	96	95⅜
10	9½	Bristol Tramways & Carriage Ord.	14¼ – 14⅜	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8½ – 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 – 99	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅞ – 3⅛	..	June, Dec	1⅜	1⅜
10	(/0	Do. 6 per Cent. Cum. Pref.....	7⅜ – 7⅝	8 2 6	Feb, Aug	7½	7⅜
St.	5%	Do. 5 per Cent. Perpetual Debs.	103 – 106	4 14 3	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 – 81	5 11 0	May, Nov	(0	79
St.	4%	Central London Ordinary Stock.....	73 – 75	5 6 9	Feb, Aug	75	73½
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	Feb, Aug	..	..
St.	4%	Do. Deferred Stock	53 – 56	7 2 8	Feb	(4	..
100	4%	Do. 4 per Cent. Debs.	103 – 106	3 15 6	Jan, July	..	..
St.	4%	Charing X. Euston & Hmpstd Per. Db. Stk.	(1 – 13	4 16 6	Jan, July	12	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 – 101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	48 – 50	4 0 0	Feb, Aug	49½	47
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 – 121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	Feb, Aug	117½	116
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	104	102½
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13⅝ – 14⅛	4 2 9	Feb, Aug	..	..
10	(/0	Do. 6 per Cent. Pref.....	18 – 14	4 6 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2 – 2⅛	..	Feb, Aug	2 1/16	2⅛
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 0	Jan, July	84⅛	83⅞
St.	4½%	Hastings & Dist. Elec. Trams. 4½ 1st Mt. St	98 – 101	4 9 0	April, Oct	..	..
10	9¼	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	0⅛ – 11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 – 99	4 10 11	Jan, July	..	..
5	1/8	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1½	..	Mar, Sept	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock.....	(6 – 71	5 12 6	Jan, July	..	..
St.	5%	†Lancs. Utd. Trams 5% Prior Lien Db. St.	93 – (6	5 4 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅝ – 1⅞	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6 – 7	7 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	88 – (0	4 9 0	Jan, July	..	..
10	5.0	†London United Trams. 5% Cum. Pref. ...	7⅜ – 8⅛	5 14 3	Jan, July	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Deb. Stock	(4 – 88	4 11 0	Jan, July	85	..
St.	..	Mersey Con. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	3/16 – 5/16	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	5/16 – 7/16	5 3 0	Feb, Aug	..	..
St.	4½%	† Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	94½	94
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	1⅜ – 1⅝	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	5⅞ – 6⅛	6 8 0	April, Oct	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	6 – 7⅛	6 13 3	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock	95 – 98	4 11 9	May, Nov	(6½	(5
1	3/66d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	5/16 – 1⅜	5 16 6	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock	(0 – 84	4 15 3	Jan, July	..	..
100	5%	†Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	14 – 18	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	(4 – 67	7 9 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅜ – 3⅝	—	..	..	..
St.	4½%	† Do. 4½ per Cent. 1st Debs.	88 – 91	4 19 0	Jan, July	..	..

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 10.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 10. Highest.	Lowest.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	5/16 – 3/8	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜ – ½	8 0 0	April, Oct	..	..
1	9/4½	Babcock & Wilcox Ord.....	3½ – 3⅝	5 1 6	April, Oct	3⅝	3½
1	0/7½	Do. Pref.....	1 1/16 – 1 1/16	3 16 9	..	1 1/16	..
5	6/0	British Insulated & Helsby Cables Ord.	6¼ – 6⅜	7 8 0	July, Feb	6 1/16	..
5	3/0	Do. 6 per Cent. Pref.	5⅜ – 6⅛	4 16 0	Jan, July	..	..
St.	4½	† Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 104	4 6 6	Jan, July	..	..
St.	4½	British Thoms'n-Houst'n 4½% 1st Mt. Db.	89 – 93	4 16 9	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	Feb, Aug	1 1/16	1 1/16
St.	4%	† Do. 4 per Cent. Mort. Deb. Stock	(5 – (0	6 6 6	Jan, July	57½	56
2	..	Brush Electrical Engineering	½ – ⅝	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	¾ – 1½	4 16 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	83 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	† Do. Perpetual 2nd Deb. Stock	71 – 74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9¼ – 10½	7 2 6	Jan, July	10	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	5⅜ – 5⅝	4 9 0	Jan, July	..	..
St.	4½%	† Do. 4½ per Cent. 1st Mort Debs. (red.)	105 – 107½	4 3 6	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1 1/16 – 1 1/16	5 12 6	May, Nov	1 1/16	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 – 102	4 8 0	Feb. Aug	99½	..
1	1/2½	Chadburn's (Ship) Telegraph Ord.	1 1/16 – 1 1/16	7 10 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16 – 1 1/16	5 4 0	April, Oct	1⅛	..
3	1/6	*Crompton & Co. (Nos. 1 to 54,000).....	1⅛ – 2⅛	3 12 9	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96⅞ – 99⅞	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1 1/16 – 1 1/16	7 1 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1½	4 16 0	Sept	1⅛	..
St.	4½%	† Do. 4½ per Cent. Deb. Stock	100 – 103	4 7 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1½ – 1⅝	9 8 0	Feb, Aug	1 1/16	..
5	4/2	Do. (£5 paid)	2¼ – 2⅜	4 11 6	Feb, Aug	..	..
St.	4%	† Do. 4 per Cent. Mort. Deb. Stock (red.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½ – 1	10 0 0	Jan, July	½	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1 – 2	..	May, Nov	1½	1⅜
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	78 – 83	5 8 0	Jan, July	..	..
2	..	Electric Construction Co.....	⅜ – ⅝	..	Jan, July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	8 0 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	79 – 83	4 16 3	..	..	..
10	5/0	†General Electric (1900) 5% Cum. Pref...	8 – 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅜ – 12⅜	6 0 0	Feb, Aug	11¾	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5¼	4 2 0	Feb, Aug	5	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105¼ – 107½	4 3 6	Mar, Sept	..	..
10	5/0	†India Rubber, Gutta Percha, &c., Wrks.	15 – 16	6 5 0	Feb, Aug	15⅝	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April, Oct	98	..
1	1/2½	Richardsons, Westgarth & Co., Ltd. Ord.	⅜ – ½	7 6 0	Nov	⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅛ – 1	6 0 0	May, Nov	1	⅛
St.	4½%	† Do. 4½ per Cent. Perp. Deb. Stock ...	95 – 98	4 11 9	Jan, July	..	..
1	..	Simplex Conduits Ord.	1¼	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5¼	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	32 – 33	5 9 6	Mar, July	32½	32¼
100	4%	† Do. 4 per Cent. Deb. Bonds (1909) ...	99 – 102	3 18 3	Jan, July	101⅜	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛ – 2⅞	5 16 0	..	2⅛	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛ – 1⅜	4 1 0	..	1⅜	1⅜
St.	5%	Do. 5 per Cent. non-Cum. Preferred	114 – 116	4 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 – 104	3 17 0	June, Dec	103⅜	102⅛
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 – 107	4 4 0	June, Dec	106	104⅜
10	6/0	J. G. White & Co. 5 per Cent. Cum. Prf.	9½ – 10	5 0 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	1¼ – 1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3¼ – 3⅜	..	Apr, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	77 – 81	4 18 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3⅛	—	June, Dec	..	..
100	5%	† Do. 5 per Cent. Debs. (red.)	86 – 89	5 12 0	June, Dec	..	..
St.	15/0	Anglo-American	63 – 65	5 18 0	F,My,Ag,N	..	..
St.	30/0	Do. Preferred	109 – 109½	5 9 6	F,My,Ag,N	109⅜	107⅜
St.	12½	Do. Deferred	2 1/16 – 2⅛	3 13 0	F,My,Ag,N	2 1/16	2 1/16
St.	4%	†Commercial Cable 4 per Cent. Db. Stk.	92 – 94	4 4 6	Jn,Ap,Jy,O	93⅛	92¼
10	5.0	Cuba Submarine Ord.....	7⅛ – 8¼	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅜ – 16½	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	2⅜ – 3⅜	5 10 6	April, Oct	..	..
5	5,0	Do. 10 per Cent. Cum. Pref.	8⅞ – 9½	5 8 0	April, Oct	..	..
50	4½%	† Do. 4½ per Cent. Deb.....	(8% – 101%	4 9 0	Jan, July	..	..
20	4/0	Direct United States Cable	16½ – 16¾	5 15 6	Ja,Ap,Jy,O	16¾	16
100	4½	†Direct West India Cable 4½% Rg. Db. (red.)	98 – 100	4 8 0	June, Dec	..	..
St.	(5/0	Eastern Ordinary	126 – 129	5 1 0	Ja,Ap,Jy,O	139	138½
St.	17/6	Do. 3½ per Cent. Pref. Stock	89 – 91	3 17 0	Ja,Ap,Jy,O	90	89
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 – 105	3 16 6	May, Nov	..	..
10	(/6	Eastern Extension	13 – 13½	5 6 0	Ja,Ap,Jy,O	13⅞	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock	101 – 106	3 15 6	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 – 101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	18⅜ – 100⅜	4 0 0	May, Nov	99⅜	98⅜
10	5/0	G.N. (of Copenhagen), ex Coupon 70.....	24 – 26	6 19 0	Jan, July	34⅜	33
100	4½%	†Halifax & Bermuda 4½% 1st Mt. Db. (red.)	98 – 100	4 19 0	June, Dec	..	..
25	52/6	Indo-European.....	56 – 58	5 12 0	May, Nov	..	..
100	$1	†Mackay Companies Common	68 – 68	5 18 6	Jan, July	..	..
100	$1	† Do. Preference	67 – 69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛ – ⅜	..	April	..	..
100	4%	†Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	97 – 100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10½	8 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛ – 1⅜	3 2 9	May	1⅛	..
100	4%	† Do. 4 per Cent. Debs.	97 – 100	4 0 0	Jan, July	99⅜	..
10	..	West India & Panama	⅛ – ⅜	..	May, Nov	⅜	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅜	7 15 0	May, Nov	7⅛	..
10	..	Do. 6 per Cent. 2nd Pref.....	6⅜ – 7⅛	..	May, Nov	..	..
100	5%	*†Do. 5 per Cent. Debs.	100 – 103	4 17 6	Jan, July	..	..
10	3/0	†Western Telegraph	13⅜ – 14⅜	4 19 0	Mr,Jn,O.D	15⅛	15⅜
St.	4%	† Do. 4 per Cent. Deb. Stock (red.)	100 – 103	3 18 0	June, Dec	100⅜	..
		TELEPHONES.					
..	4%	†Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 – 92	4 7 0	Jan. July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	100 – 103	4 17 0	Mar, Sept	..	..
5	3 0	Chili Telephone	6⅜ – 7⅛	5 11 0	August ..	6⅜	..
1	0/4½	Monte Video Telephone Ord.	1/16 – 1/16	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅝ – 1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	109 – 111	5 8 0	Feb, Aug	110	108½
St.	4½%	Do. Def. Stock.....	108½ – 109½	5 0 6	Feb, Aug	109½	108⅜
10	6.0	Do. 6 per Cent. Cum. 1st Pref.	11¼ – 13½	4 9 0	Feb, Aug	..	..
10	6.0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅜ – 6⅛	4 10 0	Feb, Aug	5½	..
St.	3½%	*†Do. Deb. Stock 3½ per Cent. (red.) ...	93½ – 96½	3 12 6	June, Dec	95½	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.)	100½ – 102½	3 18 0	Jan, July	101	100⅜
1	(/9⅜	Oriental	1¼ – 1⅜	5 2 0	April, Oct	..	..
1	(/7	Do. 6 per Cent. Cum. Pref.	1 1/16 – 1⅛	4 10 0	April, Oct	..	..
St.	4%	† Do. 4 per Cent. Red. Deb. Stock	95 – 98	4 3 8	Jan, July	..	..
St.	4½%	†Telephone Co. of Egypt 4½ Db. Stk. (red.)	98 – 101	4 9 0	Jan, July	..	..
f	3 0	United River Plate	(¼ – 7⅛	5 9 6	July	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	5 – 5¼	4 11 0	June, Dec	5⅜	..
St.	5%	*†Do. 5 per Cent. Deb. Stock (red.)	—	4 9 9	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	†Elec & Gen. Investment 6% Cum. Pref.	5⅜ 5⅝	6 6 3	Jan, July	..	..
10	6 2	†Globe Telegraph & Trust.....	10⅛ – 11¼	4 17 6	Ja,Ap,Jy,O	11⅛	10⅞
10	4,0	† Do. 6 per Cent. Pref.....	13⅛ – 14⅛	4 5 0	Ja,Ap,Jy,O	13⅜	13⅛
10	6%	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Municipal Electricity at Brighton.

LAST year Mr. JOHN BURNS, when he opened the new electricity station of the Brighton Corporation at Southwick, pressed upon his hearers the foolishness of worrying about a loss of £1,000 or so during the first few years of an electricity undertaking, and he gave the advice that the Corporation should charge a flat rate of 2d. instead of such maximum demand rates as worked out to about 2½d. per unit. If the prices were only low enough profits were sure to come. It would almost appear that the Corporation have taken this advice well to heart, for although the loss in working the year before last was about £1,000, the loss last year, according to the accounts which have just been issued, amounts to over £10,000. The Council, however, do not seem to be altogether gratified at the result. Among the unusual features of the case, it is noticeable that the number of units sold has somewhat decreased, the units sold per 8 c.p. lamp connected has fallen considerably below the figure of the last two years, the maximum load on feeders has also diminished, and although the output is a little higher than in the year 1905, the load factor has fallen from 18·65 to 16·6. The average price obtained per unit in the case of private supply has fallen to some extent, but this should be compensated, more or less, by the further economy in cost of production. In his report on the situation, the engineer, Mr. J. CHRISTIE, attributes the diminished output to the use of high-efficiency metallic filament lamps, but, although the use of such lamps may diminish the output, it is difficult to see how they should affect the load factor. One cause of diminished receipts, though not of diminished output, is the adoption of 4d. as an alternative flat rate. Consumers, to the number of 1,180, who were paying at a higher rate than 4d., have naturally adopted the flat rate, and there are more to come, so that this loss is certain to increase. This shows the disadvantage of having a flat rate sufficiently low to tempt unremunerative consumers from a maximum demand tariff. The Corporation must at least congratulate themselves that they did not take the advice of Mr. JOHN BURNS so far as to adopt a flat rate of 2d.

Metallic Filament Lamps.

IT appears that Brighton is not the only town in which the high-efficiency lamp is affecting the yearly balance-sheet, for at Dudley also the increase in income from private consumers is smaller than would otherwise have been expected. Nevertheless, the borough electrical engineer, Mr. C. E. SAVAGE, evidently feels that the metallic filament lamp should be cultivated, for he suggests that it may be necessary when laying mains in new streets to put in a five-wire system with local balancers in place of a three-wire system, so that houses may be supplied at half the present pressure. No doubt he is right in saying that the running of two metallic filament lamps in series is inconvenient and unpopular, and results in a unit which is too large for private house lighting. It is, however, rather doubtful if engineers will care to follow the lead of Mr. SAVAGE, for the addition of such a network with balancers necessarily adds considerably to the cost, and defeats the entire object of the higher pressure supply which is now almost universally adopted. The necessity of keeping down capital cost will inevitably result in the higher pressure of supply being retained, and therefore it is probable that engineers will prefer to wait for further developments in the hope that metallic filament lamps will be produced suitable for the higher pressures. Although the

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true metallic filament may not be adaptable to the higher pressures, there is every indication that filaments will soon be produced of some compound with a sufficiently high specific resistance for use on the higher pressures.

The Electrobus.

ONE of the most interesting events of the week is the appearance of the Electrobus in actual competition with other motor omnibuses on the London streets. A trial of the new comer will show that this vehicle is comfortable and even ornamental in its interior. The comfort is certainly greater than in the more usual motor omnibus, because the motion is smoother, though it is not necessarily so fast, and a further advantage is that the length is less. In the words of the daily Press, the Electrobus has come; but what we are anxious to know is whether it has come to stay. The flotation of the Company was carried through in a storm of criticism, and so far it has survived; but as yet there is no proof that the criticism was ill-founded. We shall await this proof, and when it is shown conclusively that the accumulator vehicle is the solution of the motor omnibus problem we shall not be slow to offer our congratulations.

Accounts of Local Authorities.

IN the report just issued by the Departmental Committee appointed to inquire into the accounts of Local Authorities, a number of recommendations are made with the object of introducing uniformity, and of making the accounts of such a nature that it will be possible to see the true financial state of a municipal undertaking. With regard to depreciation, the Committee are of opinion that repayment of debt may be regarded as a provision for depreciation, but they admit the possibility of the period allowed for repayment being excessive, and that on that account further provision for depreciation may be necessary. Capital accounts are to be charged with the true capital expenditure; no valuations of assets should be included, but only the capital outlay at the original amounts. Repairs and replacements of plant are to be charged to revenue or reserve fund in all cases, and accounts are to show what provision has been made in the way of reserve for meeting any special burden which may arise in connection with the replacement of plant. Among the costs of the undertaking are to be included a fair share of any common charges which may concern the management of the undertaking, and all law and Parliamentary costs and financial charges. Perhaps the most important recommendations are that where capital expenditure relates to other matters in trading undertakings, or to more than one undertaking, a reliable and, if possible, an independent apportionment of the burden should be obtained; and that where transfers have to be made in respect of services rendered by one department to another, as in the case of gas or electric current supplied for the lighting of streets, sufficient data should be provided to establish the fair and reasonable nature of the charge. There have been so many instances in which one department, or one section, of a municipal business has been made to suffer for the sake of another, that these recommendations will be welcomed by all who desire to see municipal accounts kept in such a way as to show the true financial results.

London County Council Tramways.

ON their system of tramways the London County Council have so uniformly made use of the conduit system that any other methods are generally dismissed without consideration. This result may be partly due to the action of the metropolitan borough councils, who evidently do not feel disposed to accept anything which may be considered as an inferior system, and partly, no doubt, to the very overrated notion that the overhead trolley is a serious obstruction, or a great disfigurement. Now, however, the Highways Committee are recommending that the tramways between Aldgate and Bow should be electrified on the "G.B." surface contact system. This is one of the latest of its kind, but appears to be giving satisfaction at Lincoln. Any surface contact system necessarily has inherent defects, and it remains to be seen whether the "G.B." system will survive in a satisfactory manner the stress of London traffic.

Personal.—Mr. A. H. Norway has been appointed an Assistant Secretary to the Post Office, vice Mr. H. Buxton Forman, C.B., who has lately retired.

Engineering Standards Committee.—The Council of the Institution of Civil Engineers have appointed Sir William Matthews, K.C.M.G., President of that Institution, to succeed the late Sir Benjamin Baker, K.C.B., K.C.M.G., as one of their representatives on the Main Committee of the Engineering Standards Committee.

Imperial College of Science and Technology.—The first meeting of the governing body of this institution was held at the Victoria and Albert Museum on Friday last. Mr. McKenna, who opened the meeting, explained the arrangements which were necessary for the transfer of the Royal College of Science and Royal School of Mines to the control of the governing body, and referred to the importance of the work required from them, in connection with advanced technical education within the Empire. Lord Crewe was elected chairman and several preliminary committees were also appointed.

University of Wales.—A committee has been appointed by the Lords Commissioners of His Majesty's Treasury to inquire into the character of the work carried on by the University of Wales and its constituent colleges, and also regarding their financial position, staff requirements, &c. The members of the committee are: Sir T. Raleigh, K.C.S.I., D.C.L. (chairman); Sir John Rhys, Litt.D., LL.D. (Principal of Jesus College, Oxford); D. MacAlister, LL.D., D.C.L. (Principal of Glasgow University); F. G. Ogilvie, C.B.; Prof. W. S. McCormick, LL.D.; and Dr. Alexander Hill (Master of Downing College, Cambridge). Mr. G. L. Barstow, of the Treasury, is to act as secretary to the committee.

Institution of Electrical Engineers.—We have received a bound copy of the Papers read at the meetings of the Manchester section of the Institution of Electrical Engineers during the past session, along with a report of the discussions. Any member of the Institution can obtain a copy for the sum of 6s. from the assistant secretary, Mr. A. L. Green, 2, Churchill-avenue, Manley Park, Manchester. It is the first time that a volume of this kind has been issued by a local section, and although it may prove useful to those interested in purely local section affairs, it is a little difficult to see the object of so much duplicate publication. Papers of value are already published in the *Proceedings* of the Institution, which are distributed free of charge to members, so that subscribers to the present volume will apparently only get in addition such Papers and discussions as the Editing Committee do not consider of sufficient interest for publication in detail.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Faroe Islands—Shetlands....	July 8, 1907 ..	July 13, 1907
Trinidad—Demerara.....	July 9, 1907 ..	July 15, 1907

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Electrical Operation of Terminal Stations.—According to the *Scientific American* the results of electric operation at the Grand Central station and terminal yard, New York, as shown during the six months which have intervened since electric traction was adopted, have been very gratifying. Already the new system has reduced the congestion, practically abolished the delays to incoming and outgoing trains, and restored the spirits and good temper of the company's patrons to their normal reading. The reduction in train movements is very great. In December of last year the total number of movements was 1,213, which amount has now been decreased to 523. The diminution of noise, and the absence of steam, smoke and cinders are also very noticeable.

City and Guilds of London Institute.—We have received copies of the programme of the Department of Technology for the coming session and the report of the Council for 1907. It is noticeable from the latter that whereas the number of students in civil and mechanical engineering at the Central Technical College is rapidly increasing, the number of students in electrical engineering shows a marked falling off; the number during 1905-6 being practically the same as during the session of 1902-3. Nearly half the number of degrees conferred by the University of London since 1903 have been conferred upon internal students of the University from the Central Technical College. In the Technical College at Finsbury the same tendency in the number of students in the mechanical engineering and electrical engineering departments respectively is noticeable.

University of Liverpool.—The following honorary engineering degrees were conferred last week by the University of Liverpool: Doctor of Engineering (D.Eng.), on Sir A. B. W. Kennedy; Master of Engineering (M.Eng.), on J. A. F. Aspinall (general manager of the Lancashire & Yorkshire Railway), J. Brodie (city engineer), A. Bromley Holmes, W. H. Watkinson (Professor of engineering, Liverpool University), and J. W. Anderson (dean of the Faculty of Engineering); Doctor of Science (D.Sc.) on Sir Oliver Lodge, Sir William Ramsay, Sir Henry Roscoe and Prof. W. Ostwald. Prof. Watkinson, in presenting Sir Alex. Kennedy as a candidate for the doctorate, said that it was peculiarly appropriate that the first honorary degree in engineering bestowed by the University should be given to the founder of the first laboratory for experimental work on the engineering scale. By solving this difficult problem Prof. Kennedy did for engineering education what Lord Kelvin had previously done for physics.

Obituary.—We regret to record the death of Sir William Perkin, which occurred on Sunday last at his residence at Sudbury, Middlesex. Sir William, who was best known as the founder of the coal-tar industry, was born in London in 1838, and received his technical education at the Royal College of Chemistry. While conducting researches on the possibility of artificially preparing quinine, he found that by heating aniline with an oxidising agent a precipitate was obtained which contained a brilliant colouring matter, known as aniline purple or mauve. This discovery and its adaptation led to the formation of the well-known firm of Messrs. Perkin & Sons and to the foundation of the aniline dye industry. Sir William Perkin's physical work chiefly consisted in researches on magnetic rotation, for the results of which he was awarded the Davy and Longstaff medals. He was elected a Fellow of the Royal Society in 1886, and was awarded the Royal medal in 1879 and the Davy medal in 1889. He was president of the Chemical Society in 1883, president of the Faraday Society during the present session, and was an honorary Ph.D. of Würzburg, and an honorary LL.D. of St. Andrews.

British Association—Section G.—Engineering.—The following provisional programme has been arranged for this section:—Thursday, August 1st: Presidential address by Prof. S. P. Thompson, F.R.S. Mr. D. Clerk, "The Present Condition of Gas and Petrol Engines." Friday, August 2nd: Joint meeting with the members of the Chemical Section (B) to discuss "Gaseous Explosions with Special Reference to Temperature." Monday, August 5th: Sir W. H. Preece, K.C.B., F.R.S., "Pupin's Compensated Cable for Telephone Transmission." Mr. J. T. Morris, Note on "An Oscillograph Study of Duddell Arcs of Low Frequency"; Mr. L. Gaster, "Developments of Electric Incandescent Lamps"; Mr. H. I. Brackenbury, "Modern Machinery and Its Future Developments"; Mr. J. F. Brooks, "A Machine for Weighing the Forces on a Cutting Tool"; Mr. R. S. Ball, "Note on the Governing of Hydraulic Turbines." Tuesday, August 6th: Mr. J. S. E. de Vesian, "Ferro-concrete and Examples of Construction"; Mr. W. Noble Twelvetrees, "Some New Uses for Reinforced Concrete"; Mr. H. T. Barnes, "The Ice Problem in Engineering Work in Canada"; Prof. E. G. Coker, "The Equipment of the Engineering Laboratory of the Finsbury Technical Institute"; Mr. J. F. Millet, "Submarine Signalling." On the afternoon of Friday, August 2nd, members of the section are invited by Mr. C. Bennion to a demonstration of boot and shoe-making machinery at the works of the Union Company. On Saturday, August 3rd, an expedition is arranged for members of the section over the Leicester and Swannington Railway, one of the earliest railways laid down in England. In Section A (President Prof. A. E. H. Love, F.R.S.) the Papers are chiefly of mathematical interest. Prof. H. E. Armstrong, F.R.S. will read a Paper on "Ionisation," and Sir Oliver Lodge, F.R.S., will deal with ether density.

New Method of Photo-transmission.—At a recent meeting of the Société Internationale des Electriciens M. Blondin described a new method of photo-transmission, due to M. Carbonnelle, in which selenium is not used. After experimenting with various selenium arrangements the inventor abandoned this method for another which seemed to promise more success. This system, which, since March 1st, has been submitted to official tests on the telegraphic circuit between Brussels and Antwerp and back (a total distance of about 57 miles) is very simple. There are two cylinders revolving synchronously, one at the transmitting and one at the receiving end. On the first is wound a sheet of metal on which is written or photographed by a special process the messages or other matter which is to be reproduced. On the second is a layer of some plastic substance such as wax, or of some soft metal such as lead, or even sheets of white paper separated by carbon paper. A metallic style, which is connected to one pole of a battery, presses on the surface of the conducting sheet carrying the message. This latter is connected to earth through the support. The other pole of the battery is connected to the line. The metal style has a lateral motion along the axis of the cylinder. At the receiving end is a telephone connected to the line and to earth. This receives a current varying with the movements of the transmitting cylinder. A graver fixed to the diaphragm traces a groove in the wax or lead, or draws lines on the sheets of white paper. The action is as follows: When the transmitting style passes over an insulating part of the message no current passes to the line and the receiving point presses on the surface of the receiving cylinder. When, on the contrary, a current flows, the style is raised. A reproduction in wax, in lead or in black lines on white paper is thus obtained. It is claimed that, as regards the speed of transmission, this apparatus is superior to that of Prof. Korn. In the Carbonelle system a photograph measuring 9 cm. by 18 cm. was transmitted in 80 seconds. By Prof. Korn's method it takes about 12 minutes to send a photograph 13 cm. by 18 cm. and to get a reproduction 6 cm. by 10 cm. To obtain the various degrees of light and shade one of the following methods is employed: A special reticulation of gums or gelatine bichromates, or a heliograving process, or base of metallic salts obtained by a special method or those obtained by the carbon process. In the first two methods the thickness of the layer is proportional to the degree of light and shade and the current varies in the same proportion. In the case of metallic salts the thickness of the layer is the same all over, but the strength of the salt is different at different places. When carbon is used the layer is again of varying thickness.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, July 20th.

JUNIOR INSTITUTION OF ENGINEERS.

Visit to R.M.S. "Oruba" and the Tilbury Dock Pumping Plant.

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THE ELECTRO-THERMIC COMBUSTION OF ATMOSPHERIC NITROGEN.*

BY F. HOWLES, M.SC.

Among important problems at the present time, the fixation of atmospheric nitrogen is one of the most prominent. Birkeland and others have succeeded in working out processes of more or less commercial value, but it is probable that a good deal yet remains to be done, and that pioneering work will yet be turned fo account. In the present article, Mr. F. Howles, who was one of the earliest workers on the subject, discusses the factors involved, and gives a general summary of what has been done.

After the researches of Sir William Crookes (1892) and Lord Rayleigh (1897), some investigations were made (1898-9) by Mr. McDougall and myself in order to determine the most favourable conditions for the oxidation of nitrogen in the flame exhibited by Sir William Crookes before the Royal Society. These researches led to the following conclusions:—

1. The form of arc chamber used exerted a great effect on the yield of nitric acid.

2. The rate at which the air was supplied to the flame also exerted an effect—too great a supply rendered the arc unsteady, thereby diminishing the yield of nitric acid and increasing the difficulty of absorption. A deficient supply, on the other hand, also showed a diminished yield of nitric oxide. owing to the oxide produced remaining for too long a period in the neighbourhood of the arc, and so undergoing dissociation.

3. With an arc of constant voltage and the electrodes remaining at a constant distance apart (20 mm.), an increase of the current caused a drop in the yield of nitric oxide, whilst a decrease of current beyond a certain amount (0·15 ampere) caused the arc to become unsteady and liable to extinction.

4. The yield of nitric oxide under the most favourable conditions represented 51·5 per cent. of that theoretically obtainable.

5. When air most intensely heated was passed through the apparatus the result was a decrease in the yield of nitric oxide compared with that obtained when air at ordinary temperatures was used, this phenomenon being attributable to the fact that the increased temperature of the air prevented the sufficiently rapid cooling of the gases after leaving the arc, thus facilitating dissociation of the nitric oxide.

6. The yield of nitric oxide from a low-tension arc playing between carbon electrodes was a mere fraction of that obtained in a high-tension arc.

7. The loss of metal from the electrodes was exceedingly small.

8. The substitution of electrodes of oxides of the earth metals for the usual metallic electrodes did not yield satisfactory results in our hands, as those we used were too long and not heated to a sufficiently high temperature.

These results have been amply confirmed by subsequent investigators—No. 3 more particularly by Muthmann and Hofer†, who practically repeated the experiments indicated, apparently unaware that the ground had been previously covered.

With regard to the composition of the gases leaving the arc. In addition to nitric oxide, the excess oxygen and nitrogen appear to be the only gases present, since nitrous oxide has not been observed in the exit gases, and if produced would not subsequently oxidise.

Nitrogen peroxide is formed only at temperatures below 600°C., and nitrogen pentoxide is non-existent at the temperature of any part of the arc. Thus of all the known oxides of nitrogen only nitric oxide remains.

It is now generally conceded that the oxidation of nitrogen in the arc is not due to any specific chemical or electrical action, but is a purely thermal phenomenon. In support of this view we have the work of Bunsen and Kolbe‡, who exploded mixtures of electrolytic gas and air in varying proportions, and observed nitric oxide in the products of combustion. They further observed that, as the percentage of electrolytic gas was increased, and consequently the temperature of explosion, the volume of nitric oxide in the residual gases also increased.

The experiments of Nernst have a very important bearing on this question. By passing air through a platinum or iridium tube, heated by means of an alternating current, the formation of nitric oxide to the extent of 0·64 per cent. by volume at 1,760°C., and 0·97 per cent. by volume at 1,922 deg., was observed. From the above experiments we see also that the volume concentration of the nitric oxide is a function of the temperature.

In the case of an endothermic reaction, such as the combustion of nitrogen, the value K in Guldberg and Waage's formula $K = \frac{V.NO^2}{V.O_2 . VN_2}$ (where $V.NO$, $V.O_2$ and $V.N_2$ represent the partial pressures of nitric oxide, oxygen and nitrogen respectively, K being a constant) becomes higher with increasing temperature, and falls to zero as the temperature decreases. Thus for every temperature there is a definite volume concentration of nitric oxide. These values have been determined by Nernst*. He led air through his electrically heated platinum-iridium furnace, maintained at a definite temperature. After equilibrium had been attained, the gases were rapidly cooled by withdrawing them from the furnace by means of a platinum capillary, in order to prevent the reverse action taking place. They were then analysed in order to determine the nitric oxide content. These results were checked by the values obtained in the electrolytic gas explosions, and finally compared with those obtained by interpolating from the values calculated. The following table offers a comparison of the data thus obtained, in which the percentages of nitric oxide are given under x.

Calculated.		Values of x.		
T.	x.	T.	Observed.	Interpolated.
°C.		°C.		
1,500	0·10	1,811	0·37	0·35
1,800	0·34	1,877	0·42	0·43
2,000	0·61	2,023	0·52	0·64
2,500	1·79	2,033	0·64	0·67
3,000	3·57	2,195	0·97	0·98
..	..	2,580	2·05	2·02
..	..	2,675	2·23	2·35

The velocity of reaction is also dependent, in a very high degree, upon the temperature: at 1,000°C. it is immeasurably small, requiring 81·68 years for the attainment of ½ equilibrium. At 2,100 deg. it is exceedingly great, only 5·06 seconds being necessary for the ½ equilibrium point to be reached.

Thus, the first consideration in the technical production of nitric oxide from an economic point of view is the attainment of an arc of the highest possible temperature, whereby both high nitric oxide concentration and high reaction velocity ensue.

The ordinary high-tension arc in air consists of three superimposed zones, all mounting upwards, and of different size and temperature. The first, or lower zone, carries the major portion of the current, and consequently possesses the highest temperature, which is in the neighbourhood of 4,200°C. It is probable that in this zone alone the oxidation of nitrogen takes place.†

The second, or middle zone, is greenish blue in colour, with a temperature of at least 1,400 deg.‡ Brode§ has shown that in pure oxygen a flame is obtained by the high-tension discharge practically identical with zones 1 and 2 of the air flame, and that ozone is produced in this flame, but the velocity of dissociation of ozone is exceedingly great—in fact, several million times as great as that of nitric oxide at 1,000 deg.,‖ and its formation is never observed unless special precautions are taken to very quickly cool the gases leaving the flame.

Such being the case it is highly probable that in the middle zone of the flame in air a complete dissociation of ozone takes place, and also a partial dissociation of nitric oxide, and that zone 2 is caused by these reactions.

The third, or highest, zone forms the greatest bulk of the flame. It is of a pale yellowish-brown colour and possesses a temperature as measured by Muthmann and Hofer of 900 to 1,000 deg. It cannot, however, as stated by them, constitute a zone of oxidation of nitric oxide to nitrogen peroxide, since the latter body dissociates completely into oxygen and the lower oxide below a temperature of 600 deg. It is more probable that a further destruction of nitric oxide takes place in this zone. In the electric flame we thus have a system of constantly decreasing temperature, which is very unfortunate for our purpose. For, as we have seen above, the nitric oxide is probably all produced in the first zone. Here, also, would obtain the greatest concentration in the gas. Now, the nitric oxide in the mixed gases in leaving zone 1 and passing through zones 2 and 3 would suffer a partial dissociation, since the velocity of reaction at the temperatures represented by these zones is quite appreciable. I am of the opinion that Muthmann and Hofer's determination of the temperature of zone 3 is too low.

We thus come to the second condition, that must be fulfilled for an economic production of nitric oxide—*i.e.*, the nitric oxide, containing gases, must be removed from the sphere of influence of the arc as quickly as possible after the reaction has taken place, in order to prevent dissociation in the cooler parts of the arc of the

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* Paper read before the Society of Chemical Industry. Abbreviated.

† Ber., XXXVI., 438 (1903).

‡ *Annalen der Pharmacie*, XLIX., 208-217 (1846).

* *Zeits. Elektrochem*, XXXI., 1906.

† Brode, "Oxydation des Stickstoffes."

‡ Muthmann and Hofer, Ber., XXXVI. (1903).

§ "Oxydation des Stickstoffes."

‖ J. H. Clement, *Ann. d. Physik*, 1904, pp. 334-353.

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nitric oxide produced in the hottest part. That is to say, one must endeavour to produce such a rapid fall of temperature that the gases retain that nitric oxide concentration which they possessed at the highest temperature to which they were subjected. Of course, in practice this is impossible, but we can attain to a near approximation. I may cite an example from the work of Mr. McDougall and myself, where, in one experiment, we obtained a concentration of 7·5 per cent. of nitric oxide in the gases leaving the arc chamber. Assuming 4,200 deg. as the highest flame temperature, the maximum concentration for which would be 10 per cent. of nitric oxide, there is thus a loss in cooling of 2·5 volumes, or 25 per cent.

Muthmann and Hofer* obtained a maximum concentration of 6·7 per cent. of nitric oxide, and Brode†, by withdrawing the gases from between the electrodes by means of a water-cooled quartz tube, obtained a concentration of 8·1 per cent. of nitric oxide and, in order to show the gradual dissociation of this gas as it ascended to zone 3 of the flame, he withdrew the gases from this part by means of a water-cooled platinum capillary, and obtained a nitric oxide concentration of 6·7 volume per cent., whilst in the gases immediately surrounding the flame a volume concentration of only 4·6 per cent. was observed. Thus, in zone 3, one-third of the nitric oxide leaving zone 2 was decomposed.

We are thus confronted with a third consideration in the oxidation of nitrogen for technical purposes—*i.e.*, one must endeavour to reduce, by some means, the relative volumes of zones 2 and 3 of the flame, in which dissociation of nitric oxide takes place, and at the same time to increase the capacity of the first zone, in which nitric oxide is produced.

So far the results predicted by theory have been well confirmed by the values obtained in practice, and confirm the conclusions Mr. McDougall and myself arrived at from our experiments, a *résumé* of which is given at the beginning of this Paper.

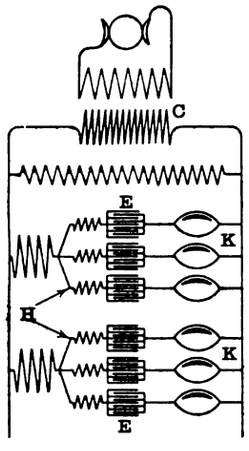

Fig. 1.

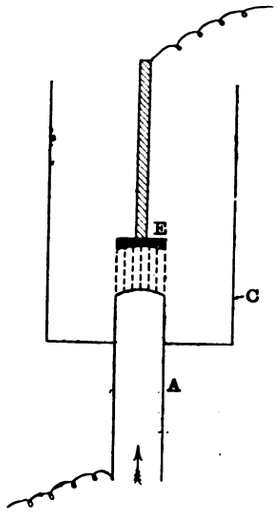

Fig. 2.

A fourth important consideration in the technical production of nitric oxide is the concentration of large amounts of energy in a unit of plant. With the ordinary high-tension flame it is not possible, or at least not advisable, to use currents of more than 0·1 to 0·2 ampere, for, as the researches of Mr. McDougall and myself have shown, a diminished yield of nitric oxide results. But as the yield of oxide is a function of the energy consumed, since the reaction $N_2+O_2=2NO$ requires an expenditure of 43,200 cals., a plant constructed for the utilisation of a large number of low-current arcs would entail the erection of an enormous number of units, if any large quantity of acid had to be produced. The upkeep and labour charges on such a plant would necessarily be high, and to this fact is attributable the failure of the earlier processes.

Technical Processes.—I now propose to briefly review some of the more important processes that have been suggested, or are actually in operation, for the production of synthetic nitrates.

The process proposed by Mr. McDougall, which yielded about 300 kilos. of nitric acid per kilowatt-year, is now only of historic interest, as is also that of Bradley and Lovejoy, since both processes suffer from the inherent defects mentioned above.

The process of J. de Kowalski and M. Moscicki, which has been investigated by the Initial Comités zur Herstellung Stickstoffhaltiger Produkte, at Freiburg, offers some novel features. These workers state that the output of nitric acid per unit of electrical energy is increased by augmenting the frequency and voltage of the current.

* Ber., XXXVI. (1903).
† "Oxydation des Stickstoffes."

They obtained a maximum output of 440 kilos. per kilowatt-year when using a current of 0·05 ampere of 6,000 to 10,000 periods per second, at 50,000 volts. Their apparatus possesses some special features of construction, as will be seen by reference to Fig. 1, in which the arcs are denoted by K, E represents condensers, C and H induction coils. It is for this special arrangement that a patent has been granted.

Whether a current of high periodicity and voltage, such as the one described above, possesses some special advantage or whether the increased yield is merely the result of some mechanical property of an arc so produced, does not appear to be clear from the experiments of these authors. The latter view is probable, since the yield of nitric acid obtained by Kowalski and Moscicki has been far surpassed by subsequent workers, who used currents of only moderate periodicity and voltage.

This process also, if worked commercially, would require a large number of units of plant, since only 2½ kw. are condensed in each arc.

In 1903 an English patent* was granted to Eyde and Birkeland for an apparatus in which large quantities of electrical energy could be used for the purpose of effecting reactions between gases at high temperatures.

Plücker†, in 1861, had shown that, when a high-tension discharge passed between electrodes situated in a magnetic field and at right angles to the magnetic lines of force a disc of sparks resulted, and that when this phenomenon occurred in a vessel filled with air the formation of brown oxides of nitrogen was observed.

Lehmann‡, in 1898, applied this arrangement to the high-tension electric flame and obtained a similar spreading of the arc. When a direct current is used the arc resembles a half-circle; with an alternating current, an approximately circular disc is formed.

Of other methods of burning atmospheric nitrogen, it will be interesting to notice those of Naville and Guye§ and of Pauling‖, who appears to be working in conjunction with the Saltpetersäure Industrie Gesellschaft.

The former workers, by rotating a disc-shaped electrode, E (Fig. 2)—situated in a cylinder of refractory material C—over a metal tube, A, conveying the air to be treated, and which forms the

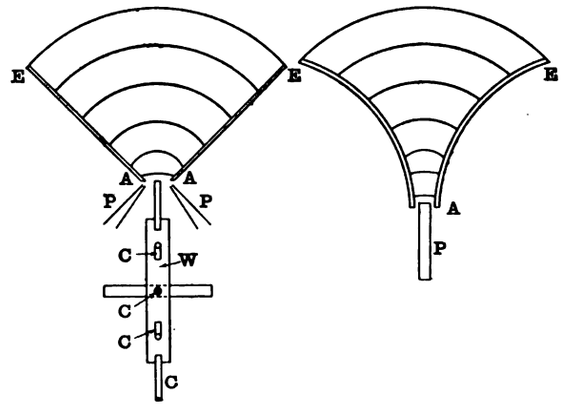

Fig. 3.

second electrode, obtained a spreading of the arc round the periphery of both the tube and the disc. By this method a yield of 400 kilos. of nitric acid per kilowatt-year has been obtained.

The apparatus, devised by Pauling, consists of either straight or curved fixed electrodes, A E, inclined to one another in a vertical plane (Fig. 3). At regular intervals, solid conductors, C, which are fixed on the periphery of a revolving wheel, W, pass between the lower ends of the electrodes, thus causing an arc to spring across. By means of an air blast conveyed by pipes, P, the arc, continually increasing in size, is made to travel upwards along the electrodes until the points E are reached, when it becomes extinguished. As each solid conductor passes the electrodes a new arc is formed, which in its turn goes through the same process.

In another method the wheel carrying the solid conductors is not used. Opposed tuyères, conveying an air blast, cause the arcs, which are continually produced at A, to lengthen and break at E, as described in the previous process. I have not been able to discover any data relating to the electrical energy consumed in such arcs, or to the yield of acid per kilowatt-year by these processes.

Pauling has also endeavoured to oxidise nitrogen without the intervention of electrical energy.¶ By passing a mixture of air and steam through thin-walled porcelain tubes heated to incan-

* English Patent 20,049 of 1903.
† *Pogg. Ann.*, 133, p. 252.
‡ "Die elektr. Lichterscheinungen und Entladungen," 1898, 353.
§ French Patent 361,827 of 1905.
‖ French Patents 368,715 and 368,717 of 1906.
¶ English Patent 21,828 of 1902.

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descence, he observed the formation of nitric oxide and hydrogen. The latter gas diffused through the walls of the tubes, and this diffusion was increased either by means of a pressure inside the tubes or a partial vacuum outside. Later the gases issuing from the incandescent porcelain tubes were rapidly lowered in temperature by the injection of cold air*, thus minimising the action due to the phenomenon of reversibility. I am not aware that any statements have been made public concerning the yield of nitric acid obtained by this process.

Häusser† also avoids the use of the electric flame in the combustion of nitrogen. He reverts to the explosion method of oxidation, the feasibility of which, as mentioned above, was first demonstrated by Bunsen and Kolbe in 1846. The special apparatus used by Häusser consists of a gas engine, in which the usual mixture of air and gas is exploded. The products of combustion are, however, rapidly cooled by the injection of cold water into the combustion chamber. As with the process last described, there appears to be no published data relating to the yield of acid thus obtained.

Thus, in glancing through the processes, either projected or in actual operation, on a commercial scale, for the oxidation of nitrogen, we find that a yield of 650 kilos. of nitric acid per kilowatt-year represents the greatest output so far realised. Assuming a mean flame temperature of 3200°C., this amount is equal to $\frac{650}{819}=0{\cdot}793$, or 79·3 per cent. of that theoretically obtainable. Whether it will be possible in actual practice to increase this quantity either by raising the mean flame temperature, or by a more rapid removal of the gases after reaction from the sphere of influence of the arc, simultaneously with sudden reduction in temperature, is a question which will have to be decided by further investigation.

The relative reduction in volume of zones 2 and 3 of the flame, which I mentioned above as being so essential to successful working, would appear to have been partially realised in the Birkeland-Eyde furnace. The spreading of the "current paths" by magnetic force should tend to equalise the temperature of the flame, and prevent that great opportunity for gradual temperature fall which is observed in the ordinary high-tension flame, and which is so inimical to the attainment of a satisfactory yield.

Against this advantage, however, must be placed the energy required to maintain the magnetic field, amounting as it does to 10 per cent. of the quantity consumed in the arc, and which is not included in calculating the yield of acid. The temperature of the flame might be raised by increasing the resistance of the gases, by working under pressures above that of the atmosphere.

It will be interesting in this connection to note some experiments of Muthmann and Hofer‡, who found that by increasing the pressure of the gases surrounding the arc from 1 to 1·4 atmospheres, the velocity of the air passing into the arc chamber could be accelerated, and although the exit gases contained the same percentage of nitric oxide, yet the yield was increased threefold per unit of energy consumed.

Such a result could only be due to increased flame temperature, caused by the added resistance of the air to the passage of the current, consequent upon increased pressure.

These experiments are important, containing, as they do, two elements of success—*i.e.*, an increase in flame temperature and a more rapid removal of the nitric oxide from the arc, due to the greater air velocity, and this without increased dilution. An extension of this work would probably yield interesting results.

Against the increased yield, however, must be set the cost of compressing the gases, and the difficulties which always obtain in practice in working at high temperatures under pressure.

Absorption of Nitric Oxide and the Preparation of Nitric Acid.—So far I have dealt only with the gaseous products of oxidation. After leaving the furnace the air contains about 2 per cent. by volume of nitric oxide, which becomes rapidly converted by means of the excess oxygen present into nitrogen peroxide. The mixed gases then pass on to absorption towers, which present no special features of construction, and down which water or dilute acid flows. In the case of the last tower milk of lime is used, as it is difficult to absorb the last traces of NO_2 by means of water alone. By this process one obtains an acid of not more than 50 per cent. strength.

The preparation of a concentrated nitrous-free acid from the nitrous gases constitutes one of the most serious problems in connection with this process.

The reaction represented by the equation

$$2NO_2+O+H_2O=2HNO_3$$

does not take place in the absorption towers; such an equilibrium appears to exist only in the gaseous state. On condensation the right-hand side of the equation is not produced. The most concentrated acid which has so far been obtained by the condensation of nitrous gases in water in the presence of oxygen corresponds to the formula $HNO_3 2H_2O$, and possesses a density of 40·6°B., representing 63·63 per cent. of anhydrous nitric acid. The formation of this acid takes place, according to the following equation, in the Lunge and Bohrmann plate towers, $2NO_2+O+5H_2O=2(HNO_3 2H_2O)$, from which acid of 40°B. to 41°B. is obtained. By passing the gases, however, through towers down which water flows, an equimolecular mixture of nitric and nitrous acids results, which, at the most, cannot attain a concentration greater than that obtained in the Lunge towers. Attempts at further concentration, by the passage of nitrogen peroxide through the solution, simply results in an increase of nitric acid, at the expense of the nitrous. The strongest acid is thus never free from nitrous acid, and each succeeding absorption tower contains less and less nitric acid, whilst at the same time the nitrous acid increases, for, as the free oxygen in the gases becomes consumed, the NO and NO_2 tend to react, as N_2O_3, yielding only nitrous acid. It is not possible to prepare much stronger acid by fractionating the 50 per cent. acid from the first absorption tower, since a product of minimum vapour pressure, boiling at 120° and containing 68 per cent. of anhydrous acid, is obtained as residue.

Thus in order to prepare the most concentrated acid by the nitrogen combustion process, it would be necessary to either add the 50 per cent. acid to concentrated sulphuric acid, until a dilution of, say, 54°B. be obtained*, and distil off the nitric acid; or to prepare a salt of nitric acid, and distil, in the usual way, with sulphuric acid, or a bisulphate.

An electrolytic method for concentrating and oxidising the weak tower acid has lately been patented†. The process consists in refrigerating the oxides of nitrogen evolved during electrolysis at the cathode, and leading them, in the liquid state, slowly to the anode compartment of the cell, where in presence of the nascent oxygen there generated a solution of pure nitric acid results, all nitrous acid undergoing oxidation. I am unable to say if this process has proved a commercial success.

Thus, although the electro-thermic production of nitric acid has attained a fair degree of efficiency in some of the processes touched upon in this Paper, the problem of directly manufacturing from the furnace gases a 98 per cent. acid has not yet been solved.

The author concludes by giving figures of the cost of electrical energy by water power, steam and gas, the effect of the cost of power being shown in the following table :—

Comparative cost per 1,000 kilos. anhydrous nitric acid when produced from powers of different sources.

Source.	Cost per kilowatt-year.	Cost per ton (1,000 kilos. of anhydrous nitric acid.
Water	£4 (average)	£6 13 4
Steam	£6 (S.E. Lancs.)	10 0 0
Mond gas	£3. 13s. 6d.	6 3 0
Blast-furnace gases	£1. 13s. 4d. (excl. cost of gas)	2 15 6

A yield of 600 kilos per kilowatt-year is assumed.

DISCUSSION.

Dr. R. S. HUTTON considered Mr. Howles's comparison of the cost of water-power with steam and blast-furnace gas-power very misleading. The present small nitric acid factory at Notodden actually purchased its power at about 33s. per kilowatt-year, and many electro-chemical works both in Norway and Sweden and in the Alps had an inclusive cost for power ranging from 16s. to 40s. per kilowatt-year, the latter being considered in those countries the economical limit for such industries as aluminium, chlorates and carbide. Power at Niagara, which for some years past has been sold at figures ranging from £4. 15s. to £5. 10s. per kilowatt-year, had always been considered expensive. With regard to gas engines, and in particular to those cases in which blast-furnace gas was used, although much development might be expected in certain directions—*e.g.*, electric steel manufacture, the enormous capital expenditure and the actual results obtained by those who had installed gas-engine plant in this country seemed to indicate that Mr. Howles's statements on the subject were very optimistic. The production of nitrates was, in his (Dr. Hutton's) opinion, a most promising electro-chemical development; but under ordinary circumstances it must necessarily be confined to those countries where the facilities for cheap water-power development were exceptionally favourable.

Mr. HOWLES, in reply, said he agreed that the capital outlay was the main charge, but he did not know whether an adequate sum had been set aside for upkeep, interest on capital, and depreciation in the estimates of 30s. to £2 per kilowatt-year given by Dr. Hutton. If these charges were not correctly apportioned, the estimates given would be very materially affected. It was notorious that the capital outlay in water-power installation was very large. It was much larger, for instance, than that required to harness blast-furnace gases. He had based his calculations upon some figures obtained in actual practice, so that, excluding the cost of the blast-furnace gases, his figures were correct.

* English Patent 7,870 of 1906.
† English Patent 12,401 of 1906.
‡ Ber., XXXVI. (1903).

* 54° B. = 120° Tw. = 68·5 per cent. of H_2SO_4.
† French Patent 368,716 of 1906.

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BRIGHTON CORPORATION ELECTRICITY ACCOUNTS.

The accounts of the Brighton electricity undertaking for the year 1906-7 have been published and do not make pleasant reading for the Brighton ratepayer. The actual financial result is a deficit of £10,233 as against a deficit of £976 in 1905-6, while in 1904-5 the profit was £5,831.

The engineer and manager (Mr. J. Christie) in his report to the Lighting Committee on the year's working shows that the units sold were 7,849,194 as against 8,000,200 in 1905-6 (a decrease of 151,006). Of this decrease 73,350 are due to the reduced consumption of the tramways department, while the remainder are accounted for by the reduced consumption on the part of private consumers. He considers that this latter decrease is partly due to the very extensive use of the new high-efficiency lamps. The day load for power has been increased and these cheap units have, so far as number is concerned, to a large extent neutralised the loss of lighting units.

The alternative flat rate of 4d. per unit was adopted last July. It was estimated that £2,800 would be lost if all the consumers who were paying more than 4d. per unit adopted this system. The fact that only 1,180 out of 1,600 have changed over shows that the total loss under this heading has not yet been reached, and has to some extent been neutralised by a portion of the 1,700 consumers who have already adopted this tariff, but in all probability were paying less than 4d. per unit on the average under the old conditions.

The revenue from all sources has fallen from £86,076 to £81,415, or a decrease of £4,661. During the year the capital has been considerably increased and the interest and sinking fund charges in respect of this have risen from £38,408 to £43,623, an increase of £5,215. The total capital expenditure to date is £758,330. 19s. 3d., £40,592. 3s. 2d. of this amount having been spent during the past year. The loans raised to date amount to £743,457. 7s. 9d., of which £46,490. 7s. 9d. was raised in 1906-7. This leaves a debit balance of £14,822. 2s. 6d., this amount having been expended in anticipation of sanctioned loans.

We give below an analysis of the expenditure during the past year, together with the cost per unit sold for the past year and for the year 1905-6.

		1906-7.	1905-6.
Generating Costs.			
Coal, &c.	£20,095 6 5	0·61d.	0·69d.
Oil, waste, &c.	1,499 3 2	0·05d.	0·06d.
Wages and salaries	7,821 2 7	0·23d.	0·22d.
Repairs and maintenance	3,879 10 9	0·12d.	0·08d.
Total generating costs	£33,295 2 11	1·01d.	1·05d.
Distribution Costs.			
Repairs and maintenance	£2,819 17 11	0·09d.	0·08d.
Other expenses	712 17 11	0·02d.	0·04d.
Attending public lamps, &c.	3,668 12 9	0·11d.	0·12d.
Total distribution costs	£7,201 8 7	0·22d.	0·24d.
Rents, Rates and Taxes.			
Rents	£24 0 0	—	—
Local rates	3,809 17 8	0·11d.	0·10d.
Income tax	237 14 11	0.01d.	0.01d.
Total	£4,071 12 7	0·12d.	0·11d.
Management Expenses.			
Salaries	5,076 9 8	0·17d.	0·16d.
Stamp duty, &c.	502 12 7	0·01d.	0·01d.
Stationery and printing	372 2 10	0·005d.	—
Establishment charges	559 1 2	0·015d.	0·01d.
Insurance, &c.	225 9 1	—	0·01d.
Total management expenses	£6,635 15 4	0·20d.	0·19d.
Total working expenses (excluding capital charges)	£51,203 19 5	1·55d.	1·69d.
Capital charges, &c.			
Transferred to reserve fund	—	—	0·16d.
Interest on capital	£21,354 19 2	0·65d.	0·50d.
Sinking funds	22,268 4 6	0·67d.	0·62d.
Stores	581 7 9	0·02d.	—
Bad debts	509 7 9	0·03d.	—
Total capital charges	£44,713 19 2	1·36d.	1·28d.
Total costs (including capital charges)	£95,408 10 10	2·89d.	2·97d.
Total income	85,684 9 7	2·62d.	2·74d.

On the income side of the account there is the balance of £33,971. 2s. 5d. brought from the revenue account. The resulting deficit is, therefore, £10,233. 9s.

The capital spent during the year amounts to £40,592. 3s. 2d., which includes £28,051 on machinery and plant and £6,349 on mains. We give below the details of the total capital expended to date, together with the amount in £ per kw. expended on the various items.

Capital Account.		£ per k.w.	per cent.
Land acquired	£17,918 16 3	1·86d.	2·34d.
Buildings	149,431 8 6	15·84d.	19.27d.
Machinery and plant	287,607 5 5	28·63d.	38·30d.
Mains	242,744 14 1	24·88d.	32·16d.
Meters and terminal boxes	39,504 16 10	3·66d.	5·30d.
Motors for hire	5,748 7 11	0·64d.	0·70d.
Change of voltage	4,263 7 3	0·50d.	0 50d.
Purchase of patent rights	1,337 3 0	0·13d.	0·20d.
Engineer's commission	1,496 17 9	0·13d.	0·20d.
Office furniture	550 1 9	0·07d.	0·08d.
General expenses	1,178 0 6	0·13d.	0·17d.
Purchase of Brighton Electric Lighting Co. undertaking	5,000 0 0	0·47d.	0·60d.
Parliamentary expenses	1,550 0 0	0·14d.	0·18d.
TOTAL	£758,330 19 3	77·08d.	100·00d.

The total units generated were 8,618,335, of which 1,011,253 were absorbed in public lighting, 1,798,905 in tramways, 18,407 in bulk supply and 5,020,629 were used by private consumers. The total amount sold was 7,849,194. The corresponding figures in 1905-6 were 8,977,582, 997,873, 1,872,255, 8,909 and 5,121,163, the total sold amounting to 8,000,200. The maximum load on the feeders has fallen from 5,019 kw. to 4,789 kw., while the load factor has decreased from 18·1 to 16·6 per cent. The dynamo capacity has been reduced from 5,595 to 5,400.

The average price per unit sold was for private supply 2·88d., for public lighting 1·56d., for traction 1·50d. and for bulk supply 2·29d. The average price for the total supply was 2·39d. The corresponding figures for last year were 3·01d., 1·56d., 1·50d. and 2·34d. The average price for total supply was 2·47d.

Electrolytic Process for the Production of White Lead.—A process for the production of pigments by an electrolytic process, due to Mr. C. P. Townsend, is described in the *Western Electrician*. The inventor declares that by his method a pigment of uniform grade and exceptionally high covering power may be produced in an electrolytic cell, the condition essential thereto being a definite circulation of the electrolyte successively past the respective electrodes, and preferably in the direction from the anode past or through the cathode. One type of cell which may be employed is built up of a series of sections secured together by bolts, the sections clamping between them plates, which may be formed of perforated metal or of wire-gauze, and which constitute the cathodes of the apparatus. The sections are so formed as to provide a series of channels between each other and between the sides of the cell. The anode, which may be a plate of lead, is placed above the central channel and the electrolyte is introduced at the bottom of the cell immediately below the anode. The lateral channels are connected with outlets, these outlets being prolonged to re-enter the central channel. A filter press communicates with the outlet pipes through a pipe and connections. The circulation of the electrolyte is effected by a propeller mounted upon a shaft and driven by a pulley. The shaft is preferably hollow, and through it carbon-dioxide may be introduced into the cell, thereby assisting in the circulation of the electrolyte and regenerating the same. Water is introduced through the filter-press and is employed for washing the pigment. Valves in the pipes, control the circulation through the cell. The pigment formed at the anode is carried upward by the electrolyte past the cathode to a region outside the field of electrolysis. In operation a lead anode is employed and an electrolyte consisting of any salt the acid radical of which forms a soluble compound with lead. To this solution is added a soluble carbonate. A mixture of sodium nitrate or acetate and sodium carbonate, in proportions approximating 10 to 1, constitutes a satisfactory electrolyte.

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ELECTRIC COOKING AND HEATING IN HOTELS.

Summary.—In this article an account is given of two heating and cooking installations in Switzerland of considerable size. At the Hotel Moserboden a load of 93·4 kw. results from the requirements of the kitchens, laundry and hot-water plant alone, irrespective of energy required for heating the hotel. At the Eismeer station on the Jungfrau the whole of the cooking is effected electrically by energy taken from the railway. Details are given of the apparatus in use.

In the case of hotels and other buildings erected in inaccessible places on the sides of mountains, or in out-of-the-way country districts, the transport of the various materials necessary for the upkeep of the establishment is a serious problem. This is especially the case with coal. The recent great strides which have been made in adapting electricity to cooking and heating have demonstrated to hotel proprietors the great advantages which may be obtained by utilising electrical methods for their work. Not only does electricity dispense with the cost of bringing coal to the hotel itself, but it entirely does away with carrying it to the various rooms,

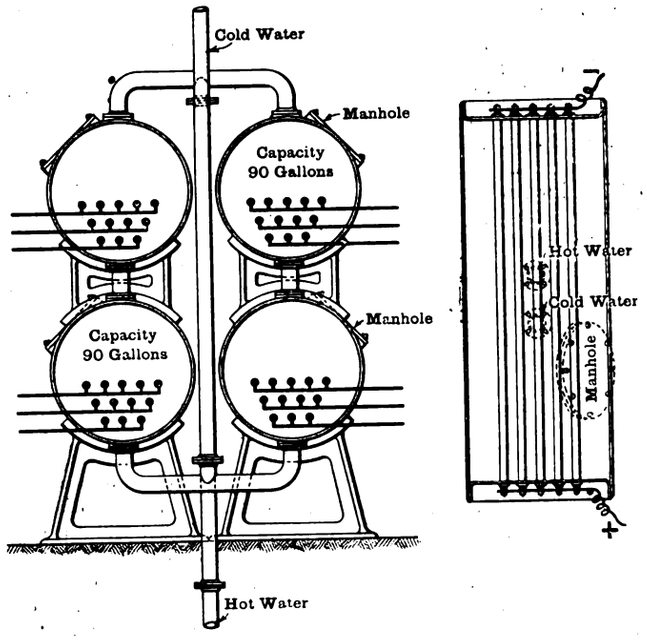

FIG. 1.—DIAGRAM OF BOILER FEEDING THE MAIN HOT-WATER SUPPLY.
Scale 1 : 30.

and none of the usual smoke and dust nuisances are in evidence. A large amount of waste, which must always be attendant on the use of coal in small quantities, is entirely avoided, and the direct saving of energy is, of course, very great, as any electrical apparatus can be switched off when not actually in use.

These considerations have lately led many Continental hotel proprietors to completely equip their establishments with the necessary apparatus for electric heating and cooking, and we are enabled through the kindness of Messrs. Isenthal & Co. to give some details of two of these plants working on the Elektra system. One of these has recently been installed at the Hotel Moserboden and the other at the "Eismeer" station of the Jungfrau Railway, at a height of about 10,500 ft. above sea level.

In the Hotel Moserboden electricity is used for cooking and heating purposes, as well as for lighting. Current is supplied from a small private generating plant, which consists of two 140 H.P. Escher-Wyss water turbines direct coupled to two generators. The working voltage is 120. Switchboards of the same general type are situated in different parts of the building, in close proximity to the apparatus which they control. A main ammeter and voltmeter are provided, together with a single-pole switch and fuse, for each of the circuits fed. All the apparatus is connected to a common return.

Two kitchens have been equipped. In the smaller kitchen of the two are fitted a boiler for soup and meats, a potato steamer and a table range. The boiler has a consumption of 3 kw. when working at full load, but it can be regulated to take either one or two-thirds of this amount by cutting out the requisite number of heating elements. Its capacity is 15 gallons, and it is fitted with heaters both at the

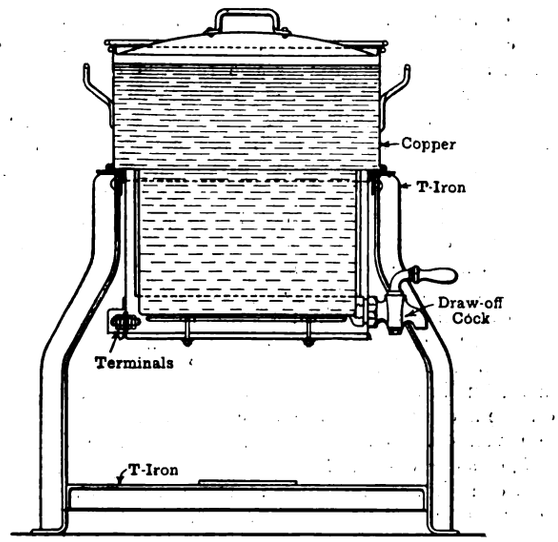

FIG. 2.—HOT-WATER COPPER.
Scale 1 : 15.

sides and at the bottom. When filled with a supply of water obtained from the hot-water service, the whole can be brought to boiling in 30 minutes. The potato steamer is made of copper, and has a capacity of 10 gallons. The lid, which is of cast iron, is fitted with six pressure screws, a safety valve and a blow-off tap. The normal working pressure is 1½ atmospheres. The water jacket of this steamer is capable of holding about 5 quarts of water, supplied from the hot-water service, which amount can be brought to boiling in 10 minutes. The same arrangement of coils is preserved in this case also, and the method of control enables either or both sets to be used.

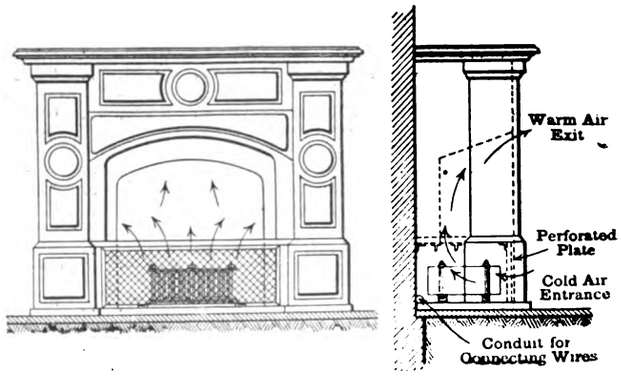

FIG. 3.—DRAWING-ROOM STOVE.
Scale 1 : 15.

The total consumption of this heater is about 1 kw. The table range is made of wrought iron, with a machined cast-iron top plate. There are four cooking plates 12 in. in diameter, each consuming 1·5 kw., and four 8¾ in. in diameter, each consuming 1 kw. Each plate is regulated by separate switches fixed on the range. The top plate is independently heated and controlled by two switches, also fixed to the side of the range. The cooking plates are removable, and all the heating spirals are made of platinum. The total consumption of this range is 11·2 kw. The arrangement of the switches

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followed on all the various apparatus is shown on the hot plates in Figs. 4 and 5.

In the larger kitchen is a range whose construction is similar to that just described. It contains eight cooking plates. Built into the framework of the range are two roasting ovens with independent top and bottom heaters, consuming 3 kw. each. All the regulating switches are mounted on the frame of the range, and the distribution of the current inside

FIG. 4.—GENERAL VIEW OF LARGE KITCHEN.

is effected by means of aluminium 'bus bars and wires. The total consumption of the whole range is 16·2 kw. A roasting oven, a hot cupboard and carving table are provided, as well as grills and frying pans. A coffee roaster, with a capacity of 4½ lb., is driven by a motor through worm gearing and is provided with internal heaters. Its consumption is 1 kw. Three switchboards, with the requisite fuses, switches and pilot lamps, placed conveniently near the cooks, permit of easy control.

The hot-water plant for supplying the kitchen, scullery and laundry as well as two bathrooms is shown in sectional elevation and plan in Fig. 1. It consists of four boilers each with a capacity of 90 gallons. Each boiler is fitted with 12 tubular heaters consuming 0·75kw., or a total of 9 kw. per boiler. The hourly consumption of hot water at 194°F. is 50 gallons, for the heating of which 24 kw.-hours is required. In order, however, to use the boiler as a kind of accumulator for the storage of energy, the heaters have been arranged for a much higher consumption and the engineer-in-charge may at any time divert superfluous energy into the boilers. The switchboard for these is placed in the engine room. Cold water enters the two lower boilers and after being warmed rises into the upper boilers, where a higher temperature is attained. Each boiler is provided with a manhole for cleaning purposes through which the tubes are accessible. The total consumption is 36 kw.

The laundry contains a large copper (Fig. 2) of the same general description as the heater described above. Its consumption is about 5 kw. There are also a large number of electrical hand-irons and an ironing machine is shortly to be erected.

General views of the large and small kitchens are shown in Figs. 4 and 5. In Fig. 4 will be noticed the type of switchboard that is used throughout.

The following shows the total consumption exclusive of that required for heating the rooms:—

Small kitchen	15·2 kw.
Large kitchen	31·1 kw.
Laundry	11·1 kw.
Hot-water plant	36·0 kw.
Total	93·4 kw.

The general heating of the hotel is also carried out by electricity. The dining-room contains a stove similar to that shown in Fig. 3, consisting of 28 flat elements, each consuming 300 watts and placed inside a closed tiled stove. The office, reading-room and lobby are provided with similar heaters, having a consumption of 1,200, 1,400 and 2,400 watts respectively. The bedrooms have heaters varying in capacity from 600 to 1,800 watts, according to the size of the room. All the various stoves are fitted with triple regulation, and each has its separate switchboard with switches and fuses. As a basis for calculating the size of the various heaters, the outside temperature was taken as 0°C. and the maximum temperature to be attained 18°C. The time allowed for reaching this temperature was two hours. The bedrooms are unusually well supplied with wall plugs, so that electric heaters of all kinds can be easily fitted.

The capacity of the cooking plant at the "Eismeer" station on the Jungfrau Railway has been designed for serving from 100 to 120 persons at short intervals, or 60 diners at one time with a meal of four or five courses. The principal features of the plant are: (1) A warm-water reservoir of 50 gallons capacity which is required to supply the water necessary at a temperature from 80 to 90°C. The arrangement has been planned in such a way that the energy consumption during the

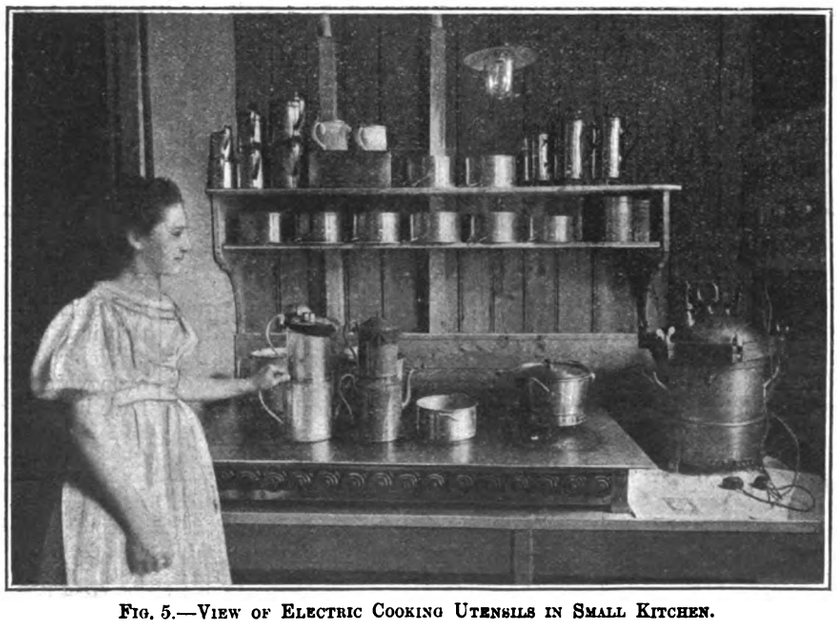

FIG. 5.—VIEW OF ELECTRIC COOKING UTENSILS IN SMALL KITCHEN.

time when the other utensils are in operation is a minimum. To maintain the water at the above temperature only a small fraction of the total consumption is required. The provision of such a warm-water heater was dictated by the consideration that the various cooking utensils when filled with already heated water require but a very short time to bring them to the boil, and thus orders can be very quickly executed. This plant also furnishes the necessary hot water for cleaning

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utensils, plates and dishes. (2) A large electric range with four 12 in. and four 9 in. cooking plates which can be separately regulated. This range also contains the necessary roasting and baking ovens, and a general hot plate for keeping

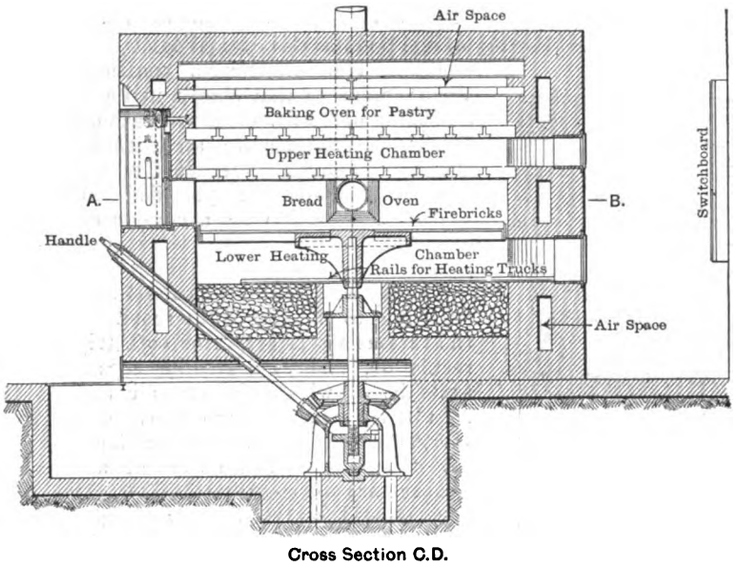

FIG. 6.—DIAGRAM OF THE BAKING OVEN.
Scale 1 : 50.

the food warm until it is served. (3) A number of separate self-contained electric cooking utensils, such as a 15 gallon soup boiler, seven vegetable boilers, with a capacity of 25, 15, 12, 10, 6, 4 and 2 quarts respectively, besides a number of others for milk, coffee, compotes, &c. There are also a number of electric frying-pans, a potato boiler which works under a pressure of two atmospheres, and a large electric grill. All these utensils are controlled from several switchboards which are fitted with pilot lamps to indicate what apparatus and what circuits are under current. (4) A large electric hot cupboard for warming plates and dishes as well as food. (5) A series of separate apparatus comprising a large buffet coffee machine for use at different parts of the station.

We understand that the reliability of the various parts of the installation is excellent, and in the rare cases of accident provision has been made for quickly exchanging the elements.

The energy is supplied by a 60 k.v.a. transformer which gives a secondary pressure of 125 volts. In actual operation very little more than 30 k.v.a. is required at one time, as it is unlikely that all the various appliances are operating with their maximum consumption simultaneously, and arrangements have been made to use the larger utensils, such as the hot-water heater, the hot cupboard and the potato steamer, during the times when the range and other similar apparatus are not working at full load.

We are informed that this electric cooking plant has been in operation without any hitch whatsoever during the whole season, and many hotel proprietors in the Bernese Oberland and other districts have taken the opportunity of studying this installation with a view to putting in similar plants.

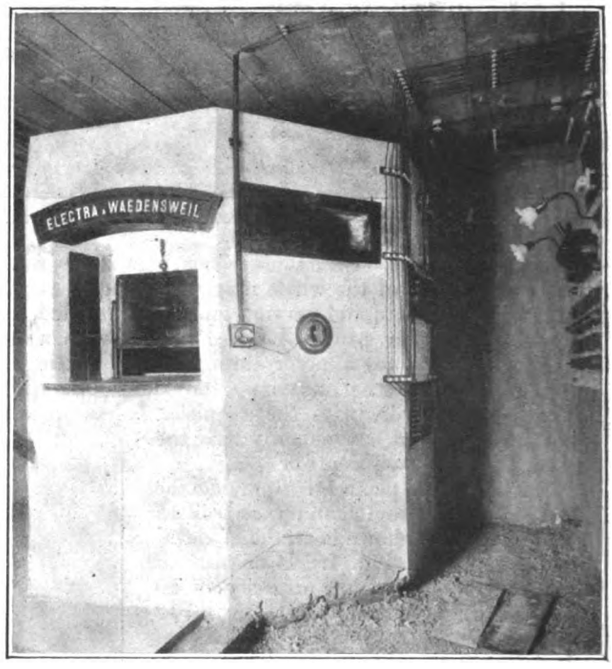

FIG. 7.—GENERAL VIEW OF THE BAKING OVEN.

We are also able (Fig. 7) to give an illustration of a baking oven which is one of a series of five various installations which have been in uninterrupted use for several years past. It is arranged so that the baking platform can be mechanically rotated. In charging the platform with loaves they are gradually moved away from the opening and pass round the oven until they can be withdrawn. There is, therefore, no

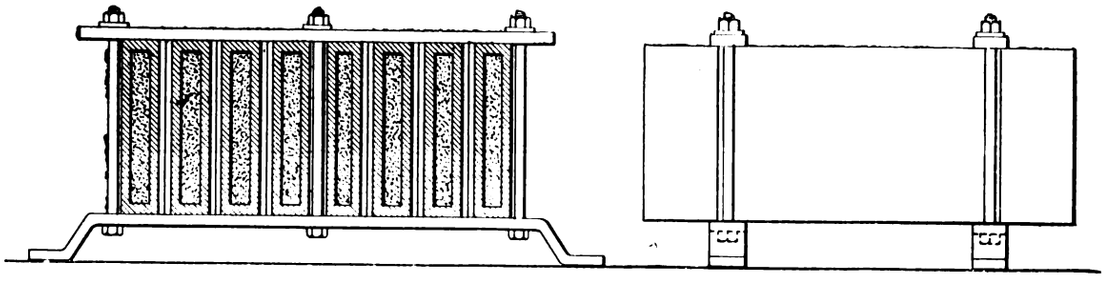

FIG. 8.—HEATING BATTERIES.
Scale 1 : 5.

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need to charge the oven simultaneously with the whole number of loaves and withdraw them at one and the same time, the process thus becoming a continuous one. Fig. 6 is a sketch of the general arrangement of this oven, showing the rails on which the trucks bearing the heating elements are run in and

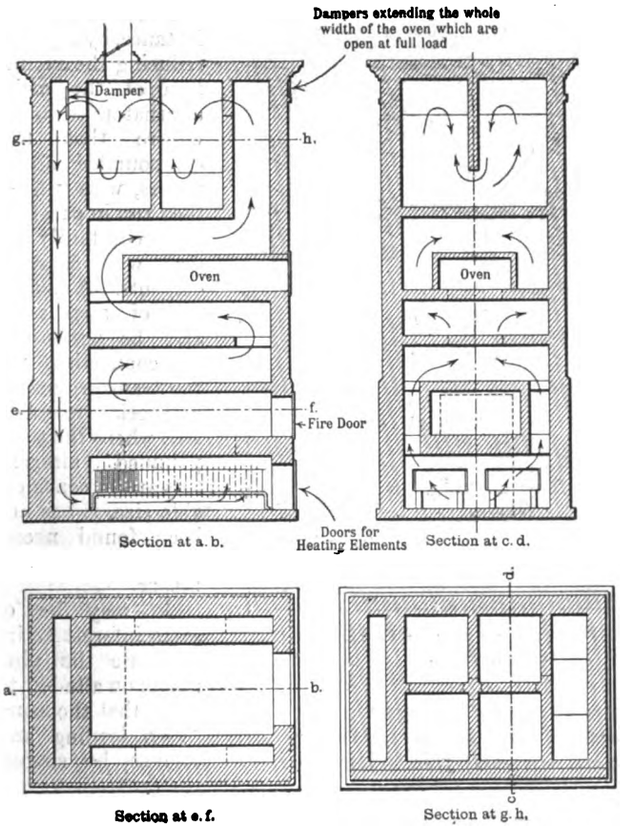

FIG. 9.—DIAGRAM OF OVEN ADAPTED FOR COMBINED ELECTRIC AND COAL HEATING.
Scale 1 : 40.

out. Fig. 8 shows some heating batteries out of a convector. Fig. 9 is a diagram of an oven which can be used for either electric or coal heating or the two may be combined.

COMPOUNDED ALTERNATORS WITH COMMUTATORS.

BY A. HEYLAND.

Summary.—In this article the author describes a number of practical experiences with some large compounded alternators with commutators, which have been running for several years.
Through a misunderstanding this article appeared last week in the *Elektrotechnische Zeitschrift*.

Figs 1 and 4 are views of three compounded alternators and their compounding transformers, erected at the works of the Compagnie Générale pour l'Eclairage et le Chauffage par le Gaz, Valenciennes, and in constant operation since the beginning of 1905. Each of the three alternators is designed for an output of 890 kw. at a speed of 375 revs. per min., and for a frequency of 50 cycles per second. The compounding transformers are mounted behind the switchboard shown in Fig. 1.

Figs. 2 and 3 show a self-exciting and compounded alternator, together with the compounding transformers, installed at the works of the Société Métallurgique de Senelle-Maubeuge (Division des Aciéries de Senelle) in Longwy and in regular service since the end of 1904. The output of the alternator is 450 kw. at a speed of 83 revs. per min., the frequency being 25 cycles per second.

These alternators are of some interest, not only on account of their considerable size and the length of time during which they have been doing regular work, but also because they afford a proof that commutation troubles, which some have averred to be insurmountable, can be overcome without great difficulty. That no difficulty is experienced in running several of these machines in parallel is proved by the installation at Valenciennes, where the three 890 kw. alternators run in parallel. In this plant the transformers are connected by equalising conductors, with the result that the compounding effect is common to all three machines. In consequence the mutual behaviour of these alternators is exactly the same as with three alternators of the ordinary type working in parallel.

The experience gained with these compounded alternators with commutators has thrown light on a number of interesting points. It has been found, for instance, that it is advisable to design such machines with a stiff field and not too small a density for the field flux. The explanation is that these alternators, being self-exciting, should not be too sensitive to fluctuations in the engine speed; they resemble in this respect ordinary continuous-current dynamos.

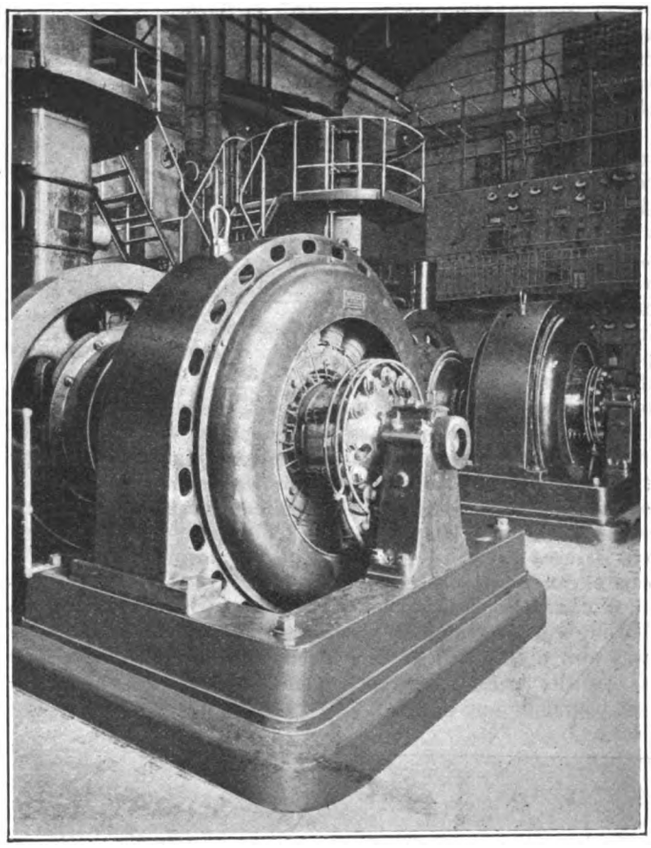

FIG. 1.—THREE COMPOUNDED 390 KW. 50 ∿ ALTERNATORS, RUNNING AT 375 R.P.M. AND INSTALLED AT THE COMPAGNIE GÉNÉRALE POUR L'ECLAIRAGE ET LE CHAUFFAGE PAR LE GAZ, VALENCIENNES.

A point to which sufficient attention has hitherto hardly been paid relates to the behaviour of compounded alternators when dealing with heavy leading currents. Such leading currents may cause the machine suddenly to lose its excitation, especially if the machine is of small size.

This phenomenon was first observed in a small experimental machine, but the firm which carried out the experiments was at a loss to find an explanation for this peculiar behaviour. This was early in 1904, and the firm in question wrote to me at the time that they had intended to use small compounded alternators as automatic voltage regulators in lighting networks. These machines were not intended to supply current, but were merely to be used as motors, running light and connected to those points of the lighting system at which the voltage was to be kept constant. The circuit was a pure lighting circuit, and in normal conditions there was no phase displacement between current and voltage. A small compounded alternator, running light, was connected in parallel with the lighting system, and it acted for a while in

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the desired manner by supplying to the circuit a sufficiently large magnetising current to keep the voltage constant. But afterwards the machine fell several times out of step without apparent cause. I did not witness these tests myself, and when I visited the firm later on, the machine had been disconnected from the lighting circuit, and put to other use. The same phenomenon was subsequently experienced at the Felten and Guilleaume-Lahmeyer Works, and was found to be entirely due to the leading currents through the compounded alternator resulting from the rise in pressure of the main alternator when the load diminished. Since a lagging current causes an increase in the field of a compounded alternator, it is evident that a leading current must have a weakening effect upon the field, and this weakening effect grows at an accelerated rate owing to the simultaneous decrease in the saturation. It is, therefore, clear that a compounded alternator will lose its pressure and fall out of step when loaded with a leading current of sufficient strength or phase displacement. This falling out of step is not a direct result of the compounding arrangement, but is due to an indirect action. A closer investigation went to show that the machine fell out of step when loaded with a leading current equal to about half the normal current; it was also observed that the phenomenon took place with a smaller leading current when the machine was over-compounded, but did not take place at all when the alternator was under-compounded. Further, the alternator fell sooner out of step the larger the main alternator and the smaller its armature reaction; the phenomenon did not occur when the main alternator was of relatively small size.

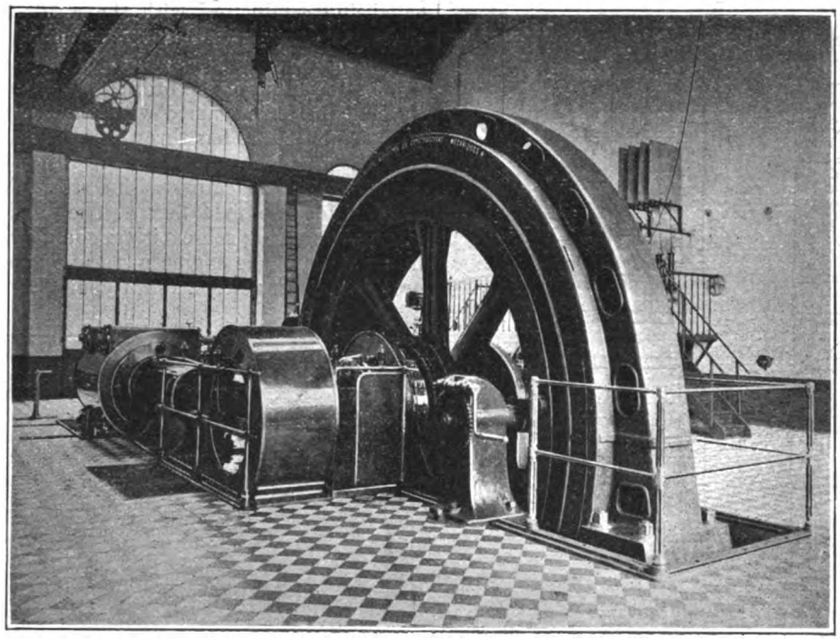

FIG. 2.—VIEW OF 450 KW. 25 ∿ COMPOUNDED ALTERNATOR, RUNNING AT 83 R.P.M AND INSTALLED AT THE ACIÉRIES DE SENELLE, LONGWY.

There are thus a number of means of preventing compounded alternators from falling out of step. It is far the simplest, of course, to avoid leading currents as far as possible, and this may generally be accomplished without difficulty, for instance, by slightly reducing the excitation of the main alternators so as to ensure that the compounded alternators, with which they run in parallel, have constantly to deal with lagging currents. A falling out of step may also be prevented by connecting up the transformers in a special manner. But where the compounded alternators are of considerable size, it has not been found necessary to resort to this means.

It may be of some interest to investigate the phenomenon alluded to above by means of diagrams. We will assume that the compounded alternator is alternately loaded with leading and lagging currents, this being done, for instance, by successively over-exciting and under-exciting a standard alternator with which the compounded machine is connected in parallel. In Fig. 5 the abscissæ to the right of the origin denote the lagging currents, while the abscissæ on the other side of the

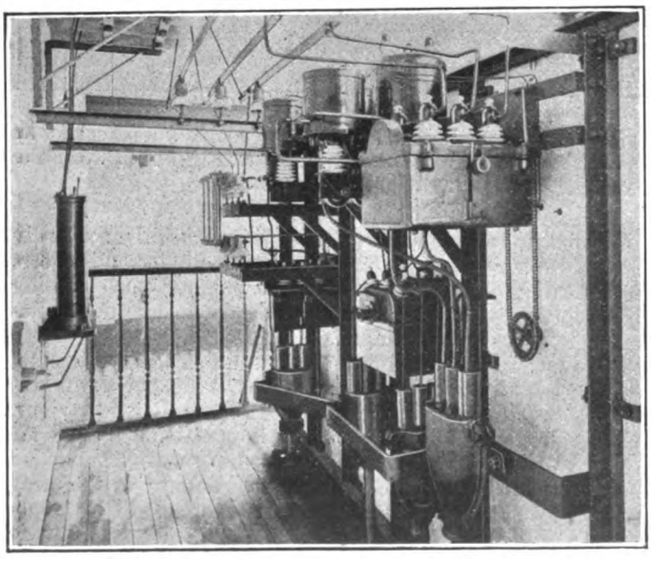

FIG. 3.—COMPOUNDING TRANSFORMERS FOR THE ALTERNATOR AT SENELLE.

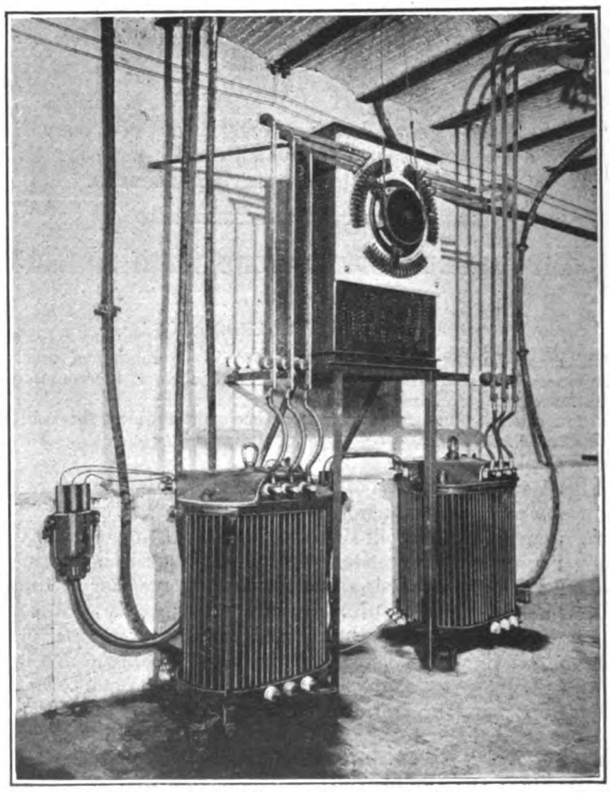

FIG. 4.—COMPOUNDING TRANSFORMERS FOR THE ALTERNATORS INSTALLED AT VALENCIENNES.

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origin represent the leading currents. The ordinates represent the field excitation of the compounded alternator. For a constant voltage, the field excitation would have to vary with the wattless currents as indicated by the curve *c* which is slightly bent upwards, this being due to magnetic leakage. The total field exciting current generated in a compounded alternator is influenced by the compounding arrangement in such a manner as to increase in proportion

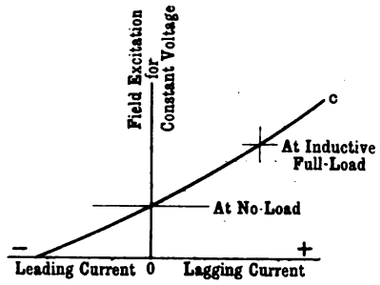

FIG. 5.—DIAGRAM SHOWING THE RELATION BETWEEN THE FIELD EXCITATION AND THE ARMATURE CURRENT FOR A CONSTANT TERMINAL VOLTAGE.

with the lagging currents and diminish in proportion with the leading currents. In the case of a machine with a non-saturated field circuit, this relation would be represented in the diagram by a straight line. On account of the increasing saturation, however, this relation is given by a curve, bent downwards as indicated by the dotted line in Fig. 6. On the assumption that the alternator is to be exactly compounded at full load, the dotted curve must be so situated as to intersect the curve *c* at the points corre-

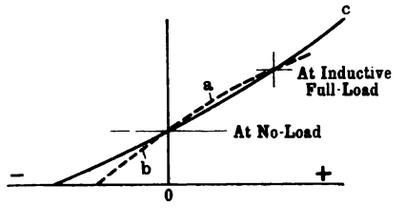

FIG. 6.—DIAGRAM ILLUSTRATING THE COMPOUNDING EFFECT OBTAINED WITH A POSITIVE REGULATION. (Normal Compounded Alternators.)

sponding to no load and full load. Between these two points, the dotted curve (marked *a* in Fig. 6) lies above the curve *c*; *i.e.*, the alternator is somewhat over-compounded between no load and full load. If, on the other hand, the alternator has to deal with leading currents, the dotted curve (marked *b* in Fig. 6) is below curve *c*. This implies a decrease in the voltage of the alternator, and this drop in pressure is larger the greater the magnetic leakage and the saturation of the machine. If a compounded alternator is running in

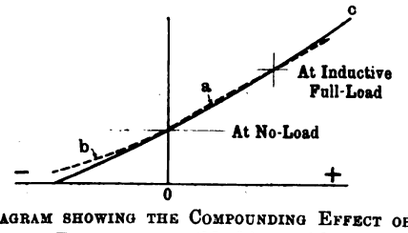

FIG. 7.—DIAGRAM SHOWING THE COMPOUNDING EFFECT OBTAINED WITH NEGATIVELY-ACTING REGULATION. (Machines with a negative auxiliary flux.)

parallel with an ordinary alternator having a comparatively small armature reaction or, what amounts to the same thing, with an alternator of relatively large size, and if the leading current through the compounded alternator does not reduce the latter's voltage to a proportionate extent, the leading current will increase, thus reducing the voltage of the compounded alternator still further, and so on, until the machine loses its voltage completely. If such a machine is to run satisfactorily heavy leading currents would have to be avoided, and this can be easily arranged for, as already pointed out.

But the disturbance just described could be entirely circumvented, if it were possible to bring curve *c* and the dotted curve into coincidence, or, better still, to cause that part of the dotted curve which corresponds to leading currents (marked *b* in the diagrams) to lie above curve *c*, as indicated in Fig. 7, for instance. This could actually be achieved by connecting up the transformers in a special way; but as it has not been found necessary to employ this means where large machines are concerned, there is no need to give a detailed description of an arrangement of this kind.

It may be pointed out, however, that the modification represented by Fig. 7 corresponds exactly to the alternator with a negative auxiliary regulating flux, as described in *The Electrician*, Vol. LVIII., pp. 632, 671 and 998. In this design the regulating curve assumes automatically the shape indicated in Fig. 7 by reason of the field flux of the alternator being more and more opposed by the negative auxiliary flux as the load diminishes.

A COMPARISON OF THE UNIT OF LUMINOUS INTENSITY OF THE UNITED STATES WITH THOSE OF GERMANY, ENGLAND AND FRANCE.*

BY EDWARD P. HYDE.

In inaugurating the work in photometry at the Bureau of Standards several years ago the British candle was adopted as the unit in terms of which the standard of the Bureau should be expressed. But the British candle as a standard is unreliable and a fresh unit was obtained as follows: The Hefner unit was obtained directly from the Reichsanstalt by means of incandescent lamps verified at that laboratory in terms of their Hefner lamps, and the unit of the Bureau was obtained from these lamps by the use of the ratio, 1 Hefner = 0·88 candle.

In order to obtain an accurate comparison of the unit of the United States with those of England and France, and to obtain a further comparison with the unit of Germany, the writer carried a number of seasoned lamps abroad in the spring of 1906, and had them compared with the recognised standards of these countries. Eighteen lamps were taken, nine of which were 50 volt, 64 watt, horseshoe filament lamps which had been standardised for intensity in a specific direction defined by lines etched on the bulb. The other nine lamps were 110 volt, 64 watt oval anchored filament lamps which had been standardised for mean horizontal intensity (the mean intensity perpendicular to the axis of the lamp) by the method of rotating the lamps at 180 revs. per min. Three lamps of each type were left at the National Physical Laboratory at London as a check on the others which were taken to Paris and Berlin.

The lamps were hermetically sealed in copper boxes and were carried entirely by hand in order to avoid excessive jarring. They were taken in the order named to the National Physical Laboratory, the Laboratoire Central d'Électricité at Paris, the Physikalisch-Technische Reichsanstalt at Berlin, and then again to the National Physical Laboratory. They were intercompared and measured in terms of the standards of the bureau immediately before leaving and as soon after returning as practicable.

At each laboratory, except the Reichsanstalt, the method employed for determining the mean horizontal intensity of the six 110 volt lamps was the same as that used at the Bureau. At the Reichsanstalt the method of rotating a pair of mirrors about the lamp was employed. Moreover, the distance at which both the stationary and rotating lamps were measured was approximately 125 cm. at each laboratory except the Reichsanstalt, where the 50 volt stationary lamps were compared at a distance of 300 cm., and the other six lamps at a distance of 450 cm. The difference in distance was occasioned by the use of the *two* mirrors in measuring the mean horizontal intensity of the 110 volt lamps.

An investigation was subsequently undertaken at the bureau to determine what differences in the values of mean horizontal intensity might result from the two different methods of making the measurements. The results of this investigation are given in a separate Paper in the last volume† of the *Bulletin*. It is found that the measurements made at the Reichsanstalt are comparable with those made in England and France and at this Bureau.

The results of the determinations made in England were obtained by comparison with incandescent lamps, which in turn had been compared with the standard Harcourt pentane lamp of the National

* Abstracted from the *Bulletin* of the Bureau of Standards.
† Vol. II., p. 415.

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Physical Laboratory. This lamp is supposed to have an intensity of 10 British Parliamentary candles, and therefore the intensities of the incandescent lamps verified for the Bureau are expressed in British candles. In France the comparisons were made against incandescent lamps which had been measured at the Laboratoire Central in terms of the Carcel lamp. By assigning to the Carcel lamp an intensity of 9·6 bougies décimales, a value obtained by Violle from a direct comparison with the platinum standard, the results are expressed in bougies décimales.

In Germany the comparisons were made against incandescent lamps which had in turn been compared against the Hefner amyl acetate lamp. The results are expressed in Hefner candles. Since at the Reichsanstalt the E.M.F. of a Clark cell at 15°C. is taken as 1·4328 volts, instead of 1·4340 volts (the value used in England, France and the United States), the voltages and currents of the incandescent lamps were modified accordingly, but in the following tables, for purposes of comparison, all voltages and currents are expressed in terms of the same units.

In Table I. are given the complete results obtained for the individual lamps at the different laboratories, in the order in which the laboratories were visited. The first six lamps, B.S. Nos. 44, 45, 46, 49, 50 and 64, are the 50-volt stationary lamps, the remaining six, B.S. Nos. 4, 7, 8, 13, 30 and 40, are the 110-volt lamps that were standardised for mean horizontal intensity and are hereafter designated as the *rotating* lamps. The six lamps, three stationary and three rotating, which were left at the National Physical Laboratory, are not included in this table. They were used merely as a check on the constancy of the other 12 lamps.

At the Bureau of Standards and at the National Physical Laboratory the lamps were measured twice. The values given in the fifth and sixth columns are those obtained at the first visit to the National Physical Laboratory, but since for lack of time only a single set of readings was made, the results are not guaranteed by the National Physical Laboratory to a high accuracy. They are, therefore, omitted in the final comparisons of the units.

Table I. reveals several interesting and important facts in regard to the present stage of development of the science of photometry. A comparison of the mean values of the stationary and rotating lamps before being carried abroad and after their return gives some idea of the constancy and portability of seasoned incandescent lamps as secondary photometric standards. The lamps were carried about for two months, were packed and unpacked five times, were burned in all about two or three hours, and yet the mean value of the six stationary lamps was found to have changed by less than 3 parts in 1,000, while the mean value of the six rotating lamps apparently changed less than 1 part in 1,000. It is not to be inferred from this that the lamps necessarily remained as constant as the results would indicate, since it is impossible to measure with certainty even the mean value of the lamps with an accuracy better than several parts in 1,000. The constancy of the resistance of the lamp filaments as shown by the agreement between the mean current values is another indication of the constancy of the lamps, and emphasises the importance of accurate electrical measurements in the photometry of incandescent lamp standards.

A second interesting fact, on which some light is thrown by Table I., is the ultimate accuracy of photometric comparisons. It also shows the accuracy with which different experienced observers using different apparatus can obtain the relative values of two light sources under favourable circumstances.

In order to compare the unit of the Bureau with those of the other laboratories, the values given in Table I. are grouped in a more convenient form in Table II. In this table the unit of each laboratory is expressed in terms of the unit of the Bureau of Standards, except that the Reichsanstalt unit is expressed in terms of 0·88 times the Bureau unit. The ratios are given as obtained both from the stationary and from the rotating lamps, and it is interesting to note the differences between the two values. In every case the ratio obtained from the rotating lamps is lower than that obtained from the stationary lamps.

Table II.—*Values of Units of Different Laboratories in Terms of the Unit of the Bureau of Standards.*

Units of various laboratories.	Values in terms of B.S. unit.		
	Stationary lamps.	Rotating lamps.	Means.
Bureau of Standards unit	1·000	1·000	1·000
Reichsanstalt unit	1·001 × 0·88	0·996 × 0·88	0·998 × 0·88
National Physical Laboratory unit	0·987	0·981	0·984
Laboratoire Central unit	0·985	0·978	0·982

It is seen from Table II. that the unit of the Bureau is equal to $\frac{100}{88}$ of the Reichsanstalt unit to within the errors of measurement. Since the unit was originally obtained in this way nearly four years ago it indicates that the Bureau has maintained through incandescent lamp secondary standards a unit which, compared with the unit of the Reichsanstalt, has not changed appreciably in that time. But though the Bureau has been able to maintain for several years a constant unit by means of incandescent lamp secondary standards, and could probably continue to maintain it in this way for an indefinite period, nevertheless the need of a suitable primary photometric standard is fully recognised and an investigation of primary standards will be undertaken in the near future.

It is evident from Table II. that the value of the British candle obtained from the Hefner by the use of the fraction 0·88, which is supposed to represent the mean of the best determinations of the ratio, is not the same as the British candle defined in terms of the Harcourt (10 c.p.) pentane lamp at the National Physical Laboratory. The difference is about 1·5 per cent., according to the values given in Table II.; but, as will be seen later, there is an uncertainty in this ratio amounting to several per cent. Before passing to a brief résumé of the recent determinations of the ratios of the three lamps recognised as standards in England, France and Germany, it is desirable to call attention to the approximate agreement between the bougie décimale, the British candle, and the candle in use in the United States in the testing of electric lamps. The difference of about 2 per cent. is small compared with the accuracy usually obtained in industrial photometry, and no serious results would follow a compromise by which the three countries would agree upon a unit to be the same for all. This highly desirable end will become more difficult of accomplishment each year, as a higher accuracy of photometric measurement is demanded, and even now a change in unit of over 1 per cent. would be felt in the United States. Unfortunately the unit of Germany is so different from all the others that it would probably be impossible to agree upon a unit common to the four countries, but the ratio of the Hefner candle to the candle of France, England and the United States could be accurately fixed.

Table I.—*Values of Candle-power and Current Obtained at the Different Laboratories.*

Lamps.	Volt-age.	Bureau of Standards.		National Physical Laboratory.		Laboratoire Central.		Reichsanstalt.		National Physical Laboratory.		Bureau of Standards.	
		Candle-power.	Current.	Candle-power.	Current.	C.p. in bougies décimales.	Current.	C.p. in Hefner's.	Current	Candle-power.	Current.	Candle-power.	Current.
B.S. No. 44	49·0	17·4$_1$	1·3326	17·6$_8$	1·3330	17·7$_0$	1·3325	19 9	1·333	17·7$_2$	1·3330	17·3$_6$	1·3325
B.S. No. 45	49·0	17·3$_1$	1·3304	17·6$_3$	1·3306	17·5$_5$	1·330	19·6	1·331	17·4$_2$	1·3306	17·2$_4$	1·3302
B.S. No. 46	49·5	17·3$_1$	1·3225	17·6$_3$	1·3229	17·5$_7$	1·323	19·5	1·323	17 6$_0$	1·3230	17·2$_8$	1·3225
B.S. No. 49	49·5	17·5$_9$	1·3301	17·7$_9$	1·3302	17·7$_5$	1·3295	19·9	1·330	17·7$_4$	1·3305	17·5$_2$	1·3301
B.S. No. 50	49·5	17·3$_8$	1·3283	17·5$_6$	1·3284	17·5$_0$	1·328	19·6	1·328	17·5$_0$	1·3288	17·3$_0$	1·3282
B.S. No. 64	50·5	17·7$_0$	1·3328	17·9$_5$	1·3325	18·0$_0$	1·333	20·1	1·333	18·0$_0$	1·3331	17·6$_8$	1·3328
Means	..	17·4$_5$	1·3294	17·7$_1$	1·3296	17·6$_8$	1·3293	19·7$_7$	1·3297	17·6$_6$	1·3298	17·4$_0$	1·3294
B.S. No. 4	109·0	16·2$_5$	0·5973	16·5$_0$	0·5975	16·5$_5$	0·5965	18·5	0·597	16·5$_1$	0·5975	16·1$_5$	0·5974
B.S. No. 7	108·0	15·9$_0$	0·5947	16·1$_1$	0·5944	16·0$_5$	0·5937	18·0	0·594	16·2$_5$	0·5946	15·8$_8$	0·5944
B.S. No. 8	109·0	16·0$_2$	0·5851	16·3$_0$	0·5852	16·4$_0$	0·5850	18·3	0·584	16·3$_0$	0·5852	16·0$_5$	0·5850
B.S. No. 13	109·0	15·7$_8$	0·5936	16·0$_7$	0·5938	16·4$_0$	0·5932	18·1	0·593	16·0$_8$	0·5939	15·8$_1$	0·5937
B.S. No. 30	109·0	15·7$_8$	0·5852	16·0$_4$	0·5855	16·0$_5$	0·5848	18·0	0·585	16·0$_8$	0·5855	15·7$_3$	0·5854
B.S. No. 40	109·0	16·2$_5$	0·5984	16·7$_3$	0·5986	16·7$_0$	0·5970	18·6	0·598	16·6$_4$	0·5986	16·3$_1$	0·5984
Means	..	16·0$_0$	0·5924	16·2$_9$	0·5925	16·3$_6$	0·5917	18·2$_5$	0·5923*	16·3$_1$	0·5926	15·9$_9$	0·5924

* The current values in this column were only given to three decimal places by the Reichsanstalt, but since the corrections for difference in value of the standard cells amounts to five in the next place for the rotating lamps, and is the same for all the lamps, the mean is increased by five in the fourth decimal place.

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The question of a uniform unit is to be distinguished from that of a uniform standard lamp in terms of which the unit is expressed. Thus at present the Carcel lamp in France has an intensity of 9·6 bougies décimales, and the Harcourt pentane lamp in England has an intensity of ten British candles. Only in Germany has the standard an intensity of one unit, and even here in stating the intensity the word *candle* is affixed (Hefnerkerze). Of course it would be very desirable to adopt a common standard as well as a common unit, but the adoption of the unit is the more important of the two. As soon as an entirely satisfactory standard is presented, its general adoption will probably follow, and this is much more likely to result if the adoption of a new standard does not entail the adoption of a new unit. The Hefner lamp was recommended by the Geneva Congress as a secondary standard, but owing partly to the fact that the Hefner was not found as satisfactory in other laboratories as it had been found at the Reichsanstalt, and partly, no doubt, because of the different value of the unit, its general adoption did not follow. The Carcel continues to be used in France, and the Harcourt pentane lamp is coming into general favour in England.

In response to requests from the Commission appointed by the Paris International Congress of Gas Engineers in 1903, determinations of the ratios of the three units have been made, and the results are summarised in Table III.

Table III.—*Summary of Ratios of Hefner, Harcourt (10 c.p.) and Carcel Lamps.*

—	Harcourt (10 c.p.) / Hefner.	Carcel / Hefner.	Harcourt (10 c.p.) / Carcel.
Reichsanstalt (using an electric comparison lamp)	10·9	10·7	1·02
Laboratoire Central (using an electric comparison lamp)	10·76	10·76	1·00
Laboratoire Central and Laboratoire d'Essais (direct comparison)	10·72	10·73	1·009
National Physical Laboratory	10·95	10·69	1·024
Ratios computed from Bureau of Standards incandescent lamps	11·19	10·73	1·043
Best previous values (Bunte)	11·4	10·87	1·05

It is seen from this table that the best agreement is obtained in the ratio of the Carcel lamp to the Hefner lamp, whereas discrepancies amounting to 4 or 5 per cent. occur in the other ratios. The most important result to engineers is the discrepancy in the ratio of the Hefner candle to the British candle as given by the Harcourt (10 c.p) lamp. It would seem that the candle in use in the photometry of electric lamps in the United States is sufficiently different from the British candle, as obtained through Harcourt (10 c.p) pentane lamps, to justify defining the unit obtained through the Hefner by use of the ratio 0·88 as the candle instead of the British candle. It is hoped, however, that the suggestion made in a previous paragraph in regard to an international unit may be carried out, and that by a constant intercomparison of the standards of the different countries by the interchange of electric incandescent lamps the unit may be maintained uniform.

NEW DEVELOPMENTS IN ARC LAMPS AND HIGH-EFFICIENCY ELECTRODES.*

BY G. M. LITTLE

Arcs for lighting may be formed between electrodes of many different kinds. This Paper deals with the development of the so-called magnetite electrodes and of a lamp suitable for burning them. A few points of comparison between these metallic-oxide electrodes and carbon electrodes will be considered, and some of the many interesting advantages possessed by the metallic-oxide electrodes and lamp will be touched on. Among these are the long life, high efficiency and good distribution and colour of light.

The magnetite electrodes were so named because magnetite is usually one of the constituents of the negative or cathode, but it would be more satisfactory to call them metallic-oxide electrodes, as, in addition to the magnetite, there are always at least two other oxides present—namely, oxide of titanium and oxide of chromium

These electrodes are made in a very different manner from the carbon electrodes. As is well known, the latter are squirted or moulded from a plastic mixture, and are baked, the carbon furnishing sufficient mechanical strength and electrical conductivity. A metallic-oxide electrode cannot be made this way, for it is a familiar fact that a fine powder is a poor conductor, no matter of what it is composed, and as these electrodes are made for the most part from finely powdered oxides it is evident that a conducting binder or a conducting case would have to be used. In practice, the mixture of oxides is tamped into a thin iron tube and the end sealed in an arc

The oxides have distinct and separate reasons for their presence. The titanium oxide has the property of rendering the arc luminous; and it may be here noted that the metallic-oxide arc is a flame arc, the light not coming from a crater as with carbons. The oxide of iron gives conductivity to the fused mixture when cold, the other oxides being conductors only when hot. The oxide of chromium prevents a too rapid consumption, so that by its use an electrode may be given a very long life.

The positive, or anode, used with these metallic-oxide negatives is generally a metal, and is consumed much more slowly than the negative. This is contrary to what would be expected, judging by the action of carbon electrodes.

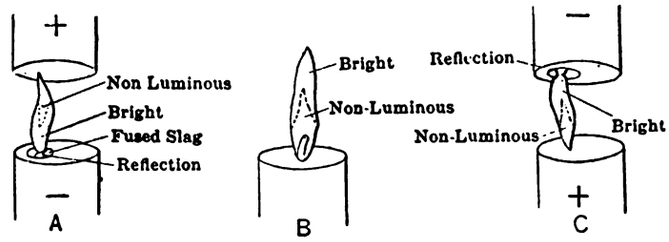

FIG. 1.

A—Metallic Arc with Negative below.
B—Candle Flame.
C—Metallic Arc with Negative above.

There are a number of advantages possessed by the metallic arc over the carbon arc. In the first place the efficiency is much better; that is, a metallic arc lamp operating on a 4 ampere current with approximately 65 to 70 volts at the arc will give a light equal or superior to that of a 6·6 ampere, 75 volt, direct current, enclosed carbon arc lamp.

The distribution of light is far better. This is owing to the fact that in the enclosed carbon arc practically all the light comes from the crater on the flat under-surface of the upper electrode, most of it being thrown down and not serving to illuminate the street between lamps. The light from the carbon arc itself is weak and of a blue colour. This is very pronounced at times, especially if the flat under-surface of the upper electrode is somewhat inclined, thus hiding the crater. In the case of the metallic-oxide electrodes, the arc is itself the source of light, practically none coming from the crater, except by reflection The metallic arc is much like a candle flame, having its luminous and non-luminous zones. The light is brightest near that end of the arc which is next to the negative

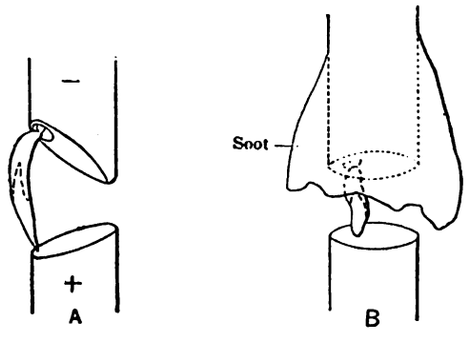

FIG. 2.

A—Showing how the ends of Carbons waste away to a bevel before using the down draught of air.
B—Showing accumulation of sponge-like masses of soot before using the down draught of air.

electrode, and comes from a hollow cone-shaped mantle of volatilised oxide of titanium rendered incandescent by the heat of the arc, just as in the candle flame the light comes from a hollow cone-shaped mantle of carbon particles made white hot by the heat of the flame.

The voltage required to maintain a metallic arc is less than that of an enclosed carbon arc. It is a familiar fact that an enclosed carbon lamp will not burn properly with the arc voltage down to 65, while a metallic arc will burn well at less than 55. Metallic arcs are adjusted to burn at from 65 to 75 volts in different cases, while the carbon arcs are all set at 80. This is a very evident advantage in favour of the metallic arc, as more lamps may be put on a circuit without raising the voltage on the line.

The life of carbon electrodes, as a rule, is not over 150 hours, while the metallic-oxide electrodes can go considerably longer.

The uniform white colour of the metallic arc is in marked contrast to the changeable blue and white of the enclosed carbon arc.

* Paper read before the National Electric Light Association, Washington. Slightly abbreviated.

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As the metallic-oxide electrodes are not burned "enclosed," there is no inner globe required on the lamp.

While it looked easy to secure all of these advantages, many difficulties appeared, but they have now practically all been overcome. In the first experiments the electrodes were trimmed with the anode or positive above and the negative or metallic-oxide electrode below, just as carbon lamps are trimmed, but a number of troubles presented themselves.

1. The bright portion of the arc was near the surface of the lower electrode, which cast a large shadow.

2. The light reflected from the brilliant surface of the fused slag on the lower electrode was thrown upward, and could only be partly saved by using a reflector.

3. An under-feed mechanism was seen to be necessary, as, contrary to the action of carbon electrodes, the negative metallic-oxide electrode is the more rapidly consumed.

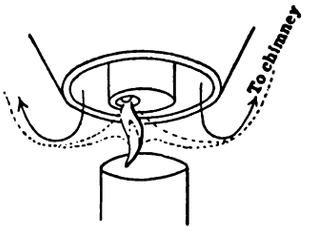

FIG. 3.

The down draught of air forces the soot to take the path shown by the dotted line, effectually keeping it from touching or depositing on anything.

4. Only a comparatively short metallic-oxide electrode could be used, as a long one would necessitate the use of an unwieldy long glass globe. This would limit the life and could only be met by adopting a negative electrode of large diameter, which it is evident would be undesirable.

5. A particularly undesirable feature was the gathering of a large amount of reddish soot that would collect in spongy masses around the electrodes, obscuring the light. This had to be removed by some mechanical means, such as scraping or shaking it off, and some receptacle other than the glass globe had to be provided to catch it.

6. The negative or metallic electrode was seen to burn to a blunt taper point, causing the arc to be very unsteady, as it tended to leave the end and run up the side in the manner of the carbon arc when flaming.

As noted above, the bright portion of the metallic arc is located near the surface of the negative electrode, and it was seen to be very desirable to burn the electrodes with the negative above, thus getting the bright portion of the arc in such a position that the shadow thrown down would be less, and that the light reflected from the brilliant surface of the fused pool of slag on the negative electrode

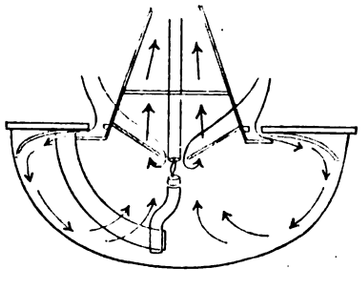

FIG. 4.—PATH TAKEN BY AIR CURRENTS IN LAMP.

would be thrown down and utilised instead of being thrown upward and wasted. The other advantages, noted above, possessed by the carbon lamp would be retained if this inverted position of the electrodes could be made practical.

The first attempt to burn the metallic-oxide electrode above and the metallic electrode below showed that there were serious obstacles to be overcome before it could become a practical method. In the first place, the electrode would not keep a square end, but would waste away on one side, and the arc would run up this bevel, or slope, giving a very unsteady light. In the second place the volatilised oxides of iron, chromium, titanium and so forth would condense on the sides of the electrodes and hang down as a fringe or curtain, hiding the light.

The first means taken to overcome these troubles was the introduction of a rotating draught of air around the arc. This had the effect of forcing the arc to hold to a central position, stopped the crooked burning and steadied the light, but did not take care of the fumes. Attempts to blow the fumes away sidewise gave only partial success. Finally, a current of air was directed down around the arc, and this gave excellent results. The electrode burned perfectly square, and the clean layer of air prevented any gathering of fumes. This was a very marked advance, as it did away with any need for a mechanical scraper or shaker, the soot practically all passing out of the chimney and not requiring to be caught in any receptacle, the globe remaining clean.

When burning metallic-oxide electrodes with the metallic oxide stick below, copper was used as an anode with fair results. On reversing the position of the electrodes, it was found that the new conditions made it possible to improve on the action of a pure copper anode, and a number of changes were accordingly made. In the first place, if the arc plays for a time on pure copper, it will oxidise the surface. This oxide will fuse to a slag that becomes an insulator when cold, and on starting a cold lamp it is necessary to strike the electrodes together hard enough to break through the slag To strike such a hard blow is undesirable, as if it is done while the lamp is burning—for example, when feeding—it is liable to spatter the fused slag out on to the glass globe. A simple remedy for this consisted in using an anode containing metals or alloys whose oxides, when fused together, would make a slag that is a good conductor when cold. The steadiness of the light largely depended on the composition of the slag, its uniformity and temperature. The anode surface is at all times covered with this slag, which slowly dissolves the metal and is itself slowly volatilised. If the arc plays on bare metal it consumes it rapidly, and it was found desirable to secure this slag cover from being knocked off. This was accomplished by providing a rough surface for it to cling to, and by running the entire anode tip very hot.

A characteristic property of the metallic arc has been a very noticeable dying down or dimming of the light, which occurred at irregular intervals, especially after the electrodes had burned for 20 hours or more. These dim spells would last from a few seconds to two or three minutes, when the normal brilliancy would return. This is explained as follows: In the metallic arc the brilliancy is largely due to the presence of volatilised oxide of titanium, and anything that interferes with the uniform evolution of vapours of

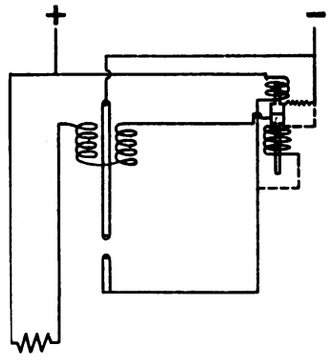

FIG. 5.—DIAGRAM OF CONNECTIONS.

titanium will cause the light to fall—for example, the presence of a high percentage of highly fusible oxide of chromium. This oxide of chromium is volatilised at a slower rate than the oxides of titanium and iron, and after the electrode has been burning some 20 hours the slag on the end of the cathode has become very rich in oxide of chromium, which forms a film on the surface of the fused pool of oxides. When the film is not present there is a plentiful evolution of oxides of iron and titanium, and there is a bright arc. The oxide of chromium can be seen to gather on and finally entirely cover the surface of the pool. This stops the evaporation of titanium and iron, and the light burns to a bluish colour and dies down until the chromium film is burned away again. This trouble was met by modifying the mixture in such a way that the oxide of chromium could not separate from the oxides of iron and titanium, thus doing away with the film on the surface and entirely doing away with the dim spells.

In carbon lamps there was very little done to keep the impurities volatilised from the carbons from depositing on the globe. This trouble had to be met by the carbon manufacturers, who were prodded up to produce carbons containing less than 0·2 per cent. of impurities, but this means was not to be considered in the case of the metallic-arc lamp. The metallic arc electrodes, being chiefly composed of oxides of iron, titanium and chromium, do not burn away to an invisible gas, as does a carbon stick, but are volatilised bodily, and the vapours instantly condense, on leaving the arc, to a fluffy reddish soot that settles on everything it touches, so that a chimney is a very necessary feature in the lamp. This soot, if it comes in contact with the reflector or globe, will smudge them badly in 10 minutes. As was noted before, a current of air flowing down around the electrode served admirably to keep it clean, so it was applied to the reflector and globe with gratifying

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re sults. A thin layer of air is introduced at the top of the reflector and forms a shield through which the soot-laden air cannot penetrate, so that the reflector and globe will keep clean for a long time.

As the air currents play such an important part in this lamp, it became necessary to do a large amount of experimental work on the design of an air intake and of a chimney top. The chimney could not be made long enough to cause a very powerful draught, so the wind was very apt to blow down it; but by persistent effort the openings have been so designed that the wind may blow from any direction (up, down or sideways), and the only effect is to increase the natural draught in the lamp. Incidentally, the increasing of this draught actually centres the arc and holds it remarkably quiet.

It was found advisable to run the lamp at 4 amperes and 65 to 68 volts at the arc with a cut-out set at 85. This low cut-out was made possible by the inverted position of the electrodes and by the peculiar arrangement of the air draught, which prevented any tendency of the arc to flame or to run up the side of the electrode. Without these features a cut-out of 100 to 110 volts would be necessary. As the power factor at which the lamps operate depends largely on the amount of variation of voltage in the arc, this 85 volt cut-out is seen to be very desirable. In actual service the lamps, including a mercury arc rectifier, run very well at from 65 to 70 per cent. power factor. In several places above we have described special conditions that must be obtained for getting the best results with these electrodes, and these conditions, of course, must be supplied by the lamp in which they are burned.

The special conditions described with regard to draughts are obtained by the down-draught tube, which directs the current of air down around the electrode, another current of air over the reflector and circling around the globe forming a means of protection to them, and a special construction of top and case for giving proper draught conditions when under all conditions of wind.

ANNUAL REPORT OF THE ELECTRICAL INSPECTOR OF FACTORIES.

We give below the Report (somewhat abbreviated) by Mr. G. S. Ram, H.M. Electrical Inspector of Factories, which has just been issued. After referring to the general progress of electrical power, as shown by *The Electrician* tables of electricity supply undertakings, the report proceeds as follows:—

ACCIDENTS REPORTED DURING 1906.

I.—Accidents at Electrical Stations of Electricity Supply Companies or Local Authorities.

Description.	Non-fatal.	Fatal.
Non-electrical.		
1. At engines, pumps and generators	14	.. —
2. At boilers and steam plant	34	.. 2
3. At coal handling plant	8	.. 1
4. Falls	53	.. 4
5. Struck by falling bodies	23	.. —
6. Miscellaneous	68—200	.. 1—8
Electrical.		
1. At switchboards when engaged in ordinary routine work, mostly due to faulty design of apparatus	9	.. —
2. Cleaning, repairing, &c., at "live" switchboards	13	.. 1
3. Cleaning, repairing, or other handling of switchboards supposed to have been made "dead":		
(*a*) Skilled persons	—	.. —
(*b*) Unskilled persons	—	.. —
4. Adjusting brushes	6	.. —
5. Miscellaneous	9—37	.. 1—2

The mechanical accidents show an increase of 20 per cent. over the previous year, but the increase lies under the heading of "miscellaneous," and is not due to the growth of any particular class of accident. Those under Class 1 are mostly due to the handling, generally cleaning, of machinery in motion. Those under Class 2 are of a general nature, and include burns and scalds. The two fatalities were due to the failure of a thermal storage vessel, the precise cause of which up to the time of writing has not been ascertained. The matter is one which will no doubt form the subject of a Board of Trade inquiry. The storage vessel was a steel drum, about 25 ft. in length and 5 ft. diameter. It was projected through the roof of the boiler-house and through a brick wall of a building some distance away, the boiler-house being practically wrecked. One of the men killed was an inspector of a boiler insurance company, who had been specially called in to examine the drum on account of a leakage which had been discovered a day or so previously, and was actually engaged in his investigation when the drum exploded. The fatality under Class 3 occurred to a man when trimming coal in a coal bunker, a quantity of coal sliding down and burying him. The next class (falls), as usual, is large, and includes four fatalities. As I have previously pointed out, many of these accidents could be prevented by the use of properly railed gangways or platforms and fixed ladders. For instance, it is a common occurrence for a man to have to manipulate the hand wheel of a large and generally stiff valve, at a considerable height from the ground, from a rickety ladder, where it would be quite practicable to fix a permanent ladder and platform. The provision of proper and safe access to valves is frequently overlooked. In boiler houses, particularly where water-tube boilers are used, there are often gaps between the brickwork of boilers, economisers, flues, &c., which might readily be bridged over by railed gangways. Although ladders may be provided at various points, the men will take the short cut and step or jump over the gaps, risking a fall from 10 ft. to 20 ft. One of the fatalities in the table occurred in this way.

The electrical accidents reported show only a very slight increase over those of the previous year. In Class 2, cleaning or repairing "live" switchboards, which includes one fatality, it is often open to doubt whether the work could not have been done at a time when the pressure might have been cut off. In the fatal case, the man was repairing switch gear, close to other "live" and unprotected switch gear, against which he stumbled. The pressure was 10,000 volts. Two accidents from short-circuit occurred to persons when taking measurements of "live" switchboards with metal rules. Another befell a man when making a sketch of a sub-station by coming into contact with a "live" switch at 10,000 volts pressure. Of the "miscellaneous" accidents, three were due to defects in hand-lamps, whereby the persons holding them received severe burns. The fatality was due primarily to the insufficient protection of an instrument transformer placed in a subway.

The corresponding electrical accidents at private electric generating stations number 14 non-fatal and no fatalities, and are of no special interest.

II.—Reported Electrical Accidents in Factories, Engineering Works, &c.

No.	Description.	Non-fatal.	Fatal.
1	(*a*) Arcing of switches	28	.. —
	(*b*) Arcing of fuses	10	.. —
2	Arcing at fuses, when replacing fuse wires	14	.. —
3	Unprotected conductors, switches, terminals, fuses, &c.	11	.. 1
4	Faulty apparatus (other than switches)	37	.. 2
5	Working on live conductors:—		
	(*a*) Skilled persons	19	.. 1
	(*b*) Unskilled persons	5	.. —
6	Flashing at motor brushes when adjusting	9	.. —
7	Electric travelling cranes:—		
	(*a*) Unprotected electrical apparatus in driving-cage	3	.. —
	(*b*) Faulty apparatus	3	.. —
	(*c*) Carelessness	9	.. —
8	Miscellaneous accidents in testing electrical apparatus in course of manufacture	22	.. 1
9	Miscellaneous	21—191	.. 3—8

The electrical accidents reported as having occurred in factories, engineering works, &c. (Table II.), show a considerable increase over those of the previous year, the number having risen from 122 to 199, or over 60 per cent., including eight fatalities against four in the previous year. The increase is scarcely to be wondered at in view of the greatly extended use of electricity and to the fact that the necessity of proper precautions being taken is often not realised by the occupier, who accepts the lowest tender for his installation without being aware that the price is low because the apparatus is inferior and often without elementary safeguards. There is little, if anything, new in the nature of the accidents and any comments which I make upon them must necessarily be in the nature of repetition of the remarks I have made in former reports.

Burns from the arcing of switches in ordinary use, 1 (*a*), are often due to faulty construction of the switches or to the absence of any cover or guard. Not infrequently the accident occurs at a motor starting panel. The double-pole switch is put on and a flash burns the operator's hand, sometimes even when there is a cover, owing to the flash passing through the slot provided for the handle. This variety of the accident is nearly always due to the use of cheap and flimsy switch gear. It arises primarily from the starting switch being of inferior construction, generally much too small for the motor it has to control. The contacts are burnt up, the spring is weak, and the lever will stick in any position. The motor is stopped by turning off the double-pole switch and the lever of the starting switch fails to automatically move back to the starting position. This failure is not noticed by the attendant; consequently when he proceeds to start the motor on the next occasion, he turns on the double-pole switch on what is practically a short circuit. If the double-pole switch is a good one, probably nothing serious will happen—the fuse will blow and there is an end of the matter. The switch will, however, generally be of a similar class to the starter. In all probability its blades are very thin and are bent or there is too much play in the spindle, with the result that proper contact is not instantly made. I have often found switches in such a condition that the blades fall actually on the tips of the fixed contacts instead of at the sides or between the clips as intended, and which cannot be switched "home" without much joggling or sideways straining of the handle, or even, as in one of the accidents reported, by shoving them into position with a screwdriver. The result of attempting to use a switch of this character with the starting resistance short-circuited can well be imagined. There is a big flash and the man's hand and face are generally badly burned. The flash is so violent, generally short-circuiting the mains at the switch, that protection of the switch by a cover having a slot for the handle is useless, as the flash comes through it. Many switches are now designed with the handle attached to an extension of the spindle, so that no slot in the cover is required, and are consequently to be preferred.

The accidents from the arcing of fuses, 1 (*b*), are due to the use of unprotected bare metal fuses. Six of them were at motor starting panels, the fuses being fixed close to the double-pole switch and consequently

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close to the man handling the same. In each case the fuse exploded at the moment of switching on, due, in some cases, to the failure of the automatic cut-off action of the starting switch referred to above. This arrangement of unprotected fuses I have described in previous reports as a trap.

The accidents from arcing at fuses when replacing fuse wires (2) were, with two exceptions, due to short circuits, and, as I have previously pointed out, are wholly preventable. They are due to the use of bare fuse metal clamped directly to the fixed terminals, which are always "alive," whilst the opposite poles are close together without any dividing partition between. Such fuses are no doubt cheap, but they invite accidents from short-circuit on every occasion when the fuse wire requires renewing. These fuses are often used on motor starting panels, and although there is almost invariably a double-pole switch on the panel the fuses are frequently connected on the wrong side of the switch, so that even when the switch is "off" the fuse terminals remain "alive." The renewing of fuses is a matter which should invariably be entrusted only to an authorised and competent person, otherwise fuses of a wrong size, probably much too large for the circuit, will often be used. The descriptions of the persons injured under this heading show that the operation was attempted by a labourer, a grinder, a carpenter and an engine-driver, amongst others, with disastrous results in each case. That the accidents were, however, due primarily to the dangerous type of fuse is indicated by the fact that in six cases they occurred to "electricians," who would presumably be aware of the danger and take every care.

Accidents due to unprotected conductors and apparatus (3) are nearly always preventable. The fatal one occurred owing to the terminals of a three-phase motor controller being unprotected.

The somewhat numerous accidents under the heading of faulty apparatus (4) occurred with one or two exceptions in connection with the use of portable appliances, generally lamps. The injuries were mostly severe burns to the hand due to short circuits occurring in the plug or the lamp fitting, or in the flexible wires where they enter the plug or lamp fitting. The severity of many of the burns is undoubtedly due to the circuits being too heavily fused, thus allowing very heavy currents to flow under short-circuit conditions. Three similar accidents occurred with electrical drills. Three accidents were from shock from portable lamps, one being fatal. In this case the system was three-phase, 400 volts, the lamp voltage being 230. The man was standing on iron floor-plates and there being a leakage in the lamp fitting which he was holding, he received the 230 volts through his body to earth. He shouted for help, being unable to move or release his hold of the lamp until assistance arrived and the current was switched off, when he fell to the ground and died in spite of efforts to restore animation by artificial respiration. I described and commented upon an exactly similar fatality in my last year's report.

The other fatality under this heading occurred under very similar conditions. The portable appliance was, however, a fan, of a type generally known as a "desk fan." The fan was placed on a shelf in a cellar in which pork was pickled. The floor was wet or very damp with brine. Two youths were in the cellar and one went to start the fan by turning on the switch in its base. He took hold of the pedestal of the fan with one hand and turned on the switch with the other. The fan was leaky and he therefore received a shock through his body to the ground, from a 200-volt alternating supply. He pulled the fan off the shelf and stood rigidly holding it, unable apparently to drop it. He shouted to the other youth to turn off the current. This was quickly done at the main switch in the next room. He immediately dropped the fan and fell to the ground and died in spite of medical assistance being at hand almost at once. This class of accident, shock to earth when handling portable appliances, is one which should be more carefully guarded against. Wherever portable appliances are used in places where the persons handling them are not insulated from earth, special precautions should be taken, as there is always a possibility or even a probability that there will be a leakage in the portable appliance. As is evident in the case of these two fatalities the person holding the lamp or other appliance may be unable to drop it and a fatal shock is the result, even when low pressures are used. The obvious precautions appear to be that the portable appliance should be connected to earth or that no part of the metal of the appliance which can be touched can under any circumstances become charged by leakage. It is not sufficient in the case of a portable lamp, for instance, that it be provided with an insulating handle (the lamp which caused the fatality described above had such a handle) unless arranged so that no metal can be touched. If there is a metal guard over the lamp, it should be attached to the fitting through the medium of a insulating sleeve. Where portable appliances are regularly used in factories, &c., as, for instance, electric irons in laundries, special care should be taken that there is no danger of shock to earth.

A curious accident from shock occurred in a shipyard to a man standing on the ground and touching the side of a ship on the stocks. He received a severe shock owing to the whole ship having become charged up by reason of leakage from the portable or temporary electrical installation in use. A number of riveters and other men at work on the stagings also received shocks.

The next class of accident—working on or near live conductors—is indicative of the familiarity which breeds contempt of danger. It is clear from the reports that, in most of the cases where the 19 skilled persons met with accident, the work need not have been done while the conductors were alive. The fatal accident again shows the danger even with low pressures. It occurred to an electrician when running wires for a temporary light in an unfinished building for the use of some workmen. He omitted to tape up a joint before turning on the current, and subsequently took hold of it and was killed by shock to earth at 200 volts. He probably held the popular but erroneous idea that with such a low pressure there is no danger.

In one case a youth was killed whilst trimming an arc lamp. He had lowered the lamp to within a few feet of the ground, having previously turned it out by the double-pole switch. He was standing on wet ground. The switch was of a faulty type, and although the lamp was extinguished, the circuit was broken on one pole only, one blade of the switch remaining just in contact on the other pole. The lamp was therefore alive at 200 volts above earth, the system being three-phase, 350 volts per phase. He vainly struggled to release his hold of the lamp until the switch was turned off by someone else, when he fell to the ground. Artificial respiration failed to save his life. It is an elementary requirement of most codes of wiring rules that a switch shall be incapable of remaining in partial contact. This switch, like many others in use elsewhere, had no spring or other provision to prevent it remaining in partial contact, and hence the fatality.

In addition to my ordinary inspections, I visited during the year, at the request of His Majesty's Inspectors of Mines, several sub-stations on mines and quarry premises where the supply is taken from the mains of electrical power companies.

In my previous reports I have described a number of the various dangerous conditions of electrical plant which I have come across during the year. I have again a similar selection to bring to your notice. They present different varieties of the same dangers which I have described before. Whilst in some cases they are excused on account of being merely the survival of old installations, perhaps considered good at the date of their erection, in others, the plant being of quite recent date, there can be no excuse on the score of antiquity, and there would appear to be none on any other grounds than those of thoughtlessness or neglect. Perhaps the most striking example is one which I found in an important generating station for public supply in regard to a switchboard for three-phase working at 6,000 volts pressure, which had recently been erected and put to work. This switchboard was apparently satisfactory so far as the working platform was concerned, but the various passage-ways in connection with it were a series of death-traps. One long passage had on one side rubber-covered cables at 6,000 volts without any protection by metallic sheathing or casing, and on the other, exposed live terminals at the same pressure at frequent intervals. The floor of the passage was of iron, and 2 ft. 4 in. wide. The 'bus-bar galleries were even less inviting. In one of these there was on one side of the passage-way sheet metal for protecting glass water resistances, used in connection with the spark-gaps. On the other side, at about 1 ft., 2 ft. and 3 ft. from the floor respectively, were the three bare and unprotected 'bus bars at 6,000 volts. The floor of this passage-way was of iron, and the clear width was about 18 in.! In another the passage-way was a little wider on account of the absence of spark-gap resistances, and the edge of the iron flooring was fenced with an iron railing; there was, therefore, a passage-way about 2 ft. wide, with the bare 6,000 volt 'bus bars on one side and the iron railing on the other. One would naturally suppose that such passages were never intended for use when the 'bus bars should be alive, but such restriction did not appear to have been contemplated, as half-way along the gallery the 'bus-bars were divided by means of plug switches, with the idea that the two halves of the board might be run together or from independent generators. No means of access was, however, provided for getting to these plug switches other than along the passage-way described. Even assuming that the attendant should safely reach the plug switches there was no room for him to work them, the iron railing being less than 2 ft. away. These plug switches were heavy, and would necessarily have to work stiffly in the contacts in order to make a good connection, and would, therefore, require a strong effort to work them. There was exposed live metal within 3 in. or 4 in. of the handles, and the 'bus bars were, of course, close to, the combined arrangement being such as to offer a great and totally unwarrantable risk in operation. The safeguards, usually present in switchboards for extra-high pressure systems of this kind for preventing danger of accidental contact with live metal, were conspicuous by their absence, whilst the narrowness of the passage-ways and the provision of earthed metal to stand on provided all that could be wanting to contribute a maximum degree of danger. Other new switchboards in connection with the same undertaking exhibited a like disregard for safety. Thus, a single-phase 2,000-volt switchboard had a long passage at the back, 2 ft. 10 in. wide, with iron floor. On one side bare terminals and 'bus bars were exposed at intervals all along. An undesirable feature, not infrequently met with, was also present here—namely, apparatus requiring occasional handling fixed on the wall of the other side of the passage-way. In this case some of it was arranged in a particularly dangerous manner. Some high-pressure switch fuses for instrument transformers were fixed on the back wall at 6 ft. from the iron floor. In order to handle them a man would have to stand with his back towards the live terminals of the main portion of the switchboard, one of which was so placed that he would almost certainly touch it with the back of his head when handling the switch fuses. It is difficult to account for the apparent reckless want of thought in cases such as this, where the danger is so obvious and of such serious kind—*i.e.*, sudden death to the unwary attendant, particularly in view of the importance of the undertaking and the high standing of the makers of the apparatus.

The risk of personal accident is closely associated with that of breakdown of the supply, and it is often a matter of surprise that it is not more carefully guarded against as a pure matter of business. Want of foresight is frequently apparent in the arrangement of switchboards; thus, again, at the new generating station of an electrical power supply company, furnishing electrical energy for working tramways and for power purposes in collieries and for general supply in several townships, a class of supply which must necessarily be maintained night and day, the main high-pressure switchboard was so designed that it could not be made dead for adjustment or repairs in sections; consequently in order to carry out any work upon it in safety, the whole supply would have to

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be shut down. In practice it would probably not be shut down, and any repairs or other work would be carried out at considerable risk to the workers—a risk which could have been entirely obviated by a proper design of switchboard in the first instance.

I noticed various other points of greater or less importance which had been overlooked in new stations. For example, in a generating station of a local authority for providing continuous current at 440 volts, the switchboard was placed so that it might have had plenty of clear space behind, but the advantage was entirely lost on account of rods and cables being fixed across so as to completely block the passage way. In another case of new work in a large station a glass-tiled floor had been laid behind the switchboard. The glass floor was only 20 in. wide, and at the sides the iron framework projected an inch above the glass, thereby nullifying to a great extent the safety, as regards insulation, provided by the glass. A person doing any work behind the board would be likely to have his foot against or upon the metal frame. The projecting edge of metal was no doubt provided to prevent him from slipping over the edge of the tiles, but this object could be easily attained with glass if the outer row of tiles were specially shaped for the purpose.

In sub-stations, both new and old, I found many examples where safety had been insufficiently provided for, and some where the means intended to procure safety added considerably to the dangers. In some colliery sub-stations, where it was important that the supply should be available continuously, the high-pressure switchboards were arranged so that it would be impossible, without great danger, to carry out any repair or adjustment unless by completely shutting down the supply. In two others I found that the consumers' medium-pressure switchboards were within the sub-stations, regardless of the Board of Trade regulation that the sub-stations should be in the sole occupation of the supply authority. These sub-stations were supplied at 10,000 volts pressure three phase. The 10,000-volt conductors were of bare copper. The transformers and high-pressure switch gear were on one side of the room and the consumers' switchboard on the other, with only a few feet space between. The arrangement of exposed high-tension conductors was dangerous in any case, and particularly so in view of the consumers' employés having access. I made strong representations as to the dangers and as to the breach of the Board of Trade regulations, and it was agreed that the power company's men should alone have access until suitable screens had been erected to entirely shut off all the high-pressure side of the room. The consumer, however, employed an electrical engineer who, perhaps, did not agree with my view of the danger, at any rate, as applying to himself, and contrary to the instructions of his employers, he, a few days later, went into one of the sub-stations and walked against a 10,000-volt conductor. That he was not killed was due to the fact that the current did not pass through a vital part of his body, but he was very severely burned about the legs. Subsequent inquiries showed that this man had been previously employed in a high-tension generating station, and should therefore have been fully aware of the dangers. This fact merely emphasises the necessity of proper protection being provided equally whether skilled or unskilled persons have access. I found other cases of extra high pressure sub-stations on consumers' premises, where the consumer had access to the extra high-pressure apparatus without the sanction of the Board of Trade, but where the protection being good there could be little objection, a competent staff being also employed, who might reasonably be supposed to be as capable of looking after the sub-stations as any employés of the power company.

In some less recent transforming sub-stations I found a form of protection provided for the high-pressure switch gear which distinctly added to the danger. The switches and 'bus bars were of bare metal exposed, but the whole switchboard was surrounded by an iron cage with a door. When any switching or replacing of fuses became necessary the attendant would therefore have to go into the cage, which was so confined that he would inevitably be in contact with its iron bars, thereby being in contact with earth, and would, besides, have insufficient room to work in. In some other underground chambers, far too small, I found some survivals of a bygone age in the form of protection of the high-pressure terminals of the cables by metal covers or bells. The terminals were bare, and, in order to get at them for any purpose, the bell, which was heavy, had to be lifted vertically with a very steady hand, or it would touch the terminals. An earth wire was attached to the bell, but in one case this wire proved to be very much alive!

On factory premises I found the usual examples of exposed switches, terminals, &c,, in dangerous positions; that is to say, in places where a person who might accidentally touch the live metal would be in connection with earth, either by standing on damp ground or iron floor-plates or otherwise, and would consequently obtain a severe shock. One particularly dangerous type of switch appears to be a universal favourite. It has two or more blades, hinged at one end, and held together at the other by a bar of insulating material, on the other side of which is the handle. The insulating bar is attached to the switch blades by studs or screws having heads or nuts on the handle side, and generally close to the handle. In the better makes of these switches these nuts or studs are covered by insulating caps, or are sunk in the bar and covered over with insulating material, but usually they project above the bar in such a way as to be naturally in contact with the hand of a person grasping the handle. The connections of the switch are variously arranged. In some the blades of the switches are only alive when the switches are in the "on" position, in others the connection is through the hinged ends and the blades are always alive. The studs are therefore always alive when the switch is "on," and in some cases also when it is "off." The danger is obvious. When the studs are close to the handle, as is frequently the case, a person may touch both studs with his hand when working the switch. The switches are often used as motor switches with 440 or 500 volts across the studs, with the result that the operator is likely to get severely burned. When, as is often the case, such a switch is fixed over a damp floor or over iron floor plating, there is the additional danger of a serious shock to earth. In a previous report I described a fatal case of shock due to such a cause. The current was alternating, 250 volts. The victim was going to stop a motor. He touched one of the studs with his little finger in grasping the handle of the switch, and, although the latter was of insulating material, he could not release his hold or pull the switch "off" and was killed. I refer to this accident again, as the particular type of switch is being constantly supplied. I found them in new installations in factories, on cranes in docks, in electrical stations, &c., in dangerous positions. I also found them in use as high-pressure switches in sub-stations, 2,000 volts across the studs, and placed in dangerous situations where the person using them would be in contact with an earthed transformer case. A more dangerous trap could hardly be devised.

Questions as to guarding overhead transmission wires occurred in connection with a large private installation. The supply was by a three-phase system at 3,300 volts. The wires ran alongside and over roadways and footpaths and places where people were working. Some system of protection against falling wires seems necessary at such points, but none had been provided.

All the fatal accidents reported as having occurred on factory premises were due to shock from alternating current, at various pressures down to 200 volts, no less than four occurring at the latter pressure. It is customary when fatalities occur at such low pressures for people to say that the victims must have had weak hearts. This view, however, is seldom confirmed, the post-mortem examination often proving the contrary. The danger with low pressures depends upon the path of the current through the body and the kind of contact. People who are responsible for electrical installations do not sufficiently realise the hidden dangers of low-pressure currents, and hence the weak-heart theory is brought out at every inquest, but until recently I had never heard of it being seriously put forward to account for a fatality where the pressure exceeded 5,000 volts.

The following is a list of electrical fatalities occurring during the year, including those not reportable under the Factory Act, so far as I have been able to ascertain them:—

III.—Electrical Fatalities in 1906.—*Reported under the Factory Act.*

Date.	Place.	Voltage of system.	Probable voltage of shock.	System.
April ..	Wednesbury	350	200	Alt. three-phase
May	Belvedere	8,000	8,000	Alt. single-phase
June ..	Blaina	440	250	Alt. three-phase
July	Wednesbury	5,000	3,000	Alt. three-phase
July	Leeds	280	200	Alt. two-phase
Sept. ..	Brimsdown	11,000	6,500	Alt. three-phase
Sept. ..	Derby	200	200	Alt. single-phase
Nov.....	Ramsbottom	400	230	Alt. three-phase
Dec.....	Scotstoun	350	200	Alt. three-phase
Dec.....	Burnbank	11,000	6,500	Alt. three-phase
On Mains of Electrical Supply Undertakings.—(*Reportable to Board of Trade.*)				
July	Near Glasgow	10,000	..	Three-phase
Mining.—(*Reportable to H.M. Inspectors of Mines. Probably incomplete.*)				
January.	Lower Duffryn Colliery ..	3,300	..	Alt. three-phase
January	Cadeby Colliery	500	..	(?)
May	Emily Mine	..	..	(?)
July	Cwmneol Colliery	3,000	..	Alt. three-phase
July	Cwmneol Colliery	3,000	..	Alt. three-phase
August .	Dean & Chapter Colliery .	500	..	(?)
Railways and Tramways.—(*Reportable to Board of Trade.*)				
March ..	London—Notting Hill Gate (Central London Rly.)	5,000	..	Alternating
March ..	Heywood	500	..	Contiuuous
July	East Ham—Metropolitan Dist. Rly.	600	..	Continuous
August	Byker—North-Eastern Rly.	600	..	Continuous
Sept. ..	London—Mansion House Station, Dist. Rly.	600	..	Continuous
Sept. ..	Darlington	500	..	Continuous
Miscellaneous.—On Private Consumers' Premises.—(*Reportable to Board of Trade*).				
..	....	..	..	..

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With the number of THE ELECTRICIAN for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with THE ELECTRICIAN. The twelfth monthly issue of the Supplement will be published (Gratis) with THE ELECTRICIAN for July 26th.

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ACCIDENTS IN FACTORIES DURING 1906.

The Annual Report of Mr. G. S. RAM, which we give almost in full elsewhere, does not show any striking developments, but rather a lack of progress. Naturally, accidents have been somewhat more numerous during the past year owing to the more extended use of electrical power, the advantages of which are rapidly being recognised by most manufacturers. A certain number of accidents, due to carelessness and defects through wear and tear, are always likely to occur. Defective apparatus of a minor kind are certain to be used, the more so when the cutting of prices is carried to an excessive degree. Apparatus of a cheap, and often of a faulty, design, because it is cheaper to manufacture, is certain to be placed on the market, and will be used by those who regard prime cost as the essential factor and who look upon technical qualities as a matter of indifference, because they are more or less ignorant of the principles involved. Consequently accidents due to defective apparatus of a minor kind must be expected.

It is discouraging, however, to find that important new work is still apt to be carried out in such a way as to be a permanent source of danger to attendants and to be a discredit to the manufacturer. Mr. RAM describes, as he has on previous occasions, the death traps which he occasionally

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discovers. They generally consist of high-tension switchboards, in which so little room is left for manipulation that it is surprising how switchboard attendants can escape fatal shocks in manipulating certain parts of the mechanism. It is generally at the back of the board that insufficient space is left, where conductors are crowded together regardless of consequences. Of course, it sometimes happens that space is necessarily rather restricted, and the owner may be quite unaware as to what is really desirable; but in such cases, if he does not employ a responsible engineer to look after his interests, it behoves the manufacturer to see that proper provision is made for safe working.

The other point which arises from Mr. RAM'S report is important as affecting the safety of the general public. Every year a certain number of fatal accidents occur through defective apparatus on low-tension circuits, such as lamp standards which have become alive through a fault, and have caused a shock sufficiently severe to be fatal to a person standing on wet ground, or on ground of such a kind as to make a good earth. The acceptance of the lowest tender may have something to do with accidents of this kind, but it is well to remember that faults are liable to occur in due time in all apparatus through wear and tear, and for this reason special attention should be paid to any fittings which may become a source of danger. As Mr. RAM remarks, the fatal results of such accidents are apt to be attributed to a weak heart. This theory, however, is really quite insufficient to account for such occurrences, and it is time that engineers recognised clearly that precautions should be taken such as will render accidents of this kind almost impossible.

Having regard to the increasing use of gas as a motive power for driving generating plant, the paragraph in the report of the Medical Inspector dealing with carbonic oxide poisoning will be of interest to electrical engineers. During the past year 55 persons are reported as having suffered from poisoning of this kind, including four fatal cases. Twenty of these cases resulted from producer, Mond, or suction gas, and the causes mentioned are improper situation of gas plant, defective fittings, starting suction gas plant by the fan with the chimney valve closed, cleaning out scrubbers, &c., and defective gasometers.

At times much has been made of the possibilities of electric power as a factor for improving the lot of the worker by enabling him to carry on his occupation in a more extended area, or very possibly in his own home. Judging from the report of Mr. C. JOHNSTON upon the cutlery industry at Solingen, this happy state of affairs seems to be realised to a large extent in that district. The town has a population of 50,000, and the surrounding land a population of 120,000. There are 415 factories of the usual kind, but in addition there are a very large number of "home workers," by which term is meant workmen who own their houses, generally with a garden attached, and at the back of this a small factory. There are no fewer than 1,475 factories of this kind in the district, and in them the greater part of the grinding and glazing of razors, scissors and pocket knives is carried on, the finishing processes being effected in the larger factories. The necessary machinery is driven by electric power, without the aid of which such decentralisation would, no doubt, be difficult.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Modern American Machine Tools. By C. H. BENJAMIN, Professor of Mechanical Engineering, Case School of Applied Science, Cleveland, Ohio. (London: Archibald Constable & Co.) Pp. 320. 18s. net.

The object of this treatise is to show to the buyer and user the prominent characteristics of modern machine tools as now manufactured in the United States, the various points in which they differ and some recent data as to their performance. Details of design, construction, adjustments, &c., are not described further than is necessary for showing the prominent characteristic of each machine.

The types of machines referred to include only machines which would be found in a general machine shop, special machinery for special manufactures being excluded. Chapter I. deals with planing machines; cutting speed and horse-power are given for a number of machines. Electric driving is briefly discussed. Crank-planers (the word meaning a planing machine in which the motion of the table is derived from a crank), shapers and slotters are described in Chapter II. A few heavy milling machines are here discussed, on account of the close resemblance to the planer in frame, adjustment and feed.

Chapter III., on engine lathes, contains much useful information as to cutting speeds and endurance with different air-hardening tool steels. The horse-power required for driving lathes is discussed, data from numerous tests being given.

The succeeding chapters deal with turret lathes and other special lathes, boring mills (vertical and horizontal), drilling machines, gear-cutting, grinding machinery, punching and shearing machinery, screw-cutting machinery. The last chapter is on "Tendencies in Modern Machine Design," electric driving, abandonment of belts in favour of gears or silent chains, use of high-speed steels, increase of number of cutting tools and other tendencies being referred to. The author gives a reminder that the use of the new tool steels means a redesigning of the entire tool to secure the increased power, speed and strength which are necessary.

The book is not intended to be a treatise on the design of machine tools, and within the limits stated by the author it forms an ideal volume. Our only grumble is directed to the publisher's portion of the work. The book is printed in large type and on thick, smooth paper, the photo reproductions of the various machines probably necessitating the latter. The illustrations are most excellent. These two conditions probably determine the somewhat high price of the book, but this high price will have the effect of restricting the number of purchasers. At a lower price, which, we trust, a second edition may render possible, the book should be in the hands of all designers, draughtsmen and foremen interested in machine tools. After all, the buyer and user of modern machine tools relies on the advice of his technical staff, and the more widely diffused throughout the staff is information regarding recent practice, the more judicious will be his investments in new machinery.

La Telegraphie Sans Fil et la Télémécanique. By E. MONIER. Preface by Dr. E. BRANLY. (Paris: H. Dunod & E. Pinat, 1906.) 2 fr.

In his preface Dr. Branly rightly says that in a book such as this, intended for the general reader, it is unwise to load the subject with abstract scientific facts. The author has certainly avoided this error, and the result is an eminently readable, and, in most respects, correct exposition of the principles and practice of spark telegraphy. It cannot be said, however, that it is up to date, as its descriptions are limited to an untuned system. Syntonisation and directive methods are dismissed in a page or two without any indication of their importance in modern practice or theory, and no mention is made of the many types of detector which have to a large extent taken the place of the coherer.

One or two historical statements are not quite in accordance with fact. Mr. Marconi did *not* use a dozen Leyden jars in communicating between Dover and Boulogne, as stated on p. 65. Other slips of a like nature occur, though on the whole the author is well informed. The last chapter is devoted to a description of a mechanical arrangement invented by Dr.

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Branly, by means of which a receiver may be made to perform automatically several distinct functions, according as one or other of a variety of properly-timed groups of sparks is transmitted. A résumé is included of a lecture given by Dr. Branly in 1905, at which an example of this apparatus was shown which fired a revolver, started a fan, switched on a lamp, or energized an electro-magnetic at the will of the operator in the distant station.

Die Turbinen fur Wasserkraftbetrieb. With Atlas. By A. Prabr. (Berlin: Julius Springer.) 36m.

Those whose special branch of engineering is turbine design and installation will find in this book an exhaustive treatise on the subject. It is hardly a book for students who merely wish to acquaint themselves with the general principles of turbine design, as will be understood from the mere statement of the fact that there are 821 pages of text illustrated with 496 figures, and in addition a separate atlas containing 46 beautifully executed plates which amount to working drawings of a detailed character. The text is divided into 28 chapters, and after the necessary statement and elucidation of the general properties of flowing water, the pressure on fixed and moving vanes and in pipes, &c., the author proceeds to classify the different types of turbine, after which the work done by water flowing through a turbine is discussed. Chapters follow on the methods of design, on regulation, the general arrangement of the water supply; in fact, every question which is connected with a water turbine installation is touched upon and receives thorough treatment. The atlas contains drawings of single, double, treble and quadruple Francis turbines, besides turbines of other well-known types, with complete details of the regulating apparatus and the constructional work connected with the turbine. The atlas itself forms a valuable collection of working drawings which can be understood by an engineer without the necessity of reading the text.

A PRACTICAL LIMITATION OF RESISTANCE FURNACES: THE "PINCH" PHENOMENON.*

BY CARL HERING.

The object of the present Paper is to describe a limiting condition sometimes encountered in practice with resistance electric furnaces, which appears not to have been known and was very unexpected, and which may at times be serious and perhaps quite insurmountable. It applies to that type of resistance furnace in which the material to be treated forms the resister, in the form of a column of liquid in a trough, as distinguished from that type in which the resister is a foreign body like graphite of platinum, which is surrounded or enclosed by the materials to be treated. Of these two classes of furnaces, the latter is by far the simpler in theory, in practice and in operation. Innumerable difficulties encountered in the former are overcome in the latter, and it is probably a good rule to use the latter whenever possible in preference to the former.

As the reason for using an electrical furnace instead of a combustion furnace is generally the high temperature it produces, the conditions encountered in practice which limit the temperature may become very important. In the present Paper the term limitation will, therefore, be used to refer to those conditions which limit the temperature.

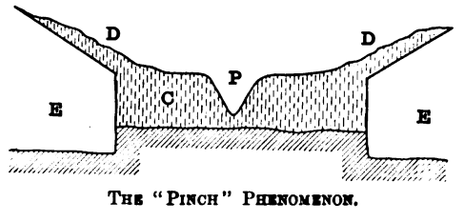
It is well known that if a wire be connected between the two poles of a source it will be heated to a certain temperature. Now if it be made shorter and shorter, and at the same time smaller and smaller in cross-section, so as to have the same resistance, it will become hotter and hotter, although the current and voltage, and therefore the watts, are the same. In other words, the watts per cubic inch are thereby increased. It might, therefore, be argued that by simply increasing the watts per cubic inch in a furnace any desired high temperature may be reached up to that of volatilisation, which means the destruction of the resister.

This, however, is not the case. A limit may be reached which is far below this temperature, due to a curious and surprising phenomenon which the writer has observed and which he has termed the "pinch phenomenon." This limit may at times be a very serious one, as it is sure to exist, and may sometimes limit the temperature to such a low value as to entirely defeat the object of the furnace. This phenomenon has, apparently, never been mentioned or described in the leading treatises, and therefore does not seem to be generally known, and as it may at times be a very serious limitation to the possible temperature in some electric furnaces of this class, it was thought that a description of it and its effect on their operation may be of interest to furnace designers. Theoretically, this curious phenomenon is also of considerable interest. Dr. E. F. Northrup, of Philadelphia, to whom the author described this phenomenon some months ago, took a great interest in it, and made a very thorough and able study of it, both from the mathematical and physical, as also from the experimental standpoint, including also the quantitative relations. His very interesting Paper was read before the American Physical Society on March 2nd.

The phenomenon is as follows: When the current density in a liquid conductor in an open channel is increased sufficiently, the conductor will be found to contract in cross-section with considerable force, especially at a place where there is some slight obstruction in the channel, or where, for any other reason, the cross-section is less than the average. This contraction resembles the depression in plastic material that has been pinched between the fingers; as the column of liquid looks as though it were being pinched by some mysterious and invisible force, the writer termed it the "pinch phenomenon," for want of a better name.

In the adjoining figure, EE are the cold electrodes of such a furnace; C is the column of liquid conductor which acts as the resistance, and P is one of these pinched contractions. The liquid on both sides of the contraction slopes like the letter V, with inclinations of 45 deg. and over. The liquid will stay in this position, thus forming a stable state. The inclined surfaces of the liquid, though smooth, showed signs of great internal agitation, as though the liquid was continually running downhill, but was being as rapidly forced uphill again. It was a somewhat curious and interesting sight to see the surface of a liquid sloping at a steep angle and yet be in a stable state. The first impression was that a large leak had suddenly formed, and that the molten metal was rapidly flowing down and out through it; but it was soon found that the condition was a stable one.

When, under these conditions, the current density is still further increased, this V-shaped depression becomes deeper and deeper until it finally reaches the bottom of the channel; this, of course,



The "Pinch" Phenomenon.

breaks the circuit and the liquids then immediately flow together, only to be instantly parted again, thus forming a violent automatic interrupter of the current, accompanied by a spluttering of the metal, loud crackling sounds, and, incidentally, to the great disgust of the man who is running the furnace, as it means that the limit has been exceeded, and if the circuit is not opened at once at the switch, to allow the parted liquids to flow together again to their normal level, there is a strong likelihood that the reduction of the current will cause the core to freeze in this parted condition, which gives rise to serious difficulties in mending the break so that it will carry current again.

If there is any dirt, infusible material, or pasty, poorly conducting slag floating on the surface of the liquid, it will naturally fall into this cavity, and as the conductor in the narrow neck is apt to volatilise, owing to the high current density, while the rest of it is apt to freeze, owing to the reduction of the current, the result is that a complete break is apt to form, through which it may be very difficult and sometimes impossible to start the current again, thus requiring a dismantling and reconstruction of the furnace. It is obvious that this phenomenon places a limit to the current, which can be passed through a liquid resistance of given cross-section, thereby limiting the temperature which can be obtained. This limit may be far below that desired, thus completely defeating the purpose of the furnace. It, therefore, is an important factor to be taken into consideration by the designers of this class of furnace. What the limit of temperature will be will depend, of course, on the particular circumstances; it is evidently not possible to give any fixed rule. It may, perhaps, be subject to calculation, but this is doubtful, as this local pinching seems to be originally induced by some obstacle or contraction in the channel, which, being generally accidental, is not within the reach of mathematics.

It is certain, however, that this tendency to pinching and consequent parting exists and must be guarded against. If, for instance, a portion of the channel is made smaller than the rest for the purpose of increasing the temperature locally, great danger exists that this phenomenon will defeat that purpose, and it should first be determined by experiment whether it will take place before dependence is placed on the operation of such a design. Under

* A Paper read before the American Electrochemical Society. Slightly abbreviated.

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some conditions this temperature limit will be quite low; with mercury, for instance, this pinch phenomenon will take place under favourable conditions before the temperature has risen appreciably.

One of the experiments made by Dr. Northrup, at the writer's suggestion, has shown that if the channel is quite uniform, the contraction in cross-section will also be uniform over its whole length —that is, the level of the liquid will lower uniformly, and therefore the danger of parting will not be so great. This explains the observation made by the writer that in a furnace of this type the liquid conductor kept creeping up on top of the cold electrodes, as at DD in the illustration, piling itself up in large quantities, and solidifying after it got there. Fresh material had to be added for some time to keep up the level, until the stable conditions were finally reached. This stable condition is different for each current.

The question naturally arises, how can this pinch phenomenon be avoided? As the forces which cause it—namely, radial pressures toward the central axis—are bound to exist, the only way seems to be to render them as harmless as possible instead of trying to resist them. To do this, the channel should be made as perfectly uniform as possible and kept free from obstructions. A very liquid flux should be used, if possible, to dissolve any solid foreign particles and to float or wash them away. The cold electrodes should have vertical faces where they are in contact with the liquid resistance, so as to obstruct as much as possible the piling up of the liquid conductor at those places. When the current is stopped the level of the liquid will become horizontal again, and will therefore rise, hence an additional range of regulation must be provided for starting up again with an enlarged cross-section. But even with all these precautions an increase of current density will lower the level until at some weak point a rupture will be likely to take place.

Another precaution is to make the channel as deep as possible, and, therefore, narrow in width. The writer noticed, and Dr. Northrup has since confirmed it by experiment, that the force which causes this pinching does not act to produce an unstable equilibrium; the contracting force reaches a stable state when it is balanced by the hydrostatic pressure of the liquid. Hence, by making the channel deep, the tendency to a complete break is reduced. This, however, necessitates making the channel narrow, thereby increasing greatly the tendency to develop a weak spot due to some obstruction or contraction. It also greatly increases the loss of heat through the walls of the furnace. Hence, both depth and width should be made large, which means short channels, low voltages, enormous currents, or else a large capacity of the furnace. In other words, the danger from this source is greatly increased as the furnace becomes smaller in capacity. Some idea of the strength of this contracting force may be had from a case in the writer's experience, in which the V-shaped depression extended down as much as 6 in. through molten iron to the bottom of the channel, causing a complete rupture, followed by freezing, which necessitated the dismantling of the furnace.

Another good rule is, do not use liquid resistances if the conditions permit using a solid one, which heats the materials by contact. There are other reasons, also, for this conclusion.

Those interested in this phenomenon from a physical standpoint are referred to Dr. Northrup's Paper, mentioned above. He therein demonstrates, mathematically, the correctness of the writer's first assertion—namely, that the contracting force was due to the encircling lines of force, and that its effect was, in some, though not in all, respects like that of stretched elastic bands, tending to compress the conductor radially toward the centre. He furthermore found that this compression produced a pressure at the centre, causing the material there to be forced out at both ends along the central axis, somewhat like when a rubber tube, filled with liquid, is squeezed or pinched with the hand, which will tend to force the liquid out at both ends. With a vertical column of mercury, he has succeeded in thus producing a small fountain of mercury issuing from the centre of a large conductor, and by letting this mercury flow back near the outside of the conductor, the fountain plays continuously; thus he produced continuous motion by merely passing a current through one conductor, without magnets, commutators, brushes, bearings, &c., presumably the first time such motion was ever produced. As was originally observed by the writer, the phenomenon is independent of the direction of the current, hence takes place with either direct or alternating currents.

The action might be explained, as Dr. Northrup suggested, according to the principle that currents flowing in a like direction attract each other. Hence, all the linear current elements in a conductor should be attracted to its centre, causing a contraction This does not, however, explain why these current elements should drag the material of the conductor with them; why does not the current simply become denser at the centre? An electrical current passing across a running stream does not seem to be carried down with the stream as though it were inseparable from the water; but it always seems to take the shorter path across it; then why should the electric current, when in motion, drag the conductor with it as though it were inseparable from it? Yet it does do so in some cases, as in a unipolar disc motor, and one is therefore led to conclude that this matter has not yet been clearly explained by physicists.

The writer's belief is that his original suggested explanation is more satisfactory—namely, that this pinch phenomenon is due to some action of the ever-present encircling magnetic lines of force, which are all under tension like stretched rubber bands, and therefore exert a radial pressure on the material which carries the current. Dr. Northrup's mathematical investigations confirm this suggested explanation, in so far that he has shown that the contracted conductor has many more lines of force encircling it on the outside than the original had when both carry the same current; he shows that many additional lines of force are created by this contraction, and their radial pressures, due to their tension, have, therefore, been added to that of the others which were there before; this would explain the increased pressure on the contracted conductor.

Although this phenomenon is a serious obstacle in electric furnaces having liquid resisters, it at once suggested to Dr. Northrup an application to simple forms of measuring instruments like those of the indicating and integrating types, that measure direct and alternating currents equally well, and it may raise in the mind of the inventor new visions of the possibilities of the long-looked for commutatorless direct-current dynamo and motor, or self-starting single-phase, alternating-current motor.

An analysis of this phenomenon leads to many interesting deductions, which, however, are not in place in a paper on furnaces. One of these is that Ohm's law may perhaps not be strictly true for high-current densities. Another is that the action of fuses and of the Caldwell interrupter may be due, in part at least, to this phenomenon. Perhaps the action of the speaking arc is due to this phenomenon, as was suggested by Dr. Northrup.

This phenomenon should be clearly distinguished from the well-known and entirely different one, according to which a flexible circuit tends to enclose the largest possible area, and, therefore, tries to enlarge itself into a circle. The latter has been observed in induction furnaces, in which, it seems, the molten iron in the circular trough sometimes acts as though it were under the influence of a strong centrifugal force, and to such an extent that the bottom of the trough can be seen.

AN UNDERGROUND CLOSED CIRCUIT FOR RECEIVING WIRELESS SIGNALS.*

BY G. W. PICKARD.

In the reception of wireless signals, it has been quite generally supposed that some form of antenna, or elevated wire, and a ground connection or its electrical equivalent are necessary. It is true that in certain systems a so-called "balancing" or "counterpoise" capacity is used in lieu of a direct ground, but consideration will show that as these capacities are in the vicinity of the earth's surface, the effect is simply that of a condenser, inserted in an earth connection.

The writer, from a consideration of the structure of an earth-attached electrical wave, has been led to try other methods of receiving, among these being a simple closed circuit, including a condenser for tuning purposes. To clearly illustrate the theory of its action, Fig. 1 shows a section of a portion of a wave train, made in the vertical plane including the source, or distant transmitting station. In this section, which includes only the lower portion of the waves, which in the immediate neighbourhood of the earth's surface is normal thereto, is shown in full line, while the magnetic component, 90 deg., or a quarter wave-length behind the electric component, is shown as a series of dots, which are in reality the cross-sections of the magnetic lines, which run parallel with the earth's surface, and formed closed circles around the transmitting station or source. The intensity of either component at any point is indicated roughly by the heaviness of line or dot.

As such a wave train passes an antenna of the conventional type, certain of the lines composing the electric component terminate momentarily on the antenna, and thereby raise or lower its potential with respect to earth. As the series of waves pass, a series of such potential changes in the antenna take place, resulting in a series of up-and-down surges of current between the antenna and its ground connection. At the same time, the antenna is cut by the magnetic lines in the waves, and an E.M.F. is set up between its upper and lower terminals, co-operating with the electrically-induced surge. But as this E.M.F. exists only between the upper and lower terminals of the antenna itself, and not between the antenna and earth, it probably contributes little to the total effect in the detector circuit.

To use the magnetic component, it would be necessary to utilise the E.M.F. set up in a conductor cut by the magnetic lines. By

* From the *Electrical Review*, N.Y. Slightly abbreviated.

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the use of a closed circuit, so placed as to include a maximum number of the lines in a section of the passing waves, and properly tuned, or made resonant to the frequency of the distant station, a highly efficient receiving circuit results, the amount of received energy being directly proportional to the enclosed area of the circuit. It is hardly necessary to dilate upon the advantages of such a circuit over the conventional antenna, as it is apparent that a long, low rectangle may be made of very considerable area, without the use of high masts. In fact the only limitation is that the length shall not exceed a quarter wave length, as with a length in excess of this the circuit would include lines passing through in opposite directions, which would partially cancel the total effect.

In Fig. 2 is shown a rectangular closed circuit, constructed by the writer in his garden at Amesbury, Mass. The vertical plane of this rectangle is south-east by south, including the Marconi station at South Wellfleet, Mass., about 90 miles away. As shown in the sketch, the terminals of the rectangle are connected to a variable air condenser C, and in shunt with this is placed the thermo junc-

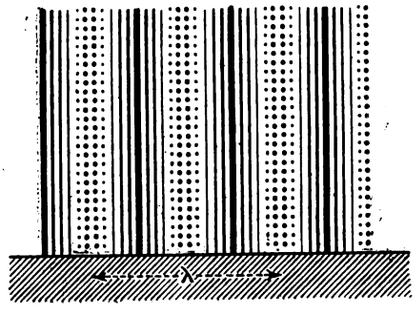

FIG. 1.—SECTION OF A PORTION OF A WAVE TRAIN MADE IN A VERTICAL PLANE, INCLUDING THE SOURCE OR DISTANT TRANSMITTING STATION.

tion detector, consisting of a brass point bearing upon a silicon surface.* The telephone receiver R is connected in shunt to a small fixed value condenser *c*, so that the telephone circuit through the detector is completed by the rectangle itself. This leaves the detector, as far as the received oscillations are concerned, without any capacity shunt, such as telephone leads, &c., and as this type of detector is of very high ohmic resistance, the circuit as a whole is left quite free to oscillate.

This rectangle received clear, distinct signals from Wellfleet, and, when the condenser was adjusted to give the maximum response in the telephone, the measured† intensity was found to be approximately 0·01 erg per dot. Considering the small dimensions of the rectangle, the strength of the received signals was rather surprising, particularly as the garden is surrounded by houses and trees, of many times the elevation of the rectangle itself.

To determine whether any portion of the received energy came from the electric component of the waves, a ground connection was made from various portions of the rectangle, at the sides, top and bottom. It was found that there was not the slightest observable

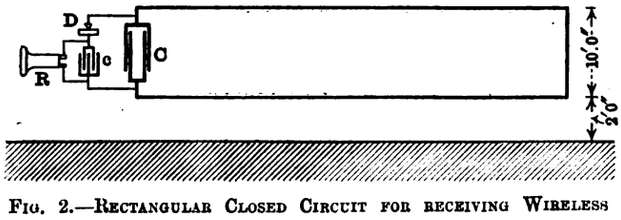

FIG. 2.—RECTANGULAR CLOSED CIRCUIT FOR RECEIVING WIRELESS TELEGRAPH SIGNALS.

effect upon either the tune of the circuit or the intensity of the signals, whatever the point grounded. It was further found immaterial whether the condenser and detector were placed at the end of the rectangle furthest from the transmitting station, the end nearest, or the middle of either the top or bottom horizontal wires.

Owing to the rectangular shape of the circuit its inductance could readily be computed, and was found to be 106 microhenries When in tune with the Wellfleet station the capacity of the condenser was 0·0090 mfd. These constants give a period of 163,000 cycles per second for the circuit, which is quite approximately that of the Wellfleet station, as determined by other and independent measurements.

In tuning the circuit to various stations, it was soon found that the best results were obtained by having only the inductance of the circuit wire itself included, and varying the condenser capacity. While very sharp tuning could be accomplished by a fixed value of condenser, and an inserted, variable inductance, the intensity of the response steadily decreased as the inductance increased, although the circuit was kept in perfect tune. This was true whether the detector was directly linked with the circuit by being placed in shunt to the condenser, or inductively linked through an oscillation transformer.

This circuit is not alone interesting as one solely utilising the magnetic component of the electromagnetic waves employed in wireless telegraphy, but it forms a practical receiving circuit, capable of operating, as the writer has determined by extensive tests, over the longest distances at present covered by wireless communication. As elevation is not essential, it is inexpensive to erect, and the fact that it is directive in its action—*i.e.*, will only receive efficiently from stations in its own plane, and not at all from stations at right angles thereto, is of distinct value in certain cases. Using a rectangle mounted in such manner as to rotate, it forms an excellent direction finder, as the null point, when the plane of the circuit is at right angles to the source of the waves, is very sharp.

* See "Silicon Detector and Measurement of Wave Energy," by Maver, *Scientific American* Supplement, May 25, 1906.

† See "Measurement of Received Energy at Wireless Stations," by G. W. Pickard, *Electrical Review*, N.Y., December 15, 1906.

PHYSICAL SOCIETY.

The last meeting of the session was held by the invitation of Prof. W. E. Ayrton, F.R.S., at the Central Technical College, on June 28th, and, in the absence of the President, the chair was taken by Prof. Ayrton.

Mr. J. T. IRWIN gave a demonstration of the uses of his

"Hot-Wire Oscillographs and Hot-Wire Wattmeters."

After giving an explanation of the principle of the hot-wire oscillograph, and pointing out how to obtain exact compensation for the heat capacity of the wires by means of electric capacity or self-induction, Mr. Irwin showed the following experiments with the oscillograph:—

1. The P.D. from a rotary converter (*a*) with the ripples due to sparking damped out by resistance in the condenser-circuit, (*b*) with the ripples shown at their proper size with critical damping, (*c*) with the ripples very much exaggerated owing to want of damping.

2. The pericdic discharge of a condenser through a self-induction (*a*) with a small resistance in circuit and therefore an oscillatory discharge, (*b*) with a large resistance in circuit and the oscillations damped out.

3. The P.D. across the stator of an induction motor and the current in the rotor below, above, and at synchronous speed, (*a*) as a two-phase machine, (*b*) as a single-phase machine.

4. The current through and the P.D. across the armature of a single-phase commutating compensated motor run up to and above synchronous speed, (*a*) with the auxiliary brushes short-circuited showing the current and P.D. in phase with each other at synchronous speed, (*b*) with the auxiliary brushes open-circuited showing the P.D. and current differing by nearly 90 deg. in phase.

5. A circle and a straight line produced by combining, by means of a beam of light, the vertical harmonic motion of a mirror with the simple harmonic motion of the oscillograph due to a sine wave of current, the circle being produced when the two movements were at 90 deg. difference in phase, and the straight line when the two movements were in phase.

6. A hysteresis loop for glass-hard steel wire, showing the rounding off of the tips at a frequency of 40 per second.

Mr. Irwin also showed a new type of synchronous motor which he has invented and which can be run easily at synchronous or half-synchronous speed. This motor consists essentially of a series motor with laminated fields and with two points on the commutator 180 electrical degrees apart shorted.

A hot-wire instrument to measure mean watts was also shown.

Mr. W. DUDDELL expressed his interest in the fact that Mr. Irwin had succeeded in designing an oscillograph depending for its action on thermal effects. Referring to the hysteresis loops shown by the Author, he said it was important to know the form of these loops in actual work. He was doubtful, however, whether the blunted points were due to hysteresis effects or whether they were due to instrumental defects.

Mr. A. RUSSELL congratulated the Author on his extremely novel and interesting instruments. Apart from the practical utility of the invention, which the experiments shown amply demonstrated, there were many points in connection with the working of the instrument which elucidated physical laws. For instance, in his Paper to the Institution of Electrical Engineers, Mr. Irwin gave figures from which it could be deduced that Newton's law of cooling was very approximately true for the wire strips of his instrument slowly cooling in air. The practical working of his oscillograph proved that Newton's law of cooling was also very approximately true even when the periodic time of the temperature fluctuation of the strips was only a very small fraction of a second—a physical result of considerable importance.

Mr. J. S. Dow described

"A Form of Photometer in which the Cosine Law is Utilised."

In this form it was unnecessary to move either the photometer or the sources of light. The adjustment of the illumination of the photometrical surfaces was carried out in the photometer itself by the

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rotation of a Ritchie wedge about the boundary line between the photometrical surfaces as axis. The ratio of the candle-powers of the two sources of light compared could then be read off on a suitably calibrated scale attached to the photometer.

This type of instrument is very convenient. Attention was drawn, however, to the possibility of "angle errors" and the means of avoiding them.

This instrument could be used on the equality of brightness principle, or, by utilising an oscillating lens, as a flicker photometer. The results of using these two photometrical methods were, in this case, in very good agreement. Yet this might not have been the case if a different portion of the retina had been utilised, especially at low illuminations.

An experiment was then shown illustrating the behaviour of the "rods" and "cones" as regards flicker. At strong illuminations, when the cones are predominant, the perception of form and colour is most acute when the central portion of the retina is utilised; but at low illuminations, when the rods are in action, visual acuteness is best when the outer region of the retina is used.

In the same way the perception of flicker was demonstrated to be only most acute over the portion of the retina removed from the centre of the eye when a weak illumination is employed. A distinction must be drawn between "rod-flicker" and "cone-flicker."

Some experiments were then shown illustrating the detail-revealing powers of red and green light. A green or blue surface loses in luminosity as the image of it fades more and more towards the centre of the retina. But apart from the question of luminosity, the red end of the spectrum gives the best definition in the case of distant vision and the blue end in the case of very close vision. This arises from the want of achromatism of the eye.

Two exactly similar patches of red and blue light were thrown upon a screen on which a black and white chessboard-pattern had been traced. The black and white squares were then seen to be more sharply defined when illuminated by the red light, in spite of the fact that the illumination due to the blue light was much the brighter of the two. The red end of the spectrum is therefore, in general, the most effectual portion for the illumination of clocks, shop-signs and objects which must be viewed from a distance.

Mr. PATTERSON complimented the author upon his Paper and experiments. With reference to the cosine instrument he asked if the cosine law was trustworthy at the very acute incidence of the light. The unequal sensitiveness of different parts of the retina accounted for the fact that it was possible to obtain different balance-points by fixing attention on the different sides of a Ritchie wedge.

Mr. J. S. DOW, in reply, said he had only worked with photometers with wedges of 90 deg., but he was certain that the cosine law would not hold at acute incidence on account of the large amount of regular reflection.

A Paper entitled

"Experiments on the Production of Sand Ripples on the Sea Shore"

was read by Mrs. AYRTON. The sand ripples, which formed so marked a feature of the sea-shore, although parallel to the line of the breakers, are not produced by their edges, but are formed entirely under water. It is difficult to imagine that the long, sweeping, to-and-fro motion of the sea that one watches from the beach can produce row after row of quite small ripples, such as are seen in certain places on the beach. Yet it is this long, steady, see-saw motion of the water that produces the ripple, as was first observed in 1882 by Mr. Arthur Hunt.

To show this, a glass trough 6 ft. long, in which there was level sand covered with a foot of water, was pushed to and fro on rollers by means of an electro-motor. This motion set the water oscillating, and soon small ridges were seen in the sand, at nearly equal distances from one another, growing larger and larger as the oscillation continued.

Twenty years ago Prof. George Darwin discovered that certain vortices that he observed in water oscillating over ripples helped to build the ripples higher, but he left the problem of the *birth* of the ripples practically untouched. He thought that each ripple was started solely by friction, but this suggestion is apparently negatived by the regularity of the ripples, even in their earliest stages. By deduction from the shape of certain sand vortices, it appears that every ridge or furrow in otherwise smooth sand must produce two other ridges, one on either side of the first, and that these two give rise to two other ripples, one on the right of the right-hand one and the other on the left of the left-hand one, and so on, till the whole becomes ripple marked. In other words, it wants but one *single* irregularity in otherwise smooth sand to cause the whole sand to become ripple marked under oscillating water. Experiments were shown to demonstrate this fact.

Next, to show that the vortices generated by the original ripple actually swept out the succeeding ones, an artificial barrier was put across the trough to increase the size of the vortices, a handful of moist black pepper was thrown in, and the water oscillated. Immediately large vortices were seen whirling first on one side of the barrier, and then on the other, hollowing out furrows in the sand, while the great brushes of water that flowed over the vortices swept up new furrows. In fact, the actual process by which the water started and built up the ripples was shown.

Mrs. Ayrton illustrated how the sand ripples on the sea-shore could be exactly imitated, even when the water ran in one direction alone, if only the sand were sloped, as it is on the sea-shore, so that the water ran up it, and, if by means of a paddle, a series of waves were sent along the water in the direction in which it was running—if, in fact, the motion of the incoming tide were imitated. But if the long, surging motion of the sea produces the sand ripples, why is not the whole of the sandy shore seen ripple-marked? The answer is that it is all ripple-marked when the tide is high, but the waves at the edge of the retreating tide wipe out the ripples except where there is a pool, so that the water is left over the ripples until after the sea has retired. Further, while the water is oscillating over the sand ripples which it has formed they never remain constant either in height, distance apart or position. Their heights and distances apart are greater the more violent the oscillation, the longer it has been going on, and the greater the periodic time of the wave and the shallower the water. The greatest depth at which ripple marks can be formed at the bottom of the sea depends on the violence of the motion of the water. At depths of 60 ft. or 70 ft. the sand is said to have been found ripple marked. If the depth of a vessel is large compared with its cross-section, a depth of water can be found beneath which no sand ripples can be formed. In the case of a pickle bottle, for example, this limiting depth of water over the sand is an inch or two.

During the whole of the demonstration the water in the 6 ft. trough was kept oscillating, and the sand was seen to heap itself up in the form of a large ripple-marked heap at about the middle of the trough, having a contour very unlike that of the sea-shore ripples. On sprinkling a very little sand in the water in a small trough, and rocking it to and fro, the sand was seen to quickly assemble in a straight line across its middle. Watching these grains carefully, it may be noticed that the result arises from every swing carrying each grain on one side of the centre nearer to the middle than the next swing carried it away again. And not only each separate grain of sand, but each ripple as a whole, when ripples have been formed, tends to move towards the middle of the trough. In the 6 ft. trough, and in a small trough, the water was kept oscillating so as to form a stationary wave twice the length of the trough, and the place where the heap of sand was formed was where the level of the water changed least, and its horizontal velocity was the greatest. In a trough 3 ft. long the water was oscillated by means of an electro-motor, so that the length of the wave was only two-thirds of the length of the trough, so that there were three places where the level changed least, and the horizontal velocity was a maximum, and at each of these three places the sand was seen to heap itself up.

Referring to the Goodwin Sands, which she had had an opportunity of observing, Mrs. Ayrton said she found it impossible to avoid recognising the resemblance between the hillocks and hollows of these sands and those made in her glass troughs, and it seemed, therefore, very possible that they were also produced by stationary waves. If so, then was it not possible, she asked, to imagine some means of altering the trend of the sea so as to keep it from forming the stationary waves which she believed heaped up the Goodwin Sands?

CORRESPONDENCE.

RADIO-TELEGRAPHIC CONVENTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your invitation inquiring whether I wished to make any criticisms on the Radio-Telegraphic Convention, I beg to submit the following remarks:—

Prof. Fleming advocates, if I understand him rightly, the exclusion of Great Britain from the Convention, but I cannot comprehend the arguments which he brings forward. He divides (*The Electrician*, Vol. LIX., p. 272) the electrical waves at present in use into three categories: (1) The strongly damped (antennæ with statical starting charge); (2) the feebly damped (condenser circuit); and (3) the so-called undamped or continuous wave trains. He explains particularly that a receiving station arranged for one of these kinds of waves may be disadvantageously placed if it is hailed by one working with another kind of wave and has to refuse it. Apart from this consideration, experience has not up to now confirmed these fears to the extent supposed by Prof. Fleming. The principal thing appears to me to be whether the necessity for mutual communication is acknowledged, and Prof. Fleming's opinion on this subject is not clear. If this is the case a solution will be sought as far as is physically possible. This point of view was brought out in the evidence and indeed

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reiterated, *e.g.*, *The Electrician*, Vol. LIX., p. 238. I can only confirm it.

Prof. Fleming appears, however, to discover both an injustice and an injury to the Marconi Company in the Convention. He debates this at length (*The Electrician*, Vol. LIX., p. 238). He also states that the use of an earthed antenna is the property of the Marconi Company, is protected by their patents, that without it wireless telegraphy is impossible and that this idea first appeared in Marconi's English patent of June, 1896. Although a discussion of these questions does not appear to me to be evidence, now that the question has been raised perhaps I may be allowed to draw attention to the following points.

1. Some years before the Marconi patent, Edison proposed a vertical lead connected below to earth and above to a plate in a similar way to Marconi's first transmitter, as he wished to generate relatively slow oscillations. It may be added that with this arrangement only small distances can be bridged.

2. In connection with this circumstance it may be mentioned that on account of the strict tests in force at that time in Germany, Marconi only patented the connection of a spark-gap in circuit with the above arrangement, and rightly so, as this is in fact the characteristic of his apparatus.

3. It is possible, however, to work overland without an earth connection and without a spark-gap, for I showed it in the year 1898. Indirect electrical oscillations are generated in the transmitter by using for this purpose an oscillation circuit consisting of a condenser with self-induction (an arrangement first due to me) either inductively or, in my arrangement, direct connected. The apparatus without direct earth connection is the only possible one in many land stations.

4. Much has been done in the way proposed by me, but in a more advantageous manner; for the waves generated in the condenser circuit belong to the second class (weakly damped) spoken of by Prof. Fleming. The use of these waves is legally protected by me—and through me by the Telefunken Company, in whose possession the patent is—in the English patent No. 1,862 of January 26, 1899. In spite of this the Marconi Company have for some years employed the methods which are legally assigned to and protected by me. All their large stations, such as Poldhu, would have been impossible except by the use of these methods. The Marconi Company are, therefore, infringing the patent law and their claims are at least questionable.—I am, &c.,

F. BRAUN.

Strassburg, i/E, July 3.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The difficulties of an international connection between wireless stations may best be considered by dividing them into those which result from working the stations by different systems and those of a technical character.

Those arising from the first, that of the organisation itself, are small, as several years' practical operation has already shown. There are a whole series of stations which belong to one or other of the systems and which, notwithstanding, intercommunicate without trouble. For instance, the coast station of the Dutch Post Office at Scheveningen is equipped with the Telefunken apparatus, but for a considerable time it has held communication with ships carrying the Marconi apparatus or some other absolutely different system. Communication is established at a satisfactory distance, while from a technical point of view this installation is interesting as it has no earth connection, but works with an electrical counterpoise. Another example of this is that ships equipped with the Telefunken system can communicate with the French coast station at Ouessant as well as with stations on the American coast fitted with the various American systems. The only data known about these stations is that which was brought up for discussion and published at the Berlin Conference—namely, their electrical wave-length and approximate amplitude.

There has recently been a large amount of discussion, especially in the daily papers, about the second kind of difficulties—namely, those of a technical nature. These have, however, been overcome by experience, and no longer exist. Naturally difficulties occasionally occurred with ships which were only for a short time in connection with each other. For example, as Mr. Marconi stated, on a cruise made by the German Emperor the Marconi apparatus on the Italian warships was only able to communicate at short distances with the Telefunken apparatus on the royal yacht. The ship was only using a very short wave-length, differing from the "standard wave" by more than 100 per cent. If regulation of the wave-length had been possible at that time a considerably more favourable working would have been obtained. I may quote an example of the opposite kind. The coast station of the Nord Deutscher Lloyd at Bremerhaven was worked four or five years ago on the Telefunken system, and communicated very satisfactorily at distances of several hundred kilometres with the company's ships equipped with the Marconi apparatus.

It may be asked whether in future difficulties will occur if the much-talked-of continuous oscillations, generated by one method or the other, are adopted in practice. These fears are without foundation, as Sir Wm. Preece has already very clearly stated. Moreover, I am of opinion that even if the difficulties, found both by Prof. Fleming and the Gesellschaft für Drahtlose Telegraphie, of maintaining the frequency constant when using arc lamp generators were removed, and in place of this arrangement new generators were discovered whose periodicity could be maintained constant for minutes or even hours without varying more than $\frac{1}{10}$ per cent., even then the prospects are small for the introduction of continuous oscillations, principally on account of the inefficiency of transmission. For as the accumulation of energy must take place entirely at the receiving station, if the accumulation occurs in a resonance circuit damped as little as possible, yet owing to the unavoidable loss in damping, a very awkward method of obtaining an economical accumulation is constituted. If this fault is removed by the introduction of an integrating detector with a relatively great useful damping in the resonance circuit, the advantage of great economy is obtained with the disadvantage of an oppositely damped sender and with no increase in the sharpness of tuning.

That Sir William Preece was right in his evidence when he said that "mixed stations could work with one another" has been shown by the Gesellschaft für Drahtlose Telegraphie in a series of practical tests. One of our wireless telephony stations received telephonic speech and telegraphic signs at the same time, first with undamped and then with damped oscillations. Both may have equal wave lengths and may be received with the same detector and the same telephone receiver without any trouble. On the other hand the receiving stations for undamped oscillations received, besides the telegraphic signs intended for them, telephonic speech which was quite intelligible. This showed that when working with continuous oscillations the present arrangements for measuring waves is sufficiently accurate to focus properly a received oscillation. The accuracy determined with a wave measurer was very good, being within $\frac{1}{2}$ per cent., and a dissonant receiver can very easily be tuned, although the useful damping in the secondary resonance circuits is gradually decreased, as is the total damping. The connection in circuit of a simple interrupter in accordance with a proposal by Tesla, afterwards modified by Herr Poulsen and called the "Tickerschaltung," is sufficiently perfect to be used in a receiving station for both damped and undamped oscillations.—I am, &c.,

Berlin, July 5. G. G. ARCO.

NOVELTIES IN SWITCHES.

It is highly desirable that switches on lighting circuits which are submitted to frequent movement should be of strong design. This becomes increasingly important if the switches are fixed on board ship or in places where they are specially liable to vibration.

Various methods are employed for obtaining this result; among these is one due to Messrs. A. P. Lundberg & Sons, which is employed in their patent "Pivot" switch. This depends upon a variable lever action producing a safe locking of the contact arm when conveying the current, thus rendering it impossible for any vibration to jar the contact arm to the "off" position, and produce annoying extinction of the lamps controlled.

This locking action is obtained by the use of a movable fulcrum producing a variable leverage on the switch arm, the slot on the switch arm and the pin on the switch handle allowing this with a

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minimum of dead centre. Fig. 1 shows a single-way switch fitted with a three-pin plug. Contacts for the insertion of the three-pin plug are fitted in the base, the plug being provided with one large and two small contact pins to prevent insertion in any but the correct manner. Hence the name "Tripin" combination. As shown in Figs. 1 and 2, in the single-way type the plug is inserted from beneath, while in the two-way type it may be inserted from either the right or left-hand side. The two-way type can also be adapted for charging motor-car ignition cells from the ordinary lighting circuits in series with lamps or radiators. Fig. 3 shows the diagram of connections necessary for this purpose. It is claimed that this type simply replaces the ordinary house lighting switch without extra wiring and allows the lamps to be lighted whether the cells are being charged or not. As shown

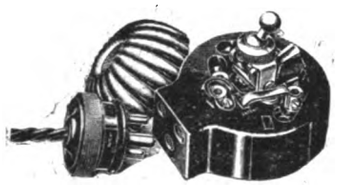

FIG. 1.—SINGLE-WAY SWITCH.

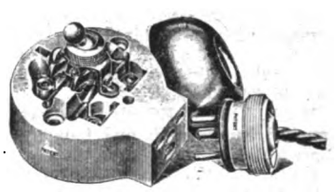

FIG. 2.—TWO-WAY SWITCH.

in the diagram (Fig. 3) there is no possibility of short-circuiting the cells and it is immaterial whether the plug be left connected or not. Fig 4 shows a very useful adaptation of the two-way type of switch. It can be fixed wherever ordinary single-way switches can be used or of replacing such switches as at present fixed without any additional wiring, thus allowing a portable two-way switch in connection with the special plug extension to be used It is claimed that this system allows control of the lamps in circuit from both fixed and portable switches.

By adapting these special switches and portables Messrs. Lundberg & Sons have obtained some interesting arrangements applicable to any desired method of lighting. For instance, by means of a two-way switch and plug three lamps may be placed in

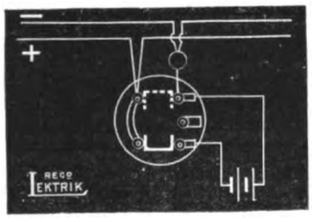

FIG. 3.—DIAGRAM SHOWING METHOD OF USING TWO-WAY SWITCH FOR CHARGING CELLS FROM THE ORDINARY DIRECT-CURRENT CIRCUIT.

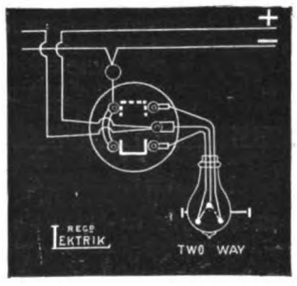

FIG. 4.—DIAGRAM SHOWING CONNECTION OF PORTABLE TWO-WAY SWITCH.

circuit, one of them being controlled by the ordinary switch contacts independently of the others; either of the other two lamps may be switched on by the portable switch. This method is also applicable to two-filament lamps, and can be used for radiator coils.

PARLIAMENTARY INTELLIGENCE.

LONDON ELECTRIC SUPPLY COMPANIES' BILL, 1907.

This bill, promoted by the Electricity Supply Companies of London, with a view to obtaining powers to interconnect their several systems, came before the House of Commons yesterday (Thursday) for second reading, but being an opposed measure the consideration of the bill was postponed.

RADIO-TELEGRAPHIC CONVENTION.

In our issue of the 5th inst. we gave an abstract of the report and recommendations of the majority of the Select Committee of the House of Commons on the Radio-Telegraphic Convention, and in our last issue we gave the names of the four members who voted against the ratification of the Convention.

In the draft report drawn up by Mr. Arthur Lee (one of the four dissentient members) it is set out that the main objects of the Convention are desirable in themselves, and it is, doubtless, inevitable that they will some day be effected, but it does not seem clear that the problem is yet ripe for solution, or that it can be solved on the lines of the present Convention. Owing to superior foresight and enterprise, coupled with unique geographical conditions, England has gradually built up, and at present possesses and controls, the only extensive and efficient organisation for carrying on a public wireless telegraph service. This organisation, provided by the Marconi Co., covers a large proportion of the chief maritime routes, and places England in a predominant position as regards the wireless telegraph service of the world. If England ratifies the Convention she will necessarily place at the disposal of other countries and of rival wireless telegraph companies the unique conditions which she has secured for herself without receiving in return reciprocal advantages in any way commensurate with those she offers. In the matter of wireless telegraphy England has far more at stake than any other Power, owing to the scattered and world-wide nature of her Empire, which depends for its security upon the control of the sea by its fleets. To this country, therefore, the wireless telegraph question is primarily one of national strategic importance, commercial interests—however vast—necessarily taking second place. The Committee have felt themselves (continues this report) greatly hampered by their inability to elicit any official assurance (either public or private) that the Convention had been even considered by the Committee of Imperial Defence. The Committee, therefore, felt that they were without sufficient authoritative information upon which to base a final judgment as to the desirability of ratification from the standpoint of high national or international policy. The consequences to this country of non-ratification, or of decision to postpone ratification, have (in the opinion of the minority) been greatly over-estimated, and in any event the geographical and strategic advantages possessed by the British Empire place it in an impregnable position. In the extremely improbable event of a "wireless war," it would not be this country which would suffer most, and the ultimate victory would necessarily rest with us. International commercial convenience would prove too strong for any policy of official boycott. Whilst advocating a policy of delay and further consideration, the minority do not wish to take up an attitude in any way antagonistic to the principles aimed at in the Convention. Their objection to immediate ratification is based solely upon the belief that the problem is not yet ripe for solution, and that a premature attempt at international regulation may do more harm than good. They recommend that the Government should do what it can, short of immediate ratification, to meet the views expressed in the Convention and its regulations, particularly that it should facilitate the establishment of a reasonable number of "intercommunicating stations" for general use throughout the British Empire. It would also be desirable to agree to adopt the proposed international code of signals, and to accept the obligation, both for its military and commercial stations, to "interfere" as little as possible, and to respond to all signals of distress. With these reservations it is felt that the interests of this country and the future development of the science will best be served by promoting a preliminary era of free competition between all systems until such time as the future of wireless telegraphy can be more nearly foreseen. If and when a system of international regulation is adopted, it should be general in its application and deal not only with intercommunication between ship and shore, as in the present Convention, but also with services between ship and ship and shore and shore. These two latter services are admittedly not yet ripe for control, and until they are it seems undesirable to deal with the subject piecemeal.

The international control of private and competing companies by their respective Governments presents great difficulty, and the necessity for it does not appear to have yet arisen, seeing that, in Europe at any rate, there is apparently only one company at present carrying on any extensive public service of wireless telegraphy, and that company (the Marconi) is already subject to British control. International control would seem to be premature until there are serious competing interests to be controlled, and at present, whilst there is no lack of desire to compete, the only serious competition that appears actually to exist is between rival types of apparatus and not between rival working organisations. Arrangements for harmonious co-operation would (the minority consider) very soon be come to by competing companies which possessed practical organisation and the experience which comes from actual working, but it seems inevitable that confusion and disorganisation would result if the one existing organisation were compelled to place itself at the disposal of every purchaser of a single set of apparatus of any other pattern. It is obvious that the machinery which the Convention seeks to create is altogether unprecedented, and there does not appear to be any parallel to the proposed organisation of an extensive public service (telegraphic or otherwise), involving the use of highly-specialised apparatus carried on by the co-operation of the employés of a multiplicity of authorities, and involving the common use of that apparatus by rival companies, or even by comparatively irresponsible individuals. The minority think that, in view of admitted facts, as much consideration should be shown to the Marconi Co. as is compatible with national interests, and that no unnecessary assistance should be extended to its foreign competitors. As to the legal position, the minority consider that some authoritative legal opinion, in rebuttal of that produced by the Marconi Co., should have been offered as to the interpretation of the existing agreements, as it did not seem to be clear that the agreements admit of the interpretation placed upon them by the Post Office.

In conclusion, it is stated that the minority recognise the advantages of general intercommunication, and hope to see these re-opened at a later period without injury to existing organisations, and without hampering the development of the science. They believe free competition, under the control of the Government, is more in consonance with British ideas and more likely to bring about a right and lasting solution of the whole problem than international control. They therefore recommend that the Government, while expressing willingness to consider any rules for international working which experience may have shown to be essential, should avail itself of Article 16 of the Convention and postpone ratification until after the Conference of 1911, or until such time as the scope

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and ultimate character of wireless telegraphy are more clearly established and sufficiently stereotyped to make international control feasible and desirable.

In reply to questions in the House of Commons, the Prime Minister last week stated that, having already allowed a day for the discussion of the question of the ratification of the Convention, and appointed a Committee of Inquiry, he did not think that he could find any more time for discussion this session.

ABERDEEN CORPORATION BILL.

As stated in our last issue, the preamble of this bill was found proved by a Select Committee of the House of Commons last week, and the clauses were adjusted on the 10th inst., when the following additions to clause 18, submitted by Aberdeen Corporation, were approved:—

The following provisions shall have effect with respect to the purchase of that portion of the electricity undertaking of the Corporation which is situated beyond the city:—In this section the local authority of the county of Aberdeen and the local authority of the county of Kincardine are respectively referred to as the purchasing local authority, and the area of the supply of the company means the area of supply defined in the Cults and District Electric Lighting Order, 1905. The purchasing local authority of the county of Aberdeen shall be entitled to purchase on the terms in this sub-section provided, if they so desire, not only the whole of such portion of the undertaking, but any one or more of the following parts thereof, namely:—(1) The part within the area of supply of the company; (2) The part within the parish of Peterculter, including the area of supply of the company; (3) The part within the parishes of Newhills, Old Machar and Dyce.

If the purchasing local authority of the County of Aberdeen purchase that portion of the undertaking within the area of supply of the company only, the corporation shall be entitled to lay down, maintain, renew, alter and enlarge mains through the area of supply of the company for the purpose of supplying electrical energy to the parish of Peterculter, so far as situate beyond the area of supply of the company.

Provided always that if the purchasing Local Authority of the County of Aberdeen purchase a part or parts only of the undertaking of the Corporation situate beyond the city, the provisions of this sub-section shall apply only to the part or parts so purchased.

Clause 17 was also amended so as to provide that the prices to be charged to ordinary consumers or for public lighting in the area of supply of the corporation beyond the city should not exceed those charged in like circumstances within the city.

Miscellaneous Bills.—The preamble of the *Sunderland* Corporation Bill, which makes further provision as to electricity supply and amends the Sunderland Electric Lighting Order (1891), &c., was found proved by a Committee of the House of Lords on Tuesday.

The *Central London Railway* and the *North Metropolitan Electric Supply* Bills were passed on Tuesday by the Committee of the House of Lords on unopposed bills. In the case of the North Metropolitan Co.'s Bill Lord Onslow, chairman of Committees struck out the electrolysis clause, which was inserted by a committee of the House of Commons for the protection of the Metropolitan Water Board.

LEGAL INTELLIGENCE.

United Incandescent Lamps & Electrical Co. v. Tanqueray.

In the City of London Court on Friday last the United Incandescent Lamps & Electrical Co., of Buda Pest, sued J. T. Tanqueray, lately trading as the Wholesale Supply Co., London, W., to recover £24 for lamps supplied.

Mr. EDMONDSON, for plaintiffs, said plaintiff company were represented in this country by Mr. H. G. Mayer. Defendant endeavoured to carry on an electrical business in the West End of London under the name of the Wholesale Supply Co. Defendant wrote to plaintiffs and discussed the purchase of 50,000 lamps, his expressed desire being to obtain a large supply, as he was appointing agents and sending travellers throughout England. In the course of the negotiations defendant asked if the lamps were the same as those certified by the Westminster Electrical Testing Laboratory, and Mr. Mayer said he thought they were, but that he could not guarantee them without making inquiries. Considerable quantities of mushroom lamps were supplied and sent to different parts of England. A large quantity were returned on the ground of delay in delivery. There was ground for that complaint, because the time occupied in getting the lamps from Hungary was longer than plaintiffs anticipated. Defendant had complained that, while the lamps were guaranteed to burn for 1,000 hours on low-voltage circuits and for 600 hours on high voltage, in many cases they only burned for a few hours. It was contemplated that the sale by defendant would amount to 50,000 lamps for the first 12 months. A merchant at Hastings sent an order for 700 dozen lamps, and when they were delivered to defendant's traveller in Hastings he had left. One merchant had sold as many as 330,000 lamps.

Mr. H. G. MAYER said he told defendant he had a certificate from the Westminster Electrical Testing Laboratory to the effect that specimens of the lamps had burned satisfactorily for 500 hours. That certificate referred to pear-shaped lamps and not to the mushroom-shaped lamps which had been supplied to defendant. The plaintiff company employed 7,000 people making incandescent electric lamps, motors and other electrical appliances. The mushroom-shaped lamps were a novelty, and he and defendant were both anxious to push them. He guaranteed the pear-shaped lamps would burn 1,000 hours on low-voltage and 600 hours on high-voltage circuits, but not the mushroom lamps. Defendant returned some of the lamps as bad, but one of them had been burning in his (witness's) office for 18 months, and was still good. They could not burn more current than 3½ watts, and there was no ground for the suggestion that the lamps burned an excessive amount of electric current.

The defence was a charge of fraud and misrepresentation, and that orders for the lamps were only given on the certificate. Mr. TANQUERAY said that Mr. Mayer distinctly told him that the certificate referred to the mushroom lamp and not to the pear-shaped lamp. In consequence of the lamps being defective he had lost £75. He counterclaimed for £112 for damage suffered. Plaintiffs supplied him with hundreds of copies of the certificate, and he had sent them to customers. That had brought him into trouble in his business. He employed 12 travellers, to one of whom he paid £4 a week.

Mr. N. KNOWLES, electrical expert, said he had examined the lamps supplied by plaintiffs and found them defective. Quite 50 per cent. of those tested went out before they had burned 600 hours.

On the counterclaim Mr. MAX HACKER, of Manchester, said he had sold 300,000 of the mushroom lamps supplied by plaintiffs, and he found them satisfactory, repeat orders following. None of them were faulty.

Mr. A. DAWSON, electrical engineer, said he had sold plaintiffs' mushroom lamps, for which he obtained a better price than for any other.

The jury here stopped the case, and said they could not see that defendant had suffered any damage. Judgment was given for plaintiffs on the claim (subject to formal proof before the Registrar of delivery, &c.) and on the counterclaim, with costs.

United Motor Industries (Ltd.) v. Vandervell & Co.

Judgment was given by Mr. Justice Walton on Monday in this action (reported in our last issue, p. 527).

His LORDSHIP said he thought the fair meaning of the verdict of the jury was that an action for damages ought not to have been brought, but he could not regard the action for an injunction as frivolous. He thought the plaintiffs were entitled to judgment for their injunction and one farthing damages, and that in the matter of costs justice would be done to all parties if they had judgment with costs, except as to two-thirds of the cost of the trial.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The Electricity and Lighting committee of Sunderland Corporation require a technical assistant to work in, and take the more immediate charge of, the test-room. Applicants must possess an intimate experience of testing methods, and of the checking and calibration of instruments and keeping of test records. Salary £156 per annum. Applications to the borough electrical engineer and manager (Mr. A. S. Blackman), Town Hall, Fawcett-street, Sunderland, by noon 26th inst. See also an advertisement.

There are vacancies for two premium pupils at Bedford Corporation electricity works. Particulars from the borough electrical engineer (Mr. R. W. L. Philips, A.M.I.E.E.), Cauldwell-road, Bedford. See also an advertisement.

A lecturer in electricity and physics is required in September next at the City of Birmingham Municipal Technical School. Commencing salary £140. Particulars from the secretary (Mr. George Mellor), Suffolk-street, Birmingham. See also an advertisement.

The Electric Construction Co. (Ltd.) require two experienced draughtsmen. Applications to the Secretary, Dashwood House, New Broad-street, London, E.C. See an advertisement.

An assistant superintendent of telegraphs is required for service in Ceylon. Candidates must be qualified telegraph engineers and possess a thorough knowledge of Morse signalling. Engagement three years. Salary £300, rising to £350 per annum by annual increments of £25. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by July 29. See an advertisement.

An assistant lecturer and demonstrator in applied mechanics and engineering design and drawing is wanted at the University of Liverpool. Salary, £100. See also an advertisement.

An instructor in wireman's work, for one evening a week, is required at the Municipal Technical Institute, West Ham. Commencing salary 10s. per evening. Further particulars from the Principal, at the Municipal Technical Institute, Stratford, E. See also an advertisement.

An electrician is wanted to take charge, under works manager, in an old-established cable factory in England. Applicants should be young, energetic and good mathematicians and have had previous experience in testing both rubber and paper core made to Govern-

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ment specifications, and also be familiar with high-pressure testing apparatus. See an advertisement.

A telegraph inspector is required for Southern Nigeria, age 25 to 35. Salary £240, rising to £300. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by 26th inst. See also an advertisement.

Two telegraph construction foremen are required in Southern Nigeria. Salary £20 and £25 a month respectively. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by 31st inst. See advertisement.

A professor of civil engineering (Rs.500 per month) and a professor of mechanical engineering (Rs.500 per month, rising to Rs.1,000, with a pension) are required at the College of Engineering, Madras. Applications to the Secretary, Public Department, India Office, London, S.W., by July 31.

Keighley Education committee require teachers of electrical engineering, practical mechanics, and inorganic chemistry for evening classes. Applications to the Principal of the Technical School.

The position of head of the engineering department of Woolwich Polytechnic will shortly be vacant. Commencing salary £300 per annum. Particulars from the Principal. Applications by July 22.

South Shields Corporation require a mains superintendent. Salary £150, rising to £200. Applications by July 26.

Kent Education committee require lecturers in physics and mathematics and chemistry and mathematics. Applications to Mr. R. L. Wills, 6, New Road-avenue, Chatham, by July 22.

Mr. F. Pernet, of Alexandria, has been appointed assistant mechanical and electrical engineer by the Municipality of Alexandria (Egypt). Messrs. V. di Pasquale (of Rome) and D. Falik (of Vienna) have been appointed general engineers on the permanent staff. On the recommendation of the chief engineer the municipality have decided to re-advertise the appointment of chief electrical and mechanical engineer. There were about 500 applications for the various vacant positions.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne. See an advertisement.

City and Guilds of London Institute.—The entrance examinations of the Institute's Colleges are held in September. Particulars of the entrance examinations, scholarships, fees and courses of study may be obtained from the respective colleges or from the head offices of the Institute, Gresham College, Basinghall-street, E.C. The City and Guilds Central Technical College, Exhibition-road, W., is a college for higher technical instruction for day students not under 16 preparing to become civil, mechanical, or electrical engineers, chemical and other manufacturers or teachers. The College is a school of the University of London in the Faculty of Engineering. The City and Guilds Technical College, Finsbury, is a college for intermediate instruction for day students preparing to enter the engineering and chemical industries, and for evening students.

King's College, London.—The Michaelmas term of the faculty of engineering and applied science commences on Wednesday, Oct 2. A list of the teaching staff appears in an advertisement. Evening classes are held for civil, mechanical and electrical engineering, workshop practice, drawing, metallurgy, mathematics, physics and all science subjects. Prospectuses and further information can be obtained from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

University College of North Wales.—A systematic course of instruction in electrical instrumen's and practical electricity for students proposing to enter the electrical engineering profession commences in October next. The course extends over two sessions. The physical laboratory at the college is very well equipped. Prospectuses, &c., from Mr. J. E. Lloyd, M.A., secretary and registrar.

Argentina.—The "Bulletin" of the French Chamber of Commerce at Buenos Ayres states that the Municipal Council have decided upon a project for the construction and leasing of two underground electric tramways for 25 years. The estimated cost of the works, including electrical equipment, is $2,700,000 (paper) per kilometre. The contract will, it is said, be open to tender for six months after specifications have been prepared.

The "Review of the River Plate" says plans have been prepared and a site secured for electricity works at San Justo.

Ashton-under-Lyne.—The salary of the tramways manager (Mr. J. W. Dugdale) has been increased from £200 to £260 per annum.

An unopposed inquiry was held last week into the Council's application for sanction to a loan of £27,500 for extensions of the electricity undertaking.

Australasia.—The "Australian Mining Standard" says *Korumburra* (Victoria) Council are obtaining expert advice on the question of establishing electricity supply.

Mr. A. U. Alcock, as representative of the Electro-Dynamic Co., has submitted to a meeting of *Charlton* (Victoria) citizens a scheme for electricity supply, with a capital of £2,000. A committee is canvassing for shareholders.

Fremantle Municipal Tramways and Electric Lighting Board have come to an agreement with *North Fremantle* Council for the extension of the tramways into North Fremantle.

Ayr.—The salary of the electrical engineer (Mr. R. Marshall) is to be increased by £50 per annum.

British and Foreign Cables.—Grimsby Electric Lighting committee had again under consideration on Monday the tenders recently received for cables.

In the discussion it was stated that a continental manufacturing firm quoted the lowest price, some £200 less than their nearest British competitor. The prices became public, and on Monday the committee received a letter from the British firm suggesting that they would amend their price should opportunity be given them, and pointing out that every order placed abroad was "a nail in the coffin of the British electrical manufacturing industry."

Upon a vote being taken six voted for the foreign firm and six in favour of the amended tender. The chairman gave his casting vote in favour of the latter, and it was ultimately decided to advertise again, limiting competition to British firms supplying British cable.

On Tuesday a somewhat similar question arose at Pontypridd. It transpired that in the original tenders the German manufacturers offered to supply the cables at about £600 less than the lowest figures submitted by any British firm. In order to keep the order in England, however, one of the British firms offered to amend their tender so that the difference only represented £140 between them and the German firm. It was contended that it was unfair to allow anyone to submit an amended tender, and upon a vote it was decided by a majority of three to accept the German firm's tender, provided that they gave two English securities for efficiently carrying out the contract.

Carmarthen.—By 12 votes to 10 the Council decided last week to proceed with the electricity scheme submitted by Messrs. J. B. Saunders & Co.

Chorley Wood (Watford).—The Northwood Electric Light Co. propose to obtain a provisional order for this parish.

City of London.—A further section of the Guildhall is to be re-wired during the forthcoming recess, at a cost of £500. One of the service lifts is to be fitted with electric power.

Clock Tower Lighting.—The new clock tower at St. George's Circus, London, S.E., which has recently been erected by Messrs. Faulkner to replace the Obelisk originally erected at that spot by Ald. Crosby, was declared open by the Lord Mayor of London on Monday. The tower is illuminated at its four corners by "Excello" arc lamps, controlled as to the time of lighting and extinguishing by the clock mechanism. The building is of quite original style and finish, in yellow sandstone, and was designed by Mr. Jan F. Groll, architect.

Customs Duties.—A recent Roumanian Customs circular directs that electric cables sheathed with sheet iron, iron wire or bands is dutiable at 12 lei per 100 kilogs. (=4s. 10½d. per cwt), under No. 750 (*a*) of the Tariff, even if also protected with jute or other common materials.

Dundee.—On Tuesday the Electricity committee approved the plans prepared by the city electrical engineer (Mr. Harry Richardson) for the new electricity works at Carolina Port. The estimated cost of the new station is £55,000.

Ealing.—The Electricity committee have accorded a vote of thanks to Mr. J. Douglas Knight, borough electrical engineer, for the able manner in which he has carried out the extra work in connection with the report on the offer of the Metropolitan Electric Supply Co. to supply electricity in bulk.

Electric Haulage on Quays.—The Derry Port and Harbour Commissioners are in negotiation with the Lancashire Dynamo and Motor Co. for the erection of electric capstans for haulage on their bridge tramway.

Electric Power in Collieries.—At the new Devonshire works of the Staveley Coal & Iron Co. a 1,000 kw. Brotwett Lindley-Vickers set is being installed. The installation also includes six Babcock & Wilcox boilers, each capable of evaporating 20,000 lb. of water per hour.

The formal opening of the electric power installation at the Cambrian Collieries (which was described in our issue of July 5) took place on 9th inst.

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Exhibition.—The seventh Ironmongery & Hardware Exhibition was opened on July 9 at the Agricultural Hall, London, and closes to-day. Among the exhibitors are The Harquin Pendant Co, of 136-138, Kentish Town-road, London, N.W., who are exhibiting the Harquin patent rise-and-fall pendant for electric lighting, a special feature of which is that it has no moving joint or rubbing contact, the electric wire being wound on to a fixed drum. W. H. Libenfield shows an entirely new process for brazing cast iron, the essential feature being a special flux known as "Castohn." By means of this material it is claimed that the user of cast-iron machinery can repair any of his machines on his own premises. The two parts to be joined have only to be thoroughly cleaned, clamped together, brought to a red heat and brazed in the ordinary way with the help of this special flux. The Aluminium Castings Co., of Greenock, and E. A. Brandon & Co. are also amongst the exhibitors.

Fatality.—An inquest was held on Friday last into the death of a lad named Farrell, who was killed in the sub-station at Messrs. Samuelson's works, Middlesbrough, on the 5th inst.

Deceased had been employed by the Electrical Co., and was engaged on some work at the sub-station. Deceased had often worked in the place before, and, on the 5th inst., he gave out that he had orders to vaseline the connections on the "dead" switches. Deceased was warned by a fellow-worker named Baker to be careful, and he was also shown which were the "dead" switches and which were the "live" ones. Deceased asked for some turpentine, and shortly after a loud report was heard and deceased was on the floor opposite one of the "live" panels, which he had evidently been painting. The front of the tank had been freshly painted, although all the switches had been painted some time previously. The back of deceased's right hand was burnt. Assistance was procured and artificial respiration was tried for about 20 minutes, but failed.

Mr. CARL PETERSON, engineer in charge of the work, said that the station was well protected, and there were levers which showed which panels were "alive" and which were "dead. It was against orders to go near a live panel.

Mr. T. W. KENNEDY, electrician, who supervised the work, said he had not instructed Farrell to do any painting. He told deceased to finish cementing a tube and then close the chamber. There was no painting to be done. Deceased was an attentive and willing lad and no complaints were made regarding him.

Dr. BENSON said that when he was called Farrell was quite dead. Both hands were burnt and in his opinion death was due to electric shock.

The jury returned a verdict to this effect.

Hemel Hempstead.—The Chesham Electric Light & Power Co. intend to apply for a provisional order.

India.—"Indian Engineering" says the *N.W. Railway* staff are testing the American Pyle electric head-light.

Infirmary Lighting.—Plymouth Guardians have decided to adopt electric lighting at the new infirmary.

Islington (London).—Mains extensions, estimated to cost £872, have been authorised. The Finance committee, reporting upon the alleged improper handing out of stores and leakages of stock, &c., state that they failed to obtain the least evidence of irregular conduct, and the resignation of the clerk who made the charges has been accepted.

Lambeth (London).—The litigation between the Council and the South London Electric Supply Corpn. in regard to the dust destructor contract has been settled on the terms following:—

The company to give to the Council free electric current for lighting (but not for power) to the extent of £1,000 a year (current to be reckoned at 3½d. per unit) in public buildings so long as the provisional order is held by the company or its assigns; the company to wire and supply fittings to the Council's libraries or other public bulidings (excepting the Town Hall and baths) making up the £1,000 a year; the company to pay £300 towards the Council's out-of-pocket costs.

Leyton.—An inquiry was held here last week into the application of the Council for sanction to borrow £5,770 for electricity extensions.

The clerk (Mr. R. VINCENT) gave particulars of the existing loans and expenditure on electricity supply.

The inspector (Mr. R. H. BICKNELL) said that if the amount asked for included the payment of men permanently employed, such payments must be deducted from the amount.

Mr. F. HARMAN LEWIS (electrical engineer): Suppose the job is continuous?

The INSPECTOR: Then it must be paid for out of the rates. The wages or salaries of permanent men or officials cannot be paid out of the loan.

Mr. VINCENT said if the work of laying the mains was done by a contractor it could be charged for out of the loan, but the Council wished to employ their own men.

The INSPECTOR said if the Council had 20 men employed in laying the cable, then their wages could come out of the loan, but if the men were employed partly in laying cable and partly about the yard their wages must come out of revenue. Mr. Lewis could discharge his men, and then take them on, say, for three months for laying cables. In his report he would call attention to this particular case. If Mr. Lewis liked to state a case he would place it before the Board.

Light Railway.—The Llandudno & Colwyn Bay Light Railway has been officially inspected on behalf of the Board of Trade.

London Building Act and Inspection Boxes.—At Clerkenwell Police Court on Tuesday the County of London Electric Supply Co. were summoned by the district surveyor for Holborn (Mr. W. G. Perkins) for failing to give notice under sec. 145(a) of the London Building Act, 1894.

Mr. R. O. B. LANE, jun. (for the prosecution), explained that the work complained of was not discovered until it was well on in course of execution. It consisted of an inspection box of 32 cubic ft., which was placed in the footway, close to the kerb, in Leather-lane. The offence was in not giving notice of intention to do the work.

Mr. S. MORSE (for the defence) contended that notice had not to be given to the London County Council, and that the prosecutor was a servant of the Council. Some 12,000 of these boxes had been laid, and that was the first case taken. The public were protected by provisional orders under the Electric Lighting Acts, apart altogether from the Building Acts. Electrical inspectors of London County Council saw the works by notice under the orders.

Mr. ROSE said he considered himself bound by the decided cases, but he offered to state a case. He imposed a penalty of 40*s.*, with three guineas costs.

London County Council.—On Tuesday the General Purposes committee submitted a proposal for a deputation to wait on the Prime Minister to urge the necessity of the establishment of a London Traffic Board on the lines indicated in the report of the Royal Commission on London traffic.—Postponed.

Repairing Depot for Tramcars.—The adjourned report of the Highways committee recommending capital expenditure of sums of £51,400 and £16,000 for the erection and equipment of a central car-repairing depot was agreed to.

Electric Supply Bill.—Replying to a question, the Hon. W. Peel said that the expenses incurred by the Council in the promotion of the Electric Supply Bill were £8,500.

Tramways Bill.—The Hon. W. Peel stated that the L.C.C. Tramways Bill had passed the House of Lords and the House of Commons and was only waiting for the Royal assent, but they were met with extraordinary opposition from the First Commissioner of Works, who wished to impose on them a clause for the protection of the Royal palaces and parks. The First Commissioner had put forward a clause to deal with nuisance by smoke or the emission of oxide of sulphur. He felt that such a procedure ought to be strongly protested against.

Tramway Sub-station.—It was resolved to expend £5,791 on the erection of the Forest Hill tramways sub-station, the work to be done by the Works committee.

Protection of Post Office Wires.—It was resolved that the Council should concur in the proposal to submit to arbitration the question whether the expense incurred by the Post Office in providing heat coils, fuses, &c., for the protection of telephone and telegraph wires in the neighbourhood of tramways worked on the overhead trolley system of electric traction should be borne by the Post Office or by the tramways authority concerned.

Surface-Contact System for Tramways.—A lengthy report was submitted by the Highways committee with regard to the reconstruction for electric traction of the Aldgate to Bow tramways at capital costs of £72,210 and £50,000. The committee point out that, in view of the heavy commitments of the Council and in order to secure the completion of the electrification of the tramways as quickly at possible it is necessary that a cheaper system of traction shall be adopted. Having had before them information with regard to the various types of surface-contact traction in use on other tramways, it appeared that, speaking generally, the most satisfactory results were secured from the "G.B." system. That system had been in operation in Lincoln for about a year, and they had visited that city and made a careful inspection of the tramways there. They had since had before them full reports upon the results obtained from the working of the system, and also upon its merits compared with other surface-contact systems, having regard to the particular conditions obtaining in London, including the necessity of providing a system which would work satisfactorily in conjunction with conduit and overhead traction. The cars used on the tramways could without difficulty be fitted with ploughs or with trolley arms in addition to the contact skates, so that arrangements could readily be made for through services of cars between surface-contact and conduit tramways or between surface-contact lines and lines equipped on the overhead system. They had come to the conclusion that it would be to the Council's interest to lay an experimental line of tramways on the "G.B." system with a view to ascertaining whether it could be satisfactorily used generally on the tramways in London. Under normal conditions the cost of trackwork (excluding cables, &c.) on that system compared with conduit and overhead traction appeared to be approximately as follows: Underground conduit system £17,000 per mile of single track, "G.B." surface-contact £10,500 and overhead trolley system £9,500. As regarded working costs it appeared probable that the "G.B." system would be not less economical in point of power consumption than either the conduit or the overhead system, while there would probably be a saving in respect of maintenance over the former system, as the expenditure necessary for cleaning the conduits would be avoided. The "G.B." Surface Co., Ltd., who owned the system, had submitted terms on which the company would be prepared to agree to the use of the system as an experiment on the Aldgate to Bow tramways, a total length of about 3 miles of double line. The details of the offer were, shortly, as follows:—(1) The Council to pay to the company a royalty of £500 a mile of single line in respect of the reconstruction and working on the "G.B." system of the existing horse lines in Whitechapel, Mile End and Bow-roads; (2) the same royalty to be paid in respect of tramways constructed or reconstructed for the system up to a

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total length of 30 miles (including Aldgate to Bow lines); (3) a royalty of £250 a mile of single track to be paid in respect of tramways so constructed or reconstructed beyond 30 miles and up to a total of 50 miles; (4) a royalty of £150 a mile to be paid on all lines on which the system is used beyond a total of 50 miles; (5) the royalty in respect of the Aldgate to Bow tramways not to be payable by the Council until 12 months after the opening of the lines, and then only if the system works satisfactorily and the Council decides to retain it. They had been in communication with Dick, Kerr & Co., whose tender was accepted (on Jan. 22, 1907) for the roadwork and platelaying for the reconstruction of the tramways in Bow-road, between Coborn-road and Bow Bridge, as to the terms upon which they would be prepared to reconstruct the whole route from Aldgate to Bow on the "G.B." system. As a result the firm had submitted a tender amounting to £48,618. 6s. 11d., which included a provisional sum of £5,000. In addition, there would be about £3,000 for royalties at the rate of £500 a mile of single line, which amount covered all patent rights involved in the use of the system, about £11,000 for rails and £3,000 for special trackwork, making the total cost for the trackwork for the whole length of about 6 miles of line about £66,000, or £11,000 a mile of single track, compared with about £19,000 a mile which it is estimated would be involved by the adoption of the underground conduit system from Aldgate to Coborn-road. It should, however, be borne in mind, in considering these figures, that the difficulties on this particular route are exceptional, whether conduit or surface-contact traction was adopted, and the figures referred to, therefore, were not a fair comparison of the respective costs of the two systems under normal conditions. The committee recommended that the Council accept the offers.—The discussion on the matter was adjourned.

L.C.C. Testing Fees.—At a recent conference of Borough Councils at Hackney Town Hall, the following resolutions were passed:—

1. That this conference is of opinion that the establishment by the L.C.C. of testing stations in London is at the present time unnecessary, and therefore wasteful, having regard to the fact that a sufficient test can be made on the premises of any consumer.
2. That the Borough Councils be asked to request the members of the L.C.C. for their respective districts to support the action of this conference when the matter is considered by the County Council.
3. That a committee be appointed, consisting of one representative from each Borough Council, to take what steps may from time to time be considered necessary.

Lowestoft.—An inquiry was held on Monday into the application of the Council for sanction to borrow £18,150 for extensions of the electricity undertaking.

The borough electrical engineer and manager (Mr. G. A. Bruce) and the deputy town clerk (Mr. E. Cann) gave evidence in support of the application.

The inspector (Mr. R. H. Bicknell) pointed out the desirability of giving details of the street-lighting portion, for a longer period was allowed for cables than for arc lamps.

Mr. Bruce replied that it included standards, boxes, &c., but he had not yet subdivided the various items.

The Inspector asked how it was assumed that there would be a good profit on "free" wiring.

Mr. Bruce said consumers paid the cost of the hire charges, and the additional consumption of current would mean an additional income.

Mr. Cann said they expected to do good business in free wiring, as the local company had just raised the price of gas 4d. per 1,000.

Mr. Bruce said the charge per unit was 4½d., but there would be 1d. more per unit for the use of the fittings, or alternatively to the additional 1d., a charge of 1s. 6d. per "point" per annum, and 6d. extra for each lamp beyond one on the point.

The Inspector: When you once get a start and people begin to pay back, if you put the money to the general undertaking you will want to borrow again. Why not credit the free wiring account with the 1d. extra and keep a separate book? Free wiring was being watched closely by the experts of the Board of Trade, who were not sanguine that "free" wiring would bring a profit.

Mr. Fry thought they had one or two concrete cases of prospective profit already. In one case, which might cost £150 to "free" wire, they anticipated an annual revenue of £100.

It was also stated that the Corporation were covered as to the possible destruction of their fittings, as the customer was under agreement to insure.

Marylebone (London).—The Electric Supply committee recommend the revision of meter rents, so that the maximum charge shall be 20s. per quarter. Receipts from the sale of current during the June quarter were £50,931. 0s. 1d.

Mountain Ash.—In order to preserve their electric lighting powers the Council have instructed a committee to consider the advisability of erecting a small generating station.

Obituary.—The death is announced of Mr. Joseph Dorrington, who was at one time chief superintendent of the Birmingham Postal Telegraph department. Mr. Dorrington entered the service of the International Electric Telegraph Co. in 1854, and in 1883 became superintendent at Birmingham, a position he held until his retirement in 1899.

Oystermouth.—The Council have been notified by the Oystermouth Electric Supply Co. that they intend to apply for a provisional electric lighting order for the Mumbles district.

Portsmouth.—On the recommendation of the Electric Lighting committee, the Council decided on Friday to apply for sanction to a loan of £5,000 for public lighting.

Presentation.—A presentation was made on the 10th inst. in the Mayor's Parlour, Sunderland, to the late borough electrical and tramways engineer (Mr. John F. C. Snell), who has started in practice as a consulting engineer with Mr. Moore Ede in London.

The Mayor (Councillor S. M. Swan) presided, and there were also present the town clerk (Mr. Fras. M. Bowey), Ald. Bruce (chairman of the Electricity committee), and several aldermen, councillors and public officials, including Mr. A. S. Blackman, borough electric engineer, and Mr. A. R. Dayson, tramways manager.

The Mayor, addressing Mr. Snell, said that, on behalf of the Corporation, he had very much pleasure in handing to him a testimonial (on parchment) of his connection with the Corporation. He had been with them 11 years, and they trusted those years had been pleasant and profitable to him. Coming as he did a young man he undertook the beginning of the municipal enterprises with remarkable success. The Corporation would watch his future career with great interest, and trusted he would have health to enjoy his well-earned reputation.

In making the presentation of a solid silver tea and coffee set and tray, Ald. Bruce thanked the Presentation committee for giving him the honour of making it. He had (he said) been associated with Mr. Snell closely and intimately for nearly 11 years, and it had been a great pleasure to him to be associated during that period with a gentleman of Mr. Snell's character and sterling worth. It had also been a pleasure to him, when visiting other towns, and especially in connection with the Municipal Electrical Association's annual meetings, to see that Mr. Snell's worth was appreciated by those best qualified to judge of his merits and ability. It was also satisfactory to know that those gentlemen were unanimously of opinion that the Sunderland undertaking was a model of municipal work and management. It was only fair and due to Mr. Snell that this should be known. Mr. Snell had been, in his estimates made from time to time, as near perfect accuracy as it was possible to be, even when estimating for two years ahead. Though Mr. Snell came to them a comparatively young man, they were soon able to gauge his ability, and when the time came for further extensions of the Dunning-street station, though they had not actually severed their connection with Sir Alex. Kennedy, the consulting engineer, they decided to entrust Mr. Snell with the work, and he had in every way satisfied the confidence they then had in him. They had also showed their confidence in Mr. Snell by entrusting him with the electrification of the tramways, and every burgess felt proud of the tramways system when they compared it with that in any other town in the neighbourhood. Another great feature of Mr. Snell's work was the introduction of the three-phase system. The work Mr. Snell had been doing was really laying the foundation, and as a result in the next three years they would receive results which would be most gratifying. As to what had already been done, if they called the sinking fund profit they would understand the position much better. They had £60,000 in that fund and that amount was absolutely net profit on the transaction, and represented all that they spent on it in the first 4½ years. He had great pleasure in making the presentation to Mr. Snell, on behalf of the Corporation and its chief officials. They wished Mrs. Snell to share in the honour that they had conferred upon Mr. Snell, and that was why they had selected the silver service. They desired to express the hope that the change Mr. Snell was making would be successful to him.

In returning thanks, Mr. Snell said that he was at that moment the victim of mingled feelings of pride at their regard (of which that testimonial was an outward and visible sign, and which had been so eulogistically proclaimed by the Mayor and Ald. Bruce) and of distress which he sincerely felt at severing his connection with the Corporation. Eleven years was a big slice out of a man's life, but in that time he had met, not only in the Council but throughout the town and from all classes, with nothing but kindness from everyone. He felt that during that period, so far as he could remember, he had not made a single enemy. His experience with the Council had been peculiarly happy and he did not know of any one sharp conflict of opinion that had risen between the Council and himself or between an individual member and himself. He knew he had a great deal of work entrusted to him. There was much he would have liked to have done better, but he had done everything from time to time to the best of his knowledge at the time, and as cautiously and ungrudgingly as was possible. The labour had been hard, but he was not happy unless he had plenty of work. They had been good enough to entrust him with the construction of the tramways. He would be a humbug not to say that he knew they had been successful in every way. The electricity undertaking had a fight because it was not a monopoly. There was competition, but that he thought was healthy. The electricity undertaking had been placed on a good foundation, not by him alone, but with the untiring help of Ald. Bruce and the committee and staff, and he was certain that in three or four years they would have those net profits which many gentlemen in the Council would like to have in tangible form. He had tried not only to be a hard worker and loyal official to the Corporation, but he had also tried to be a loyal citizen. He should value the testimonial, which, however, he thought spoke far too eloquently of his services. He should value it highly, and he should also value, and was quite sure his wife would, the very tangible and very handsome present.

Colonel Reed proposed a vote of thanks to the Mayor and sub-committee that had charge of the presentation arrangements.

The motion having been carried, the Mayor responded, and the proceedings terminated.

Provisional Order Transfer.—Bury Rural District Council give notice of transfer of their powers, &c., under their 1905 electric

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lighting order to the Lancashire Electric Power Co., the pecuniary consideration being £300. The Council have right to re-purchase at the end of 7, 10 or 14 years, or any subsequent 7 years.

Richmond.—The Council last week adopted a resolution moved by Councillor Bisgood that the General Purposes committee inquire into the advisability of taking steps for the promotion of a bill by the Corporation, either separately or in conjunction with other local authorities, authorising the construction of tramways in the borough, with the right to the Corporation to lease or work the tramways, or in conjunction with the Barnes and Mortlake District Council; and to obtain the option of acquiring, by arbitration or otherwise, the interest of the London United Tramways in the existing line from Kew Bridge to Richmond.

Offers have been received from the Traction Corpn. and from Richmond Electric Light & Power Co. to construct the proposed tramways or to take a lease after construction.

Russia.—The British Vice-Consul at Kieff (Mr. H. P. Smith) states that dynamos are now manufactured in St. Petersburg, Moscow, Riga and Revel. Plant in this class that is imported is of German manufacture, and lamps and electric light fittings are also mostly German.

Southall-Norwood.—The Board of Trade have intimated to the Council that unless they have taken steps to carry out the terms of their 1905 Provisional Order by June 30 next the order will be revoked.

Spanish Submarine Cables.—The Madrid "Gazette" publishes a decree granting an extraordinary credit for the repair of the cables connecting Spain with Tangier and Melilla.

Stepney (London).—On Wednesday, on the recommendation of the Electric Lighting committee, the Council decided, as the L.C.C. Electric Power Bill had been rejected, to proceed with the Blyth's Wharf electricity scheme.

The General Purposes committee, reporting on the decision to increase the salary of the borough electrical engineer (Mr. W. C. P. Tapper), recommended that until tenders for the work at Blyth's Wharf were actually accepted, no decision upon the subject should be arrived at. The recommendation was declared not carried, 19 voting for and 17 against, a two-thirds majority being necessary for its adoption.

Swanage.—Messrs. Foote & Milne propose to apply for a provisional order.

Telephone Facilities.—The National Telephone Co announces that in case of any fault in connection with subscribers' telephones, and in the event of there being any difficulty in making notification of such fault to the exchange, a call office may be used for the purpose without charge.

West Bromwich.—An inquiry was held here on Tuesday into the application of the Corporation to borrow £4,925 for extensions of the electricity undertaking.

The town clerk (Mr. A. CADDICK) pointed out that £4,600 had already been spent, and the balance was required for extension of mains.

On the suggestion of the inspector (Mr. H. R. HOOPER) the application was amended as follows: £4,150 for expenditure up to March 31, 1907, and £2,000 for mains and services during the next two or three years, total £6,150.

Whitehaven.—New consumers will be supplied with electric current free of charge during July.

Will.—The will has been proved of Mr. W. E L. Gaine, late general manager of the National Telephone Co., whose death occurred on June 18. The gross value of the estate was £22,590, with net personalty £22,123.

Sports.—Liverpool Corporation tramway employés had their annual sports on Wednesday and Thursday. Amongst the guests on Wednesday were the Lord Mayor, the Lady Mayoress, Sir Chas. Petrie (chairman of the Tramways committee) and Lady Petrie, several aldermen and councillors and many ladies. An excellent programme was carried out by a committee under the direction of Mr. C. W. Mallins, tramways manager, and the prizes were distributed by Lady Petrie.

Outing.—The annual outing of the employés of Stegmann & Co., Clapham Junction, London, took place on the 6th inst. at Brighton, where the company (about 50) had good weather. Mr. Stegmann met the party at dinner at the "Queen's," and subsequently the party met at the Crichton Restaurant, Clapham Junction, where several speeches were made before the party dispersed.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Aberdeen.—For the year ended May 31 the total revenue of the tramways department was £72,605, an increase of £2,097. Working expenses came to £40,434, decrease £249. Interest and sinking fund came to £18,747, an increase of £586, and the available balance is £13,422, increase £1,760. The available balance has been placed to renewal account. The number of passengers carried was 17,676,008, and the car-miles run were 1,529,682. The income per car-mile was 11·3d. and the average receipts per passenger 0·98d.

Bootle.—The accounts of the electricity undertaking for the year ended March show capital expenditure £110,123 (against £108,542), income £17,394 (£16,621).

Expenditure was £7,878 (£7,289), gross profit £9.516 (£9,332), interest and sinking fund £6,766 (£6,889). £1,702 (£1,510) has been placed to renewal fund, £700 (£1,000) to relief of rates, and £359 put to reserve. The average revenue per unit sold for all purposes was 1·7d. (against 1·74d.), for private lighting 3·35d. (3·4d.), motors 1·16d. and public lighting 2s. 11d. (both as in previous year), traction 1·16d. (1·18d.) Works cost was 0·58d. (0·57d.) per unit sold. Total costs, 0·77d. (0·76d.), interest 0·26d. (0·3d.) and repayment of capital and sinking fund 0·4d. (0·42d.) Units generated were 2,710,000 (2,577,000), sold for private lighting 446,000 (429,000), power 479,000 (453,000), street lighting 356,000 (354,000), traction 1,167,000 (1,057,000). The maximum supply demanded was 1,113 kw. (1,232 kw.).

The report of the borough electrical engineer (Mr. T. D. Clothier) states that an agreement could not be come to with regard to supplying in Litherland, and the negotiations were discontinued. No applications have yet been received for supply in Orrell, so that the extension has had no effect on the undertaking. The receipts from slot-meter supply of current increased from £101 to £177, and Mr. Clothier anticipates this will become an important branch of the undertaking.

Dudley.—The electricity department accounts to March show capital expenditure £81,411.

Revenue was £11,705 (against £11,068) and total expenses £6,461 (£5,969). Gross profit was £5,244 (£5,099). Interest on loans required £1,986 (£2,009), repayment of loans £2,224 (£2,144), bank charges £967 (£623), leaving the net profit at £68 (£323), 1,991,904 (1,815,063) units were generated, 134,431 (135,462) supplied to public lamps, 711,518 (503,060) to private consumers and 966,244 (972,979) to the tramway company. The maximum supply demanded was 632·5 kw. (512 kw.) for lighting and 850 kw. (as in previous year) for tramways.

A statement by the borough electrical engineer (Mr. C. E. Savage) accompanies the accounts, and states that the smallness of the increase in income from private consumers is to a great extent accounted for by the advent on the market of cheap and economical incandescent lamps and efficient and reliable arc lamps. In order to obtain consumers at a sufficient rate Mr. Savage considers it may be necessary, when laying cables in new streets to put in a 5-wire system with local balancers, and, to adopt the 460 volt supply at Dudley for the present metallic filament lamps, houses would be wired to take the half voltage of the two outers —namely, 230 volts—and when the lamps are manufactured at a marketable price for 250 volts, the outer and the second outer in the case of a 5-wire system on both sides would be made the true outer, thus giving consumers supply to the middle wire by 230 volts. Mr. Savage thinks this suggestion might pay, as he finds that wiring houses for metallic filament lamps is inconvenient and unpopular, the present metallic filament lamp two in series in one holder being too large a unit for private-house lighting.

Dundee.—The gross receipts of the tramways department for the past year amounted to £57,672 1s. 1d, and the working expenses (including maintenance of lines) to £35,403. 16s. 3d., leaving £22,268. 5s. 8d. The balance (with the exception of £85. 19s. 6d. carried forward) has been absorbed by interest, sinking fund, depreciation (£1,416) and renewal fund (£6,900). The total mileage run was 1,162,792, an increase of 156,881 and the number of passengers carried 15,554,905, increase 2,468,509. The receipts per car mile were 11·94d., and the average fare per passenger was 0·878d.

Farnworth.—The capital expenditure on the electricity undertaking for the year to March was £40,186.

Revenue was £6,577. Total expenses, excluding wages and materials on motor hire and street lighting accounts (£360), were £3,494 (1·06d. per unit, coal cost 0·42d. per unit sold). Interest required £1,253 and sinking fund £1,259, leaving net profit £300 (against a loss of £136 in previous year). The equivalent of 23,888 8 c.p. lamps is connected, including motors 460 H.P. and radiators 297 8 c.p.

The engineer (Mr. R. B. Leach) states that no steam traps are now used on engines or boiler-house pipes, all condensed water being fed back into the boilers by the American Holly gravity system. The Tudor storage battery (continues Mr. Leach) has been overhauled and is a most useful auxiliary to the works, being in regular use at meal hours and after midnight. For public lighting there are 45 arc and 135 incandescent lamps.

Hammersmith (London).—The borough council's electricity department accounts to March show capital expenditure £275,195, an increase of £14,775 on the past year, compared with £49,676 in the previous year.

Revenue was £37,302 (against £37,013), including £30,597 for current supplied to private consumers, £4,645 for public lighting, £174 meter rents, £135 motor rents, £1,492 for materials sold and work done; total receipts for current being £35,243 (£34,908) and revenue from other sources £2,059 (£2,105). Generation and distribution cost £21,753 (£20,519). Gross profit was £15,549 (£15,978), interest on loans £7,651 (£6,707), instalment of redemption of capital £7,829 (£6,459), and, after writing off £55 for bad debts, the net profit was £14 (£2,631). The accumulated net profits to date are £13,598. 4,974,758 units were generated and 4,220,736 (3,644,146) sold, including 3,657,610 to private consumers and 563,126 to public lamps. The total maximum supply demanded was 3,710 kw. (3,297 kw.). There are 254 arcs and 65 incan

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descents in use for public lighting. 1,935 (1,818) private consumers are connected, with 127,764 (112,122) equivalent 8 c.p. lamps. The motors connected number 260 (229), with an aggregate horse-power of 1,727 (1,420). The average price obtained per unit was 1·33d. (2·13d.) for public and 2·01d. (2·33d.) for private supply.

A report by the borough accountant states that rates, taxes, and rents and wayleaves for cables amounted to £2,851 (against £1,503), an increase which largely accounts for the decrease in the net profit.

Hove.—The past year's accounts of the Aldrington electric light undertaking show a deficit of £592.

King's Lynn.—At the Council meeting last week the electrical engineer (Mr. J. Pilling) was congratulated on the profit of £593 on the working of the electricity supply department during the past year.

Receipts were £6,609, and the capital charges included £1,208 for interest and £1,924 for sinking fund. The connections of private consumers are equivalent to 28,400 8 c.p. lamps. The profit balance is to be placed to suspense account.

The Council decided to reduce the charge to ordinary consumers for lighting from 5d. to 4½d. per unit, and to long-hour consumers 4½d. per unit, after the September meter readings.

St. Pancras (London).—The gross income of the electricity department for the year ended March 31 was £74,518. 6s. 5d., an increase of £2,426. 13s. 9d. compared with 1905-6.

£61,376. 15s. 2d. was received from sale of current (£59,997. 17s. 4d.) and £10,733. 13s. 3d. from public lighting (£10,048. 15s.). Total expenditure was £43,495. The balance was £31,018. 6s. 5d., and after paying interest and instalments off loans and making an allowance for bad debts the net profit was £6,495. 0s. 4d. (against £9,441), which is recommended to be carried forward as a working balance.

Sheffield.—The accounts of the tramways department for the year ended March 25 show capital expenditure £1,074,166, increase £13,331.

The total revenue was £279,586 (against £258,730). Working expenses were £168,419 (£157,070), including traffic expenses £97,590 (£88,831), power expenses £20,922 (£19,194), repairs £29,662) £29,290) and general expenses £20,245 (£19,754). Gross profit was £111,167 (£101,660); interest on stock, mortgages, bills, &c., came to £41,393 (£40,966), and income tax on profits £2,203 (£1,805). Sinking fund instalment was £25,392, leaving a surplus on the year's working of £45,696 (£36,595), of which £22,119 has been placed to renewals fund, £2,000 to special purposes fund, £911 to accumulated surplus fund and £24,783 (£12,773) has been transferred to general district rate.

The population served by the tramways was 447,951 (440,414); 73,966,299 (68,244,937) passengers were carried, and 6,804,656 (6,236,561) car-miles run. 12,832,535 (11,472,710) units were generated and 11,546,500 (10,658,492) used for cars, the total cost per unit being 0·658d. (0·712d.). 1·697 (1·709) unit was used per car-mile. The total revenue per car-mile was 9·996d. (10·066d.) working expenses (including power cost) 6·390d. (6·556d.), and the average fare per passenger 0·898d. (0·902d.).

Wallasey.—The fifth annual report of the tramways undertaking for the year ended March 31 states that the receipts were £43,601. 12s. 11d., against £40,570. 18s. 4d. 1in 1906.

Working expenses were £27,315, leaving a gross profit of £16,292. 12s. 11d., or nearly £2,000 more than last year. £3,340 was voted in relief of rates (£1,240 more than last year), and the net profit, after payment of interest, depreciation, &c., was £1,952. Nearly 8,000,000 passengers were carried, or 467,000 more than in the previous year, 356,481 representing 1d. fares. The number of car-miles run was 862,123, compared with 819,216.

Wolverhampton.—The accounts of the electricity department for the year ended March show capital expenditure £184,430, increase £12,189 on the year.

Revenue was £27,525 (against £24,722 in previous year). Total expenses were £13,073 (£11,327). Gross profit was £14,302 (£13,245), capital charges were £10,905 (£10,194), and the net profit £3,653 (£3,216). 4,553,855 (3,758,264) units were generated, 151,472 (141,352) supplied to public lamps, 2,115,058 (1,539,728) to private consumers and 1,585,992 (1,516,324) for traction. There are 56 arc and 167 incandescents (56 and 142) for public lighting and the total number of (equivalent) 32-watt lamps connected is 110,706 (85,126). The maximum load at the works was 2,075 kw. (1,674 kw.). 235 motors (=1,539 H.P.) are connected.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Portsmouth Tramways committee invite alternative tenders for periods of 6 or 12 months for the supply of best large smokeless Welsh steam coal for their power station. Specification, &c., from the engineer (Mr. V. G. Lironi, M.I.M.E., A.M.I.E.E.), engineer's office, Fratton-grove. Tenders to the Town Clerk, Town Hall, Portsmouth, by 12 noon, Monday, Aug. 5. See an advertisement.

Dublin Corporation want tenders for 12 months' supply of machinery oils for their electricity works, Pigeon House Fort, Dublin. Specification from the town clerk (Mr. Hy. Campbell), City Hall, Dublin, to whom tenders by July 23. See also an advertisement.

The *Metropolitan Water Board* want tenders by 10 a.m. July 24 for supply of two 25 kw. generators, motors, four triple-expansion marine type engines, three hydraulic turbines, 10 water-tube boilers, mechanical stokers, coal conveyor, ash hoist, pumps, valves, economisers, pipes, &c. Specification, &c., from the Engineer, Southwark Bridge-road, S.E.

Bristol Docks committee want tenders by 10 a.m. July 26 for supply, erection, &c., of 10 2 ton electric waggon capstans, and two 10 ton, two 3 ton and 16 30 cwt. movable electric jib cranes for the new Royal Edward Dock, Avonmouth. Specifications from the Engineer, Cumberland Basin, Bristol.

Wednesbury Corporation want tenders by mid-day July 23 for supply of balancer boosters and for alterations and extensions of accumulators. Specification, &c., from Mr. W. Fennell, Camp-street, Wednesbury.

Birmingham Tame and Rea District Drainage Board require tenders by 9 a.m. 26th inst. for three-phase induction motors (800 H.P.) and electrically-controlled sluice valves, with switch gear. Specification may be seen with the Engineer, Tyburn, near Birmingham.

Walthamstow Council want tenders by 5 p.m. July 26 for supply of nuts and peas coal for the electricity department. Further particulars from the Electrical and Tramways Engineer, Priory-avenue, Walthamstow.

Rochester Corporation want tenders by July 22 for construction of tramway permanent way and overhead line equipment. Specification, &c., from Mr. E. Rotter, 47, Victoria-street, London, S.W.

Wimbledon Corporation want tenders by noon July 22 for supply of Edwards air pump equipment and voltmeters. Particulars from the Borough Electrical Engineer.

Chorlton Guardians invite tenders for wiring two hospital pavilions at Withington workhouse. Tenders to the clerk, All Saints', Manchester, by 23rd inst.

The *Benares* tramway order and electric supply licence have been gazetted, and construction work will commence after the monsoon.

Tenders will be received until noon, Aug. 5 by the Deputy Postmaster-General, *Brisbane*, for supply and delivery of 73 tons 400 lb. g.i. wire, 38¾ tons 200 lb. h.d. copper wire, 2,000 ⅝ in and 1,000 ¾ in. iron spindles, 2,000 200 lb. wire and 1,000 70 lb. wire copper jointing sleeves, 10,000 Acme insulators, 10 cwt. bolts and nuts, and 5,000 200 lb. wire copper tapes and binders. Specifications, &c., from the Commonwealth Offices, 72, Victoria street, London, S.W.

TENDERS RECEIVED AND ACCEPTED.

The following tenders were received by London County Council for the manufacture, delivery and erection of two of the four sets of 5,000 kw. three phase steam turbo-generators required for the second portion of the Greenwich generating station:—

	Turbo-generators.	Extra for spare parts.
Willans & Robinson (*accepted*) ..	**£42,200**	.. **£1,875**
General Electric Co.	48,628	.. 462
James Howden & Co.....	48,000	.. 489
British Thomson-Houston Co...	47,480	.. 392
Electric Construction Co.	44,900	.. 491
C. A. Parsons & Co.	£44,276 & £39,866	.. £746 & £655
British Westinghouse Co...	£42,443 & £36,000	..£1,366 & £1,205

Stepney (London) Council have received the following tenders:—

For supply of 7,000 yds. 4 in. single way conduits and 100 bends, Sutton & Co. (*accepted*), (1) conduits **1s. 0½d.** per yard, (2) bends **1s. 0½d.** each (less 2½ per cent.); Albion Clay Co. (1) 1s. 0½d., (2) 1s. 0½d.; T. Wragg & Sons, (1) 1s. 0½d., (2) 1s. 0½d. (less 2½ per cent.); Doulton & Co., (1) 1s. 0½d., (2) 1s. 0½d.; Johnson & Phillips, (1) 1s. 3d., (2) 2s. 9d.

For cable boxes —Johnson & Phillips (*accepted*) (1) six-way disconnecting joint boxes **£91**, (2) five-way ditto **£91**, (3) four-way ditto **£90**, (4) three-way ditto **£54**, (5) straight through ditto **£54. 7s. 6d.**, (6) end connecting ditto **£5. 4s.**; W. T. Glover & Co. (1) £97, (2) £98, (3) £99, (4) £60, (5) £58, (6) £6. 16s.; Siemens Bros. & Co., (1) £97. 10s., (2) £103. 5s., (3) £99, (4) £57, (5) £58, (6) £6. 4s.; W. T. Henley's Co. (1) £162. 10s., (2) £138. 5s., (3) £96. 15s., (4) £55. 10s., (5) £58, (6) £6; British Insulated & Helsby Cables (1) £221, (2) £225. 15s., (3) £126, (4) £75, (5) £79. 15s., (6) £8. 8s.

For (1) 7,400 yds. 0·125 sq. in., and (2) 400 yds. of 0·2 sq. in. l.t. triple-concentric lead-covered cable, and (3) 120 yds. of 0·2 sq. in. l.t. triple concentric lead-covered and steel-armoured cable, Callender's Cable Co. (1) (*accepted*) **£2,980**, (2) **£226. 5s.**, (3) 0·2 by 0·2 by 0·1 steel armoured, £79. 2s. 6d.; Johnson & Phillips (1) £2,931. 17s. 4d., (2) £229. 16s. 5d., (3) (*accepted*) **£75. 4s. 5d.**; British Insulated & Helsby Cables, (1) £3,034, (2) £236, (3) £76. 16s.; W. T. Henley's Co., (1) £3,040, (2) £235, (3) £76. 10s.; W. T. Glover & Co., (1) £3,041, (2) £235, (3) £76. 18s.; Siemens Bros. & Co., (1) £3,078. 10s., (2) £237. 18s., (3) £77. 5s.

For a feed pipe, Pryke & Palmer's tender was accepted at **£3. 2s. 6d.**

The tender of the Silvertown Oil Storage Co. has been accepted for dynamo oil at 1s., cylinder oil at 2s. 6d. and crank chamber oil at 2s. 2d. per gallon, and that of C. C. Wakefield & Co. for forced lubrication chamber oil at 1s. 5d. per gallon.

Stepney Council have also received the following tenders:—

Meters up to a capacity of 10 amperes: Reason Mfg. Co. (*prov. accepted*); Chamberlain & Hookham, and Ferranti Ltd., for meters above 10 amperes;

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Ferranti, Ltd. quoted on the basis of one year's free maintenance against three years by Chamberlain & Hookham (*prov. accepted*). Tenders from ten other firms for both classes of meters were declared informal.

The tender of the Reason Mfg. Co. for demand indicators was *prov. accepted*. The tenders of Engineering Instruments (Ltd.) and Monté Callow & Co. were declared informal.

For the annual supply of carbons the tender of the Sloan Electrical Co. was *prov. accepted* at £767. 1s. 2d. Johnson & Phillips tendered at £793. 5s. 6d.; Crompton & Co. at £800. 15s.; G. Braulik at £839, 7s. 1d. (less 5 per cent. for cash), and Union Electric Co. at £894. 8s. 7d.

The Mirrlees Watson Co., Glasgow, have received orders from Franco Tosi for three sets surface condensing plant (duty each 20,000 lb. steam per hour); from Fraser & Chalmers two surface condensers (each 3,200 sq. ft. cooling surface); and from the Lancashire & Yorkshire Railway Co. (per W. H. Roy & Co.) for one counter-current jet condensing plant (duty 50,000 lb. steam per hour).

Bermondsey (London) Council have provisionally accepted the tender of Chas. Franklin for 2,000 tons of Welsh and 2,500 tons of bituminous coal, and that of Kaye, Son & Co. for 2,000 tons of bituminous coal.

Marylebone Borough Council have accepted the tender of C. A. Parsons & Co. for the insertion of a steam temperature buffer on the turbines for £200.

Prescot Guardians have accep'ed the tender of the British Insulated & Helsby Cables for the supply of cables, fittings, wiring and current (3d. per unit) for lighting at the workhouse.

Bolton Electricity committee have accepted the tender of the British Westinghouse Co. for a centrifugal pump.

Gravesend Council have accepted the tender of the Lancashire Dynamo & Motor Co. for motors for hiring out.

Rochdale Council have accepted the tender of Yates & Thom for additional plant for the electricity works.

York Electricity committee have accepted the tender of the Adams Mfg. Co. for 12 months' supply of Igranic motor-starting rheostats.

Croydon Council have accepted the tender of T. Harding Churton & Co. for an electric motor and pump at £178.

Keynsham Council have accepted the tender of Parfitt & Webber for public lighting by 126 electric lamps from Aug. 10 to May 10 at £262.

Long Eaton Council have accepted the tender of Browett, Lindley & Co. for a steam dynamo and water-tube boiler at £3,948.

Bristol Docks committee have placed a contract for two electric capstans with Royce Limited.

BUSINESS NOTICES.

Notice is given that the businesses of the Amalgamated Dry Batteries (Ltd.) and the Universal Battery Co. have been amalgamated as from July 1, and will in future be carried on as one business under the style of "The Associated Battery Co. (Ltd.)." Telegraphic address, "Unibaco London"; telephone, Sydenham 166. For the purposes of this absorption the Amalgamated Dry Batteries (Ltd.) is being wound up voluntarily.

Mr. Douglas C. Bate informs us that, having severed his connection with the Electric & Ordnance Accessories Co., he has opened an office at 40, Brazennose-street, Manchester, where he will receive orders or inquiries for the various lines of goods for which he has hitherto received orders, as well as for artistic bronze fittings, insulation materials, wires and cables, soldering compounds, &c. Telephone 5602.

Mr. E. Harris, 36, Richmond-mount, Headingley, Leeds, expert in fuel economy and boiler-house plant, has joined Messrs. Ed. Bennis & Co. as their representative for East and South Yorkshire. The firm's old and valued representative, Mr. Wm. Higson, Grindleton Villa, Levenshulme, Manchester, will still continue to be the firm's general representative for Lancashire and Yorkshire as heretofore, but the business has grown to an extent to render necessary a sub-division of the work and the appointment of a number of representatives in the busy manufacturing centres of the North.

Norman McKenzie and Walter T. Wright (trading as Norman McKenzie & Co.), electrical and mechanical engineers, 4, Watts-place, Chatham, have dissolved partnership. Debts by Mr. Wright, who continues as Walter T. Wright & Co.

Electromotors Limited, Openshaw, Manchester, intimate that the works and offices will be closed for the annual holiday from the night of Aug. 2 to the morning of Aug. 12, a small staff being kept in attendance for the purpose of dealing with estimating and urgent correspondence.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of Arthur H. Dodd and Horace J. Whateley (trading as the Garrick Electrical Co), Walsall-street, Bilston, and lately at Bilston-street, Wolverhampton, the first meeting of creditors will take place on July 24 at the O.R.'s, and the public examination on July 31 at the County Court, Wolverhampton.

Claims against Francis Williams, electrician, 17, Orchard-street, Bemerton, Salisbury, by July 22, to Mr. T. Barton, O. R., Cambridge Junction, High-street, Portsmouth.

Benham & Sons (Ltd.) is being wound up voluntarily. Mr. W. J. Benham, 66, Wigmore-street, London, W., is liquidator, with authority to consent to the registration of and to enter into an agreement with a new company with the old title.

Electric Safety Appliances (Ltd.) is being wound up voluntarily. Mr. H. A. Grimsdick, 82, Victoria-street, London, S.W., is liquidator.

A meeting will be held on Aug. 13, at 3-5, Goat-street, Swansea, to receive an account of the winding up of the British Electric Separating Co. (Ltd.).

The Capilliform Telegraph Instrument Co. (Ltd.) is being wound up voluntarily. Mr. H. Clough, 54, Gresham House, London, E.C., is liquidator.

The De Forest Wireless Telegraph Synd. (Ltd.) is being wound up voluntarily. Mr. W. L. Davis, 601, Salisbury House, London, E.C., is liquidator. Claims by Aug. 31.

Chatham, Rochester & District Electric Lighting Co. (Ltd) is being wound up voluntarily. Mr. C. T. Smith, Violet-hill, Rochester, is liquidator. Claims by Aug. 16.

The May-Oatway Fire Appliances (Ltd.) is being wound up voluntarily for reconstruction. Mr. E. W. Elliott, 22-26, Paul-street, London, E.C., and Mr. C. A. Underwood, Threadneedle House, London, E.C., are liquidators.

Businesses for Sale.—Old-established electrical and general manufacturing works in London are advertised for sale as a going concern.

An installation and small repair business in Yorkshire is advertised in another column for immediate disposal.

The "Journal."—Part 184 of the "Journal" of the Institution of Electrical Engineers is now ready. Price 5s. Particulars of contents are given in an advertisement.

"Ediswan" Specialities.—An "Exhibition of Materials" was inaugurated at Venice on July 7, which continues open for some time. After the opening ceremony the Royal party visited the stand where the British-made exhibits of the Edison & Swan Co. were shown and thoroughly examined by them. The Queen Mother personally expressed her pleasure at seeing so great a variety of useful and ornamental electrical appliances. The exhibition is proving a great success.

Flame Arcs and Poultry.—Messrs. Baughan & Co., electrical engineers, of Reading, wrote to the Union Electric Co., under date July 13, as follows:—"We have returned to you the six 'Excello' lamps sent for garden party, &c. It may interest you to know that these lamps were used for lighting the grounds, &c., at the University College for the National Poultry Show. When the lamps were lighted at night the birds had previously gone to sleep, but they immediately woke up and started crowing and cackling!" Perhaps the birds were able to distinguish that the lamps were "Excellos."

Garden Party Illumination.—Organisers of garden parties find the electric light, with its infinite possibilities in the way of hidden lights and general decorative effects, a very useful servant. A large party gathered on Saturday last at Mr. Edgar Cohen's house at St. John's Wood, London, and the function proved a great success, thanks, in no small measure, to the electric light. Messrs. Roger Dawson (Ltd.), of Berners-street, installed about 5,000 electric lights in four days, and every lamp was alight the whole evening, not even a fuse going, and this notwithstanding the wet period during the work of installation. Coloured lamps were fixed on all the big trees in the garden, and numerous flower-beds were outlined in colours, as well as the whole of the house and all the garden paths, &c. A large bandstand was erected for the Coldstream Guards and was beautifully decorated, over 400 coloured lights being fixed on the stand.

CATALOGUES, &c.

Steam Generators.—The Union Electric Co. are sending out their list No. 1,006, which describes and prices a line of vertical high-speed steam engines and dynamos for capacities varying from 3½ kw. to 56 kw. The sets are provided with open and closed-type engines.

Sirocco Fans.—We understand that in a recent action the German Supreme Court upheld the patent of S. C. Davidson for his well-known centrifugal fan. These fans, as our readers are doubtless aware, are manufactured at the Sirocco Engineering Works of Davidson & Co., Belfast.

Installation News.—The July issue of "Installation News" is just out and contains an illustrated report of the annual outing of Simplex Conduits (Ltd.), also a description of a new pipe-bending machine.

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Electric Light Fittings.—The London Electrical Fittings Co, 15, Newman street, London, W., send us a copy of their latest catalogue of electrical fittings, which is certainly distinct by the excellence of the drawings and the effective manner in which they display the good points of the company's designs. To comment upon the catalogue in detail would be impossible in the space at our disposal, but its pages will certainly bear close study by those contemplating the introduction of modern examples of electric light fittings.

From the same firm comes a general catalogue of the Wandsworth Electrical Mfg. Co., giving details of the electrical accessories manufactured at the Birmingham works of this firm.

Flame Lamps.—The "Blaze" flame lamp is described in a pamphlet just issued by the Armorduct Mfg. Co.

Bennis Plant.—A number of illustrated sheets showing Bennis stokers and conveyor plant erected and giving brief decriptions of these plants are now available, and copies of the lists can be obtained on application to Messrs. Ed. Bennis & Co., either at Little Hulton, Bolton, or at the London offices, 28, Victoria-street, S.W. Our readers may be referred to a description of Messrs. Bennis's stoker installation at Wimbledon, which appeared in our last issue, p. 526.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from July 10 to 16, with the ports of destination:—

Africa—Alexandria, £744; Beira, £24; Durban, £374; East London, 14 tons (iron telegraph poles); Mombasa, £359; Port Elizabeth, £85; Port Said, £151; Port Sudan, £151; Suakin, £100 (including £35 telegraph material); Taltal, £11. *Argentina*—Buenos Ayres, £72. *Australasia*—Adelaide, £190 (including £118 telegraph material); Auckland, £556; Brisbane, £168; Fremantle, £134; Lyttelton, £149; Melbourne, £2,131; Otago, £180; Perth, £465; Rockhampton, £74; Sydney, £834 (including £61 telegraph material); Wellington, £51 (telegraph material). *Belgium*—Antwerp, £14; Brussels, £725; Ghent, £25; Ostend, £148. *Brazil*—Bahia Blanca, £1,732. *British Guiana*—Berbice, £34. *Canada*—Halifax, £3,748 (telegraph material); Montreal, £39; *Ceylon*—Colombo, £23 (telegraph material). *Channel Islands*, £45. *Chili*—Valparaiso, £60. *China*—Foochow, £162; Hankow, £47; Shanghai, £5,795; Tientsin, £9. *Denmark*—Copenhagen, £113. *France*—Boulogne, £135; Havre, £18. *Gibraltar*, £20,922 (telegraph material). *Holland*—Amsterdam, £503 (including £259 telegraph material); Rotterdam, £290. *Hong Kong*, £562. *India*—Bombay, £1,119; Calcutta, £3,716 (including £79 telegraph material); Madras, £899. *Italy*—Genoa, £650. *Japan*—Yokohama, £83. *Malta*, £56. *Mexico*—Vera Cruz, £852. *Persia*—Balek Pappan, £31. *Peru*—Mollendo, £289. *Russia*—Kureh, £904; St. Petersburg, £767 (including £727 telegraph material). *Spain*—Barcelona, £15; Bilbao, £220. *Straits Settlements*—Penang, £59; Singapore, £594 (including £33 telegraph material). *Sweden*—Gothenburg, £200 (telegraph material); Stockholm, £701 (including £436 telegraph material). *West Indies*—Dominica £24; St. Kitts, £36 (telegraph material); Trinidad, £14. Total £52,736, against £28,325 in the corresponding week last year (July 11 to 17).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

April 24, 1907.

9,513 BOWLEY. Steam turbines.
9,515 BULLERS LIMITED & CHAMBERS. Insulators for telegraph poles and the like.
9,516 THOMAS. Combination of a door lock and alarm bell or converting it into an electrical lock.
9,535 EXPANSION SPRINKLER SYND., FIDDES, & WATT. Automatic fire-alarms.*
9,554 MUDGE. Dynamo-electric machines. (Date applied for, 24/8/06.)*†
9,557 HAENNIG. Thermodynamic machines. (Date applied for, 28/4/06.)*†
9,571 B.T.-H. Co. (G.E. Co., U.S.) Dies and die supports used for squirting metal or other material to form wire.
9,572 B.T.-H. Co. (G.E. Co., U.S.) Manufacture of electric lamps having incandescing bodies of metal.
9,576 THURSFIELD. Apparatus for starting electro-motors and regulating their action.
19,805A/06 ARTOM. Receivers for wireless telegraphy. (Date applied for, 5/9/06.)*†

April 25, 1907.

9,585 GREAVES. Brush holders for dynamos and electric motors.
9,591 GROSS. Means for guiding and supporting carbons, or electrodes in pairs in arc lamps.
9,609 LA SOCIÉTÉ ANONYME WESTINGHOUSE & LEBLANC. Jet condensers. (Date applied for, 27/4/06.)*†
9,623 VANSTONE. Insulated couplings or hangers for electrical purposes.
9,636 BUCKAU. Recovering chromic acid from solutions of sulphate of chromium in an electrolytical manner. (Date applied for, 8/5/06.)*†
9,637 BUCKAU. Increasing the durability of carbon and graphite electrodes in aqueous solutions. (Date applied for, 8/5/06.)*†
9,652 WATSON. Electric switches.
9,674 HADDAN. (Marius Ratignier and the firm of H. Peroilhac et Cie.) Means for preventing direct contact of the ear with telephone receivers.*
9,675 PÖRSCKE. Turbines.*
9,681 B.T.-H. Co. (G.E. Co, U.S.) Wire-cutting machines.
9,685 B.T.-H. Co. (G.E. Co., U.S.) Supports for the filaments of incandescent electric lamps.
9,686 B.T.-H. Co. (G.E. Co., U.S.) Winding machines.

April 26, 1907.

9,689 SWINBURNE. Incandescent lamps.
9,700 COOK. Measuring clearances in steam engine cylinders and steam and water turbine engines.
9,701 MORRIS. Electric motors and dynamos.
9,705 ARTHUR. Controlling systems for electric railways.
9,713 WALTERS. Steam turbines.
9,720 HERBST. Telegraphic code.
9,726 MURGAS. Constructing antennæ of wireless telegraphy.*
9,740 SANG. Depositing metallic coating on metal surfaces.*
9,743 DAY. (Paul Meyer Akt.-Ges., Germany.) Means for locking electric switch boxes.*
9,747 STOCKALL, Jun., & STOCKALL. Electric tell-tale indicators.
9,748 STOCKALL, Jun., & STOCKALL. Switches for electric circuits.
9,761 OGLE. Thermo-mecurial contact makers for fire-alarm and other purposes.*
9,791 BRAZIER & BRAZIER. Timing wheel device for valves and magnetos used in conjunction with internal combustion engines.

April 27, 1907.

9,794 GREEN. Heads for the trolley poles of electric tram-cars.
9,796 SHARMAN D. NEILL LTD. & CALDWELL. Setting-back arrangement for marine electric clocks.
9,833 TURNER. Telephone systems, and apparatus therefor. (Date applied for 12/5/06.)*†
9,850 B.T.-H. Co. (G.E. Co., U.S.) Measuring instruments.
9,851 B.T.-H. Co. (G.E. Co., U.S.) Maximum demand electric indicators

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS

7248A FRANKLIN & SEIFERT. Electrical commutation devices. (Date applied for, 26/3/06.)
7,752 ANDREWS. Oscillating electric motors.
7,942 EISENSTEIN. Wireless telegraphic and telephonic systems.
10,148 WOOD & WOOD. Rendering overhead wires "dead" in case of fracture.
10,220 MORGAN CRUCIBLE CO. & SPIERS. Brush holders.
10,238 BOWLEY. Turbines.
10,396 GIN. Production of steel and an electric furnace for said process. (Date applied for, 3/5/05).
10,549 LAKE. (Stromberg-Carlson Telephone Mfg. Co.) Electrical switching devices for telephonic purposes.
10,795 B.T.-H. Co. (G.E. Co., U.S.) Commutators for dynamo-electric machines.
11,238 RAWORTH. (Clayton). Induction motors.
11,298 FYNN. Generators, converters and alternate current motors.
11,333 PEACE. Means for lubricating tramway trolley wheels.
11,606 WAKELAM & LANDER. Rail joints of light railway and tramway tracks to prevent looseness and to secure immovability.
11,936 B.T.-H. Co. (G.E. Co., U.S.) Rotary members for dynamo-electric machines.
12,010 RECORD & BEVIS. Coat indicator applicable for electrical meters.

COMPANIES' MEETINGS AND REPORTS.

Electric Construction Co. (Ltd.)

The fourteenth annual general meeting was held yesterday under the presidency of Mr. WALTER S. B. MCLAREN.

The SECRETARY (Mr. David Willock) having read the notice convening the meeting,

The CHAIRMAN, after referring with regret to the death of Mr. Barclay, the late chairman of the Company, said: Gentlemen, the Directors greatly regret that the year's operations now under review show a loss of £1,442, but, in view of the late chairman's remarks at the last annual meeting, this result will not surprise you. It should, however, be noted that this loss is only arrived at after writing off £5,000 for general depreciation and about £2,000 for new tools and patterns in excess of the amount usually expended on such matters, and, in fact, treating the business in the most drastic way by charging everything to revenue which can properly be so charged, although many items might have been transferred to a suspense account and written off over two, or even three, years. Before dealing with other matters, let me call your attention to the balance sheet. On the liability side the capital and debenture stock issued are unaltered. Sundry creditors and bills payable amount to about £52,000, as

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compared with about £50,000 last year. The general reserve fund has been reduced by £1,500, this sum having been transferred to sundry debtors reserve merely as a precautionary measure to provide for contingencies. Turning to the assets, you will note that the sum of £7,614 has been expended on additions to plant which are strictly in the nature of new capital expenditure. This is almost exclusively on fixed machinery of the latest type, and as its installation has been followed by reduced cost of working, the Directors consider this expenditure thoroughly justified. You will notice, also, that the depreciation fund, which formerly appeared among the liabilities, has this year been deducted from the value of our properties, but this change is merely a matter of book-keeping. Shares in other companies have been increased by £18,893, representing a further allotment of preference shares in the Madras tramways in part payment of the equipment of four miles of extensions supplied by this Company. As these were allotted towards the end of our financial year they do not, of course, carry the full dividend with them. Sundry debtors are practically the same. Stock-in-trade and work in progress shows a diminution of £14,665, but you must not infer from this that we have less work on hand. It simply means that last year we had more work near completion, but not yet invoiced, than we have this year, for, as stated in the report, the orders on the books are greater than they were at this time last year. In fact, I may say that the orders taken since May 1 are as large as those that were taken up to October last year; we have practically done double the amount of business during the present financial year that we did up to this time last year.

Turning to the credit side of the profit and loss account, it will be seen that our gross profit on manufacturing and contracting is £4,000 less than last year. It is necessary, however, to explain that the gross profit of the past year has been reduced by nearly £2,000 for new tools, to which I have already referred as an exceptional outlay which might have been carried to suspense. The Board, however, after careful consideration, decided to adhere to the conservative policy which they have always adopted of debiting to the current year everything which could properly be charged to it. They are satisfied that the new designs for which these tools and patterns are necessary will assist the Company to meet the severe competition with which it will continue to be faced, but which the Board are quite prepared to meet. Dividends on shares of other companies show an increase of £744, chiefly from the Madras Tramways. Our investment in the Electrical Power Storage Co., which is under the management of your Director, Mr. Courtenay, is thoroughly satisfactory, and continues to yield us the same good dividend as before.

On the debit side of the profit and loss account general charges and maintenance show increases of £344 and £556 respectively. The former have been so well looked after during recent years that it does not seem possible to effect any reduction. The increase in the cost of maintenance depends on the necessities of the year, the Directors being convinced that the best policy is to maintain everything in the highest state of efficiency. The result of all this is a net loss of £1,442. 2s. 10d., a result quite inconsistent with the hard work and anxiety which have devolved upon the Board and the management, and I feel sure that, apart from your own disappointment at this result, you will sympathise with the officials of the Company and the staff generally, who, having devoted so much hard work and energy to the business, have this disappointing result. It is intensely disappointing to our hard-working staff at the works and in the London office to find that, nothwithstanding their unremitting labours, there is not a more satisfactory result to bring before the shareholders. It is but small consolation to know that such absence of profit is not exceptional nor confined to this Company, for I cannot find that any electrical manufacturing concern of importance carrying on a purely manufacturing and competitive business similar to ours can show any better result and some show a great deal worse.

For the purpose of satisfying myself that undue competition is responsible for the present state of affairs, I have compared the average selling prices of the year 1903–4, the last year the company paid a dividend upon its ordinary shares, with those of the past year, and find that, while the output of machinery has been approximately the same, the turnover, in consequence of the slump in prices, has been diminished by no less a sum than £28,000. I need hardly remind you that copper, the Company's staple article of consumption, has increased in price since 1904 by 80 per cent., or £50 per ton. You will therefore recognise that, if the methods of the Company had not been progressive, and if the production had not been cheapened and strict economy exercised, the results would have been still more serious, but I am glad to assure you that we can produce as economically as any of our competitors and that the standard of excellence for which this Company is well known has not been in the slightest degree reduced. It is always dangerous to prophesy, and it is particularly so when an industry is suffering from over-production, but nevertheless I am justified in saying that at present the outlook is more encouraging. We have more work in hand than at this time last year, and at distinctly better prices. There is not so much evidence of a disposition on the part of manufacturers to accept work upon almost any terms, and if only reasonable selling prices can be maintained we are confident that the Company's former prosperity will be restored at no distant date. We have a very large and important order on hand from the London County Council in connection with tramways, and we have just secured a large contract amounting to well over £20,000 from an important firm in the Midlands in face of very vigorous German competition. As, however, we are well aware that keen competition in the electrical industry will continue, the Directors have under their consideration the necessity of adopting further branches of engineering, and arrangements to this end have been made in one important direction, which, however, will not involve the Company in any serious additional expenditure, and we have every reason to believe that our works will be kept fully employed.

You are aware that the Company is the chief owner of the Madras tramways, and I need not remind you of the circumstances under which the property came into the possession of this Company. While we are satisfied that the tramways will ultimately yield a satisfactory return, its development has been slower than was anticipated. It is no part of our business to continue to hold all these shares, and we have just completed negotiations for a sale of a portion of our interest in that company. Concurrently with this, the Board of the tramway company have signed a contract with the Madras Electric Supply Corporation for a supply of electric energy to operate the tramway, and in consideration of this contract that Corporation will subscribe for £20,000 of 4½ per cent. preferred ordinary shares, while we are subscribing for £5,800 of similar shares. With this money the tramway company will meet its liabilities, and the contingent liability referred to in that note on our balance-sheet will be discharged. It is expected that the supply of energy by the Corporation and the identification of the interests of the two Companies will be beneficial to them both, and that the profits of the tramway company will consequently increase. Your Directors have taken advantage of this negotiation to assent to the reorganisation of the capital of the tramway company, the preference shares and ordinary shares of which are now converted into 4½ per cent. preferred ordinary and into deferred ordinary shares. They have sold a portion of the Company's holding, the sale of which will give this Company a large amount of additional working capital. But as, owing to the slow development of the tramway already referred to, the value of the shares has proved to be less than was anticipated when the tramway company was incorporated, your Directors propose next year to apply the amount now standing at the credit of General Reserve Fund in writing down the value of the shares which they hold in this undertaking. This step has already been foreshadowed to you, and the financial advantages to be gained from the whole re-arrangement will fully justify what has been done and what is contemplated. I now move the adoption of the report and accounts.

Sir HENRY C. MANCE, C.I.E., LL.D., seconded the motion.

A discussion followed, and

The CHAIRMAN, in reply, said that the various remarks had all turned on the question of competition. In a trade like theirs, where anyone could start fresh business, and where competition could not be shut out by trusts or other similar arrangements, the chances were that if they tried by artificial means to rig up prices, they would only bring fresh competitors into the field. At the same time the Board were perfectly ready to consider any fair scheme of co-operation, and attempts had been made in that direction, in which they themselves took a very active part, and they endeavoured to obtain standard prices and specific rates in competition. Two of the leading firms positively refused to come in, and it was felt that without the co-operation of, at any rate, all the leading firms, it was impracticable to go on. But there was still in existence a somewhat loose association of electrical manufacturing companies, and it was always possible—and the directors would welcome it—that a closer union might be formed so as to maintain prices in that way. As to the price of the Company's shares, mentioned by one shareholder, if anyone wished to buy them they could not be obtained at that price. The dividend on the shares held by the Company in other companies had been very much more than 3½ per cent. Other great companies had shown no profit at all, but that was the first year in which the Electric Construction Co. had not shown a profit. Without wishing to be too sanguine, he recommended the shareholders to wait for the next year's balance sheet, and, as he had intimated before, he trusted that it would be a pleasant surprise to them.

The resolution was then carried.

The retiring directors and auditors having been re-elected, a vote of thanks to the chairman and directors terminated the proceedings.

Chili Telephone Co. (Ltd.)

The eighteenth ordinary general meeting was held yesterday, Mr. GEORGE KEITH presiding.

The SECRETARY (Mr. Edmund Petley) read the notice convening the meeting, and also the report of the auditor.

The CHAIRMAN said: Gentlemen, I am glad to be able to submit a favourable statement of accounts for the 12 months under review. It has been a very exceptional year and one of great difficulty for the Company's business. The terrible earthquake disaster which took place on the evening of August 16 last caused great loss of life and property in the central portion of Chili, especially near the coast. Valparaiso, Chili's principal port, and other smaller towns were laid in ruins and our offices and plant were complete wrecked. The whole of our subscribers in Valparaiso and district were disconnected. Santiago, the capital, also suffered very severely and most of the public buildings were seriously damaged and rendered unsafe, but, fortunately, our plant there escaped with comparatively small injury. Mr. Johnston, our general superintendent and manager, lost no time in taking steps to meet the unprecedented position. All communication with Valparaiso being interrupted, he proceeded there on horseback. On the way he made arrangements for the restoration of the trunk line communication. On his arrival at Valparaiso he found everything in confusion and that seven of our employés had been killed in trying to escape from the central building, while others were missing. He immediately took steps to relieve the distress and to re-establish communication. A wooden shed to serve as a temporary exchange was put up by permission of the authorities in the street in front of the wrecked building and a department opened to provide food for the employés. Amongst the generous assistance otherwise given to them it is with much satisfaction I mention the spontaneous contribution made by the staff and employés of the United River Plate Telephone Co. in

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the Argentine. Within a fortnight of the disaster telephone communication was again established with Santiago to the great convenience and satisfaction of the Government and authorities, and a commencement was made to join up those subscribers who had been able to establish themselves in temporary premises. After some months the central building was repaired and the exchange re-established in it. The other smaller offices which had been wrecked were also restored and before the close of our financial year on March 31 a large portion of the subscribers who had been cut off by the disaster were re-connected and the business resumed its normal condition of working. Business generally throughout the country has been active and prosperous. The diminished number of subscribers at Valparaiso has in a measure been covered by the increase at the other centres, which has reduced the aggregate loss for the year to 155 subscribers. The Company's property at these centres has also been extended to meet the growing requirements for telephone communication and the cost amounting to £4,011 has been carried to the capital account The increase shown in the currency revenue has been due partly to increase of business at the centres unaffected by the disaster and partly to the higher rates charged in order to cover the heavy fall in the value of the currency and the great rise in wages and cost of materials of every description. This as well as the exceptional re-construction work at Valparaiso has largely increased the year's expenditure and the net profit in Chili comes out at £30,414, showing a decrease for the year entirely due to the disaster of £7,021. The total income including interest on investments and transfer fees amounts to £31,252, and after meeting the London expenses and charges and adding the amount brought forward from last year's account there remains a credit balance for the year of £29,892. An interim dividend of £6,600 was paid in January and £9,564 has been put to the reserve. The Directors now propose a final dividend of £11,000. making a total distribution for the year of 8 per cent. on the shares free of income tax, the same as for the previous year, and leaving a balance of £2,727 to be carried forward to next year's account. Under the circumstances, I think I may congratulate the shareholders on the outcome of the year's business. Its recovery from the set-back caused by the earthquake disaster has been, to say the least of it, most remarkable, and was in a great measure due to the assistance rendered by our legal representative, Mr. Huneeus, who was at the time Minister of Foreign Affairs, and to Mr. Johnston's energy and ability in meeting one of the most difficult positions which could have arisen. To both these gentlemen I take the opportunity of recording our appreciation and grateful thanks, as also to the staff and employés for the loyal services they have rendered to the Company under such trying circumstances. Our business during the present year, as far as it has gone, continues to make satisfactory progress. The rebuilding of Valparaiso has been commenced on an improved plan, and, though the work will necessarily be slow, there is no doubt that when it is rebuilt it will be a finer and more prosperous city than it was before the disaster. I now move the adoption of the report and accounts.

Mr. FRANK W. JONES seconded the motion.

Dr. J. R. LEESON, speaking as an old shareholder, said that he wished to express his satisfaction with the report. It spoke volumes for the excellent way in which the business had been managed, and he believed that he was voicing the feelings of his brother shareholders when he said that he was extremely grateful to the Directors for the way in which they had conducted the Company's affairs through such a time of trial.

The resolution was carried unanimously.

Resolutions were then passed approving the dividend, re-electing the retiring director (Mr. F. W. Jones) and the auditor (Mr. T. A. Welton), and a very cordial vote of thanks to the chairman and directors terminated the proceedings.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The report of the directors states that the total receipts from Jan. 1 to June 30 (including £1,146. 13s. 8d. brought forward) amounted to £203,906. 1s. 11d. The traffic receipts show an increase of £2,200, compared with the corresponding half-year of 1906. Working expenses amounted to £74.763. 2s. 8d., a decrease of £5,461. 4s. Quarterly interim dividends of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred stock were paid May 1 (absorbing £52,500) and second quarterly interim dividends of like amount on both stocks will be paid on Aug. 1. The balance (£24,142. 19s. 3d.) will be carried forward.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—An extraordinary meeting will be held on 26th inst. to consider the scheme for the amalgamation of the company with the Buenos Ayres and Belgrano Co., &c. The company proposes to create £3,400,000 new ordinary shares, in addition to the £1,600,000 required for the Buenos Ayres and Belgrano purchase, and the directors ask for authority to devote the whole or any part of these to the purchase of shares in other local tramway undertakings.

BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—The report of the directors for the year ended Dec. 31, 1906, states that the capital expenditure at that date amounted to £1,229,349. 11s. 5d. Gross receipts amounted to £102,192. 8s. 4d. Deducting all expenses chargeable to revenue, including repairs and maintenance, there remains £41,900. Interest absorbed £28,056. 15s. 11d., and the balance of £13,843. 4s. 1d., added to £3,163. 2s. 2d. brought forward, leaves a total available of £17,006. 6s. 3d. Cumulative preference dividend absorbs £15,642. 14s. 9d., leaving £1,363. 11s. 6d., which is carried forward.

Tramways.—Considerable progress has been made with the electrification of the tramways. The lines at Dec. 31 worked by horses consisted of 17·37 route miles, and 3·43 miles of the authorised extensions are being undertaken. Of the reconstructed lines, 4·39 miles were working electrically on July 8. A further 3·24 and 2·73 miles of extensions will, it is anticipated, be opened during the month. The receipts per car-mile from May 7 to June 7 earned by the electric cars averaged 13·85d., compared with 8·31d. with horses.

Electricity Supply.—This section of the business is developing satisfactorily and many important installations have been completed. The installations connected to the mains since June, 1906, represent an equivalent of 42,560 8 c.p. lamps, making 68,748 equivalent 8 c.p. lamp connections at June 14, 1907.

The progress made with the electric lighting and power supply branch of the undertaking has, in the opinion of the directors, been very satisfactory, and with the benefit of the tramway load there is every indication that this branch of the business will shortly make an important contribution to the company's profits. The number of passengers carried on the company's lines (17·37 route miles) was 24,863,228, and the proportion of expenses to traffic receipts was 56 per cent.

BUENOS AYRES GRAND NATIONAL TRAMWAYS CO. (LTD.)—The report of the directors for the year ended March 31 last shows the gross receipts of the lines (the lines of this company and of the Buenos Ayres New Tramways Co., Ltd.) amounted to £321,256. 9s, compared with £252,956. 18s. 5d. for the previous year. Working expenses amounted to £220,389. 8s. 4d., compared with £192,893. 5s. 9d. Net receipts were £100,867. 0s. 8d., compared with £59,703. 12s. 8d. The G.N. Co.'s share of the above net receipts under the agreement amounted to £68,405. 14s. 4d., compared with £45,556. 14s. 1d. After payment of London expenses, debenture interest, &c., there remained £27,230. 4s. 1d., from which £900 has been transferred to debenture reserve and £3,726. 3s. to income bondholders' interest, and there was paid on Feb. 15 £9,000 as interim dividend of 2 per cent. on the 5 per cent. cumulative preference shares, leaving £13,604. 1s. 1d. The directors recommend £13,500 should be appropriated to a further 3 per cent. on these shares (making 5 per cent. for the year) and £104. 1s. 1d. to the contingency fund, which will then stand at £6,955. 11s. 7d. Since the last meeting further progress has been made with the work of converting for electric operation the joint system, and at June 30, 1907, there had been converted a total length of 75¾ miles.

CITY OF LONDON ELECTRIC LIGHTING CO. (LTD.)—The interim report for the past half-year states that at June 26 there were 12,233 consumers, representing 9,469,868 c.p. lamps connected, against 12,295 consumers and 900,278 8 c.p. at Dec. 31 last, and 11,960 consumers and 818,955 8 c.p. at Dec. 31, 1905. In addition to the lamps connected there were (on June 26) 45,991 awaiting connection on completion of consumers' wiring, delivery of motors, &c., compared with 30,014 at June 27, 1906. For the half-year the gross revenue from sale of electricity, and meter rentals (but excluding sundry receipts) was £135,776, an increase of £7,253; and the net revenue (including sundry receipts) was £60,331, which, with £20,621 brought forward, makes the total available £80,952. The lamps connected to the company's mains show a net increase of 46,708 during the six months, chiefly due to the additional connections for motive power. The gross and net revenue are larger than for the same period in any previous year. This result is mainly attributable to the increase in the number of units sold, especially for power, the total sale having been 11,856,427 units for the half-year, compared with 11,143,662 for the corresponding period of 1906. The 1906 figures included 662,210 units given as a temporary supply to L.C.C. tramways, which supply ceased in May of that year. The directors have declared the following dividends on account of the distribution for 1907: 6s. per share on the preference and 5s. per share on the ordinary shares.

CITY & SOUTH LONDON RAILWAY CO.—The accounts for the half-year ended June 30 show a balance, after providing for debenture stock interest, payment of the 5 per cent. preference dividend and the transfer to renewal fund of £1,500, sufficient for a dividend on the consolidated ordinary stock at the rate of 2½ per cent. per annum, carrying forward £1,857. This compares with 2½ per cent. for the corresponding period of last year, carrying forward £1,870.

CONSOLIDATED ELECTRICAL CO. (LTD.)—At the meeting on Tuesday the chairman (Mr. H. Allen) said their income had increased to £7,532 from £3,581 in the previous year. Their general charges were £1,604, a reduction of £307. Having dealt with the company's interest in the Consolidated Supply Co., the Private Wire & Telephone Installation Co., and the Anglo-Portuguese Telephone Co., and the prospects of these concerns, the report was adopted.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The balance of estimated net revenue for the half-year to June 30, after providing for debenture interest, establishment and standing charges, shows an increase of £8,004 compared with the same period last year. The directors have declared an interim dividend on the 6 per cent. preference shares (less tax) for the half-year and an interim dividend on the ordinary shares at the rate of 4 per cent. (less tax), both payable Aug. 1.

CROMPTON & CO. (LTD.)—The directors' report for the year to March 31 states that the company's works at Chelmsford have been fully occupied, and it has been found necessary to make still further extensions to the shops to deal with the increasing business. The improved results of the works referred to in last year's report have been more than maintained, and, notwithstanding the increased cost of raw material, the selling and contracting departments of the company have succeeded in earning satisfactory profits. The net profit for the year amounts to £38,290. 19s. 6d., compared with £20,060. 6s. 4d. in the preceding year. From this has been deducted £6,572. 6s. 9d., as loss on stock which, owing to the introduction of improved designs, it has been thought advisable to sell or scrap. After providing for debenture interest, &c., there is, with the sum brought forward, an available balance of £30,164. 16s. 9d. The directors propose to declare a dividend at the rate of 5 per cent. for the year, to provide £1,500 for doubtful debts and contingencies, to place £10,712. 6s. 3d. to reserve (bringing that account to £20,000) and to carry £5,840 forward.

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Although the accounts of the Electric Supply Corpn. for the last financial year are not yet published, the directors have reason to believe the undertakings of the Corporation are making steady progress. £8,950 has been invested during the year in shares of the guaranteeing company, being the estimated amount required for the year's dividend on the shares of the Electric Supply Corpn. The amounts so invested are repayable out of future profits of the corporation. The directors are of opinion that the amount proposed to be placed to reserve out of the year's profits is sufficient to provide for any possible depreciation of the investments.

In view of the activity of the company's business, and particularly of the importance of some of the contracts in hand, the directors will ask the shareholders to increase their borrowing powers from the present limit of £150,000 (in which is included the debenture issue of £100,000) to £200,000. The orders and contracts already secured are of such volume that satisfactory results for the current year may be anticipated.

DIRECT UNITED STATES CABLE CO. (LTD.)—The report of the directors for the six months ended June 30 states that the half-year's revenue, after deducting out-payments, amounted to £57,055. 19s., compared with £56,264. 19s. 5d. for the corresponding period of 1906. The working and other expenses (including income tax) amounted to £24,699. 2s. 6d. (against £23,924. 8s. 9d.), leaving £32,356. 16s. 6d. as the net profit, making, with £17,031. 15s. 1d. brought forward £49,388. 11s. 7d. Three quarterly interim dividends of 4s. each per share, amounting to £36,426, have been declared and paid during the financial year, and a final dividend of 4s. per share is now proposed, together with a bonus of 2s. 6d. per share, making 4⅝ per cent. for the year, representing a total distribution of £56,156. 15s. After transferring £15,000 to reserve, the balance (£2,515. 1⁰s. 7d.) is to be carried forward. The reserve fund has been debited with £4,184. cost of cable maintenance, and £40,000 provision on account of market depreciation of securities, and after being credited with interest on investments, profit on sale of securities, and amount transferred from revenue, the balance now amounts to £491,968. 9s. 9d.

NATIONAL TELEPHONE CO. (LTD.)—The report of the directors for the half-year ended June 30 last states that the income accrued in respect of the company's business of the half-year amounted to £1,314,790. 14s., compared with £1,195,151. 11s. 9d. for the corresponding period of 1906, an increase of £119,639. 2s. 3d. Working expenses amounted to £753,207. 11s. 3d., compared with £691,737. 14s. 6d., an increase of £61,469. 16s. 9d. The net result (after deducting the Post Office royalties, £125,311. 15s.) is a profit balance of £436,271. 7s. 9d., compared with £390,065. 13s. 3d., an increase of £46,205. 14s. 6d. Rentals carried forward for unexpired terms of running contracts amount to £1,210,117 0s.6d., compared with £1,106,639. 3s. 5d., an increase of £103,477. 17s. 1d. Out of the available balance of £331,978. 19s. 3d. shown the board will recommend to the shareholders on Tuesday next payment for the half-year of a dividend at the rate of 6 per cent. per annum on the first and second preference shares, 5 per cent. per annum on the third preference shares, 6 per cent. per annum on the preferred stock, and 6 per cent. per annum on the deferred stock and new shares (less tax in all cases). It is proposed to transfer £130,000 to reserve, and to carry forward £9,661. 17s. 1d.

£583,757. 15s. was expended on capital account during the half-year in the erection of 20,967 additional exchange and private stations, and in the construction of underground works.

The lamented death of the general manager, Mr. W. E. L. Gaine, has deprived the company of an officer whose conspicuous ability and devoted service have been of the highest value. The duties of general manager will in future be discharged by a managing director, and at the unanimous request of his colleagues, Mr. George Franklin has consented to accept that position in addition to his office of president. The board have elected the Right Hon. Lord Balfour of Burleigh as a director to fill the vacancy caused by the death of the Right Hon. Sir James Fergusson, Bart.

SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)—The directors' report to May 31 (with accounts from Shanghai to end of April) states that the expenditure shown in the balance-sheet covers a period of nearly 18 months. It is probable that the whole of the undertaking will be ready by Oct. 10, the date fixed by the tramway concession. It is proposed to split each of the existing shares of £1,000 each into 100 shares of £10 each.

SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.—The directors in their report for 1906 state that the undertaking has since June 1, 1906, been carried on by an arrangement with the consumers, under which they have paid prices for current supplied which have enabled the works to be kept going without loss. Every effort has been made to raise the further capital required to enable the company to complete the part of the undertaking then in hand, and to supply power to various collieries with which agreements had been made, and to others with which negotiations were in progress. Certain financial firms, largely interested in the company, were prepared, under the advice of the most experienced experts, to find the £500,000 thought necessary to put the undertaking on a sound footing if 40,000 H.P. could be guaranteed under contracts for 15 years. After long negotiations with consumers, this was found to be impossible, and since then other schemes have been put forward in the interests of the shareholders, who will be asked to approve certain proposals at the extraordinary meeting to be held at the close of the ordinary meeting on the 27th inst. The retiring directors (Messrs. W. S. B. McLaren, T. H. Weguelin and W. W. Hood) do not seek re-election, and the other directors (Lieut.-Gen. Sir Richard Heiram Sankey, K.C.B., R.E., Mr. H. Watts and Mr. H. Ruffer) have sent in their resignations. The chairman will resign at the meeting. It will, therefore, be necessary for the shareholders to appoint new directors and the names of the following gentlemen will be submitted: W. F. Brown, Cardiff mining engineer; J. W. Hutchinson, Glamorgan, colliery agent; Wm. Cope, Glamorgan, barrister-at-law; W. G. Dalziel, Newport, Mon., colliery proprietor; R. Thomas, Glamorgan, tinplate manufacturer; T. Griffiths, Glamorgan, colliery agent; W. L. Madgen, London; G. T. Hutchinson, London; and T. O. Callender, London.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—The report of the directors for the year to March 31, states that the gross receipts in sterling in the River Plate were £216,204. 4s. 4d., against £181,085. 6s. 1d. for last year. Deducting debenture interest, preference dividend and interim dividend on ordinary shares, and adding interest, transfer fees, &c., there is a profit of £61,993. 9s. 4d. added to £2,076. 10s. 9d. brought forward, making £64,070. 0s. 1d. After putting £25,000 to renewal of plant and transferring £10,000 to reserve, the directors recommend a final dividend of 5 per cent. on the ordinary shares, making 8 per cent. for the year, tax free. £4,070 is carried forward. The directors have availed themselves of their powers for increasing the debenture capital granted in November last. This has necessitated the redemption of the 5 per cent. debenture stock, which was paid off on July 1. The company continues to make satisfactory progress, and the directors consider the outlook favourable. The board take pleasure in announcing the appointment of Sir John Gavey, C.B., as a director of the company.

NEW COMPANIES, MORTGAGES AND CHARGES.

NEW COMPANIES.

WESTERN ELECTRIC CO. (AUSTRALIA) (LTD.) (94,135.) Registered July 11, capital £2,000 in £1 shares, to carry on in Australia or elsewhere the business of dealers in telephones, telephonic, telegraphic and electric lighting apparatus, instruments and machinery, electric cables and wires, &c. Reg. office, 171, Queen Victoria-street, London, E.C.

MORTGAGES AND CHARGES.

ST. AUSTELL & DISTRICT ELECTRIC LIGHTING & POWER CO. (LTD.)—Particulars of £2,000, second debentures, created June 21, 1907, charged on company's undertaking and property (present and future), including uncalled capital, subject to £2,000. first debentures, have been filed pursuant to sec. 14 (4) of the Companies Act, 1900. No trustees.

D. SANTONI & CO. (1906) (LTD.)—Issue on July 5 of £330 6 per cent. debentures, part of series created May 31, 1907, to secure £2,750, charged on company's undertaking and property (present and future), including uncalled capital. No trustees. Previously issued of same series, £2,090.

UXBRIDGE & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—Issue on July 1 of £1,000 6 per cent. second debentures, part of series, to secure £15,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £14,000.

WHITE JACOBY & CO. (LTD.)—Re-issue on June 29 of £300 5½ per cent. debentures, part of series created May 31, 1897, to secure £1,500, charged on company's property (present and future), including uncalled capital. No trustees. Previously issued of same series, £1,500.

CITY NOTES.

MEMORANDA (July 18).—Bank rate 4 per cent. (since April 25, 1907), Price of silver 31⅜d. per oz. Consols 84 1/16—84 3/16 for money, 84⅛—84¼ for account; 2½ per cent. annuities 82¼—82¾. Consols Pay Day, Aug. 1; Stocks and Shares Continuation Days, July 29 and Aug. 13; Ticket Days, July 30 and Aug. 14; Pay Days, July 31 and Aug. 15; Mining Share Carry-over Day, July 26.

CANADIAN GENERAL ELECTRIC CO.—The directors are seeking powers to increase the capital by $3,000,000, of which $1,000,000 is to be common and $2,000,000 preferred stock.

COUNTY OF LONDON ELECTRIC SUPPLY CO. (LTD.)—The transfer books are closed from July 18 to 31 inclusive, preparatory to payment of interim dividend on the preference and ordinary shares for the half-year to June 30.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—The interest on this company's 4 per cent. mortgage debenture stock for the half-year ending 31st inst. will be paid by warrant on Aug. 1. The register will be closed from 27th to 31st inst., both days inclusive.

HOBART ELECTRIC TRAMWAY CO. (LTD.)—A dividend has been declared of 1s. per share (tax free), payable 31st inst.

KENSINGTON & KNIGHTSBRIDGE ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend of 5 per cent. on the ordinary shares for the half year ended 31st June.

METROPOLITAN RAILWAY CO.—A dividend is recommended on the ordinary stock for the past half-year at the rate of ½ per cent. (carrying forward about £3,000), against 1½ per cent. last year.

NOTTING HILL ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend of 3 per cent.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have granted a quotation to a further issue of £11,000 5 per cent. debenture stock of the *Madras Electric Tramways (1904) (Ltd.)*

TELEGRAPH CONSTRUCTION & MAINTENANCE CO. (LTD.)—The transfer books of this company are closed from 15th to 23rd inst., both days inclusive, preparatory to the payment of an interim dividend of 12s. per share.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 10	1,485	- 130	6	8,415	- 290
Airdrie	,, 5	231	+ 3	26	5,856	- 8
Anglo-Argentine	,, 15	16,687	+ 2,260	28	461,427	+ 46,576
Ashton-under-Lyne Corp	,, 13	383	+ 23	16	6,221	+ 607
Ayr Corporation	...	...	...	...	...	...
Baker St. & Waterloo Ry.	,, 13	2,595	+ 1,155	2	5,380	+ 2,494
Barnsley	,, 5	158	- 4	26	4,275	- 17
Barrow	,, 5	298	- 10	26	6,235	- 98
Bath Electric Trams, Ltd.	,, 10	865	- 140	28	20,839	- 319
Birkenhead Corporation	,, 14	1,163	+ 110	2	2,243	+ 88
Birmingham Corporation	,, 13	6,085	...	15	89,378	...
Birmingham & Mid.	June 28	834	...	25	19,812	...
Blackburn Corporation	July 10	1,084	- 32	§15	16,041	+ 535
Blackpool Corporation	,, 11	1,549	+ 17	14	14,077	- 1,548
Blackpool and Fleetwood	,, 13	943	+ 5	2	1,828	- 60
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 14	2,286	+ 45	15	33,864	+ 943
Bournemouth Corporation	,, 10	1,773	+ 55	¶14	23,947	- 155
Bradford Corporation	,, 13	4,644	- 134	15	69,391	- 471
Brighton Corporation	,, 14	998	- 31	15	13,388	- 1,359
Bristol Trams & Carriage	,, 12	5,459	- 343	22	108,724	- 5,110
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 13	1,166	- 225	15	17,076	- 228
Burton Corporation	,, 14	295	- 13	15	4,290	- 315
Bury Corporation	,, 7	1,134	...	15	16,321	...
	,, 14	1,159	...			
Calcutta Tramways Co.	,, 13	R47,106	+ R2,847	1	R47,106	+ R2,847
Camborne-Redruth	,, 13	131	+ 12	28	3,273	+ 28
Cardiff Corporation	,, 6	2,153	- 71	14	29,066	- 121
Cavehill	,, 5	110	+ 5	26	1,996	- 58
Central London Railway	,, 13	5,653	- 243	2	11,489	- 538
Charing C., Euston & H'stead	,, 13	2,685	...	2	5,345	...
Chatham & Dist. Lt. Rys.	,, 11	793	+ 37	2	19,060	+ 1,543
City & South London Rly.	,, 14	3,176	+ 717	2	6,436	+ 1,507
City of Birmingham	,, 5	2,862	...	26	72,627	...
Colchester Corporation	,, 10	219	- 41	2	437	- 48
Cork Electric Trams Co.	,, 11	554	- 25	28	12,456	- 436
Croydon Corporation	,, 12	1,506	- 82	15	21,374	- 1,532
Devonport & Dist. Trams	,, 5	466	- 65	26	11,700	+ 56
Dover Corporation	,, 13	319	- 8	15	3,422	- 436
Dublin & Lucan Railway	,, 12	144	+ 11	2	220	- 11
Dublin United	,, 12	7,768	+ 2,189	‡2	12,139	+ 2,907
Dudley Stourbridge	,, 5	833	- 71	26	21,653	- 464
Dundee Corporation	,, 10	1,131	- 6	8	9,058	+ 239
East Ham Council	,, 13	965	- 4	15	13,733	- 450
Exeter Corporation	,, 12	335	+ 33	15	4,716	+ 376
Falkirk and District	,, 10	244	...	2	547	...
Gateshead & Dist. Trams	,, 5	975	+ 50	26	26,123	+ 908
Glasgow Corporation	,, 13	17,490	+ 532	6	109,605	- 12,206
Glossop	,, 13	138	- 2	28	3,770	+ 43
Gravesend—Northfleet	,, 5	260	- 57	26	6,086	- 18
Great Northern & City Rly.	,, 13	1,708	+ 28	2	3,456	+ 60
Gt. Northern, Piccadilly, &c.	,, 13	4,405	...	2	8,845	...
Greenock & Port Glasgow	,, 5	839	- 75	26	17,112	- 192
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 5	340	- 25	26	7 078	- 423
Hastings Elec. Trams Co.	,, 11	174	+ 300	2	1,211	+ 561
Hong Kong	,, 13	$7,791	+ $610	15	$215,692	...
Huddersfield	,, 13	1,605	+ 84	14	23,728	+ 733
Hull Corporation	,, 13	2,380	+ 9	15	35,719	+ 1,588
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 10	143	+ 1	15	2,115	+ 141
Ipswich Corporation	,, 13	454	- 25	15	5,978	- 511
Isle of Thanet Co.	,, 13	994	- 130	41	15,671	- 323
Jarrow	,, 5	139	...	26	3,116	...
Keighley Corporation	,, 11	161	- 9	2	242	- 4
Kidderminster & District	,, 5	135	- 20	26	2,818	- 113
Kilmarnock Corporation	,, 13	160	- 5	8	1,306	- 1
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 11	1,251	+ 377	28	30,992	+ 6,895
Lancashire United	,, 10	1,317	+ 180	28	33,361	+ 8,870
Leamington	,, 5	173	- 221	26	3,909	- 586
Leeds Corporation	,, 13	6,500	- 12	15	97,670	- 3,125
Leicester Corporation	,, 13	2,213	- 120	2	4,404	- 252
Leith Corporation	,, 13	645	+ 61	19	4,675	- 13
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 14	1,606	+ 51	2	3,217	+ 19
Liverpool Corporation	,, 6	11,142	- 296	27	287,352	+ 3,390
*London County Council	,, 6	32,210	+ 4 982	14	433,607	+ 63,886
London United	,, 12	7,857	+ 317	‡28	169,250	+ 2,729
Maidstone Corporation	,, 13	114	- 9	15	1,597	- 109
Manchester Corporation	,, 13	15 309	+ 755	15	219,415	+ 16,757
Mersey Railway	,, 13	1,964	+ 315	2	3,871	+ 591
Merthyr	,, 5	216	+ 9	26	5,902	+ 274
Metropolitan Dist. Railway	,, 14	8,125	+ 23	2	16,339	+ 127
Metropolitan Elec. Trams	,, 5	4 819	+ 969	26	113,442	+ 28,815
Middleton	,, 5	365	- 51	26	8,937	- 167
Nelson Corporation	,, 13	117	- 8	16	2,292	- 7
Newcastle-on-Tyne Corp.	,, 13	4,061	- 1,169	15	63,019	+ 282
Newport (Mon.)	,, 13	661	+ 17	15	10,947	+ 1,423
Northampton Corporation	,, 12	436	- 40	‡15	6,436	- 316
Oldham, Ashton & Hyde	,, 5	586	- 13	26	15,519	+ 745
Oldham Corporation	,, 14	1,957	+ 144	16	30,636	+ 1,997
Perth (N.B.) Corporation	,, 10	177	- 4	8	1,323	+ 16
Perth (W.A.) Elec. Trams	,, 12	1,291	- 95	28	40,181	- 1,362
Peterborough	,, 5	132	- 21	26	3,021	- 96
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 13	2,269	- 196	15	29,289	- 1,300
Potteries	,, 5	2,065	+ 13	26	48,998	+ 1,199
Preston Corporation	,, 3	777	- 12	15	11,346	+ 113
	,, 10	799	- 23			
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 11	600	+ 100	‡15	8,660	+ 1,289
Rothesay	,, 5	392	- 90	26	3,401	- 415
Salford Corporation	,, 15	4,839	+ 271	15	71,022	+ 1,213
Sheerness	,, 3	73	+ 4	26	1,405	- 24
Sheffield Corporation	,, 14	5,536	+ 321	16	85,091	+ 3,632
Singapore Trams	,, 13	$9,282	+ $2,381	15	$144,523	+ $27,087

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	July 10	448	- 76	15	5,318	- 345
South Metropolitan	,, 5	848	+ 379	26	19,418	+ 1,764
Southport Tramways	,, 5	363	- 20	26	7,100	- 499
South Staffs	,, 5	874	+ 25	26	23,190	+ 1,677
Stalyb'dge, Hyde, &c., Jt. Bd	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 14	1,519	- 78	15	21,307	- 164
Sunderland and District	,, 10	483	- 16	28	12,027	+ 1,477
Swansea Trams	,, 5	732	- 71	26	21,689	+ 480
Taunton	,, 5	47	+ 1	26	1,076	- 80
Tynemouth and District	,, 5	327	- 4	26	5,297	- 737
Tyneside Trams Co.	,, 13	414	- 80	28	12,722	+ 555
Victoria, Elec. Supply Co. of	...	...	...	...	...	...
Wallasey District Council	,, 13	910	+ 10	15	12,453	+ 165
Walsall Corporation	,, 13	541	+ 7	28	13,069	- 492
Warrington Corporation	,, 4	438	+ 23	15	5,619	+ 214
	,, 11	382	+ 20			
West Ham Corporation	,, 11	2,390	- 8	15	35,631	+ 930
Weston-super-Mare	,, 3	200	- 52	26	2,098	+ 294
Wolverhampton Co.	,, 5	466	+ 25	26	11,539	+ 449
Wolverhampton Corpn.	,, 10	907	- 23	25	12,250	...
*Worcester	,, 5	323	- 26	26	6,891	- 191
Wrexham	,, 5	100	- 2	26	2,592	- 36
Yorkshire W.R. Trams	,, 14	1,221	+ 429	28	31,226	...
Yorkshire Woollen District	,, 5	920	- 27	26	24,720	+ 17

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., July 17.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to July 17. High-est.	Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	Anglo-Argentine Ord. Shares	8⅛—8⅜	4 12 9	Ap, Oct	8⅛	8⅜
5	2/9	Do. 5½ per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	6 1/16	6 1/16
St.	6%	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	103½	103
5	2/0	Brisbane Electric Trams, Invest. Ord.	2 15/16—3 1/16	3 2 6	May ..	3⅛	3 1/32
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	My, Nv	..	..
St	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	123 —124	5 8 6	Mr, Spt	127½	126
St.	7%	Do. Pref. Ord. Stock	108 —112	4 8 9	My, Nv	111	110
St.	5%	† Do. 5% Cum. Perp. Pref. Stock	101 —104	4 16 0	Ja, Jul	102½	..
4	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	102¼	..
100	4½%	† Do. Vancouver Power Debs.	101 —103	4 7 3	Ja, Jul	1 4½	..
£	3/0	Buenos Ayres & Belgrano Ord.	4⅛ - 4⅜	8 11 9	Ap, Oct	4 3/16	4 1/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4¾—5⅛	5 14 0	Ap, Oct	..	..
5	3/0	Do. "B"	4¾—5⅛	5 14 0	April ..	4⅞	4 13/16
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	93 —98	5 2 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	99 —101	5 7 0	Ja, Jul	4 1/16	4½
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	100 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7¼—7⅜	5 3 0	Mr, Spt	7⅜	7¼
100	2/6	Do. 5 per Cent. Cum. Pref.	5¼—5½	4 7 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —105	4 5 0	Ja, Jul	1 1/32	102½
St.	.	Cape Electric Tram Shares	5 1/16—7	.. .. ..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —98	5 2 0	My, Nv	..	..
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 —87	5 15 0	Fb, Aug	8½	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 - 82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 1/16—1 1/8	3 15 0	July ..	..	..
100	6 7½	Do. 6 per Cent. Cum. Pref.	1 1/16—1 1/8	4 10 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb	95 - 98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb Stk.	96 —99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	104¾	..
St.	4%	Perth E. Trams. 1st Mt. Db. Stock	100 - 104	4 13 0	Ja, Jul	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	117 - 121	3 6 0	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92⅞—94⅞	5 6 6	Ju, Dec	94	93½
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½ - 5½	5 14 0	Mr, Spt	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8⅜	5 15 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 - 97	4 12 9	Ja, Jul	96½	95½
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅞ 7⅜	5 3 3	Ap, Oct	..	..
		Do. (80,001 to 140,000)	6¼ - 7¼	.. ..	..	7	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 - 53	4 11 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2⅛ - 2⅜	.. ..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	8 ½—9⅛	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ 96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —1 6	5 13 0	Ja, Jul	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	3 - 3⅛	3 6 9	April .	3⅛	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	1 - 1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	96 —98	5 2 0	Ja, Jul	96½	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5⅛	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101⅝	4 19 0	Ja, Jul	1 3/4	19⅞

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 17.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 17. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord....	10 – 11	0 6 0	Mar, Sept,	10¾	–
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾ – 10¼	4 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1 ½ - 10¾	5 11 6	Feb, Aug	..	..
St.	4¼	Do. 4½ per Cent. Deb. Stock (red.) ...	99 – 100	4. 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4¾ - 5¼	5 5 0	April, Oct	..	..
St.	4¼	Do. Do. 1st Debs.	98 –100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞ - 8¼	5 14 6	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	7⅛ – ⅞	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	19 - 1 2	3 18 0	June, Dec	..	..
5	2/6	Charing Cross(W.End & City)El.Sup.Co.	3¼ 4	6 5 0	Feb, Aug	4	3⅞
5	2/3	Do 4½ per Cent. Pref.	4 – 4¼	5 0 0	Feb, Aug	4⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 - 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜ - 4⅜	5 9 6	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3¼ - 4¼	5 6 0	March ..	..	..
St.	4¼	* Do. 4½ per Cent. Deb. Stock (red.) ...	102 – 105	4 5 9	June, Dec	..	..
10	5/0	†City of London Electric Lighting Ord..	9 – 9¼	6 6 0	Feb, Aug	9⅛	9
10	6/0	† Do. 6 per Cent. Cum. Pref.	11 – 12	5 0 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	120 –123	4 1 3	June, Dec	..	..
St.	4¼%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	95 – 98	4 12 0	Jan, July	98½	..
5	5%	County of Durham Elec. P.D. Ord.....	3¾ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 4⅞	5 4 11	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	7⅜	7⅛
10	6 0	Do. 6 per Cent. Cum. Pref.....	10¾ – 11½	5 4 0	Mar, Sept	11⅛	11¼
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)....	1 6 – 109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	93 – 96	4 13 9	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord	4¾ – 5⅛	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	99 – 101	4 9 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅞ 7¼	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¾ - 9¼	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6¼ - 7	4 5 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 - 99	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	101 103	3 17 9	April, Oct	..	..
3	2/4⅔	London Electric Supply Ord.	1⅜ 2⅜	5 12 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4⅛—4¾	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 - 96	4 8 8	Jan, July	..	..
5	4/0	Metropolitan Electric Sup. Ord.	5⅜ 6¼	6 8 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ - 5⅛	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 –107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	88 - 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp.for P.D.1stMort.Db.	95 –18%	4 11 9	June, Dec	97	96¾
10	5%	Newcastle & Dist.Elec.Ltg.Ord.(£9 paid)	9¼—9⅜	4 15 0	Feb, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	93 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6¾—7	5 16 4	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞ - 5⅜	4 15 3	Feb, Aug	..	..
100	4%	† Do. 4 per Cent, Mort. Deb. red. 1907.	97 – 18	4 2 10	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	–	..	Mar, Aug	..	..
100	4½%	† Do. 4½ per Cent. Deb.	97 –19	4 11 10	Jan, July	..	..
10	6/0	†Notting Hill Electric Ord.....	11¼–12¾	6 0 0	March ..	..	..
5	4/6	Oxford Electric Ord.	6¾ - 6¾	5 12 0	March ..	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock	95 - 97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord	8 – 8¼	5 17 6	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾ - 7¼	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86 - 91	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	⅜ - 1⅜	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	78 – 77	5 4 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	1⅞ - 2¼	7 7 0	April	2¼	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜ - ⅝	8 6 9	..	⅜	..
1	0/8⅓	Do. 7 per Cent. Cum. Pref.....	1⅜ - 1⅝	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 –103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1¾–2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 - 3	8 6 9	April, Oct	2⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 - 97	4 12 9	April, Oct	..	..
5	6/6	Westminster Elec. Sup. Ord.	9½ 10⅜	6 3 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	7⅛ 7⅝	4 0 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	†Baker St. & Waterloo 4% Perp. Db. St.	58 –63	4 6 0	Jan, July	90	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜– ⅞	5 14 0	April	⅜	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅝– ⅞	5 3 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 - 99	4 11 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 - 97	4 18 0	Jan, July	96	..
10	9½	Bristol Tramways & Carriage Ord.	14¼–14¾	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8½–9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 – 99	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2¾– 3⅛	..	June, Dec	2⅞	2⅝
10	6/0	Do. 6 per Cent. Cum. Pref.....	7⅜– 7⅞	7 17 0	Feb, Aug	7⅞	7½
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 103	4 17 0	April, Oct	103	1 03
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 –81	5 11 0	May, Nov	..	..
St.	4%	Central London Ordinary Stock..	78 – 75	5 6 9	Feb, Aug	74⅞	74¼
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	Feb, Aug	..	..
St.	4%	Do. Deferred Stock	53 – 56	7 2 8	Feb	56	..
100	4%	† Do. 4 per Cent. Debs.	103 – 105	3 16 0	Jan, July	..	..
St.	4%	Charing X.Euston&Hmpstd Per.Db Stk.	81 –84	4 15 3	Jan, July	82½	..
5	2/6	City of Birmingham Trams. 5% Cm.Pref.	4½– 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	58 –101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	49 – 51	3 18 0	Feb, Aug	50½	4 ½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 –121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 –118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 –118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent, Perpetual Debs.	1 2 –105	3 16 0	May, Nov	104	103⅝
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13¾– 14¼	4 2 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	13 – 14	4 5 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2 – 2⅛	..	Feb, Aug	2⅛	2
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 1	Jan, July	82⅛	..
St.	4½%	Hastings & Dist. Elec.Trams.Co.4½% b.St	93 –101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	12 – 13	6 18 6	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	9⅛–11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 – 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1¼	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	93 –96	5 4 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅛–1⅜	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6¾ - 7¼	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 – 86	4 13 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	4¾– 5⅛	5 14 3	Jan, July	8⅞	8⅝
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 88	4 11 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 – 4	–	Feb, Aug.	2⅛	..
St.	..	Do. 8 per Cent. Perp Pref.	3 – 6	–	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅝– ¾	–	April....	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝– ¾	5 3 6	Feb, Aug	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	94 – 97	4 18 0	Jan, July	94½	94⅛
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜– 1⅝	..	May	..	..
10	8/0	Potteries Electric Traction Ord.	6¾ – 7⅛	7 2 9	April, Oct	..	..
10	5%	Do. 5 per Cent. Cum. Pref.	6 – 6⅞	6 13 3	Feb, Aug	6	..
St.	4½%	Do. 4½ per Cent. Deb Stock	95 – 98	4 11 9	May, Nov	96½	..
1	3·56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝– 1⅛	5 16 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db	84 –88	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	64 – 67	7 9 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1⅛	–	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅞– 3⅝	–	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	88 – 91	4 10 0	Jan, July	..	..

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 17.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 17. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅝– ⅝	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅞– ⅞	8 0 0	April, Oct	..	..
1	2/4⅓	Babcock & Wilcox Ord.....	3⅞– 4⅛	6 1 6	April, Oct	3⅞	3⅝
1	0/7½	Do. Pref.....	1 1/16– 1 1/16	3 16 9	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¾–7	7 3 0	July, Feb	6 15/16	..
5	8/0	Do. 6 per Cent. Pref.	5¾– 6¼	4 16 0	Jan, July	..	..
St.	4½	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 –104	4 6 6	Jan, July	103	102¾
5	4½	British Thoms'n-Houst'n 4½% 1st Mt.Db.	89 - 93	4 16 9	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1½	..	Feb, Aug	..	..
St.	4¼	Do. 4 per Cent. Mort. Deb. Stock	18 – 23	6 7 0	Jan, July	..	..
2	..	Brush Electrical Engineering	½– ⅝	–	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	¾– 1¼	4 16 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 –74	6 0 9	Jan, July	..	..
5	10.0	Callender's Cable Con. Ord.....	9¼– 10¼	7 2 6	Jan, July	10¼	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅝– 5⅞	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105⅛–107½	4 3 6	Nov, May	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 64,000).....	1⅞ - 2⅛	3 10 0	Jan, July	2 1/16	2
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	93⅛ – 96⅜	5 3 6	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝– 1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1¼	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	100 – 103	4 7 6	Jan, July	100	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1¾–1⅞	9 8 0	Feb, Aug	1¾	..
5	4/2	Do. (£5 paid)	2¼–2⅝	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 –92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½– 1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1 – 2	..	May, Nov	1½	..
St.	4½%	† Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	1/16– 1/8	..	Jan, July	1/8	..
2	2/9⅔	Do. 7 per Cent. Cum. Pref.	1¼– 1⅜	8 0 0	July	..	..
St.	..	† Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	82 – 86	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11½ - 12¾	6 0 0	Feb, Aug	12	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5½	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½–107½	4 3 6	Mar, Sept	105½	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	15 –16	6 5 0	Feb, Aug	15⅝	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April. Oct	98½	97
1	1/3⅓	Richardsons, Westgarth & Co., Ltd. Ord.	⅜– 1⅜	7 6 0	Nov	⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	¾–1⅛	5 16 0	May, Nov	1	..
St.	4½%	Jo. 4½ per Cent. Perp. Deb. Stock ...	95 – 98	4 11 9	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	32 – 33	5 9 6	Mar, July	33	31½
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	99 – 102	3 18 3	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅛– 2⅜	5 16 0	..	2⅜	2 1/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜– 1⅝	4 1 0	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	112 –115	4 7 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 –104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105 – 107	4 4 0	June, Dec	..	..
10	8/0	†J. G. White & Co. 6 per Cent. Cum. Prf. xd and bonus	9¼–9⅝	6 3 0	Jan, July	..	..
1	..	Willans & Robinson Ord.	1¼–1⅝	..	Apr, Oct	..	..
1	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3¼–3⅝	..	Apr, Oct	3½	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	77 – 81	4 18 6	May, Nov	76	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3½	–	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	86 – 89	5 12 0	June, Dec	..	..
St.	15/0	Anglo-American	63 –65	5 18 0	F,My,Ag,N	64½	64⅛
St.	30/0	Do. Preferred	109 –110	5 9 0	F,My,Ag,N	109⅝	109⅛
St.	1½	Do. Deferred	104 – 06	4 5 6	F,My,Ag,N	128	126
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 – 94	4 4 6	Jn,Ap,Jy,O	93⅝	93⅛
10	5/0	Cuba Submarine Ord.	7¼–8¼	6 1 9	Feb, Aug	7⅞	7⅝
10	10/0	Do. Preference 10 per Cent	15⅞–16⅝	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅝–3⅞	5 10 6	April, Oct	..	..
5	5.0	Do. 10 per Cent. Cum. Pref.	8⅝- 9¼	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	102⅝-103⅜	4 7 8	Jan, July	..	..
20	4/0	Direct United States Cable	15⅝–16	5 16 6	Ja,Ap,Jy,O	15⅞	15⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	98 –100	4 8 0	June, Dec	98⅝	..
St.	25/0	†Eastern Ordinary	186 –189	5 1 0	Ja,Ap,Jy,O	187½	..
St.	17/6	† Do. 3½ per Cent. Pref. Stock	88 – 90	3 17 9	Ja,Ap,Jy,O	89⅝	88½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 –105	3 16 6	May, Nov	103½	..
10	2/6	†Eastern Extension	13⅝– 13⅞	5 3 0	Ja,Ap,Jy,O	13⅛	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock	104 –106	3 15 6	Feb, Aug	104½	104
100	4%	Eastern & S. African 4% Mort. Deb. 1900	98 –101	3 19 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	184 –100%	4 0 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71 ...	84 –86	6 19 0	Jan, July	38½	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	98 –100	4 10 0	June, Dec	..	..
25	£2/6	Indo-European.....	56 – 58	5 12 0	May, Nov	57½	..
100	$1	Mackay Companies Common	61 – 63	5 18 6	Jan, July	..	..
100	$1	Do. Preference	67 – 69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅛–⅜	..	April	3/32	..
100	4%	Pacific & Europe'n Tel.4% Guar.Dbs.(red.)	101 –100½	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 –10½	3 16 0	June, Dec	..	..
25	1/3	West Coast of America	1⅛– 1⅜	3 3 2	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 6	Jan, July	..	..
10	..	West India & Panama	½ ⅝	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7¼– 7⅝	7 16 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6¾– 7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	100 –103	4 17 6	Jan, July	..	..
10	3/0	Western Telegraph	13⅞–14⅛	4 19 0	Mr,Jn,O,D	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 –92	4 7 0	Jan. July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 –104	4 16 0	Mar, Sept	..	..
5	8/0	Chili Telephone	6⅞– 7¼	5 11 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1/16– 1/8	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅛–1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	109 –111	5 8 0	Feb, Aug	110	109½
St.	7½	Do. Def. Stock.....	105½–109½	5 0 6	Feb, Aug	109⅝	..
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11½–13½	4 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5½ – 5⅝	4 9 0	Feb, Aug	5⅝	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	94½ - 96½	3 12 6	June, Dec	96½	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 6	Jan, July	102½	101½
1	0/9⅓	Oriental	1¼– 1⅜	5 2 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 1/16– 1 1/8	4 10 0	April, Oct	..	..
St.	4½	Do. 4 per Cent. Red. Deb. Stock	93 – 96	4 8 8	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db.Stk.(red.)	98 –101	4 9 0	Jan, July	..	..
8	8/0	United River Plate.....	7 – 7¼	5 6 6	July	7⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	June, Dec	..	..
St.	5%	*Do. 5 per Cent. Deb. Stock (red.)	.. ..	4 9 9	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅞ 4⅜	6 6 3	Jan, July	..	..
10	6 2	Globe Telegraph & Trust.....	10¾–11	5 0 0	Ja,Ap,Jy,O	11	10¾
10	4/0	Do. 6 per Cent. Pref.....	13½–14	4 5 9	Ja,Ap,Jy,O	13 1/16	13⅛
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Smoke Nuisance.

THE prosecution, which is now proceeding, of the Underground Electric Railways Co. of London, for emitting smoke sufficiently black to be regarded as a nuisance, raises a point of some interest. Inhabitants in the neighbourhood of the generating station at Chelsea, and even at a distance of a mile or more, have been complaining of the smoke, and now the Chelsea Borough Council has taken action. The defence put forward by Mr. J. R. CHAPMAN, the well-known chief engineer of the company is to the effect that the smoke is not really black, but appears to be so on account of the large volume of smoke emitted. The point may be a little difficult to decide, for the chimneys are of rather an unusual size, being 19 ft. in diameter. It is certainly obvious that if two chimneys, one of which has a greater diameter than the other, emit smoke of the same actual blackness at the same rate, the larger chimney will appear to emit blacker smoke than the smaller one, because the observer will have double the thickness of smoke to observe as an opaque screen. Consequently, the smaller the diameter of the chimney the less likelihood there will be of trouble through prosecution for nuisance, which is a point that engineers responsible for the erection of large generating stations might do well to bear in mind.

Technical Libraries.

ENGINEERS and others living in London and having the opportunity of consulting the excellent library of the Patent Office are apt to forget the want of facilities so noticeable in the provinces. No doubt, free libraries are now often to be found, thanks to the generosity of Mr. CARNEGIE, but they are frequently of more than doubtful value, and when technical information is required they are, of course, altogether useless. At a recent meeting of the Board of Directors of the Manchester Chamber of Commerce this want of facilities was felt to be so urgent that it was resolved to urge the Libraries Committee of the Manchester Corporation to provide technical literature and copies of British, American and other foreign patents, for the use of those engaged in the industries of the district. We hope this good example will be followed by other Chambers of Commerce, and that the suggested programme may be even extended.

Free Wiring.

METHODS and inventions of a certain kind are apt to crop up from time to time, be consigned to oblivion, and crop up yet again with a sort of natural period. Free wiring seems to be one of these. There is sometimes good reason for a method to be revived, owing to altered conditions of one kind or another, but in the case of free wiring there appears to be no such reason. As Mr. G. B. BARHAM explains in another column, the large consumer does not want the system, and the small consumer will not tolerate it, unless he happens to be of the very unremunerative type which the central station engineer is by no means anxious to cultivate. But the idea has, never-

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theless, some fascination, and is evidently too alluring for the Lowestoft Council to evade. It will be interesting to see if opinions change after a few years, and whether the Lowestoft Council will then wish they had profited by the experience of others instead of buying their own.

Municipal Insurance.

IT has often been stated that municipalities, in carrying on their business, do not proceed on strictly commercial lines, and prefer to accept risks such as would never be undertaken by any private concern. With many municipalities it is a case of "Jack of all trades," because there is the security of the rates on which to fall back, and doubtless the Socialist will prefer to add insurance to his other lines of municipal business. It is probable, however, that the ratepayers of Swindon will in future desire the Council not to undertake insurance risks, and that risks of this kind should be left to those who make a speciality of providing against them, for the unfortunate accident which occurred last year on the tramway system at Swindon has resulted in very heavy claims for damages. So far, it is said that the ratepayers will have the pleasure of paying 2s. in the £ for the privilege of running a system of electric trams and of taking all the risks of insurance.

Obituary.—We regret to record the death of M. E. G. Sautter, civil engineer and Chevalier de la Légion d'Honneur which occurred at Fleury-Meudon (France) on the 21st ult.

Associazione Elettrotecnica Italiana.—It is announced that the autumn meeting of this association will be held at Parma from Sept. 23rd to 27th. Various meetings in connection with the Congressi di Scienze will also be held at the same time and place.

Erratum.—We regret to find that, through a printer's error, the word "Ungrounded" became "Underground" in the title of the article on page 563 of our last issue. The error was due to the fondness of our American friends for the creation of words. "Earth" is an acknowledged term, yet "ground" has been forced upon us.

British Association—Section A.—Among additional Papers which are to be read in this Section are the following: On "The Motions of Ether produced by Collision of Atoms or Molecules containing or not containing Electrons," by Lord Kelvin; on "Variability in the Products resulting from Changes in Radium Emanation," by Sir W. Ramsay, K.C.B.; on "The Production and Origin of Radium," by Prof. E. Rutherford and Dr. J. E. Petavel; and on "Helium and Radio-activity in Common Ores and Minerals," by Hon. R. J. Strutt.

Junior Institution of Engineers.—We are informed that M. Gustave Canet has been elected president of this Institution for the ensuing session, in succession to Mr. W. B. Bryan, chief engineer to the Metropolitan Water Board, and that he will deliver his presidential address on Monday, November 18th next, taking for his subject, "The Latest Improvements in English and French Modern Artillery." M. Canet graduated at the Ecole Centrale and passed through the Franco-Prussian war as a lieutenant in the artillery. He afterwards received an appointment in the Vavasian Gun Factory at Elswick, which he resigned to establish the Forges et Chantiers de la Méditerrannée and the Ordnance Works at Havre. He is well known in connection with hydraulic arrangements for taking up the gun recoil.

Cable Interruptions.	Date of Interruption.
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Brest—Dakar	July 22, 1907
Kotonou—Libreville	July 18, 1907

University College.—The Senate of the University of London have approved the expenditure necessary for the adaptation of the buildings lately used by University College School to University purposes. The alterations provide for extensions to the departments of electrical, mechanical, and civil engineering, as well as to some of the other departments. The Senate have also accepted offers of £2,000 and £3,000 made by Dr. A. Plummer and Dr. Ludwig Mond to enable the building of the new department of physiology to be put in hand.

Starting Current Ammeter.—The recent rules of the *Verband Deutscher Elektrotechniker* require that the starting current of a motor should not exceed a definite limit depending on the output. But owing to the fact that the initial value of the current is only momentary, the first swing of an ammeter will not measure it correctly, as the amplitude of the swing depends on the amount of damping. An instrument designed to overcome this difficulty has lately been put on the market. It is provided with a movable arm, and by means of this the pointer may be carried round to any desired part of the scale. The pointer will then only move if the current exceeds the value corresponding to the position in which it has been placed. The position in which the pointer just moves when the current is switched on is found by trial.

Prevention of Sparking in Single-phase Motors.—The *Electrical World* describes a modification of the resistance-lead method of preventing sparking in alternating-current commutator motors which has lately been patented by Mr. A. S. McAllister. Instead of placing the resistances between the armature coils and the commutator bars, where the space is limited, they are placed outside the armature, and the internal transformer voltage generated in the armature circuit by the field flux is transferred to the external circuit by means of a stationary auto-transformer. For this purpose the commutator is arranged with alternate live and dead segments, and at each point of commutation there are three independently insulated brushes, the two outer brushes being connected to the terminals of the auto-transformer. The preventive resistances are placed in the supply leads, being inserted between the neutral point of the auto-transformer and the third brush. It is claimed that the resistances can be made of ample current-carrying capacity for the maximum load of the machine, and are, therefore, not subject to burn-outs, and that the amount of resistance in circuit can readily be varied during operation.

The Telephonic Ear.—The *Electrical World* gives an account of some investigations that have been made on the ears of telephone operators by Dr. N. R. Blegvad of Copenhagen. Each operator attends to from 80 to 120 subscribers. The average calls are 125 an hour, increasing at times to 200. The results of the investigation may be given as follows: Of the 418 girls examined, 47 showed pronounced pathological changes of the ear drum, leaving 371 with a normal membrane. Of these, 26·4 per cent. showed a retraction of the membrane of the ear used for the receiver. The work does not produce a diminution of the faculty of hearing in healthy organs, neither is this sense increased, but the ear becomes accustomed to its duty and can thus accommodate itself to the conversation. The lower sound limit is higher than in the normal ear, excluding therefore the deepest sounds, while nothing can be stated about the higher sound limit. It could not be demonstrated that the work had a bad influence upon disease of the ear. But it was found that sudden noises, including that of thunder, could induce a recurrence of a chronic malady or produce a new disease. On the other hand, it was found that the work gave rise in nervous girls to headaches. Thus it would appear that the occupation of telephone operators is about as healthful and suitable for young women in good health as any other.

Electrical Patents.—Among the new inventions relating to electrical work which have been published in a recent number of the *Patents Journal* is one by Mr. W. W. Massie referring to condensers. The glass plates which carry the metal plates are

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mounted on grooved supports and held by grooved blocks. The margins are painted with asphalt or other suitable material to prevent brush discharge. In order to obtain an adjustable connection with the plates, rods carrying single or bifurcated spring contacts are passed through binding posts, and are fitted with knobs. Another invention, due to Mr. H. E. Taylor, relates to an electric time switch, in which the circuit is completed at any desired moment by a contact finger supported on an inner insulating portion of the clock dial, and lying in the path of motion of a peg, previously set in one of a ring of 24 holes round the edge of a toothed metal disc revolving once a day just beneath a correspondingly sized aperture in the dial, over the edge of which the contact finger projects. The disc is driven by a ring of pins in the hour dial wheel, and the current passes through the minute hand of the clock, the end of which meets a second projecting piece set in one of a series of holes, corresponding to every minute, which lie round the edge of an outer conducting portion of the dial, the latter forming the second terminal of the exterior circuit. M. Blondel has lately patented an arrangement, which is also described, whereby, in an enclosed arc lamp using mineralised electrodes, gases from the arc pass upwards through an orifice, and, after purification, are returned through a second orifice below the arc and co-axial with the first, circulation being obtained either by the division of the purifying chamber by a vertical heat-insulating partition, or by the use of an electrically-driven fan. A cover, preferably extending a little way into the globe, closes the latter except for the orifice. When natural circulation is relied on the purifying chamber is annular and the partition cylindrical; the outer wall of the chamber may be corrugated, grooved or ribbed to promote cooling. Chemicals such as alkaline carbonates, ferrous salts or iron shavings, adapted to absorb nitrous fumes, may be placed within the chamber. Tubes convey the gases to the lower orifice, and are provided with plugs to allow access for cleaning. The fan is driven by a motor, preferably having its armature and field coils connected in parallel with each other and in series with the arc.

Electrical Equipment of the Detroit River Tunnel.—The *Street Railway Journal* states that six 100 ton direct-current locomotives of the swivel truck type, with two 280 H.P. motors geared to each truck, will comprise the initial equipment for hauling both goods and passenger trains through the tunnel being built under the Detroit River between the United States and Canada on the Michigan Central Railroad. The Sprague-General Electric multiple unit control system will be fitted and current taken from a third rail. Each locomotive will be capable of hauling a 900-ton train up a 2 per cent. gradient at a speed of 10 miles per hour. Automatic high-speed air brakes will form part of the equipment. Power for operating the system will be purchased from the Detroit Edison Co., and will be delivered to a sub-station at Detroit at a potential of 4,400 volts and at a frequency of 60 cycles. At the sub-station two 1,000 kw. synchronous motor-generator sets will be installed for supplying direct current to the third rail. Each of these sets will consist of a 1,000 kw. 4,400 volt three-phase synchronous motor direct connected on a common base to a 1,000 kw. 650 volt, compound-wound direct-current generator. A 15 kw. 125 volt exciter for the synchronous motor will be mounted on a shaft extension of each of the motor-generator sets. A very complete electric lighting and electric pumping equipment forms a part of the project. The yards and approaches to the tunnel will be lighted by arc lamps, while the tunnel itself will be illuminated by incandescent lamps arranged on duplicate circuits. Alternating current from the main power supply at a frequency of 60 cycles will be used on the lighting circuits. To insure an uninterrupted lighting service the lighting circuits in the tunnels are so arranged that half the lamps in both tunnels will burn if, by chance, either of the lighting circuits in the tunnels should be broken. A single three-phase distributing circuit will run through each tunnel, and from these circuits suitable connections will be made to step-down transformers. The secondaries of the step-down transformers will be interconnected with duplicate circuits for half the lamps in each of the tunnels. No less interesting will be the equipment for keeping the tunnel dry. Five pumps will be provided in the tunnel, each pump drained by induction motor centrifugal pumps arranged in duplicate. The motors on the pumps will operate directly at 4,400 volts, and the controlling circuits with compensators will be centralized in the sub-station. For indicating the amount of water in each pump, a float system will be provided having both visible and audible indicating devices. At the sub-station a regulating storage battery will be provided to carry the fluctuations of the load. If the main power supply from the Detroit Edison mains should be interrupted, this storage battery will have sufficient capacity to operate the entire system for half an hour. In such an emergency, the lighting and pumping alternating-current equipment will be energised by 60 cycle alternating current from a 50 kw. motor-generator set, the driving motor being supplied with current from the storage battery. Flexible switching arrangements will be installed to enable this interchange of power supply to be easily and quickly made. The tunnel will replace the present ferry service between Detroit on the American side and Windsor on the Canadian side of the river. Two tracks will be laid in separate iron tubes 65 ft. beneath the surface of the river. The tubes will rest on beds of concrete, and will be planked by concrete walls. The electrified zone will be 3·6 miles in length and will comprise, with the yards, some 15 miles of single track.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, July 26th (to-day).

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

3 p.m. Visit to the Motor-car Works of the Simms Mfg. Co. (Ltd.), Willesden-lane, Kilburn.

TUESDAY, July 30th.

INSTITUTION OF MECHANICAL ENGINEERS.

10 a.m. Meeting in the Mitchell Hall of the University, Aberdeen. Papers on "Aberdeen Harbour," by Mr. R. G. Nicol; on "Cableways used on Ship-building Berths," by Mr. J. M. Henderson; and on "Portable Pneumatic Tools," by Mr. H. Bing.

WEDNESDAY, July 31st.

INSTITUTION OF MECHANICAL ENGINEERS.

10 a.m. Meeting in the Mitchell Hall of the University, Aberdeen. Papers on "Granite Quarrying in Aberdeenshire," by Mr. W. Simpson; on "An Electrically-controlled Single-lever Testing Machine," by Mr. C. E. Larard; and on "Observations on Present-day Practice in Jute Preparing and Spinning," by Mr. D. J. MacDonald.

British Association—Section G.

THURSDAY, August 1st.

Meeting at Leicester. Presidential Address by Prof. S. P. Thompson, F.R.S. Paper on "The Present Condition of Gas and Petrol Engines," by Mr. D. Clark.

FRIDAY, August 2nd.

Joint Meeting with Section B. Discussion on "Gaseous Explosions with Special Reference to Temperature."

Visit to a Demonstration of Boot and Shoemaking at the works of the Union Company.

SATURDAY, August 3rd.

Visit to the Leicester & Swannington Railway.

MONDAY, August 5th.

Papers on "Pupin's Compensated Cable for Telephone Transmission," by Sir W. H. Preece, K.C.B., F.R.S.; on "An Oscillograph Study of Duddell Arcs of Low Frequency," by Mr. J. T. Morris; on "Developments of Electric Incandescent Lamps," by Mr. L. Gaster; on "Modern Machinery and its Future Development," by Mr. H. T. Brackenbury; on "A Machine for Weighing the Forces on a Cutting Tool," by Mr. J. F. Brooks; and on "The Governing of Hydraulic Turbines," by Mr. R. S. Ball.

TUESDAY, August 6th.

Papers on "Ferro-concrete and Examples of Construction," by Mr. J. S. E. de Vesian; on "Some New Uses for Reinforced Concrete," by Mr. W. N. Twelvetrees; on "The Ice Problem in Engineering Work in Canada," by Mr. H. T. Barnes; on "The Equipment of the Engineering Laboratory of the Finsbury Technical Institute," by Prof. E. G. Coker; and on "Submarine Signalling," by Mr. J. F. Millet.

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EXPERIMENTS ON OSRAM, WOLFRAM, ZIRCON AND OTHER LAMPS.

BY J. T. MORRIS, F. STROUDE AND R. MILWARD ELLIS.

Summary.—In this Paper the authors publish the results of some researches made by them on the physical properties of Osram, Wolfram, Zircon and other lamps. The effect of voltage variation when the lamp is working on direct current is discussed. A simple relation is found connecting expansion and watts, and an estimation of the filament temperature is attempted. A new method of obtaining specific heats is described and some experimental results are given. Physical data concerning the materials of which the filaments are made are also given.

The experiments described below were undertaken with the object of ascertaining some of the physical properties of the more recent metallic filament lamps. In some respects this Paper may be regarded as a continuation of a research published by one of us on Carbon, Osmium and Tantalum lamps.*

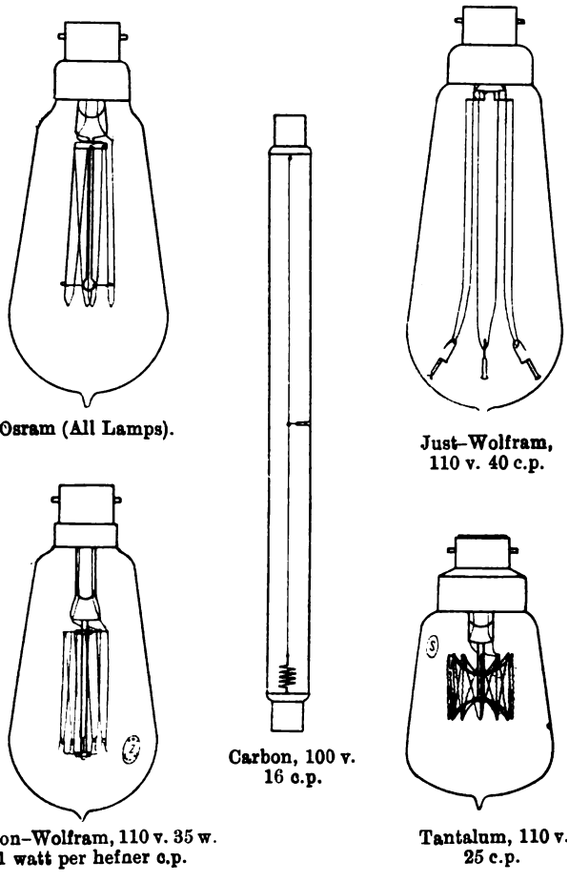

FIG 1. LAMPS USED IN THE EXPERIMENTS DESCRIBED IN THIS ARTICLE.

The subject is divided into four sections :—

1. Effect of voltage variation (when lamps are supplied with direct current).
2. Estimation of lamp temperature.
3. Obtaining specific heats of filaments by a new method.
4. Physical constants connected with the lamps.

Lamps Tested.—The lamps tested were of five kinds—namely. Carbon, Tantalum, Osram, Wolfram and Zircon. Particulars of these are given in Table I. and diagrams of the lamps in Fig. 1. T1, T2 and T3 are improved Siemens Tantalum lamps for use with direct current. The filaments appear to have been treated in the way suggested in the Paper referred to above—viz., wound into a very fine spiral before being zigzagged over the supporting framework.

Z1 and Z2 are new Zircon-Wolfram lamps.†

* "Experiments on Carbon, Osmium and Tantalum Lamps." By J. T. Morris. *The Electrician*, December 14, 1906.

† A later pattern has been made, we are informed, which can be used in any position, this being accomplished by the use of spiral springs holding the filament taut.

PART I.—EFFECT OF VOLTAGE VARIATION WHEN THE LAMPS ARE SUPPLIED WITH DIRECT CURRENT.

The photometer used was of the Bunsen grease-spot type. Electrical measurements were made by means of a Crompton high-grade potentiometer in conjunction with a set of standard low resistances and a divided resistance. The standard of light

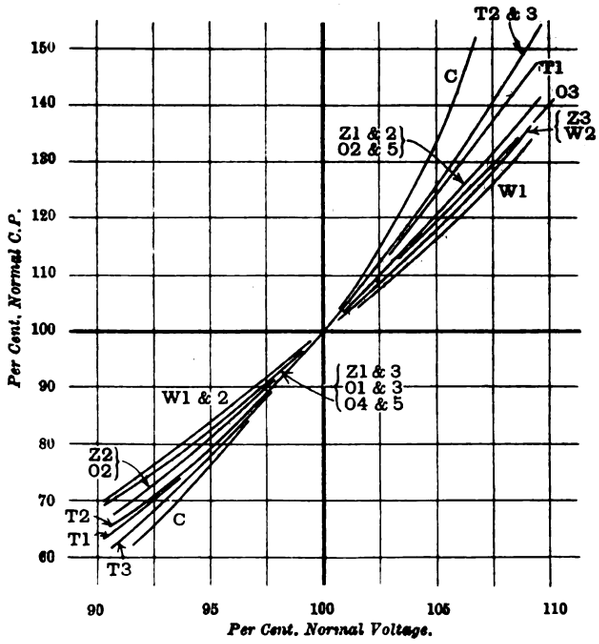

FIG. 2.—VOLTAGE-CANDLE-POWER CURVES.

was a simple 1 c.p. Simmance pentane burner, and was used to standardise a glow lamp employed at constant voltage as a secondary standard. The illumination on the photometer screen was maintained constant and balance obtained by moving the lamp under test. The degree of accuracy in relative candle-power measurements for the same lamp is about ½ per cent.

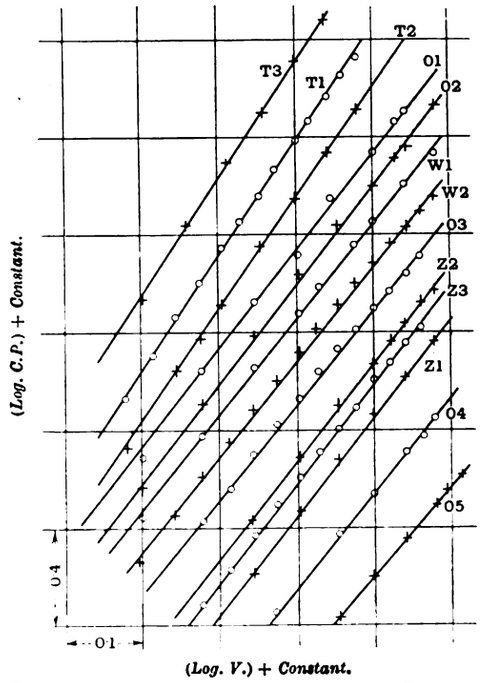

FIG. 3.—LOGARITHMIC CURVES OF VOLTAGE-CANDLE-POWER.

Results.—Fig. 2 contains the curve connecting voltage and candle-power over a range of 10 per cent. on either side of the normal voltage. Logarithmic curves for the same over the whole range are shown in Fig. 8, the results being expressed mathematically in Table II, and the indices are also given in

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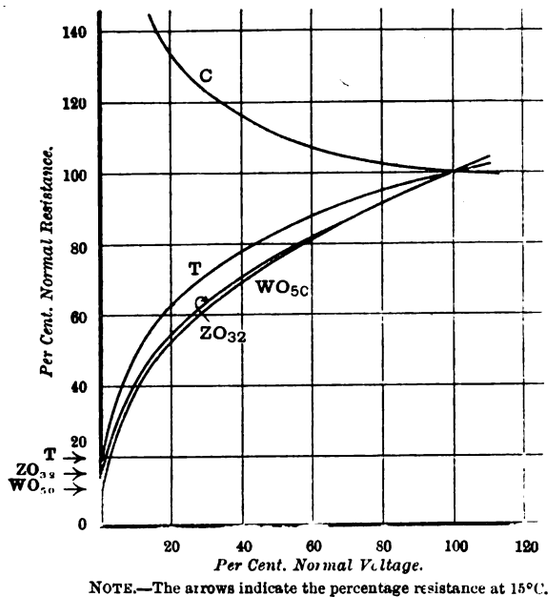
Table VI. in Part 4. It will be seen from these results that for metallic lamps a variation of 1 per cent. in voltage produces about 4 per cent. change of candle-power, as compared with the 6 per cent. change which is produced in carbon filament lamps.



NOTE.—The arrows indicate the percentage resistance at 15°C.

FIG. 4.—VOLTAGE-RESISTANCE CURVES.

Fig. 4 shows curves connecting voltage and resistance, while in Table III. will be found the theoretical ratio of starting current to final current deduced from these curves. This table also includes the values of this ratio obtained by means of a Duddell oscillograph. As a matter of fact, after switching on

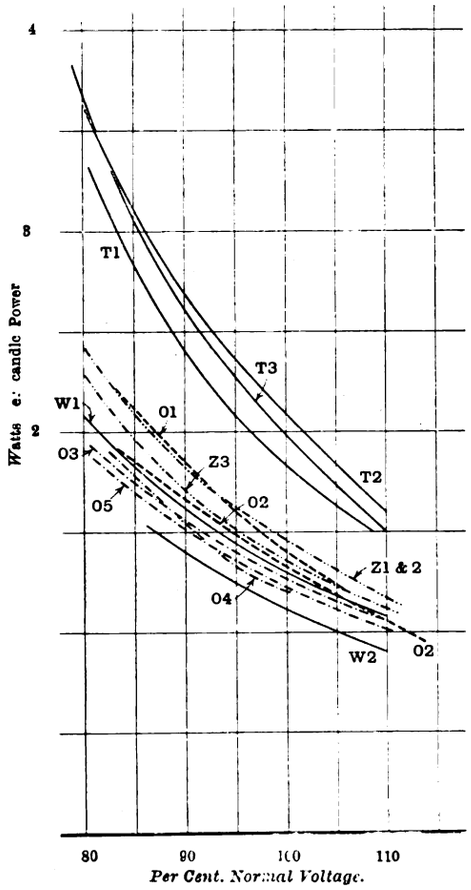


FIG 5.—VOLTAGE-WATTS PER C.P. CURVES.

a metallic filament lamp to normal voltage, the current taken is still distinctly above its final value even after two or three minutes have elapsed.

In Fig. 5 are given curves connecting voltage and watts per candle-power, while Fig. 6 contains curves connecting voltage and *efficiency*, which are of greater scientific value. It is worthy of note that the increase in life which has been obtained

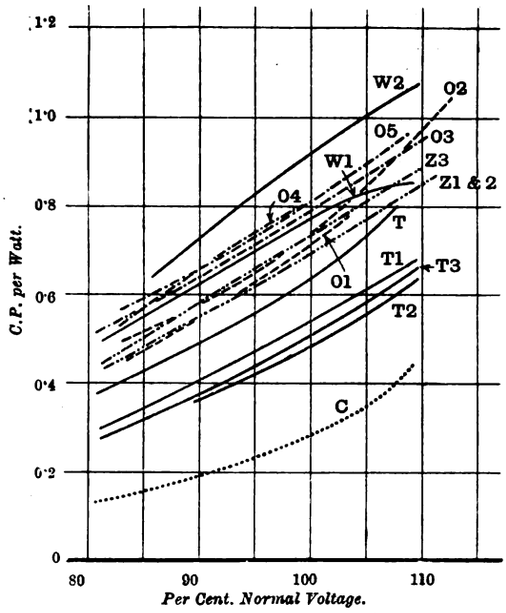


FIG. 6.—VOLTAGE-EFFICIENCY CURVES.

in the Tantalum lamp has necessitated a considerable reduction in efficiency.

PART II.—ESTIMATION OF LAMP TEMPERATURES.

Recognising the advantage of possessing some criterion of the filament temperature, the authors directed their attention to :—

(*a*) The determination of expansion.
(*b*) The application of Stefan's law.

(*a*) *The Determination of Expansion.*—The images of the filaments were projected on to a screen by means of a Nernst lamp and lantern, and a magnification of about 30 diameters was obtained. The extension of a loop of the filament was then noted for definite increases in voltage. The results obtained are shown in the accompanying resistance-expansion curves (Fig. 7). Some difficulty was experienced in keeping the filaments from clinging to the supporting hooks during the experiments.

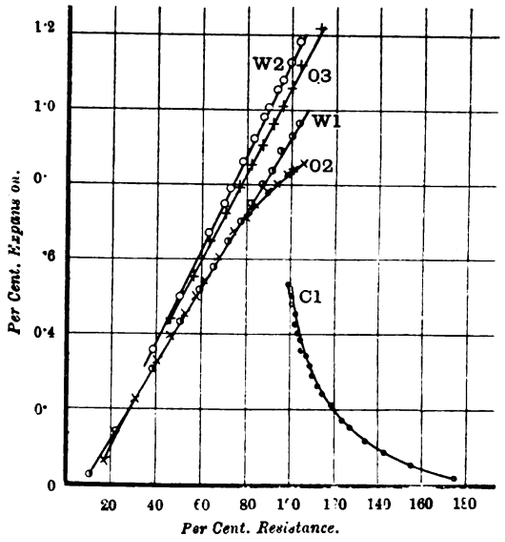


FIG. 7.—RESISTANCE-EXPANSION CURVES.

It is interesting to note that the curves of the 50 c.p. Osram and the Wolfram lamps are straight lines, whilst that of the 32 c.p. Osram lamp is distinctly curved.

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Table I.

Type of lamp.	Distinctive mark.	Volts	Amps.	Actual horiz. c.p.	Horiz. c.p. per watt.	Watts per horizontal c.p.
Carbon 5 c.p.	..	220	0·131	..	..	..
Carbon 16 c.p.	C1	100	0·461	..	..	..
* Tantalum 25 c.p. ..	T	110	0·355	24·5	0·63	1·60
Tantalum 25 c.p.	T1	110	0·385	23·15	0·55	1·88
Tantalum 25 c.p.	T2	110	0·401	21·35	0·48	2·07
Tantalum 25 c.p.	T3	110	0·361	20·45	0·52	1·94
Osram 32 c.p.	O1	107	0·332	25·9	0·73	1·37
Osram 32 c.p.	O2	107	0·359	29·1	0·76	1·32
Osram 50 c.p.	O3	105	0·555	46·0	0·79	1·27
Osram 50 c.p.	O4	120	0·450	43·9	0·81	1·23
Osram 50 c.p.	O5	120	0·502	49·0	0·81	1·23
Just-Wolfram 40 c.p...	W1	110	0·423	36·0	0·77	1·29
Just-Wolfram 40 c.p...	W2	110	0·450	43·8	0·89	1·13
Zircon 35 c.p.	Z3	110	0·349	28·45	0·74	1·35
Zircon-Wolfram 35 c.p.	Z1	110	0·430	32·5	0·69	1·45
Zircon-Wolfram 35 c.p.	Z2	110	0·447	34·6	0·71	1·42

* Lamp used in previous Paper.

(*b*) *The Application of Stefan's Law.*—By Stefan's Law the absolute "black body" temperature of a filament is proportional to the fourth root of the total radiation from it. Thus the watts supplied to the filament, assuming no conduction, are given by :—

$$W \propto (T^4 - t^4),$$

Where W represents the watts supplied electrically,
" T " the absolute "black body" temperature of the filament,
" t " the absolute "black body" temperature of the surroundings.

From this equation it is obvious that for high temperatures the term t^4 can be neglected, being less than one-hundredth part of W for temperatures above 650°C., and less than one-thousandth part of W for temperatures above 1,300°C. Fig. 8 is therefore plotted connecting expansion and $\sqrt[4]{\text{watts supplied}}$. The absolute straightness of all but one of these lines is of great interest, and would suggest that the fact might be made use of in high temperature measurement. In investigating this point three curves were plotted for a single lamp with expansion as ordinates, and the 3·9th, 4·0th and 4·1th roots of watts respectively as abscissæ; the first and last curved distinctly in opposite directions, and from a study of these curves it was quite clear that the value 4·0 was correct to within 1 per cent.

In order to transform the scale of $\sqrt[4]{\text{watts supplied}}$ into a scale of temperatures, a colour comparison test was made. The voltage on each of the metallic filament lamps was adjusted until the colour of the light emitted by it appeared the same as that emitted by a carbon lamp working at 3·5 W/CP. These voltages were assumed to correspond to a temperature of 2,000° abs. (Centigrade degrees). This assumption was made in view of the great divergence in the figures published by various experimenters for this quantity.‡

The $\sqrt[4]{\text{watts supplied}}$ corresponding to these points were calculated, and, for reasons stated above, were assumed to be $\sqrt[4]{\text{total radiation}}$. Fig. 9 was now constructed as follows: Straight lines representing Stefan's law were drawn, with

Table III.

Distinctive mark.	Name of lamp.	Starting current. / Final current.	
		From resistance curves.	From oscillograms.
..	Carbon, 220 v., 5 c.p.	..	·569
T	Tantalum, 110 v., 25 c.p.	6·32	..
T1	Tantalum, 110 v., 25 c.p.	..	4·88
T2	Tantalum, 110 v., 25 c.p.	5·70	4·88
T3	Tantalum, 110 v., 25 c.p.	5·76	4·56
O2	Osram, 107 v., 32 c.p.	8·61	..
O3	Osram, 105 v., 50 c.p.	12·86	..
O5	Osram, 120 v., 50 c.p.	12·59	7·34
W1	Just-Wolfram, 110 v., 40 c.p..	12·27	7·33
W2	Just-Wolfram, 110 v., 40 c.p..	12·79	..
Z3	Zircon-Wolfram, 110 v., 35 c.p.	6·21	..

The values obtained by the oscillograph are, as would be expected, invariably lower than those given by the resistance curves. This is due to the combined effects of the inductance of the circuit and the inertia of the oscillating parts of the oscillograph.

Table IV.

Distinctive mark.	Name of lamp.	Percentage voltage at which filament is just visible in the dark.	Temp. at which filament is just visible in the dark.	Working temperature of lamp.
C1	Carbon, 100 v., 16 c.p.	15·5	..	..
T1	Tantalum, 110 v., 25 c.p.	4·5	320°C.	..
T2	Tantalum, 110 v., 25 c.p.	4·65	370°C.	1,980°C.
T3	Tantalum, 110 v., 25 c.p.	4·8	320°C.	1,850°C.
O2	Osram, 107 v., 32 c.p.	3·75	370°C.	..
O3	Osram, 105 v., 50 c.p.	3·45	330°C.	..
O5	Osram, 120 v., 50 c.p.	..	250°C.	2,000°C.
W1	Just-Wolfram, 110 v., 40 c.p...	..	..	2,000°C.
W2	Just-Wolfram, 110 v., 40 c.p...	3·45	330°C.	..
Z1	Zircon-Wolfram, 110 v., 35 c.p.	..	..	2,000°C.
Z2	Zircon-Wolfram, 110 v., 35 c.p.	3·7	330°C.	..

The above temperatures were obtained by assuming that when the filaments emit light of the same colour they are working at the same temperature, that the temperature of a carbon filament at 3·5 W/candle-power is 2,000°Abs.(1,727°C.), and that the $\sqrt[4]{\text{watts}}$ is a criterion of the temperature.

Table II.

Distinctive Mark.	Type of Lamp.	Candle-power—Voltage. Mean over whole range.	Candle-power—Voltage. 10 % either side of normal volts.	Candle-power—Watts. Mean over whole range.	Candle-power—Watts. 10 % either side of normal volts.
T	Tantalum 110 v. 25 c.p.	C.P. $= 3{\cdot}61\ v.^{4\cdot34} \times 10^{-8}$	..	C.P. $= 2{\cdot}67\ w.^{2\cdot50} \times 10^{-3}$	..
T1	Tantalum 110 v. 25 c.p.	C.P. $= 9{\cdot}89\ v.^{4\cdot59} \times 10^{-9}$	C.P. $= 2{\cdot}75\ v.^{4\cdot37} \times 10^{-8}$	C.P. $= 1{\cdot}05\ w.^{2\cdot67} \times 10^{-3}$	C.P. $= 2{\cdot}03\ w.^{2\cdot50} \times 10^{-3}$
T2	Tantalum 110 v. 25 c.p.	†C.P. $= 1{\cdot}45\ v.^{4\cdot49} \times 10^{-8}$	C.P. $= 1{\cdot}45\ v.^{4\cdot49} \times 10^{-8}$	C.P. $= 9{\cdot}77\ w.^{2\cdot64} \times 10^{-4}$	C.P. $= 9{\cdot}77\ w.^{2\cdot64} \times 10^{-4}$
T3	Tantalum 110 v. 25 c.p.	†C.P. $= 5{\cdot}14\ v.^{4\cdot70} \times 10^{-9}$	C.P. $= 5{\cdot}14\ v.^{4\cdot70} \times 10^{-9}$	C.P. $= 8{\cdot}67\ w.^{2\cdot75} \times 10^{-4}$	C.P. $= 8{\cdot}67\ w.^{2\cdot75} \times 10^{-4}$
O1	Osram 107 v. 32 c.p.	†C.P. $= 1{\cdot}58\ v.^{4\cdot04} \times 10^{-7}$	C.P. $= 1{\cdot}58\ v.^{4\cdot04} \times 10^{-7}$	C.P. $= 3{\cdot}18\ w.^{2\cdot51} \times 10^{-3}$	C.P. $= 3{\cdot}18\ w.^{2\cdot51} \times 10^{-3}$
O2	Osram 107 v. 32 c.p.	†C.P. $= 1{\cdot}93\ v.^{4\cdot03} \times 10^{-7}$	C.P. $= 1{\cdot}93\ v.^{4\cdot03} \times 10^{-7}$	C.P. $= 3{\cdot}16\ w.^{2\cdot50} \times 10^{-3}$	C.P. $= 3{\cdot}16\ w.^{2\cdot50} \times 10^{-3}$
O3	Osram 105 v. 50 c.p.	C.P. $= 4{\cdot}45\ v.^{3\cdot97} \times 10^{-7}$	C.P. $= 6{\cdot}62\ v.^{3\cdot38} \times 10^{-6}$	C.P. $= 1{\cdot}80\ w.^{2\cdot50} \times 10^{-3}$	C.P. $= 5{\cdot}09\ w.^{2\cdot24} \times 10^{-3}$
O4	Osram 120 v. 50 c.p.	C.P. $= 2{\cdot}49\ v.^{3\cdot97} \times 10^{-7}$	C.P. $= 2{\cdot}33\ v.^{3\cdot50} \times 10^{-6}$	C.P. $= 2{\cdot}09\ w.^{2\cdot50} \times 10^{-3}$	C.P. $= 6{\cdot}82\ w.^{2\cdot20} \times 10^{-3}$
O5	Osram 120 v. 50 c.p.	†C.P. $= 1{\cdot}24\ v.^{3\cdot65} \times 10^{-6}$	C.P. $= 1{\cdot}24\ v.^{3\cdot65} \times 10^{-6}$	C.P. $= 3{\cdot}42\ w.^{2\cdot34} \times 10^{-3}$	C.P. $= 3{\cdot}42\ w.^{2\cdot34} \times 10^{-3}$
W1	Just-Wolfram 110 v. 40 c.p. ..	C.P. $= 3{\cdot}72\ v.^{3\cdot91} \times 10^{-7}$	C.P. $= 4{\cdot}97\ v.^{3\cdot36} \times 10^{-6}$	C.P. $= 2{\cdot}63\ w.^{2\cdot49} \times 10^{-3}$	C.P. $= 8{\cdot}63\ w.^{2\cdot17} \times 10^{-3}$
W2	Just-Wolfram 110 v. 40 c.p. ..	†C.P. $= 4{\cdot}00\ v.^{3\cdot94} \times 10^{-7}$	C.P. $= 4{\cdot}00\ v.^{3\cdot94} \times 10^{-7}$	C.P. $= 2{\cdot}92\ w.^{2\cdot48} \times 10^{-3}$	C.P. $= 2{\cdot}92\ w.^{2\cdot48} \times 10^{-3}$
Z3	Zircon 110 v. 35 c.p.	C.P. $= 1{\cdot}74\ v.^{4\cdot02} \times 10^{-7}$	C.P. $= 1{\cdot}79\ v.^{3\cdot53} \times 10^{-6}$	C.P. $= 3{\cdot}16\ w.^{2\cdot49} \times 10^{-3}$	C.P. $= 8{\cdot}09\ w.^{2\cdot24} \times 10^{-3}$
Z1	Zircon-Wolfram 110 v. 35 c.p.	C.P. $= 2{\cdot}59\ v.^{2\cdot96} \times 10^{-7}$	C.P. $= 7{\cdot}93\ v.^{3\cdot73} \times 10^{-7}$	C.P. $= 2{\cdot}78\ w.^{2\cdot43} \times 10^{-3}$	C.P. $= 4{\cdot}46\ w.^{2\cdot30} \times 10^{-3}$
Z2	Zircon-Wolfram 110 v. 35 c.p.	†C.P. $= 1{\cdot}98\ v.^{4\cdot03} \times 10^{-7}$	C.P. $= 1{\cdot}98\ v.^{4\cdot03} \times 10^{-7}$	C.P. $= 2{\cdot}11\ w.^{2\cdot49} \times 10^{-3}$	C.P. $= 2{\cdot}11\ w.^{2\cdot49} \times 10^{-3}$
*(*a*)	Osmin 110 v. 60 c.p.	..	C.P. $\propto v.^{4\cdot04}$	..	C.P. $\propto w.^{2\cdot53}$
*(*b*)	Osmin 100 v. 36 c.p.	..	C.P. $\propto v.^{3\cdot80}$	{From normal voltage to 36% above.}	C.P. $\propto w.^{2\cdot35}$

* (*a*) From experiments by J. Sahulka (*The Electrician*, May 31, 1907). (*b*) From experiments by A. Libesny (*Elektrotechnik u. Maschinenbau* 24, May 20, 1907).

† For these lamps there is no marked curvature in the logarithmic curves.

‡ For a concise statement of the present position see a Paper entitled "The Temperature and Emissivity of Carbon, Osmium and Tungsten Filaments," by A. Grau, *The Electrician*, June 7, 1907.

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$\sqrt[4]{\text{total radiation}}$ as ordinates and approximate "black body" temperatures as abscissæ through these points and the origin. To convert the ordinate scale in this figure from $\sqrt[4]{\text{total radiation}}$ into $\sqrt[4]{\text{watts supplied}}$, it was necessary to allow at the lower end of the curves for the fact that the surrounding temperature was +15°C. (288° abs.). This was obtained from the relation of T^4 to $(T^4 - 288^4)$ and is shown by

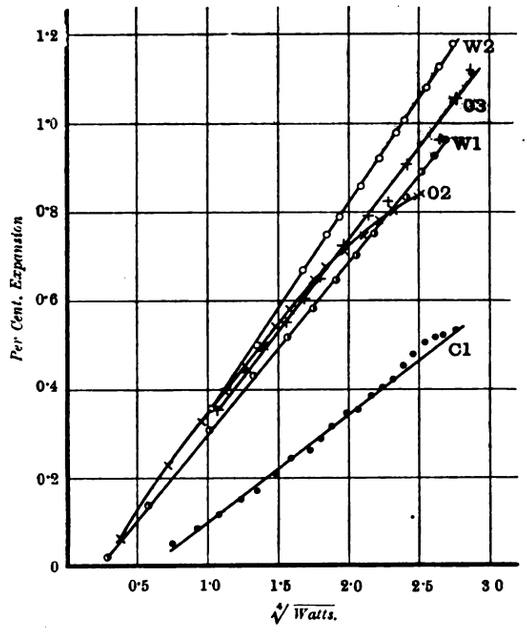
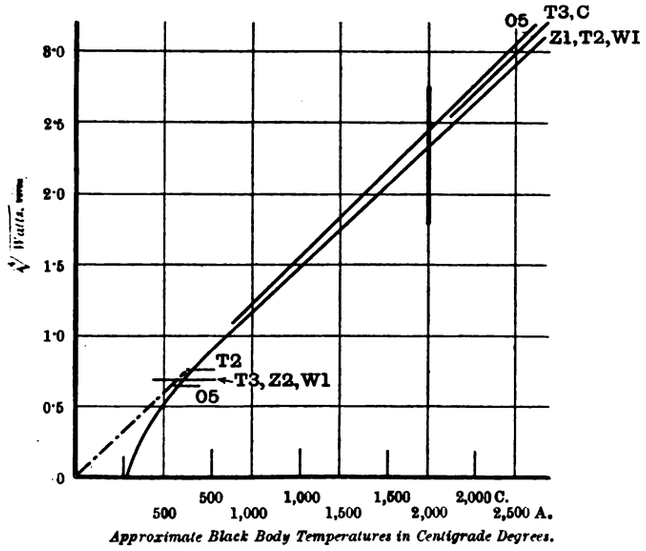


FIG. 8.—$\sqrt[4]{\text{WATTS}}$–EXPANSION CURVES.

the curving off of the straight lines toward the base; the curve ultimately cutting the scale of temperature at 288°C. absolute. In subsequent work the temperatures were all obtained by this curve. $\sqrt[4]{\text{watts supplied}}$ were obtained at the temperature at which the filaments were just visible in the dark, and it will be seen that the positions of these points on the curve range from 300° to 400°C. The individual temperatures are



The points indicated by horizontal bars are those at which filaments are just visible in the dark.

FIG. 9.—$\sqrt[4]{\text{WATTS}}$–TEMPERATURE CURVES.

collected in Table IV. It will be observed from the voltage column included in the table, that the metallic filament is still visible in the dark at a much lower voltage than is the carbon filament; the average figures—expressed as a percentage of the working voltage—being 4 per cent. for the metallic and 16 per cent. for the carbon. These experiments were carried out with extreme care in a perfectly dark room.

(To be concluded.)

THE FALLACIES OF FREE WIRING.

BY G. BASIL BARHAM.

Summary.—**The author states that the greatest fallacy in free wiring is the term "free." The methods of charging under the usual systems of free wiring lead to dissatisfaction and to an eventual decrease in consumption. The system does not encourage long hour consumers, and a fixed charge per lamp per annum is not an attraction.**

There is something alluring and fascinating in the very words "Free Wiring." To the public they conjure up the vision of a beneficent Supply Company, eager to amend its ways, presenting them with a gift of untold—and untellable—value, throwing open the blessings of electricity in the home to all who care to avail themselves thereof. Free wiring! That expensive installation of wires, switches, and fittings given, nay forced upon those sufficiently fortunate to reside near the mains. No expense, no contractor's bill to meet, no trouble, no worry; merely an order to give, a few days to wait, and then—merely to switch on, and expatiate on the comforts of electric light to those unfortunates who dwell where current is unavailable.

To some station engineers the blessed words—an electrical "Mesopotamia," as it were—bring a vision of a well-flattened peak, a district full of long-hour consumers, a crowd of delighted users voluntarily canvassing, and bringing yet more customers to the station; a means of salvation from the falling revenues due to the insidious introduction of metallic filament lamps; a largely increased use that will balance specific reduction. Free wiring! That will assist in combating the gas companies, perhaps even rout them in complete disorder, and eventually place electricity in that proud prominence it so richly merits.

I do not know with accuracy who first invented the phrase "free wiring"; I have heard many accused, and known several who proudly pleaded guilty. The expression is a misnomer, and worse: it is a malignant misnomer which perverts and distorts the imagination of those who fall a victim to its subtleties, until, with the coming of the first quarterly account, it rends the veil from the eyes of both consumer and station engineer, and fills the one with the fear of the bankruptcy court, and the other with the fear of assassination.

To begin with, there is nothing free about this Frankenstein of free wiring. When adopted and fostered by some trusting station engineer, it turns in a few months to rend first the trusting public who were deceived by it, and, after, the man who introduced it.

I had thought that the scheme was dead and decently buried; that its numerous fallacies had been exposed *ad nauseam*; but whatever be the cause, whether, as I suspect, it is the metallic filament lamp looming in the distance, or whether it is a desperate attempt to combat the growing use of other illuminants, I find to my astonishment that engineers are again falling victims to its sophistries, and that a large corporation has just declared its intention of undertaking free wiring.

Before going further, let me say that I have had a long practical experience with free-wiring work, and have taken a deep interest in all the various schemes and experiments which have been introduced or made. I have seen them tried, and assisted in their inception, in many places, and I say, definitely, that no free-wiring scheme has as yet been a financial success, and no free-wiring scheme at present devised can ever become one.

The various systems of free wiring all agree in the fact that they are based on the payment of an annual rental for the use of certain lamps, fittings, and the necessary switches and wiring. With the hire-purchase or assisted wiring, wherein the value of the installation is paid for in quarterly or other payments, and eventually becomes the property of the user, a system which is occasionally confused with free wiring, we are not at present concerned. We are considering the rental system only.

There are, broadly speaking, two methods of calculating this rental, the first, and for a long time the most popular, depending on the amount of use to which the installation was subject. The payment or rental demanded was in the shape of a tax on the current consumed, and usually consisted of a penny or smaller amount being charged, in addition to the customary price for current, on every unit sold through the installation. Many corporations and supply companies took

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this scheme up with eagerness, and one or more large companies were formed with branches in the various towns, to carry out the project with the co-operation of the electricity works.

The method adopted in the majority of cases was for the contractors to enter into formal agreement with the supply authorities, setting forth their respective positions and rights, &c., and a supplementary agreement was then entered into between the customer and the contractor, acting under this original agreement. This supplementary agreement was usually printed as between the consumer and the electricity supply authorities.

The principal clause in the agreement was generally worded as follows, and it is only right to say that, as regards the consumer, the minimum payment clause, for reasons which will be seen later, was rarely if ever enforced.

". . . The consumer shall until purchase as aforesaid pay quarterly to the supply company or their successors in title, for the use of the installation 1d. per Board of Trade unit for every unit of electrical energy supplied to the said premises and the minimum payment in any year shall be 1s. for each 8 c.p. lamp or its equivalent installed. . . ."

The immediate effect of this was invariably the coupling up of a large number of customers who would otherwise never have been obtained. The ease with which a supply of electricity became available and the immediate advantages of the use of electricity invested the whole affair with a certain amount of glamour.

But only a few months, comparatively speaking, were needed to show the glaring inconsistencies in the business.

The majority of private-house customers were connected up during the late summer, and their first quarter, from September to December, was the heaviest in the year. During this period, knowing nothing concerning the correct use of electricity, and being delighted with the excellence and comfort of the light, naturally the consumer wasted a great amount of current. Rooms or shop windows were overlighted, lamps were left burning, and visitors had to be taken round the installation, to turn on for themselves with admiration the new illuminant, and receive ocular demonstration of the ease and simplicity of electric lighting. The Christmas quarter's account was consequently exceptionally heavy, especially in those towns where the Wright maximum demand system was in operation, this being due to the fact that a number of lights had been left burning at the same time.

At once there would be a great outcry, and ill-feeling be engendered; the lamps would be overhauled, and the supply authorities fly to the opposite extreme, and instal 8 and 5 c.p. lamps wherever possible. This was shortsighted, for the lighting then would be extremely bad, and as the efficiency of the low-power lamps was generally as poor or poorer than their light, the next quarter's bill, January to March, always a heavy one, would not show an appreciable reduction. The grumbling, augmented this time by the poor lighting, would be renewed, and numbers of customers would promptly revert to other illuminants.

The obvious fallacy in this method was that the long-hour useful customer was unduly penalised, and instead of being encouraged was taxed beyond all reason. The result was that each user saw that he was charged excessively for the lights in common use. His answer was to retain the electric light in bedrooms, and places where it was rarely, if ever used, and use gas or oil where the lights would be in use from dusk to eleven or twelve o'clock. The same thing was true of the small long-hour shops, and these, who should have been encouraged by a reduction of the tariff, were soon alive to the fact that they were paying far more than their share.

As a result of this fallacious method of charging, people were loud in their warnings to others who might have become consumers, and there was a falling off in the rate of connection, as well as in the consumption of energy.

It may be said that the minimum payment clause ensured the supply company against loss, but this could, as I have said, be rarely, if ever, enforced. Owing to the unpopularity of the system, such a proceeding could only have increased the bad odour in which electric lighting was held. Also such payment would have had to be recovered in the County Court, and it was difficult to say in what view the agreement might be considered, especially after the changing of the lamps.

A number of free wired premises would fall empty in due course, owing to the uncertain tenancy of the people attracted by the scheme, and would possibly remain empty for some time. Incoming tenants might, and possibly would, look askance at the installation, having heard of the expense and trouble connected with free wiring, and the revenue would be, in a few months, in very low ratio to the capital expenditure. That is to say, that taking into consideration the various items, such as mains extensions and the cost of the installation, &c., the scheme, after the first quarter, would probably not pay its way. It may be argued that a great deal of the trouble and friction arose from the employment of an intermediary in the person of the contractor, but it may be at once pointed out that had the work been carried out direct it would, in the case of a municipal supply, have been almost certainly more costly and less efficient; in many cases it would have been impossible, owing to the absence of wiring powers, and in all cases the costs would have been increased by the necessity for providing capable supervision.

A further defect lay in the fact that the system encouraged the small short-hour class. Offices of from two to three lights opening at 9 a.m. and closing at 6 p.m., or earlier, could never show a return on the cost of connecting alone, even if the minimum payment clause were strictly enforced.

When this system became discredited, so utterly that it was with great surprise that I recently heard it championed, efforts were made to devise some other and more equitable system of charging, and the clause that was at first regarded as a penalty became the ruling factor. It was decided that a fixed charge per lamp per annum would be fair and equitable, and could be so arranged as to carry all due expenses and a certain amount of profit.

It is this system that a certain large corporation in particular is contemplating to-day.

One of the chief fallacies connected with it is the idea that such a scheme, if properly carried out, will bring customers at all. It is not financially disastrous, simply because it attracts no clients. And indeed it is difficult to see how it could do so and pay a correctly proportioned return. To begin with, the charge of 1s. is too low for the station and 1s. 6d. is too high as far as the customer is concerned. As a matter of fact the average number of lights installed in small houses of the class reached by free wiring is twelve, and as the repayment of the cost of installation, which at that number of points would be about £7, at 20 per cent. spread over a term of five years would absorb 28s. per annum, whilst the interest and sinking fund on the cost of service mains and meters, &c., would total another 5s. or 6s., it is evident that, taking into consideration the risk of the installation remaining empty for any length of time, and the question of depreciation, a charge of 1s. per lamp is obviously too low. But if 1s. 6d. per point is charged on an installation of 12 lights it amounts to 18s., and the shrewd customer who considers that an installation of that size would, if put out to tender, probably cost him not more than £6, or thereabouts, and that consequently the rental amounts to a rate of interest of about 15 per cent., is hardly likely to avail himself of the tempting offer.

I might go further and point out that the contractor himself is averse to supply authorities engaging in wiring work, and consequently speaks as disparagingly as possibly of free wiring, and further might say that by this time the business is so discredited as to render it almost impossible to get a loan from the Local Government Board to carry out the work. (One engineer who has tried a scheme of this nature raised the money by a bank overdraft—I am not sure that this could always be arranged.) But I do not think there is, at the moment, need to go further into the matter. On going back mentally for a few years I can count literally dozens of engineers who have, at one time or another, dabbled in free wiring schemes, found them unprofitable, discovered their fallacies, and—promptly dropped them! And I think very strong arguments will have to be brought forward to justify or demonstrate the advisability of a re-introduction of any system of free wiring.

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INDUCED DRAUGHT, WITH HOT-AIR ECONOMISERS, FOR STEEL WORKS AND BLAST-FURNACE BOILERS.*

BY A. J. CAPRON.

Summary.—The author describes a system of induced draught in connection with hot-air economisers, which utilise the waste heat from the boiler by heating the air required for combustion. Examples of the adaptation of this system to various types of boilers and some comparative test figures are given. The efficiency is much increased.

The subject of economy in steam consumption in engines and turbines has certainly received a great deal of attention, and has been followed up in such a thorough manner that the excellent results obtained seem to leave comparatively little room for further improvement. The same can hardly be said as to the economy of fuel generally obtained in steam raising, and for this reason I have ventured to bring forward a subject which, though not laying claim to any scientific novelty, may, I hope, prove of some practical interest.

In steam raising the most obvious source of waste is incomplete combustion accompanied by the nuisance of much smoke, and though many means have been devised for obviating this nuisance, few are really effective under all conditions of working. An excess of air lowers the temperature of combustion, and a good draught can only be obtained by the loss of much heat, unless it be produced by such means as induced or forced draught.

The system to be described, under Messrs. Ellis and Eaves' and John Brown & Co.'s patents, has been used for marine purposes for about 10 years; but its application to land boilers has only been taken up for five years, and has been coming into much more extensive use during the last year or two.

Briefly, the system consists of induced draught in combination with hot-air economisers, which utilise the waste heat from the boiler in heating the air required for combustion. A fan is placed at the base of the chimney and draws the gases, as they come from the boiler, through a series of tubes which form a heating box or hot-air economiser; the fan, working at about 2 in. water gauge, draws in the air required for combustion through apertures in the heating box; the air, circulating round the tubes through which the hot gases are passing, is raised to a temperature of about 300°F.

This arrangement is of material assistance to the working of the fan, as the heat abstracted from the gases in the air economiser reduces the volume the fan has to deal with, and also reduces the temperature so much that the fan is not liable to injury through heat

The speed of the fan can of course be regulated to the demand for steam. This is a great convenience in electric light and power plants, as any sudden demand for additional power can be promptly met. And in many such cases, where there is much variation in the power required, the economy of working with the smaller number of boilers that this system permits effects a very great saving.

In marine boilers the arrangement is very compact, the heater being formed in the smoke box, and the fan, either fixed on the top of the boiler or on a stage, draws the hot gases through the tubes of the heater and delivers them direct into the uptake. The air drawn in by the induced draught, and heated as it passes round the tubes, is delivered through apertures round the furnace front, the greater part underneath the fire bars and a portion above, the proportion being regulated by means of dampers to suit the combustion.

Fig. 1 shows the arrangement with a Lancashire boiler. The fan is placed at the back, being the most convenient position for drawing the gases from the side flues as they leave the boiler through the heater, and discharging them into the main flue or chimney. In this case the hot air is conveyed through two pipes running over the top of each boiler and drawn in through the furnace fronts as above

The author also gives figures showing the arrangement of the hot-air economiser in the case of Stirling and Babcock & Wilcox boilers.

In all cases dampers are arranged so that the boilers can work on natural draught, without the gases passing through the fan, for getting up steam at starting, or in case of the fan being temporarily disabled. No inconvenience is experienced with choking in the air heating tubes, as the draught keeps them so clear that it is never necessary to clean them, unless the boilers are worked on natural draught only for a considerable period.

It is, of course, desirable that the brickwork settings of the boilers should be in good order, as a considerable leakage allowing much cold air to be drawn in would spoil the results. With marine boilers, everything being enclosed in a steel casing, there can of course be no leakage, and the average results with marine boilers have been slightly higher probably on this account.

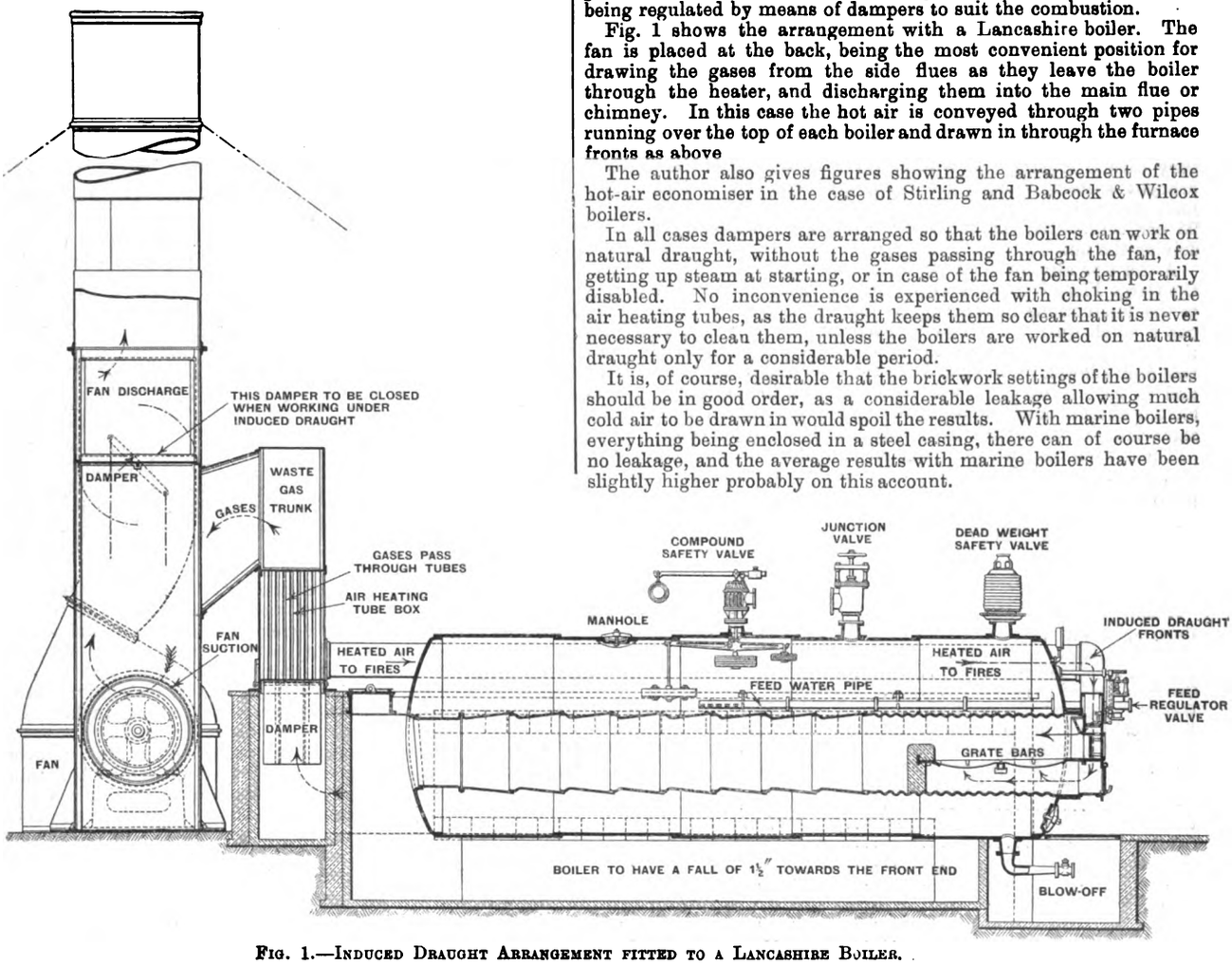

FIG. 1.—INDUCED DRAUGHT ARRANGEMENT FITTED TO A LANCASHIRE BOILER.

Various forms of mechanical stokers have been used in conjunction with the system and have given very good results; but as the results obtained by hand firing have on the whole been somewhat better, the heated air alone ensuring complete combustion without any assistance from mechanical stoking, it would serve no useful purpose to discuss the various forms of stokers that have been used, and the results given in the various tests of coal-fired boilers are in all cases with hand firing unless otherwise stated.

The principal advantages obtained are twofold—namely, a great increase in the steaming capacity of the boilers and economy in fuel. The heated air delivered mostly underneath the fire causes rapid and complete combustion at a high temperature, as shown by the whiteness of the flame and no smoke being formed. The high temperature is not, however, found to be detrimental to the boiler owing to its not being concentrated on any small area, but being very uniformly distributed.

With a hand-fired boiler the actual evaporation is generally increased as much as 40 per cent., and with coal of a calorific value of

* Abstract of a Paper read at the recent meeting of the Iron and Steel Institute.

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13,000 British thermal units an evaporation of 10 lb. of steam per pound of coal has been obtained.

With marine boilers the system has been very extensively used both in the British and American Mercantile Marine.

The following test gives the comparative results of an ordinary Lancashire boiler, and of the same boiler fitted with the induced draught, but using a somewhat inferior quality of coal.

Lancashire Boiler, 8 ft. diameter by 28 ft. long.

—	Natural draught.	With Ellis and Eaves' system.
Duration of test	7 hours	6 hours
Grate area.....	39 sq. ft.	36 sq. ft.
Fuel used	Washed hard	Rother Vale washed
Temperature of feed water	47 deg. [nuts*	142 deg. [nuts†
Steam pressure	93 lb.	84 lb.
Coal burnt per square foot of grate per hour	25·8 lb.	30 lb.
Percentage of refuse	7·08 lb.	6·2 lb.
Calorific value of coal....	14,000	13,000
Water evap. per hr., actual	6,724 lb.	10,180 lb.
,, ,, per lb. coal, act.	6·68 lb.	9·42 lb.
Water evap. per lb. of coal from and at 212 deg. ..	8·07 lb.	10·45 lb.
Efficiency	55·6 per cent.	77 per cent.

The figures given in the first column are the mean results of five tests in a prize stoking competition for the avoidance of smoke that was conducted by Mr. R. Heber Radford, and therefore represent very careful stoking. It will, however, be seen that the induced draught system, though generating approximately 50 per cent. more steam, is at the same time effecting a saving in coal of over 25 per cent., after making full allowance for the power used in driving the fan.

A test was also made on two Lancashire boilers, 9 ft. by 30 ft., at the Cargo Fleet Iron Co.'s works, fired by blast furnace gas. Owing to the fluctuations in the supply and the low temperature of the gas a small quantity of coal was burnt; but, as will be seen from the figures, the actual quantity of coal was quite insignificant, and was duly allowed for in estimating the evaporation per pound of gas and in the efficiency. It will be noticed that the use of the system has the effect of nearly doubling the actual evaporation, whilst at the same time increasing the efficiency from 48 to 75 per cent.

The system has also been applied to boilers fired with producer gas, and there is very little doubt that the results with this will prove equally as advantageous as with blast furnace gas; but I regret that I have not up to the present had the opportunity of making any tests with producer gas.

—	Natural draught.	With Ellis and Eaves' system.
Duration of test	6 hours	6 hours
Heating surface, each boiler	1,000 sq. ft.	1,000 sq. ft.
Total gas fired, in two boilers	351,540 cub. ft.	459,600 cub. ft.
Gas fired per boiler per hour	58,590 ,,	76,600 ,,
Weight of gas per boiler per hour	4,687 lb.	6,120 lb.
Total coal burnt, in two boilers.....	1,120 lb.	1,120 lb.
Total water evaporated, in two boilers....	38,250 lb.	67,500 lb.
Water evap. per boiler per hour, actual ..	3,187 lb.	5,625 lb.
Water evap. per boiler per hour, from and at 212°F.	3,792 lb.	7,031 lb.
Water evap. per lb. gas eliminating coal ..	0·67 lb.	1·04 lb.
Efficiency of plant	48 per cent.	75 per cent.
Average temperature of gas	66°F.	68°F.
,, ,, of feed water	119°F.	93°F.
,, steam pressure	183 lb.	182 lb.
,, superheater temperature	460°F.	543°F.
Temperature of air entering heater	..	68°F.
,, of air entering fires	..	315°F.
,, of gases entering heater	..	754°F.
,, of gases leaving heater	..	463°F.
Draught at chimney.....	½ in.	1½ in.
Average CO_2 chimney base.....	9·2 per cent.	13 per cent.
Calorific value of gas	1,337 B.T.units per lb.	1,337 B.T.units per lb.

The author also gives particulars of tests made on a marine boiler, a Stirling boiler and several other Lancashire boilers.

A recent improvement that has been introduced by the patentees, Messrs. John Brown & Co. (Ltd.), is the "balanced draught." This improvement consists in the use of two fans, one of which induces the draught at the chimney base at a water-gauge vacuum of about 1½ in., and the other forces in the air supply through the heater at a pressure of about 1 in. The effect of this is to balance the draught at the furnace front, so that when the fire door is opened there is neither any inrush of cold air nor the inconvenience of a tendency for the flame to be blown out. This arrangement does not increase the cost, as the slight extra involved in having two fans is counterbalanced by the somewhat smaller power that it is found is required to drive them. Also, as the vacuum is reduced by nearly one-half, the possible loss through any leakage that there may be in the boiler setting is correspondingly reduced.

To summarise briefly, the principal advantages obtainable by the use of the system are as follows: (1) Economy in fuel. (2) Great increase in the steaming capacity of each boiler, and consequently fewer boilers required and less space occupied. (3) Absence of smoke. (4) Easily controlled to suit variation in steam consumption. (5) Safety and cleanliness in working, as flame cannot be forced out, nor any dust or gases. (6) No risk of injury to the fan owing to the cooling of the gases in the air economiser. (7) No high chimney required.

Already there are a very considerable number of important installations in several of the leading iron and steel works in this country that have been in use long enough to give the system a fair test, and the results that have so far been obtained, as well as the advantages enumerated above, seem to render the system worthy of extensive application.

* Very clean; swallow wood seam. † Average quality.

AN INVESTIGATION ON THE USE OF STEAM IN GAS-PRODUCER PRACTICE.*

BY W. A. BONE, F.R.S., AND R. V. WHEELER, M.SC.

Summary.—This Paper contains the results obtained at trials on two Mond producers. Varying the temperature by altering the proportions of air and steam in the blast causes the quality of the gas to deteriorate if the saturation temperature exceeds 65 deg. The thermal efficiency and other considerations show the best saturation temperature to be about 60 deg.

The experiments recorded in this Paper were carried out with a view to determining the influence of variation in the proportions of air and steam in the blast upon the composition of the gas, its suitability for furnace operations, and upon the general and thermal efficiencies of the producers. The investigation comprised a series of five trials, each extending over a full working week, with the plant supplying washed gas both for gas-engines and for re-heating and puddling furnaces, all working under normal conditions.

The two producers selected for these trials were of the well-known Mond type. They were erected in 1903 as the first instalment of the gas plant at the works of Messrs. Monks, Hall & Co. (Ltd.), Warrington, for the supply of washed gas to their re-heating and puddling furnaces and gas engines. The Mond producer was admirably adapted to the purposes of our investigation, for two reasons—viz., (1) the superheating of the blast not only renders the use of a large proportion of steam possible, but (2) it also ensures the perfect admixture of steam and air, in easily regulated proportions, before the blast reaches the incandescent fuel. It must be clearly understood, however, that the object of our investigation was not the testing of the efficiency of the Mond system as such, but rather to determine how steam may be used to the best advantage in a producer, having regard to the quality and composition of the gas and its suitability for furnace purposes. Another consideration which must be borne in mind is that no ammonia recovery was attempted, although careful estimations were made from day to day of the ammonia actually present in the gas, during the trials.

The two producers were of the water-bottom type, and consisted of an inner shell (the producer proper) constructed of mild steel plates lined with firebrick and encased within a similar outer shell. The air and steam composing the blast passed through the annular space (5 in.) between these two shells before entering the producer below the fire-bars. The lower part of the producer was conical in shape and extended downwards into the water lute.

A large cast-iron bell maintained a constant fuel level in the producer of about 14½ ft. above the fire-bars, and also assisted, to a certain extent, in the preliminary dry distillation of the coal. The products of this distillation had, moreover, to pass out at the bottom of the bell and through the hot fuel in the body of the producer before reaching the gas exit into the superheaters outside. It is generally supposed that this arrangement brings about the decomposition of a portion of the tarry products of the distillation, but, in our opinion, its value in this respect is somewhat doubtful.

On leaving the producers, the hot gas passed through the superheaters, round which the air and steam forming the blast travelled, in the reverse direction, through the annular space between the inner gas main and an outer jacket. In this way part of the sensible heat of the gas was transferred to the blast, the temperature of the gas leaving the superheaters during the day shift ranging from about 180°C. to 260°C. as the steam saturation temperature of the blast was raised from 60°C. to 80°C. From the superheaters the gas passed through the rectangular iron washers where it met with a fine spray of water thrown up by revolving dashers.† The gas was

* Abstract of a Paper read before the Iron and Steel Institute.

† These were purposely worked more slowly than in the usual Mond practice; indeed, the gas destined for the furnaces was simply allowed to skim the surface of the water.

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here partly freed from tar vapours, and further cooled to between 94°C. and 100°C., according to the steam saturation temperature maintained during the trial. The fact that the gas was required both for furnaces and for engines rendered it desirable to differentiate between the subsequent treatment of each supply. Since the presence of a certain amount of tarry vapours in a furnace gas is rather an advantage than otherwise, not so much, perhaps, because of the increased calorific value (since this is very small) as on account of the fact that the tar vapours render the flame luminous in the furnace, the furnace supply was not washed or cooled, but sent direct to the furnace distributing mains. The engine supply was, however, further cooled to almost atmospheric temperature by being passed up the gas-cooling tower, and was finally freed from tarry vapours by passage through sawdust scrubbers.

A notable departure was made from the usual Mond practice during these trials in that no recuperation was attempted in the air heating towers.

The steam used for saturating the air blast during the trials was partly exhaust steam (in the trials at 60 and 65 deg. wholly so) and partly live steam.

The rated capacity of the two producers corresponded to a gasification of 32 cwt. of coal per hour (16 cwt. per producer), but since the demands for gas during the day shift never necessitated a gasification of more than 24 cwt. per hour, it will be seen that the plant was not worked beyond about three-quarters of its rated capacity.

The only condition which was purposely varied during the trials was the steam saturation temperature of the air blast at the producer. Beginning with a "saturation temperature" of 60°C., it was raised, week by week, in stages of 5 deg., up to 80°C., which represents the ordinary Mond practice where ammonia recovery is not attempted. Suitable arrangements were made for (1) the weighing of the whole of the coal charged into the producer, as well as of that burned under the boiler, throughout each trial; (2) the continuous sampling of the gas over a period of eight hours during each day shift, each sample therefore representing the mean composition of the gas generated in one day; (3) the daily estimation of ammonia, tar vapour and sulphur compounds in the gas; (4) the weekly collection and weighing of the tar deposited throughout the plant during each trial; (5) the weighing of the dried ashes, clinker and coke withdrawn from the water troughs at the bottom of each producer; and (6) the estimation of the amount of soot and fine ash carried over by the gas and deposited in the mains during each trial.

The samples of coal, tar, ashes, soot, gas, &c., were afterwards submitted to careful analysis, and from the data were calculated: (1) The total carbon in a ton of dry coal charged into the producer; (2) the proportion of this carbon lost in the tar, ashes, and soot; (3) the proportion of the carbon actually gasified; (4) the weight of carbon in a cubic foot of the gas; (5) the yield of gas per ton of coal gasified; (6) the calorific value of the gas per cubic foot at 0°C. and 760 mm.

Determination of Efficiency.—There is as yet no general agreement among chemists and gas engineers as to the precise definition of "efficiency" as applied to producer plants. In our opinion, the efficiency of a gas-producing plant should have reference to the gas as delivered to the furnace main or the engines, and should be based on the net calorific values of the coal and gas respectively. It should include the coal burnt under the boiler for raising steam for the blast, plus that required for the blower engine; and also where it is necessary to cool and wash the gas for engines it should include the coal equivalent of the mechanical work required for the washing. The efficiency would then represent the ratio of the available energy of the gas, as supplied to the furnace or engine, to the energy of the coal required to produce it.

The boiler used for supplying steam for the gas plant evaporated 8 lb. of water, from and at 100°C., for every 1 lb. of dry coal, of net calorific value 8,368 kg. C. units, burnt under it. This corresponds to a boiler efficiency of 58 per cent. only. As it would obviously be unfair to saddle the producer plant with the shortcomings of the boiler, we have, in calculating the various efficiency ratios, assumed a boiler efficiency of 70 per cent. In other words, the figures quoted in the tables for fuel consumed at the boiler are in each case the actual consumptions multiplied by $\frac{58}{70}=0{\cdot}83$.

The steam required for mechanical work on the plant corresponded to an average coal consumption at the boiler of as nearly as possible 2 cwt. per hour during the trials, calculated on the basis of a 70 per cent. boiler efficiency. Of this, 0·5 cwt. was required to provide steam for the blowing engine; the remaining 1·5 cwt. represented the coal equivalent to the work done during the washing of the gas.

In the case of each of the five trials we have calculated three different sets of efficiency ratios, all for the cold and completely washed gas, as delivered to the engines, and all based on the net calorific values of both gas and coal, as follows:—

z_1 = Thermal efficiency of the plant, under the actual conditions of the respective trials, the higher value including the steam required for the blower engine, the lower value including the steam required both for the blower engine and the washing plant.

z_2 = A similar pair of values, but calculated on the assumption that the whole of the steam added to the blast was live steam from a boiler with a 70 per cent. efficiency.

z_3 = A third pair of values, but calculated on the assumption that the whole of the steam added to the blast was exhaust steam.

The coal used during the trials was screened over a 1 in. mesh, and as delivered to the producer it contained from 3 to 6 per cent. of moisture.

The principal results of the five trials may be summarised in one table, thus:—

Steam saturation temperature.	60deg.	65deg.	70deg.	75deg.	80deg.
Coal consumption at producer, cwt. per hour	16·51	14·26	13·88	14·32	13·21
Coal consumption at boiler, cwt. per hour	2·0	1·8	2·38	2·87	3·35
Coal consumption for blast steam	nil	nil.	0·66	1·17	1·65
Total carbon losses, per cent.	5·8	7·8	8·1	7·1	8·4
Mean percentage composition of gas obtained. Carbon dioxide	5·25	6·95	9·15	11·65	13·25
Carbon monoxide	27·30	25·40	21·70	18·35	16·05
Hydrogen	16·60	18·30	19·65	21·80	22·65
Methane	3·35	3·40	3·40	3·35	3·50
Nitrogen	47·50	45·90	46·10	44·83	44·55
Total combustibles.	47·25	47·10	44·75	43·50	42·20
Calorific value of gas.. Gross	46·77	46·74	44·74	43·37	42·73
Net	43·60	43·32	41·14	39·65	38·69
(Kilog. cent. units per cubic ft. at 0°C. and 760 mm.)					
Yield of gas, cubic ft. per ton	138,250	134,400	141,450	145,800	147,500
Lb. of steam in blast per lb. of coal gasified	0·45	0·55	0·80	1·10	1·55
Percentage of steam decomposed.	87·4	80·0	61·4	52·0	40·0
Cubic ft. of air, at 0°C. and 760 mm., in blast per lb. carbon gasified	36 95	34·9	36·8	36·9	37·1
Ratio of $\frac{\text{oxygen from steam}}{\text{oxygen from air}}$	0·50	0·62	0·65	0·75	0·80
Ammonia in gas, as lb. of ammonium sulphate per ton of coal	39·0	44·7	51·4	65·25	71·8
Efficiency ratios in actual trial— (1) Including steam for blower engine	0 778	0·750	0·727	0·701	0·665
(2) Including steam for blower engine and washers	0·715	0·687	0·660	0·640	0·604

General Conclusions.

1. *Quality and Composition of the Gas.*—A glance at the summarised results in the foregoing table will show that the quality of the gas obtained, though always good, steadily deteriorated as the steam saturation temperature was raised beyond 65 deg. Thus, whereas at 60 and 65 deg. the average percentage of total combustibles in the gas exceeded what must be considered the high figure of 47 per cent., it steadily dropped to about 42 per cent. as the steam saturation temperature was raised to 80 deg. This fall off in quality was, it is true, partly counterbalanced by an increase in the quantity produced per ton of coal gasified; but, as will be shown immediately, the general efficiency of the process fell off as more steam was used. But the advantages gained by working at the lower steam saturation temperatures become more marked when the composition of the gas is taken into account. It will be seen as the steam saturation temperature was raised, the gas became richer in hydrogen and carbon dioxide, but much poorer in carbon monoxide, and that the gain in hydrogen was more than counterbalanced by the loss in carbonic oxide. This circumstance is, of course, due to the influence of the steam in lowering the reaction temperatures in the zone of combustion, whereby the reaction $C+2OH_2=CO_2+2H_2$ comes into play at the expense of the reaction $C+OH_2=CO+H_2$, and the equilibrium $CO+OH_2 \rightleftarrows CO_2+H_2$ shifts towards the right hand. This influence naturally increases as the steam saturation temperature is raised, with the result that the quality and composition of the gas alters as shown by our results. With a steam saturation temperature of 60 deg., the resulting gas contained no less than 27·3 per cent. of carbon monoxide, together with 16·6 per cent. of hydrogen, 3·35 per cent. of methane, and only 5·25 per cent. of carbon dioxide. But with a saturation temperature of 80 deg., the percentage of carbonic oxide had fallen to 16·05, whilst the hydrogen had increased to 22·65 per cent. and the carbon dioxide to 13·25 per cent., the methane remaining practically constant throughout the trials. The net calorific value of the gas gradually fell from 43·60 to 38 69 kg. C. units per cubic foot, at 0°C. and 760 mm., as the steam saturation temperature was raised.

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Now, as we have already pointed out, the "furnace efficiency" of carbon monoxide is much higher than that of hydrogen, and that consequently the furnace efficiency of a producer gas rich in carbon monoxide is higher than that of a gas of equal calorific value, but in which carbon monoxide is partly replaced by hydrogen. Hence we were not surprised to find that the value of the gas obtained with steam saturation temperatures of 60 and 65 deg., from the point of view of its combustion in the furnaces, was greater than that of the gas obtained in any of the other trials to an extent altogether out of proportion to its actual superiority as measured in a calorimeter. In other words, the difference between the two net calorific values 43·60 deg. and 38·69 deg. per cubic foot, for the gases obtained with steam saturation temperatures of 60 deg. and 80 deg. respectively, are magnified when their "furnace efficiencies" are taken into consideration.

2. *Thermal Efficiencies of the Plant.*— If now the thermal efficiencies of the plant be considered, it will be seen at once that the use of steam beyond that required to saturate the air-blast at 60 deg. was not attended by any increased economy of working, but rather the reverse. If, in calculating the thermal efficiencies in the various trials, account be taken of the steam added to the blast, and the work expended in driving the blower and the washers, the following values are obtained, namely, z_1 under the actual conditions of the trial, z_2 on the assumption that the blast steam was wholly live steam from a boiler with a 70 per cent. efficiency, and z_3 on the assumption that the whole of the blast steam was exhaust steam :—

Steam saturation temperature ..	60 deg.	65 deg	70 deg.	75 deg.	80 deg.
z_1	0·715	0·687	0·660	0·640	0·604
z_2	0·687	0·655	0·630	0 611	0·578
z_3	0·715	0·687	0·677	0 673	0·660

Under the conditions of the trial, therefore, the thermal efficiency of the plant fell from 71·5 to 60·4 per cent. as the steam saturation temperature was raised from 60 to 80 deg. If, however, live steam only had been used for the blast, the corresponding fall would have been from 68·7 to 57·8 per cent. And even if it had been possible to saturate the air-blast with exhaust steam entirely throughout the trials, the efficiency would have fallen from 71·5 to 66·0 per cent. Hence it is clearly proved that the use of steam over and above that required to saturate the blast at 60 deg. does not lead to higher thermal efficiencies.

3. *Amounts of Steam Used and Decomposed in the Trials.*—The amounts of steam used and decomposed in the producer during the trials, in terms of pounds per pound of dry coal gasified, are recorded below :—

Steam saturation temperature ..	60 deg.	65 deg.	70 deg.	75 deg.	80 deg.
Steam used	0·45	0·55	0·80	1·10	1·55 lb.
Steam decomposed	0·39	0·44	0·49	0·57	0·62 lb.
Per cent. steam decomposed ..	87·4	80·0	61·4	52·0	42·0

4. *Yields of Ammonia.*—If a gas producer be regarded primarily as an apparatus for ammonia recovery, then undoubtedly it should be worked with the highest steam saturation temperature consistent with the production of combustible gas. The ammonium sulphate equivalent of the ammonia in the gas during the trials increased from 39 lb. to about 72 lb. per ton of dry coal gasified, as the steam saturation temperature of the blast was raised from 60 to 80 deg. Probably the best steam saturation temperature, if ammonia recovery be considered in conjunction with the suitability of the gas for furnace purposes and the thermal efficiency of the process, is somewhere in the neighbourhood of 65 deg., or possibly between 65 and 70 deg. At 65 deg. over 30 per cent. of the nitrogen in the coal can be recovered as ammonia, or nearly double the amount usually recovered in by-product coking processes, in conjunction with a very suitable gas for furnace purposes.

(5) *Tar Production and Carbon Losses generally.*—Altogether 419 tons of coal, containing 736,200 lb. of carbon, were charged into the producer during the course of the trials. The quantity of anhydrous tar obtained, including both that removed in the washing of the gas and that carried forward to the furnaces, amounted to 24·1 tons, or 5·75 per cent. of the weight of the coal charged. The carbon in this tar amounted to 44,920 lb., or 6·1 per cent. of the total carbon charged into the producer. The carbon lost in the ashes, and as soot deposited in the gas mains, amounted altogether to 9,666 lb., or 1·3 per cent. of the total carbon charged into the producer. Thus the average amount of the carbon originally charged into the producer which appeared as permanent gas was as nearly as possible 92·6 per cent.

6. *Sulphur in the Gas.*—The sulphur originally in the coal amounted to as nearly as possible 19 lb. per ton. Of this we calculate that as nearly as possible 16·5 lb., or about 87 per cent., appeared in the gas, chiefly in the form of hydrogen sulphide. The amount of hydrogen sulphide in the gas was of the order of 0·1 per cent. by volume.

CRITICAL CONSIDERATION OF THE HIGH-TENSION DIRECT-CURRENT SYSTEM OF ELECTRIC-POWER TRANSMISSION.

We give below an abstract of an article on this subject which appeared in a recent number of the *Elektrotechnik und Maschinenbau*. It is stated to be due to a well-known English engineer, who does not wish his identity to be disclosed. The author discusses the Paper read recently by Mr. Highfield* before the Institution of Electrical Engineers, and objects to the relation obtained for the effects of insulation for direct and alternating currents. He also contends that Mr. Highfield's figures for the erection and working costs are on the wrong basis, and makes out a much better case for the three-phase system.

It is a general characteristic in all tests on insulating materials that the disruptive voltage increases at a less rate than the thickness of the material. If a sheet of insulating substance breaks down at a certain voltage, the voltage required to break down a sheet double the thickness is much less than double that in the former case. This law is also applicable to liquids and gases. In all cases the proper relation between voltage and thickness is hard to determine, as it depends on the form, nature and size of the electrodes as well as on the temperature and general properties of the material. According to Baur, who made tests on a large number of materials, the relation may be expressed by the equation :—

$$D = Kt^{\frac{3}{4}},$$

where D is the effective voltage, t the thickness in millimetres, and K a constant which must be determined for each material. The specification of the Engineering Standards Committee for three-core cables with a working voltage of 11,000 between the cores requires an insulation thickness of 9 mm. between copper and lead. The three-core cable used by the County of Durham Company, whose working voltage is 20,000, has insulation 13 mm. thick. The factor of safety for a power transmission cable is hard to determine owing to the considerable influence which the length of time the current is flowing and other practical factors have on the result. It may be supposed, however, that under certain conditions the breaking-down voltage in these cables is about three times the working voltage. K then becomes in the first case 7,600 and in the second 10,800, or a mean value of 9,200.

It may, therefore, be admitted that with the present-day methods of manufacture, and using ordinary materials, the value of K for a finished cable is about 10,000. These relations, however, appear in a new light when it is stated that a sheet of insulating material of given thickness requires a voltage 2½ times as great to break it down when direct current is used instead of alternating. For the proper discussion of this question it may be supposed that a continuous voltage has half the disruptive strength of alternating. A cable was shown before the Institution of Electrical Engineers which was in use on a 50,000 volt direct-current system. This cable had an insulation thickness of 14 mm. between conductor and lead sheath. The cable could, therefore, only be used for 25,000 volts alternating. The factor of safety would be 3 and K would be equal to 13,000. From further data given on this subject by the author it is shown that no such general law for insulation thickness at different voltages and with a certain factor can be given. The equation is of the order $D = Kt^n$, K being a constant depending on the insulating material. The exponent n is always less than 1 and decreases rapidly with decreasing diameter of conductor. No such law can be established for cables insulated with different materials.

In the sketch of the typical bulk supply area given by Mr. Highfield the direct-current system working at 100,000 volts requires 84 miles of cable 0·1 sq. in. in cross-section. The system can be earthed at the middle point, so that there is only a pressure of 50,000 volts between conductor and earth. Trenching running to 84 miles is also required. The three-phase system working at 20,000 volts between conductors requires 52 miles of three-core cable, each core having a cross-section of 0·75 sq. in., and 66 miles 0·5 sq. in. in cross-section. Earthing the neutral point requires the insulation between conductor and lead sheath to withstand 11,500 volts. Trenching amounts to 85 miles in this case.

Mr. Highfield put the total cost of the direct-current cable at £580 per mile, which is 1·57 times greater than that for the material alone. This factor will be greater for the three-phase cable, and may be taken as 1·8. Mr. Highfield puts the cost of the two three-phase cables required at £1,050 and £900 per mile. In reality they only cost £784 and £608 per mile. The costs for trenching were given as £900 per mile for direct current and £1,000 per mile for three-phase. These two items were shown in the discussion to be too high; they are sufficiently covered by £700 per mile, even taking into account the special conditions prevailing in the neighbourhood of London, where the requirements of the property owners have to be considered. The total cost for mains in this scheme

The Electrician, Vol. LVIII., pp. 794, 845, 891.

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would be £107,000 for direct current and £141,000 for alternating, a difference of 32 per cent. According to Mr. Highfield, the amounts would be £124,320 and £199,000, a difference of more than 60 per cent.

The employment of direct current is, accordingly, only to be recommended from a commercial point of view when the network expenses are small compared with the three-phase system. The greater part of these economies are, however, imaginary, and in no wise cover the higher costs of the direct-current generating station.

The following points in the Paper are open to criticism. The units chosen for the three-phase system should be larger and those for the direct-current system smaller. The largest units at present working on the direct-current system are only 600 kw. (Moutiers-Lyon), and except for these the largest is 400 kw. The buildings costs will, therefore, become smaller in the case of the three-phase and larger for the direct-current system. This also applies to the cost of the machinery proper and to the switch-gear. The costs for boilers, auxiliary machinery and coaling arrangements given by Mr. Highfield for the direct-current system are too low, as the greater number of smaller units increases the steam consumption. The lower efficiency of the direct-current system requires that a greater number of units must be generated for the consumer to receive a specified amount than if a constant voltage system were employed

Owing to the peculiar conditions of the direct-current system the distribution losses are always the same. Therefore the efficiency of transmission is low at light loads and high at full load. As far as upkeep costs are concerned direct current is at a disadvantage for the following reasons. The distribution losses are the same at all loads, and therefore the percentage loss increases as the load decreases. On a constant voltage system the reverse is the case. The percentage loss on the direct-current system may be very small, being placed by Mr. Highfield at 3 per cent. at full load.

The author concludes by stating that no great future can be predicted for the direct-current system.

THE STERILISATION OF DRINKING-WATER BY MEANS OF OZONE.*

BY G. EHRWEIN.

The idea of obtaining ozone from atmospheric oxygen and of using this powerful oxidising modification of oxygen for sterilising drinking-water dates back to the year 1889, when Werner von Siemens made his first researches on the subject. But the time for applying these experiments to the purification of drinking-water did not seem to have arrived, and the first step in this direction was in late years, when the claims of hygiene led to the building of some large ozone works for town water supply, which justified the hope that the use of ozone would in future put a stop to the foolish omissions in the general methods of purification of water.

Messrs. Siemens & Halske took the matter up, and after several years of research succeeded in patenting a process which contained the features desirable in hygienic water purification. The system is a safe one as regards technical, chemical and bacteriological considerations.

Ozone, the operative agent in this method, has, as already mentioned, an extraordinarily powerful oxidising effect on organic substances and kills the bacteria found in water. Of all known methods of generation the best is that which depends on the action of a high pressure electric discharge on the air to be ozonised.

The arrangement of the apparatus used is shown in Fig. 1. It consists of a cast-iron case, divided into three parts and fitted with box lids. There are eight parallel glass tubes, passing through water-tight glands at the top and bottom of the middle chamber. During the action the box is filled with water, which serves partly for cooling purposes and partly for conducting the current. In the cylinders the so-called inner poles are arranged so that there is everywhere the same distance between the glass cylinder and the pole surface. These inner poles are connected to the high-voltage side of an alternating-current transformer. The other pole and the box, which serves as the return, are earthed. When the transformer is excited a silent discharge takes place at a certain voltage between the inner pole and the glass cylinder. This is accompanied by a violet light in the air space. The air to be ozonised is drawn into the lower part of the apparatus by a fan, and passes to the space just mentioned, where a part of its oxygen is transformed into ozone. The ozonised air collects in the upper part of the vessel, and is led thence through pipes to the sterilising tower. In practice the apparatus described above is assembled into several groups.

Filtration of the water is next in importance to proper sterilisation. The unfiltered water is pumped into a special reservoir by a centrifugal pump, and thence passes through a filter to the collecting basin over the sterilising tower. This tower acts as a scrubber, and is, as a rule, constructed of concrete lined with water-tight plaster. In the lower part an iron grid is fixed, which divides the tower into two sections, the ozonising room and the collecting room. The ozonising space is filled with gravel resting on the iron grid. A water distributor fixed in the roof of the tower sends water through a sieve on to the surface of the gravel in the form of rain. It trickles in a finely divided state between the stones and exposes a large contact surface to the ozone which is driven up from below. The filter retains all organic suspended matter, while the ozone destroys all bacteria. The result of this process is a colourless water, free from all pathological disease-bearing germs, and complying with all hygienic demands.

The sterilisation of drinking water by ozone has been made the subject of exhaustive tests by both municipal and scientific authorities, the results of which may be summed up as follows: (1) The treatment of water by ozone generally causes the destruction of the bacteria. In this respect the process is superior to sand filtration. (2) Cholera and typhus bacteria in water submitted to this process are destroyed. (3) The chemical effects are a decrease of oxidising matter and an increase of free oxygen in the water. These are both improvements. (4) The ozone in solution is unimportant, both from the technical and salutary standpoint, as it soon passes into oxygen. (5) The process improves the water by the destruction of colouring matter. (6) Water treated by this process acquires no strange smell or taste.

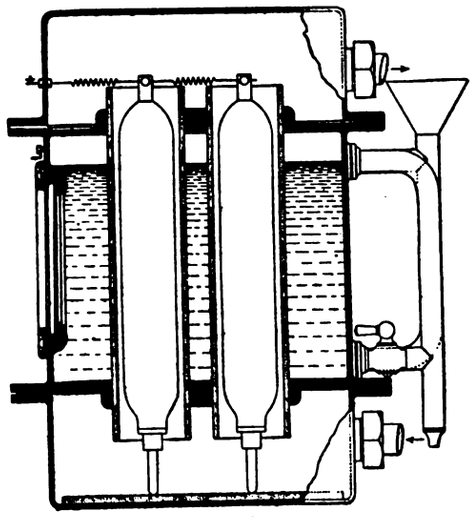

FIG. 1.—TUBE APPARATUS.

The following table shows the results of some tests carried out at Messrs. Siemens & Halske's experimental works on ordinary supply water and on water taken from the Spree. These waters were treated with pathological germs under conditions that will hardly be met with in practice in order to prove the absolute destruction of the bacteria.

Results.

Description of water.	Description of bacteria.	Bacteria per ccm. of water. Before the ozonisation.	After the ozonisation.
Ordinary water from the Spree treated with cholera or typhus bacteria	Cholera	16,350	0 pathological
	Typhus	16,590	0 ,,
	Cholera	38,330	0 ,,
	Cholera	43,890	0 ,,
	Cholera	45,170	0 ,,
Water treated with pathological bacteria	Cholera	600,000	0 ,,
	Cholera	600,000	0 ,,
	Typhus	600,000	0 ,,
	Typhus	600,000	0 ,,
	Dysentery	600,000	0 ,,

New Lamp Changer.—The *Western Electrician* gives an account of an arrangement designed to simplify the removal and renewal of incandescent lamps, when these are fitted in inaccessible positions. The device is built on the same principle as the human hand. It has a set of artificial fingers, which go over and grasp the lamp firmly while it is being removed or replaced in the socket. Rubber bands over the ends of the fingers prevent the lamp from slipping while it is being turned.

* Translated from the *Schweizerische Elektrotechnische Zeitschrift*. Slightly abbreviated.

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THE INFLUENCE OF PRESSURE ON THE SYNTHETICAL FORMATION OF AMMONIA GAS BY THE ELECTRIC SPARK.*

BY E. BRINER AND E. METTLER.

The synthesis of ammonia by the action of electrical discharge on a mixture of nitrogen and hydrogen has already been extensively studied. The exact rôle played by the various factors which influence the production, such as the pressure, the electrical action, the temperature and the distance apart of the electrodes, is, however, not known. The question has, therefore, been studied from this point of view, which is specially interesting on account of the work done on the fixation of nitrogen.

The concentration of ammonia gas, formed in a closed vessel under the action of a spark, rapidly reaches a very low limit, 3 or

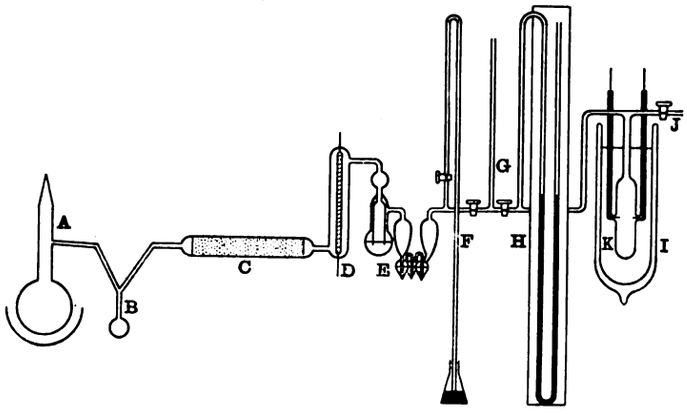

FIG. 1.—APPARATUS FOR THE SYNTHESIS OF AMMONIA.

4 per cent according to one of our experiments, on account of the destructive effect of the electrical discharge. In order to transform a larger fraction this destruction has been avoided by immersing the eudiometer in liquid air. A hot-cold system is thus constituted, in which ammonia is deposited in the form of snow with a negligible vapour tension. With a mixture corresponding to the formula N_2+3H_2 a very nearly perfect vacuum has been obtained under the synthetic action of the electric spark. Fig. 1 is a diagram of the apparatus used in these researches.

The mixture ($N_2 + 3H_2$) was prepared according to a method already employed in this laboratory. Ammonia obtained from a mixture of lime and ammonium chloride contained in a flask, A, is dried by anhydrous baryta C and decomposed in the tube D by a spiral of iron, platinum or nickel, brought to a red heat by an elec-

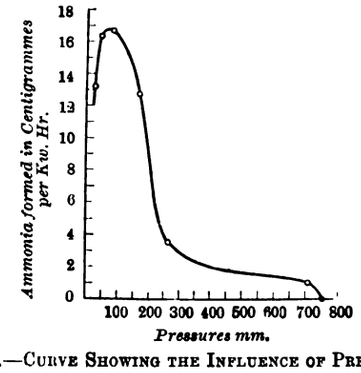

FIG. 2.—CURVE SHOWING THE INFLUENCE OF PRESSURE ON THE AMMONIA PRODUCTION.

tric current (the decomposition is most rapid when nickel is used). The gaseous mixture is freed from the small quantity of ammonia which it still contains by bubbling it through sulphuric acid, E. It then reaches the eudiometer K, which is provided with two platinum electrodes and connected with the mercury manometer H. The different parts of this apparatus are fused together and are perfectly airtight. The electrodes are placed in the secondary circuit of a Ruhmkorff coil, whose primary is fed by an alternating current of frequency 47 through a Wehnelt interrupter. The regulation is effected by rheostats, and the energy consumed can be obtained from an integrating wattmeter connected in the primary circuit. The total energy consumed in the primary is easily evaluated, and the amounts obtained are reduced to this value, which is considerably greater than that actually absorbed by the spark.

* Translated from the *Comptes Rendus*.

The quantities of ammonia gas formed are deduced from the manometer, the amount produced being given by the relation $x=100\left(1-\frac{p}{p'}\right)$ where p and p' are respectively the initial and final pressure reduced to the same temperature. *The influence of the pressure* on the production of ammonia gas (between 20 mm. and 800 mm. pressure of mercury) has been determined. Our results are represented in Fig. 2, where the pressures are abscissæ and the quantities of ammonia formed are ordinates. The curve shows a very accentuated maximum corresponding with a pressure of about 100 mm. At this pressure the production, calculated as we have indicated, is about 0·17 gramme of ammonia gas per kilowatt-hour. The cause of this maximum cannot be exactly determined. It is certain that a rise in pressure, increasing the concentration of the gases, all things being equal, should accelerate the reaction. On the other hand, the electrical conductivity of gases decreases as the pressure increases. There are, therefore, two actions working in an inverse sense and giving rise to a maximum. If, however, on account of the pressure change, the energy used between the electrodes, which alone has been taken into consideration, does not always represent the same fraction of the energy measured in the primary, this fact must also influence the existence of a maximum.

THE FARADAY SOCIETY.

A meeting of the Faraday Society was held on Tuesday, June 25, 1907, at the Institution of Electrical Engineers, 92, Victoria-street, S.W., when a general discussion on "Hydrates in Solution" took place. Prof. S. P. U. Pickering, F.R.S., was in the chair.

As contributions to the discussion the following four Papers were read :—By Mr. W. R. Bousfield and Dr. T. M. Lowry on "Thermochemistry of Electrolytes," by Dr. J. C. Philip on "Hydrates in Solution," by Dr. G. Senter on "Methods for Determining the Degree of Hydration," and by Dr. A. Findlay on "The Stability of Hydrates."

THE THERMOCHEMISTRY OF ELECTROLYTES IN RELATION TO THE HYDRATE THEORY OF IONISATION.*

BY W. R. BOUSFIELD, M.A., AND T. MARTIN LOWRY, D.SC.

1. *Energy-Changes Accompanying the Ionisation of a Salt.*—One of the fundamental difficulties of the theory of electrolytic dissociation is to discover a motive force adequate to account for the separation in aqueous solutions of elements so strongly attractive of one another as, for instance, potassium and chlorine. This difficulty has been repeatedly urged by Armstrong and others and has not as a rule received any direct or convincing answer. The difficulty was accentuated when Arrhenius (*Zeit. Phys. Chem.*, 1889, 4, 104), by making use of Van't Hoff's relationship—

$$\frac{d\log k}{d\mathrm{T}}=\frac{q}{2\mathrm{T}^2},$$

actually determined the heat changes involved in the ionisation or electrolytic dissociation of a number of acids, bases and salts, and found that in a large number of cases the process was accompanied by a liberation of heat.

Nernst ("Theoretical Chemistry," English translation, 1895, p. 562; 1904, p. 659), quoting the results of Arrhenius, observes: "In this way the result was ascertained that the dissociation of a substance into its ions is usually attended with a development of heat." Arrhenius himself points out that ordinary dissociation is normally accompanied by absorption of heat.

Ions are always assumed, when elementary, to consist of single atoms bearing a positive or negative charge. There is, therefore, no affinity of atom for atom on the right-hand side of the equation to account for a liberation of heat in the change—

$$\mathrm{KCl}=\overset{+}{\mathrm{K}}+\overset{-}{\mathrm{Cl}}+250\text{ calories};\dagger$$

on the other hand, it is well known that the formation of a molecular proportion of potassium chloride from its elements involves the liberation of a large quantity of heat, and that an equal amount would be absorbed in the decomposition of the salt into molecular potassium and molecular chlorine—

$$\mathrm{KCl}\longrightarrow\frac{\mathrm{K}x}{x}+\frac{\mathrm{Cl}_2}{2}-105{,}600\text{ calories.}$$

The decomposition into separate atoms of the molecules of potassium

* Abstract.

† Arrhenius, *Zeit. Phys. Chem.*, 1889, IV., 106. A different value is given in a later Paper (*Zeit. Phys. Chem.*, 1892, IX., 340); there appears to be much uncertainty as to the actual value of the heat-change, but the order of magnitude is all that need be noted for the purpose of the present argument.

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and chlorine would involve a further absorption of heat, and since the electrification of the naked atoms can scarcely be other than an endothermic process, the change represented by the symbols $KCl \rightarrow K + Cl$, so far from causing the liberation of 250 calories, must actually involve the absorption of more than 100,000 calories!

The extraordinary discrepancy between these two values appears to us to indicate that the process of ionisation cannot consist merely of a separation of the molecule into its constituent atoms even though these may be endowed with electrical charges, and we are driven to assume that the essentially endothermic process of dissociation must be balanced by some powerful exothermic action, associative rather than dissociative in its character.

2. *Water Combination as a Source of Energy in Ionisation.*—The general nature of this exothermic process was indicated many years ago by Fitzgerald, who (in opposition to the statements of Ostwald and others, that the solvent was quite inactive in electrolytic dissociation and merely served as a screen to keep separate the spontaneously generated ions) urged that it was a great mistake to neglect the very active part that the solvent must play in the process of solution (B.A. "Report," Leeds, 1890, 327).

Solvents such as water, hydrogen cyanide, sulphur dioxide and ammonia, which are specially active in promoting ionisation, are characterised by a high degree of "residual affinity" (Armstrong, *Trans.* Chem. Soc., 1895, 67, 1170; Dutoit and Aston, *C.R.*, 1897, 125, 240; Brühl, *Zeit. Phys. Chem.*, 1893, 27, 319), and there can be little doubt that this molecular property (of which the specific inductive capacity of the liquid* is perhaps a direct physical manifestation) is a factor of great importance in promoting ionisation.

These general considerations have in recent years found concrete expression in the hydrate theory of ionisation, which postulates that in aqueous solutions the energy required for the disruption of the salt molecule is derived from the combination of the solvent with the oppositely-charged radicles of the salt to form complex hydrated ions. On the experimental side we were led to advocate this view of ionisation as a sequel to the study of the volume changes which accompany the dissolution of electrolytes and the dilution of their solutions. According to the view which we advocate, the combination of the charged radicle, or ionic nucleus

$$\overset{+}{Na},\ \overset{-}{Cl},\ \overset{++}{Mg},\ \overset{--}{SO_4},\ \&c.,$$

with water is a powerful exothermic process, and the affinity of the ionic nucleus for water is the main source of the disruptive force which breaks down or ionises the molecule: the heat liberated in this way is of the same order of magnitude as the heat absorbed by the disruption of the molecule, and the balance may be either a small positive or a small negative quantity.

3. *Energy of Electrification of Ions.*—We are of opinion that the electrification of an atom is an operation which must normally be accompanied by an absorption rather than by a liberation of energy, and that the process of separating from one another the opposite charges of an anion and kathion cannot possibly be other than an endothermic action. In order to illustrate this point, we have made a rough calculation from the known values of the ionic charge and the ionic radius of the work required to electrify one equivalent of kathion or anion on the assumption that the ions are charged spheres immersed in a fluid dielectric.

This may be done as follows:—

1. The electrostatic capacity of a spherical conductor when widely separated from other conductors† is given by the formula $c = rk$, where r is the radius of the sphere and k the s.i.c. of the surrounding medium. The energy of the sphere, when electrified with a charge q, is $\rho = q^2/2rk$.

2. In order to apply this formula to the ions it is necessary to deduce values for the ionic charge q and the ionic radius r. If n is the number of ions in a gramme-equivalent‡ the ionic charge q in electrostatic units is given by the formula $q = \frac{Q}{n} \times 3 \times 10^9$, where Q is the charge in coulombs carried by one gramme-equivalent of ions, the factor 3×10^9 being introduced to bring the coulombs to e.s. units.

A value for the ionic radius may be deduced by assuming that the motion of an ion in an electrolyte is governed by Stokes' law for the movement of a sphere in a viscous medium. According to this law the radius is given by the expression $r = F/6\pi\mu v$, where μ is the viscosity of the medium, F the force acting on the sphere, and v is limiting velocity.

The force acting on a charge, q, in a field of 1 volt per centimetre is $q/300$ dynes, if q is in electrostatic units, the factor 1/300 being introduced in order to convert the potential gradient into the same system of units. The limiting velocity of an ion moving under this potential gradient is $v = l/Q$ cm. per second, where l is the ionic mobility and Q the charge of 96,540 coulombs carried by one gramme equivalent.°

The viscosity of water may be taken as $\mu = 0{\cdot}01$ and the ionic radius is then

$$r = \frac{Q \times 3 \times 10^9}{300n} \times \frac{1}{6\pi \times 10^{-2}} \times \frac{Q}{l} = \frac{Q^2}{nl} \times \frac{10^9}{6\pi}$$

3. Having thus deduced expressions for the ionic charge and the ionic radius, it is possible to obtain a value for the energy of electrification of an ion by substituting these expressions for q and r in the formula given above in paragraph 1. This gives for a single ion the energy of electrification

$$e = \frac{q^2}{2rk} = \frac{Q^2 \times 9 \times 10^{18}}{2n^2k} \times \frac{nl \times 6\pi}{Q^2 \times 10^9} = 27\pi \times 10^9 \times \frac{l}{nk};$$

and for a gramme-equivalent of ions

$$E = ne = 27\pi \times 10^9 \times \frac{l}{k} \text{ ergs};$$

or, expressed in heat units,

$$E = \frac{27\pi \times 10^9}{4{\cdot}2 \times 10^7} \frac{l}{k} = 2{,}000 \frac{l}{k} \text{ calories.}$$

For water k has the value 80 and the work done in electrifying one equivalent of ions is given as $125l$ calories, where l is the mobility of the ion determined in the ordinary way.

The following are typical values for the heats of electrification of ions in calories per gramme-equivalent as deduced from the above formula:—

Table I.

$\overset{+}{H}$	(318·0)	....	7,950	.... $\overset{-}{Cl}$	(65·9)	....	1,650
$\overset{-}{OH}$	(174·0)	....	4,350	.... $\overset{-}{I}$	(66·7)	....	1,670
$\overset{+}{K}$	(65·3)	....	1,640	.... $\frac{1}{2}\overset{++}{Ba}$	(57·3)	....	1,430
$\overset{+}{Na}$	(44·4)	....	1,110	.... $\frac{1}{2}\overset{--}{SO_4}$	(69·7)	....	1,740

The numbers in brackets are the ionic mobilities.

It should be noticed that these values are based on two assumptions:—

1. That the ordinary formulæ for the electrostatic capacity and energy of electrification of a spherical conductor may be applied to the ions; and

2. That their motion through the liquid is governed by Stokes' law.

Both the above assumptions are open to discussion, and the calculation is given mainly in order to emphasise the essentially endothermic character of the process by which atoms are converted into ions. It will also be noticed that the above calculation is based on the supposition that the electric charge is distributed over the surface of the ionic complex, the energy of electrification being proportional to the mobility and therefore, on our hypothesis, inversely proportional to the radius of the ion which carries the charge.

The data made use of above may also be employed to calculate values for the work done in separating two charged ions, as, for instance, during the ionisation of a neutral salt.

4. *Heats of Formation of Ions.*—In the case of several of the metallic ions and a small number of non-metallic ions, values have been deducted by Ostwald and others for the actual heat changes involved in the conversion of the elements into ions or vice versa. These values have been obtained by the study of electrode potentials.

Unfortunately, there is no general method known by which the actual P.D.s between the metals and their solutions can be separately determined All the practical methods of measurement necessitate the use of two electrodes and the figures obtained represent in all cases the sum (or difference) of at least two electrode-potentials. The separate values given by Ostwald are therefore based on an independent determination of the absolute P.D. in the case of a calomel electrode. This absolute determination, 0·56 volts for a normal KCl solution, depends on a study of capillary mercury electrodes, in which the electrical forces are balanced against surface tension, and is admittedly not of a very high degree of accuracy. Other sources of error are due to the incomplete ionisation of the metallic salts and the difficulty of determining the temperature-coefficients $d\pi/dT$.

5. *Heats of Formation of Salts in Dilute Solution as Related to the Heats of Formation of Ions.*—A second method of determining the heats of formation of the ions appears to be less generally recognised, since it is not definitely described in the standard text-

* For the relationship between s.i.c. and ionisation on the theoretical side, see J. J. Thomson, *Phil. Mag.*, v. 36, 320; Nernst, *Zeit. Phys. Chem.*, 1893, 11, 220; on the experimental side, see Walden, *Zeit. Phys. Chem.*

† The ions in a solution cannot, of course, be considered to be widely separated; but the same conditions will apply if each ion is equally influenced by a large number of positive or negative ions distributed through the surrounding medium, or, in other words, if its potential is not controlled by the immediate contiguity of one other ion of the same or of opposite sign.

‡ About 6×10^{23}; this figure, which represents the number of molecules in a gramme-molecule of any substance, is eliminated in the subsequent calculations.

* For potassium or chlorine this gives $v = 6 \times 10^{-4}$ cms. per second.

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books*, although it seems to have been used by Ostwald. The method depends on the fact that the heat of formation of a salt in dilute solution is made up of the sum of the heats of formation of the ions.

To take an illustration: The preparation of a dilute solution of potassium chloride from potassium and chlorine may be represented as taking place in two stages. (1) The preparation of solid molecular potassium chloride from potassium metal and chlorine gas, a process which involves a small absorption of heat in decomposing the molecules of potassium and chlorine and a large liberation of heat; and (2) the dissolution of the salt in a large quantity of water, whereby the solid molecular potassium chloride becomes completely ionised, which process is slightly endothermic. On the other hand, these two processes may be combined into a single process which is strongly exothermic. By so doing, the intermediate formation and dissociation of molecular potassium chloride are entirely eliminated, so that the final heat-balance depends solely on the energy set free during the conversion of the two elements into their hydrated ions.

Unfortunately, this method shares with that described in the previous section the disadvantage that the experimental data give values involving two heats of ionisation which cannot be measured separately. Thus, whilst it is clear that the total heat of formation of one equivalent of potassium ions and one equivalent of chlorine ions amounts to 101,200 calories, it is not clear how this is to be divided in order to give the heats of formation of the two ions separately. We were at first inclined to divide the heat liberated into two equal parts (in much the same way as was done by Kohlrausch in resolving the molecular conductivities into the sum of two migration velocities), on the ground that (1) the two atomic nuclei are of nearly equal mass, and (2) the ions have equal mobilities, and may, therefore, be regarded as almost equally hydrated. We prefer, however, to make use, as described in the previous section, of the absolute determination of the P.D. at a calomel electrode, and have, therefore, adopted Ostwald's figure – 600 calories as the heat of formation of one equivalent of hydrogen ions. Using this value, it is possible with the help of the heats of formation of these salts to deduce absolute values for the heats of formation of all the important ions, both positive and negative. It will be noticed that whilst the absolute values are subject to the same error as those determined from electrode potentials, the relative values are more accurate, owing to the greater ease of the operations involved and the remarkable standard of excellence attained by Thomsen in his thermochemical determinations.

The authors give the heats of formation in dilute solution of gramme equivalents of the more important acids, bases and salts together with the differences between the values for the salts and those for the acids and bases from which they are derived. In accordance with Hess's law of thermoneutrality, there is a constant difference for each pair of anions, and that this is independent of the associated kathions and vice versa.

The authors give the mean values for the heats of formation of the separate ions, obtained by taking the value for hydrogen as – 600 calories. There are also set out values for the heats of formation of the salts as calculated by adding together the heats of formation of their constituent ions; the difference between the observed and calculated values, with the exception of H_2S and $Ba(NO_3)_2$, is in all cases less than one part in 1,000.

6. *The Heats of Formation of the Ions in Relation to the Hydrate Theory of Ionisation.*—The heats of formation of the ions just referred to represent the quantities of heat given out in the formation of 1 gramme equivalent of the hydrated ions from water and the separate constituents of the nucleus taken in the ordinary physical condition of these elements at the standard temperature (say, 180 deg.). This definition is an agreement with the usual convention in reference to heats of formation, whereby, for instance, chlorine is taken in the gaseous, bromine in the liquid, and iodine in the solid state.

It will be noted at once that the heats of formation of the ions are complex quantities, and are made up of the algebraic sum of several distinct energy changes. In the case of the elementary ions, such as $\overset{+}{Na}$, $\overset{++}{Ba}$, $\overset{-}{Cl}$, the heats are made up of—

1. The heat change involved in the cleavage of the molecules of the element into their separate atoms.
2. The heat change involved in electrifying these atoms.
3. The heat change involved in the combination of the charged atoms or ionic nuclei with water.

In the case of ions derived from compound radicals, such as $\overset{+}{NH_4}$, $\overset{-}{NO_3}$, $\overset{--}{SO_4}$, a molecular cleavage must be supposed to occur in the case of each of the elements present in the ionic nucleus, but there is also superposed a fourth thermal change, namely—

4. The heat change involved in the combination of the constituent atoms of the radical.

Of these changes it is evident that (1) and (2) must normally be endothermic and involve an absorption of heat, whilst (3) and (4) will normally be exothermic and involve a liberation of heat. The heat of formation of an ion, therefore, always represents a difference, and the process of forming the ion from its elements and water will be exothermic or endothermic according as the sum of the heat changes is positive or negative.

A low or negative heat of formation may be due—

1. To a small heat of combination of the nucleus with water, as, for instance, in the case of the hydrogen ion.
2. To a large absorption of heat in cleaving the elements of the nucleus into atoms Or
3. To an abnormally large absorption of energy in electrifying the radical of the nucleus—*e.g.*, in the case of a small ion, such as hydrogen, or a polyvalent ion such as $\overset{+++}{Fe}$ or $\overset{---}{PO_4}$.

A large heat of formation may be due to much water combination, or in the case of a polyatomic ion to a great heat of combination of the atoms of the nucleus.

In view of the large number of factors involved, it was hardly to be expected that the heats of formation of the ions would correspond with the degree of hydration, and, indeed, even it were possible to determine separately the energy liberated by water combination, there would be no reason for supposing that this energy would be wholly dependent on the quantity of water combined with the nucleus and independent of the nature of the nucleus.

Finally, it may be noted that whilst the heat of formation of an ion in dilute solution is independent of the other ion associated with it, the degree of hydration, and therefore the heat of formation, may change when the concentration of the solution is increased. Further, there is no reason to suppose that any close relationship would exist between the heats of formation of ions in different solvents; in spite of the identity of the nucleus, the ions produced are quite distinct, and the energy of combination with the solvent would be entirely different when the solvent is changed. This is possibly the explanation of the widely different electropotentials observed by Johnson and Wilsmore (*Trans.* Faraday Soc., 1907) in liquid ammonia and in water. Similar considerations apply in the case of fused salts in which complexes such as $\overset{+}{K}(KCl)x$ and $\overset{+}{K}(KNO_3)y$ may be expected to have quite different heats of formation.

* Arrhenius ("Electrochemistry," p. 239) describes a method by which the thermal data may be used to calculate the heats of ionisation of metals from the heats liberated when they are dissolved in acids, but makes no mention of the heats of formation of the non-metallic ions.

INFLUENCE OF NON-ELECTROLYTES AND ELECTROLYTES ON THE SOLUBILITY OF GASES IN WATER. THE QUESTION OF HYDRATES IN SOLUTION.*

BY JAMES C. PHILIP, D.SC.

Much attention has lately been devoted to the question how far the solubility of a substance A in water is affected by adding to the water a quantity of another substance B. The case where A and B are both electrolytes has been treated with a large measure of success, and lies beyond the scope of the present discussion. The progress made in the study of the case in which A is an indifferent substance and B is either a non-electrolyte or electrolyte has been much less satisfactory, although a large amount of energy has been devoted to the solution of the problem. So far as the comparative influence of salts in lowering the solubility of these substances is concerned it is found that when the salts are arranged in a list according to the magnitude of their effects on the solubility of one such indifferent substance, the order is in general the same as when they are arranged according to the magnitude of their effect on the solubility of another indifferent substance. It appears, therefore, that the diminished solvent power of a salt solution as compared with pure water is mainly determined, not by the specific nature of the neutral substance which is dissolved, but by some factor involved in the relationship of the water and the salt What this factor is has not yet been determined with any unanimity.

There are three chief sources to which the influence of salts on the solubility of indifferent substances has been traced. Firstly, it has been suggested that the influence exerted by salts is a function of the internal pressure of the solution (Euler, *Zeit. Physikal. Chem.*, 1899, 31, 368; Geffcken, *ibid.*, 1904, 49, 257). Secondly, interaction between the molecules or ions of the dissolved substances has been assumed to account for the behaviour of strong electrolytes generally, and, as regards influence on the solubility of indifferent substances, the view is adopted that the ability to exert such influence is an almost exclusive characteristic of the ions (Levin, *Zeit. Physikal. Chem.*, 1906, 55, 603). In the third place, it has been frequently suggested that the lower solvent power of a salt solution as compared with water is due to the hydration of the salt, and the consequent diminution of the "free" solvent (see, for example, Rothmund, *Zeit.*

* Abstract.

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Physikal. Chem., 1900, 33, 413; Baur, Ahrens' *Sammlung*, 1903, 8, 466; Lowry, *Trans.* Faraday Soc., July, 1905).

The object of the present communication is to urge one or two considerations in favour of the third explanation which have not received their due share of attention. In this connection it is proposed to restrict the discussion to considering the influence of non-electrolytes and electrolytes on the solubility of hydrogen and oxygen, for if the influence of non-electrolytes and electrolytes on the solubility of relatively soluble substances such as nitrous oxide and ethyl acetate is also considered, complications are more like'y to arise.

Too much attention has generally been paid to the influence of electrolytes on the solubility of gases, whilst the influence of non-electrolytes has been disregarded, or, if considered, has been misinterpreted. Now, it appears possible to give at least a general interpretation of the behaviour of non-electrolytes and electrolytes alike by reference to two factors. Firstly, it may be supposed that in the majority of cases where a lowering of the absorption coefficient has been observed, the non-electrolyte or electrolyte, as the case may be, is not responsible for any of the absorption; if this is so, the standard absorbing volume should be, not 1 c.c. or 1,000 c.c.'s of the solution, but that volume of the solution which contains 1 gramme or 1,000 grammes of the pure solvent. Secondly, hydration of the non-electrolyte or electrolyte may occur, and it may be supposed that the solvent which is thus attached is no longer free to absorb the gas.

The utility of these suggestions may be tested first by reference to available data bearing on the influence of non-electrolytes on the solubility of hydrogen. According to Geffcken's critical review of the various investigations made up to 1904, the most trustworthy results are those obtained (1) by Knopp (*Zeit. Physikal. Chem.*, 1904, 48, 97) for the solubility of hydrogen in chloral hydrate solutions at 20 deg., and (2) by Steiner (*Weid. Ann.*, 1894, 52, 275) for the solubility of hydrogen in cane-sugar solutions at 15 deg.

According to Knopp, the absorption coefficient for hydrogen in pure water at 20 deg. is ·01883; that is, one litre of water, or, what is practically the same, 1,000 grammes of water, absorbs 18·83 c.c. of hydrogen. The absorption coefficient in a 7·69 per cent. solution of chloral hydrate at the same temperature is ·01802; that is, one litre of this solution absorbs 18·02 c.c.'s of hydrogen. But a litre of this solution contains only 952·4 grammes of water, the absorbing substance, and that volume of solution which contains 1,000 grammes of water would absorb $18{\cdot}02 \times \frac{1,000}{952{\cdot}4} = 18{\cdot}92$ c.c.'s of hydrogen, practically the same volume as is absorbed by 1,000 grams of water. For other solutions of chloral hydrate up to 80 per cent. strength, corresponding to about 2·5N. concentration, a similar result is obtained.

In the case of sugar-cane solutions the volume of hydrogen absorbed by 1,000 grammes of water gradually diminishes as the sugar concentration increases. Levin (*loc. cit.*) allows for the fact that 1 litre of sugar solution contains much less than 1,000 grammes of water, but erroneously concludes that the numbers obtained after this correction has been made are practically the same as the figure for pure water. On this very doubtful foundation he bases the statement that non-electrolytes have no influence on the solubility of other non-electrolytes.

Whilst the first of the two factors suggested above is sufficient to account for the influence of chloral hydrate in lowering the solubility of hydrogen, it is not sufficient to account for the influence of cane sugar. If, as is suggested, hydration is the other main factor to be reckoned with, then the conclusion must be drawn that chloral hydrate exists as such in solution, but that cane sugar is hydrated. This result is in harmony with the work of Jones and his pupils on the freezing points of aqueous solutions of chloral hydrate and cane sugar (*Amer. Chem. Journ.*, 1904, 32, 319), and in the latter case there may be shown to be actual numerical agreement as to the extent of hydration.

The behaviour of electrolytes in lowering the solubility of hydrogen and oxygen can also be interpreted by reference to the two factors already suggested. In the case of electrolytes the influence of the second factor predominates; 1 litre of an electrolytic solution contains not far short of 1,000 grammes of water, so that the correction to be made on this account rarely exceeds 3 to 4 per cent. for normal concentration.

If it is the case that a dissolved salt exists in solution in the form of labile hydrates, rise of temperature should cause a dissociation of these hydrates, and the numbers obtained for the average molecular hydration should fall off as the temperature rises. It has been held that the relative lowering of solubility is independent of temperature (*see* Rothmund, *Zeit. Physikal. Chem.*, 1900, 33, 401), but the most recent work on the absorption of oxygen by electrolytic solutions is opposed to this. Geffcken's measurements (*loc. cit.*) of the solubility of oxygen in solutions of sulphuric acid, sodium hydroxide, and potassium hydroxide at 15 deg. and 25 deg. serve to prove that the average molecular hydration diminishes as the temperature rises.

The average molecular hydration increases with the dilution of the solution. The same result is reached if the relative equivalent lowering of solubility is considered. After all, one may regard the numbers given for the molecular hydration quite apart from the interpretation here assigned to them. They are closely related to the relative equivalent lowering of solubility, and are to be regarded simply as an expression, if one hesitates to venture beyond the direct consequences of the experimental figures of the relative power of sugar and various electrolytes to diminish the solubility of gases. The fact that the average molecular hydration increases with dilution is of great importance, for it shows that the cause which is at work in lowering the solubility is relatively most potent in dilute solutions. This result seems to have a definite bearing on the second of the causes previously mentioned to which the influence of salts on the solubility of indifferent substances has been traced.

The question naturally arises, are the values calculated as above for the average molecular hydration of electrolytes confirmed by experimental work of other kinds? Such confirmation is forthcoming to a certain extent, and that from three sources. In the first place, the average molecular hydration of electrolytes has been calculated by Biltz (*Zeit. Physikal Chem.*, 1902, 40, 228), and by Jones (*Amer. Chem. Journ.*, 1905, 33, 534; 34, 290), from the study of the freezing-point depression. Reference has already been made to this source of confirmation in connection with the hydration of chloral hydrate and cane sugar. It must be observed, however, that the values of molecular hydration deduced by Jones and his pupils for electrolytes are much less trustworthy than the values similarly deduced for non-electrolytes, because in the former case the degree of dissociation of the electrolyte is involved, and the accurate determination of this in concentrated solutions is scarcely possible. It is, therefore, not permissible to lay great stress on confirmation from this source of the average molecular hydration for electrolytes. In the second place, Caldwell, studying the influence of various salts on the rate of inversion of cane sugar (*Proc.* Roy. Soc., 1906, A, 78, 272), finds that the salts are hydrated in solution, and he assigns to a few of the common salts numbers which have the same significance as the average molecular hydration dealt with in this communication. Thirdly, Bousfield, in his Papers on the size of ions (*Proc.* Roy. Soc., 1904, A, 74, 568; *Zeit. Physical. Chem.*, 1905, 53, 257), makes an estimate of the number of water molecules associated with the molecule of sodium hydroxide and potassium chloride at 18 deg. and infinite dilution.

To the assumption made throughout this Paper that hydrogen and oxygen are practically insoluble in the pure non-electrolytes and electrolytes considered, objection may be taken. There is a good deal of evidence showing that this assumption is justified, but if it should turn out that the solubility of, for example, hydrogen in cane sugar itself was appreciable, a correction would have to be introduced, the effect of which would be to increase the values recorded above for the average molecular hydration.

HYDRATES IN SOLUTION: DISCUSSION OF METHODS SUGGESTED FOR DETERMINING DEGREE OF HYDRATION.*

BY GEORGE SENTER, PH.D.

Owing to the large amount of successful work spent upon it, the electrolytic dissociation theory has gained many adherents and made rapid progress, whilst the association theory or the "hydrate" theory† has contributed comparatively little to the progress of chemistry. Within the last few years, however, a great deal of experimental evidence has accumulated to the effect that, at least in aqueous solution, there is, in many cases, association between solvent and solute. Armstrong‡ considers that in water there is an equilibrium between simple and complex molecules represented by the equation $(H_2O)_n \rightleftarrows nH_2O$, and that the osmotic pressure (due to the solvent and not to the solute) is a measure of the displacement of the equilibrium towards the left produced by the addition of a substance which dissolves in the water. It is suggested that non-electrolytes have a normal effect in displacing the equilibrium, and that electrolytes, in addition to the normal effect, exert an attractive action on the water molecules. It is, therefore, considered that "electrolytes are substances which attract water in proportion to the efficiency of their solutions as electrolytes."

The importance of Prof. Armstrong's theory is very much diminished by the fact that no attempt has been made to show that it affords a quantitative representation of the behaviour of aqueous solutions. Moreover, in some respects it does not appear to be even in qualitative agreement with the facts. This may, for our present purpose, be sufficiently illustrated by considering two of its important consequences.

As we have already seen, the theory indicates that electrolytes are substances which attract water in proportion to the efficiency of their solutions as electrolytes. In a later part of this Paper it is

* Abstract.

† Compare Pickering, *Watts' Dictionary*, Art. "Solutions."

‡ Compare Sutherland, *Phil. Mag*, 1898, V., 50, 469.

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shown by several independent lines of evidence that in the group of the alkali metals the amount of water associated with the chlorides diminishes with increase in the atomic weight. The attractive power of salts for water may presumably be measured* by the relative amounts with which they combine in equivalent solution. The available data show clearly that there is no direct casual connection between hydration and conductivity; lithium chloride has a lower conductivity, and the ratio of the molecular conductivity at moderate dilution, μ_v, to that at infinite dilution, $\mu\infty$, is smaller than for any of the other chlorides of this group.

A second point in the theory is the assumption that in many cases only the negative radical is hydrated, and it is suggested that the double osmotic effect of potassium chloride, for example, is due to the effect of the salt plus that of the chlorine group. The available evidence lends no support to this suggestion; there is every reason for supposing that both positive and negative groups may become associated with water molecules.

From the above considerations it seems justifiable to conclude that the association theory alone has, so far, proved quite inadequate to account for the properties of aqueous solutions. On the other hand, the electrolytic dissociation theory, though perhaps requiring modification in some subsidiary respects, gives a satisfactory representation of the great majority of the facts, and there is good reason to suppose that some of the minor difficulties still remaining will be overcome when the conditions of association between solvent and solute now to be referred to have been more fully worked out. It should be emphasised that the electrolytic dissociation theory is in no respect incompatible with a certain amount of association between solvent and solute,† and this has been recognised all along by some of the strongest supporters of the theory.‡

In the present Paper some *a priori* considerations, which may serve as criteria for estimating the relative trustworthiness of the different methods which have been suggested for determining the degree of hydration in solution, are first advanced.

General Considerations.—In the first place, the results obtained by statical methods will, other things being equal, be more trustworthy than those obtained by dynamical methods,§ because our knowledge of the laws of chemical statics is much more complete than with regard to chemical dynamics.

In the next place, the application of the law of mass action throws some light on the way in which hydration must vary with dilution, as was first pointed out by Nernst. || By the law referred to the amount of chemical action, in this case the proportion of water combined with the solute, is proportional to the active mass (of the water). It can readily be shown by thermodynamical considerations that the active mass of water is proportional to the vapour pressure, and as, in dilute solution, the latter is scarcely affected by further dilution, it is to be expected that beyond a definite point the complexity of the hydrates will not increase with further dilution. In concentrated solutions the complexity of the hydrates will probably increase with dilution. If, however, the ions combine with more water than the undissociated molecules, there will be also increased hydration with dilution on this account, but in salt solutions less than N/1 this effect will be comparatively slight and gradual. A rapid increase of hydration on dilution in dilute solutions would thus be in opposition to the law of mass action.

The third general remark has reference to the effect of change of temperature on the complexity of the hydrates existing in solution. In practically every case which has been investigated hydration is accompanied by evolution of heat, from which it follows by Van't Hoff's law connecting heat development and equilibrium that with rise of temperature association between solvent and solute must diminish.

Methods for Determining Hydration in Solution.—The four most important methods which have been suggested for the determination of the degree of hydration are as follows¶ :—

1. Abnormal lowering of freezing point, rise of freezing point, &c. (Jones and co-workers,** Smits,†† Biltz‡‡). 2. Diminution of solubility of gases, liquids and solids in water, produced by the addition of electrolytes and certain non-electrolytes (Rothmund,§§ Baur,||| Philip¶¶). 3. Transport of solvent with ions during electrolysis and consequent change of concentration at electrodes (Garrard and Oppermann,* Buckbock†). 4. Relative migration velocities of the ions (Bredig,‡ Kohlrausch,§ Bousfield ||).

Other methods, such as that dependent on magnetic rotation, have also been suggested, which may be useful in special cases.

Qualitative Results.—Coming now to the relative hydration of dissolved salts, it is of considerable interest to find that the order is the same by all four chief methods—a result which lends considerable support to the chief assumption. If, in the first place, we confine ourselves to salts with the same negative radical, such as the chlorides, the hydration increases in the same natural group from the element with the highest to that with the lowest atomic weight.

As regards negative groups, hydration increases in the order NO_3, Cl, Br, I, SO_4.

The important result that the hydration varies with the atomic weight has gradually become evident in recent years, and was indicated as early as 1899 by Abegg and Bodländer.¶ It is in accordance with their theory that the tendency shown by different ions to enter into complex compounds is so much the greater the smaller their electro-affinity; in other words, the ions which have the least affinity for electricity have the greatest tendency to form complexes (in this case hydrates).

Quantitative Results.—Although the order of affinity of positive and of negative ions for water may thus be regarded as established by entirely independent methods, the various attempts which have been made to determine the actual number of molecules of water associated with a molecule of the salt under definite conditions have not, so far, led to very conclusive results. The values obtained by the chief methods will now be considered.

Method (4) does not appear to have been used directly to determine the hydration quantitatively; but Bousfield**, from considerations based on the laws regulating the motion of a small body through a medium of great resistance, has arrived at a formula connecting the average radius of a (water-coated) ion with the dilution.

As many assumptions have to be made in the course of the deductions, it appears somewhat doubtful if this method in its present form can be employed quantitatively with any degree of certainty.

Method (3), depending on the transport of solvent with migrating ions, may be dismissed very shortly. The errors are large and comparatively little work has, so far, been done on the subject.

Method (1), depending on freezing point and conductivity measurements, has been developed more particularly by Jones and his coworkers,†† and by Biltz††; the principles on which it is based are as follows: The observed freezing point depression of many solutions is greater than the expected value, and it is suggested that, owing to the fixing of part of the solvent by the salt, the ratio of salt to free solvent is increased so that the freezing point depression actually observed is that corresponding to a more concentrated solution. If the true depression in the absence of association can be obtained, the mode of calculating the hydration will be evident, but that is just where the weakness of the method lies. Jones calculates the theoretical depression for a particular dilution from the electrical conductivity at 0 deg. in the usual way. It is now generally allowed, however, that the electrical conductivity method does not give quite accurate values for the ionisation, and considerable uncertainty is thus introduced, more particularly when it is borne in mind that the calculation of the hydration depends on a difference effect, which is comparatively small in dilute solution. From Jones's values for a 0·16 molar solution of lithium iodide, I have calculated that an error of 5 per cent. in the estimation of the ionisation (not an impossible error) would cause an error of about 25 per cent. in the value obtained for the hydration. Moreover, the uncertain validity of the primary assumption that the difference between the observed and estimated molecular depression is due entirely to hydrate formation has also to be borne in mind. It should also be mentioned that in some cases this method gives hydration values increasing rapidly with dilution, in opposition to the requirements of the law of mass action. In the case of non-electrolytes the uncertainty introduced by ionisation is, of course, absent, and on that account the results obtained for these seem to be somewhat more trustworthy.

From these considerations, it seems justifiable to conclude that the hydration values given by Jones represent only a rough approximation to the actual values.

It remains only to consider the method depending on the solubility of gases, &c., in solutions of electrolytes and non-electrolytes. This appears to be the only really statical method, as Jones's method, as we have seen, is based partly on conductivity measurements. It has been known in a general way, for some time, that

* The relative affinity of solid salts for water may be estimated by comparison of the vapour tensions of their corresponding hydrates. The available data indicate that the order of the chlorides thus obtained is the same as that indicated above.

† Compare Senter, *Science Progress*, 1906, i., 381.

‡ Ostwald, *Lehrbuch*, ii., I., 801.

§ Planck, *Zeitsch. Physikal. Chem.*, 1902, 41, 222.

|| *Theoretische Chemie*, 4th edition, p. 457.

¶ For details of the different methods *see* Baur, *Ahrens' Sammlung*, 1903, 8, 466; Lowry, *Trans.* Far. Soc., 1905, 1, 197; Senter, *Science Progress*, 1906, Vol. I., p. 381.

** *Amer. Chem. Journ.*, 1905, 34, 290, &c.

†† *Zeitsch. Physikal. Chem.*, 1902, 39, 385.

‡‡ *Ibid.*, 1902, 40, 217; 1903, 43, 41.

§§ *Ibid.*, 1900, 33, 401. ||| *Loc. cit.*

¶¶ *Journ* Chem. Soc., 1907, 91, 711.

* *Göttinger Nachrichten*, 1900, p. 86.

† *Zeitsch. Physikal, Chem.*, 1906, 55, 563.

‡ *Ibid.*, 1894, 13, 262.

§ *Sitzungsber. Preuss. Akad. Wiss.*, 1902, 26, 579; *Proc.* Roy. Soc., 1903, 71, 338.

|| *Proc.* Roy Soc., 1905, 74, 563; *Phil. Trans.*, 1906, 206 A, 101.

¶ *Zeitsch. anory. Chem.*, 1899, 20, 453.

** *Loc. cit.* †† *Ibid.*

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inactive gases are less soluble in solutions of electrolytes, and to a smaller degree in solutions of non-electrolytes, than in water, and that the solubility is most depressed by the salts which, from other considerations, are regarded as being most highly hydrated in solution, but the quantitative application of this method to determine the composition of hydrates has only been made quite recently by J. C. Philip.* It should be mentioned that some of those who have been most active in collecting data on this subject† consider that the effect in question is due, not to hydrate formation, but to change in the internal pressure of the solution produced by the electrolytes. The conception of internal pressure is, however, somewhat indefinite, and the hydrate explanation seems distinctly preferable.

In applying the solubility method quantitatively, Philip assumes provisionally that the solute is not responsible for any of the absorption, and that when the solute become hydrated, the water thus bound is no longer able to absorb the gas. It is also, of course, tacitly assumed that the decrease of solubility depends on hydrate formation alone (with a correction for the volume of the solute) and that the absorbing power of the unfixed water for gases is not altered in any way by the presence of salts. The validity of these assumptions, especially the first, is somewhat uncertain.

The results obtained indicate that the hydration values arrived at by all the methods considered are affected by considerable uncertainty and should be regarded as of a provisional character. On the whole, however, the solubility method seems less obviously open to objection than any of the others.

THE STABILITY OF HYDRATES AS INDICATED BY EQUILIBRIUM CURVES.‡

BY DR. ALEX. FINDLAY.

From a study of the freezing-point curves of concentrated aqueous solutions conclusions have been drawn, more especially by Biltz and by H. C. Jones, with regard to the existence of hydrates in solution. While the qualitative correctness of the conclusions may be accepted, grave doubts arise as to the correctness of the quantitative formulæ assigned by Jones to the hydrates of different substances. These doubts are due not only to the fact that the conclusions as to hydration were reached (in so far as the freezing-point measurements are concerned) by means of an unjustifiable extension of the van't Hoff-Raoult law, but also to the fact that certain factors, *e.g.*, heat of dilution, were not taken into account.

While the study of the equilibrium curve of solutions in contact with ice as solid phase (the freezing-point curve) may, on the basis of certain assumptions, give an indication of the "degree of hydration" of the solute, it cannot enable us to decide as to the particular hydrates present, nor the extent to which these hydrates are dissociated chemically.

On the other hand, some insight into the question of the stability of hydrates can be obtained from the study of the equilibrium curves of solutions in contact with the hydrates as solid phase, *i.e.*, what are frequently called solubility curves.

When a compound of two components is capable of existing in contact with solution of the same composition as itself—*i.e.*, when it possesses a definite melting-point—the equilibrium curve of the two-component system will exhibit an intermediate curve, which gives the conditions under which the solid compound can exist in contact with the liquid solution, or homogeneous mixture of the two components. When the compound undergoes chemical dissociation at the temperature of the melting-point, it is found that the equilibrium curve has a rounded summit, and the greater the degree of dissociation the flatter is the summit of the curve. Conversely, the sharper the summit of the curve the less the degree of dissociation. From the appearance of the curve alone, then, some idea of the stability of the compound can be obtained.

If, now, we regard the presence of the products of dissociation as causing a lowering of the freezing-point of the pure compound, and if we regard the lowering produced to be in accordance with the van't Hoff-Raoult law, then, from a knowledge of the molecular depression of the compound, it is possible to calculate the course of the freezing-point curve of the compound for different degrees of dissociation. The experimentally determined equilibrium curve is compared with the curves so obtained, and thus an approximate knowledge obtained of the degree of dissociation of the compound.

It must be pointed out that this method of determining the degree of dissociation is only an approximate one, for it depends on various assumptions which cannot be regarded as being more than approximately fulfilled. The chief of these assumptions are:—(1) the validity of the van't Hoff-Raoult law, (2) the validity of the law of mass action in concentrated solution, (3) the degree of dissociation is independent of the temperature.

So far calculations have been carried out only in the case of organic binary compounds; but the method can also be applied to the case of salt hydrates, although in this case the above assumpsions are less likely to be fulfilled.

* *Loc. Cit.*

† Euler, *Zeitsch. Physical. Chem.*, 1899, XXXI., 360; Geffcken, *ibid.*, 1904, XLIX., 257.

‡ Abstract.

DISCUSSION.

Prof. W. A. TILDEN, F.R.S., referred to the fact that in crystals it appeared to be the metal only which detained the water of crystallisation. In many cases, such as that of ammonia dissolved in water, where ammonia as such was also present, the hydrate theory could not be adopted as it stood. There was, in fact, no single theory at present able to explain all the phenomena observed.

Mr. CALDWELL criticised the various methods used for measuring hydration. In the experiments of Jones, for example, whose method was open to objection, many of the results did not follow what would be expected from the law of mass action. Philip assumed that the dissolution of a gas was mechanical and that of a salt chemical. If that were true, a gas of small molecular weight, such as helium, should be readily soluble.

Mr. W. A. DAVIS said that there were many cases of solution—*e.g.*, in dyeing—which were covered by neither the ionic nor the hydration theory, but in which the process was purely mechanical.

Mr. FENTON said that it was not always very clear what was meant by a hydrate. The methods hitherto employed for studying hydrates were chiefly physical, and the results obtained were capable of many interpretations. The problem should be studied in such a way that specific chemical properties were obtained.

In reply to Dr. H. Borns, Dr. LOWRY said he imagined ionisation to be the result of the separate hydration of the ionic constituents of the molecule.

The CHAIRMAN thought that the agreement between the heat of formation of a salt in dilute solution and the sum of the separate heats of formation of the ions shown to exist by Mr. Bousfield and Dr. Lowry proved nothing, as the proof involved reasoning in a circle.

In reply, the authors explained that the agreement proved these properties of the ions to be additive, and so gave further support to the dissociation hypothesis.

THE SPECIFIC RESISTANCE AND TEMPERATURE-COEFFICIENT OF TANTALUM.*

BY MARCELLO VON PIRANI.

In Bolton's article on the "Production and Properties of Tantalum" (*Zeitschrift fur Elektrochemie*, No. 3, 1905), the specific resistance of tantalum was given as $0{\cdot}165 \pm 5$ per cent., and its average temperature coefficient at 0·3 per cent.

It appeared to be of scientific interest to determine whether the wide differences in the specific resistance of various pieces of tantalum at white heat in vacuo were maintained, or in what manner they vary or whether it is possible to fix a uniform value for the resistance of pure tantalum in this manner.

For this purpose wires of various thicknesses were selected, the initial resistance of which deviated as much as possible from the mean value.

The following table gives the thicknesses and specific resistances of the wires experimented upon:

Diameter.	Specific resistance.
0·049 mm.	0·173
0·0505 mm.	0·18
0·06 mm.	0·175
0·126 mm.	0·188

The wires were heated in a very high vacuum to a temperature of about 1,900°C, from 100 to 200 hours, and then taken from the receptacle in which they were melted down, and, after re-drawing, measured afresh, with the result that all wires were found to have the same specific resistances, but considerably below the previous average value. The results were as follows:—

Diameter.	Specific resistance.
0·049 mm.	0·147
0·0505 mm.	0·145
0·06 mm.	0·147
0·126 mm.	0·145

The temperature-coefficient had risen to 0·33 per cent. per 1°C. between 0°C and 100°C. The temperature-coefficient of another wire 0·05 mm. thick, heated for some long time in vacuo, was tested between the temperature of liquid air and room-temperature, the average result being 0·32 per cent per degree.

If the temperature of tantalum wire in the tantalum lamp running at 1·5 watts per candle be taken as 1,750°C. (a temperature fairly nearly approaching the actual temperature), it is found that, since the resistance at this temperature is six times as great as at room-temperature, the average temperature coefficient is 2·9 per cent. (500 per cent. at 1,730 deg.).

The average values of 0·146 cited as the specific resistance and 0·33 as the temperature coefficient between 0 deg. and 100 deg. would appear to be characteristic for pure tantalum, while the values accepted previously would seem to be modified in a variable degree by the structural alterations, &c., which the tantalum undergoes in drawing.

* Translated from the *Zeitschrift für Elektrochemie*, Vol. XIII., No. 25, June 21, 1907.

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THE ILLUMINATION OF SIDE STREETS.

The lighting of side streets is a problem in itself which is often in the minds of station engineers, in comparison with which the illumination of main streets is simple, because, in the latter, it is permissible for the annual cost to be much heavier. In main streets the arc lamp is quite suitable for the purpose, more particularly the more recent flame arc lamp, because, even if the first cost may be somewhat high, the cost per candle-power and per candle-power-hour is low, and it is permissible to place the lamps so near together that any serious want of uniformity in the illumination does not occur.

In side streets, on the other hand, the subdivision of sources of illumination into smaller units becomes essential, because the capital outlay and yearly cost must be much lower, and if arc lamps are placed a considerable distance apart a very "spotty" effect is the result. It is for this reason, of course, that incandescent gas has been so frequently adopted for the illumination of side streets. Ordi-

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nary carbon incandescent lamps have been adopted to a limited extent, but their efficiency is too low generally to give a satisfactory financial result.

Metallic filament lamps, on the contrary, have such a very much higher efficiency that they afford a solution of the difficulty, and, in addition to the efficiency being high, there is the further advantage over incandescent gas that the metallic filament lamp retains its candle-power much more constant than does the incandescent mantle. In this connection the figures given by Mr. McCourt at the recent convention of the Incorporated Municipal Electrical Association are of great interest. Considering an Osram lamp which gave 54·5 c.p. and 54 c.p. respectively in two consecutive months, and taking the Osram lamp at 52 watts, with electrical energy supplied at 3d. per unit, and gas supplied at 2s. 10d. per thousand, as charged at Harrogate, he found that there was a saving in favour of electricity of 17·6 per cent. Considering that 3d. per unit is a high price for street lighting, it will be seen that the advantage of the metallic filament lamp should be very considerable. In fact if we look over a list of charges made by local authorities for public lighting it is soon evident that 3d. per unit is an unusually high figure. Occasionally, no doubt, even a higher charge is made. Thus, at Islington the price is 3·47d., at Acton 3·55d., at Barnstaple 4·35d. and at Blackpool 4·25d. But generally speaking the charge is much lower, and this is only to be expected when the comparatively good load factor usually obtainable from public lighting is taken into account. Thus, at Hammersmith the charge is 1·22d., at Fulham and Hackney 1·53d., at Bradford 1·19d. and at Belfast 1·02d. Under these conditions the saving should be large, and such a lamp really appears to afford a solution of the problem of side-street illumination.

In this connection, the comparatively low resistance of the metallic filament lamp has advantages as well as disadvantages. For ordinary use low resistance is certainly a disadvantage, but in the case of street lighting there is something to be said in favour of using a number of low-voltage lamps in series. The difficulty in doing so, however, apart from the question of extinction of a number of lamps through the failure of one, is that all lamps required for running in series on any one circuit must be made practically identical in order to give satisfactory results. At the present stage of manufacture it is quite possible that this difficulty cannot be very satisfactorily met without careful selection. A certain amount of trouble has been caused on private lighting circuits by lamps differing to some extent so that both lamps of a pair do not burn at the same efficiency, but this difficulty is, no doubt, one that will gradually disappear.

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(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Elements of Electrical Engineering." By W. S. Franklin and W. Esty. Vol. I. "Direct Current Machines, Electric Distribution and Lighting." (London: Macmillan & Co., Ltd.) 18s. 6d. net.

This work may be taken as a good example of a high-class American text book. The style is concise and clear, the diagrams are bold and simple, and the essentials of the subject are not obscured by a mass of detail or by unimportant digressions. The book has evidently been planned and written with great care. The numerous examples provided at the end of the book considerably enhance its value to teacher and student alike.

The work is primarily intended to be used as "an introductory course, not only for electrical engineering students, but also for students specialising in other branches of engineering." It is for this reason that the treatment is more or less of a general nature, the more highly specialised matter being dealt with partly in small type in the body of the work, and partly in appendixes. With a view, no doubt, of making the work self-contained, the authors have included in it a certain amount of purely non-technical matter which belongs more properly to physics. The introductory chapter is devoted to a brief elementary account of magnetism and electricity and of magnetic and electrical units. The study of dynamos is commenced in the second chapter, and is continued until we reach Chapter VII., in which a good deal of space is devoted to central station equipment and operation. Storage batteries are considered in Chapter VIII., electric distribution and wiring in Chapter IX., and photometry and electric lighting in the concluding Chapter X. The Appendices, which occupy fully one-quarter of the entire work, deal with magnetic induction, the magnetic circuit, hysteresis phenomena, characteristic curves and armature windings.

A few blemishes which we have noticed in this otherwise excellent text book may be pointed out. The treatment of Ohm's law in §17 is extremely obscure, and requires considerable revision; from the explanation given it is, in fact, not at all apparent what the law is. The use of the terms "abohms," "abamperes," &c., is not to our liking, and there seems little excuse for introducing them into a work of this kind. In dealing with the cumulative compound motor the authors reproduce the well-worn fallacy that one of the advantages of this type of motor is its large starting torque—as if it were impossible to produce an equally large, or larger, starting torque by the use of a sufficient number of ampere-turns in a shunt winding pure and simple. The decrease of speed which occurs with increase of load in a compound-wound motor is regarded as a *disadvantage*, whereas it is precisely this feature that renders the motor so valuable for driving rolling mills, as it enables us to utilise fully the regulating effect on the generator load of a flywheel coupled to the motor. Ammeters and voltmeters are disposed of in three pages in Chapter VII.; surely such treatment of an important part of the subject is woefully inadequate, and we think the mention of the tangent galvanometer might very well have been omitted in this connection. It seems a pity that in dealing with photometric units the authors do not restrict the term "quantity of light" to the meaning assigned to it by Blondel—viz., the time-integral of luminous flux. Lastly, in view of the great importance now attached to the use of commutating poles, we are surprised to find no reference to this subject in the section of the work dealing with dynamos and motors.

Les Lampes à Incandescence Électriques. By J. Rodet. (Paris: Gauthier-Villars.) 6fr.

So rapid has been the development of incandescent electric lamps during the past 12 months that M. Rodet's book, although the preface is dated November, 1906, can hardly be considered as fully up-to-date, seeing that it contains no reference to the newest metallic filament lamps. The greater part of the book is devoted, justly enough, to the carbon filament lamp, the historical chapter, dealing with its evolution, being particularly interesting and bearing evidence of having been compiled with considerable care. The description of the manufacture, on the other hand, is far less satisfactory; it is unnecessarily short and too much attention is given to early methods without sufficient distinction being drawn between what has survived and what become obsolete. This part of the book concludes with a brief account of the "metallised" carbon filament invented by Mr. Howell, and the author then proceeds to a description of the osmium, tantalum and Nernst lamps. The account of the first two of these does not call for much comment; the time since their introduction into commercial use is too short for any great amount of information relative to either their manufacture or behaviour to be available. Such as can be obtained is concisely summarised. The treatment of the Nernst lamp is too short and far from satisfactory. American

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methods are described too exclusively, and, considering the position this lamp has attained, it certainly deserved fuller and more careful consideration. The book concludes with a chapter on mercury vapour lamps, for the inclusion of which in a book on incandescent lamps the author apologises. The liberty is one which will readily be pardoned, especially in view of the fact that information relative to this type of lamp is very scattered. On the whole, in spite of some defects, the book may be commended, and will prove a useful and handy book of reference, and, as always in the case of French technical books, an eminently readable one.

Die Kohlenglühfäden für Elektrische Glühlampen ihre Herstellung, Prufung und Berechnung. By HEINRICH WEBER. (Hanover: Dr. Max Jänecke.) 5.60m.

The manufacture of carbon filaments for electric glow lamps is a highly specialized subject. There can be very few who are much interested in the matter and still fewer who can claim any real knowledge of the subject. In view of a growing tendency, abroad at any rate, to the creation of special filament factories making filaments only and supplying these to the lamp factories, the number of those interested is likely to diminish rather than to increase. Some no doubt will be inclined to say that another cause is now operating which will make the study before long one of historical value only. It requires some courage under the circumstances to write a highly technical description of this complicated manufacture. Herr Weber has approached his task equipped with a sound knowledge of his subject, and, with a freedom somewhat rare amongst those possessed of special knowledge of this kind, has allowed himself to give a very full description, keeping back but few important details. The book cannot fail both to interest and to be of great value to anyone engaged in this special branch, who is bound to find at one place or another some useful hint or suggestion for modification in his own methods. The three leading chemical processes, the nitro-cellulose, zinc chloride and cuprammonium processes, are described, the greatest attention being paid to the first. The chemical details are, however, somewhat meagre when compared with the fulness of treatment accorded to the mechanical side. The book covers the preparation of the cellulose thread, its carbonisation and flashing. A chapter is also devoted to the calculation of filaments for a given candle-power and voltage. A sequel dealing with lamp making by the same author is promised, and if this side of the subject meets with as full treatment the two volumes together will form the most valuable manual for the lamp maker yet written.

The Electrical Engineers' Ballad Book. (London: Biggs & Sons.) 1s

This book consists of a collection of verses which have mostly already appeared in the columns of the *Electrical Engineer*. The greater number are from the pen of a writer who hides his identity under the initials "J. H. C. B." Although Mr. "J. H. C. B." can scarcely claim to be a Gilbert or Calverly, yet he has managed to put forward, in a very pleasing manner, matters both grave and gay concerning electrical engineering generally and central station engineering in particular. The trials and troubles of the shift engineer and mains superintendent are most pathetically sung. Some of the ballads suffer rather from the fact that the circumstances to which they relate will not be familiar in the minds of the readers. For instance, the piece entitled "Entropy" relates to a discussion which took place between two eminent members of the profession on this abstruse subject, the circumstances of which are now probably forgotten. Several pieces are specially worthy of notice, for example, "Homo to Electra," "Ballads of Business—IV." and "Exhibition Slaves." The duties of the "Sailelectrician" as depicted by "J. H. C. B." are warranted to make a mere land-lubber's mouth water.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Evolution of the Submarine Boat: Mine and Torpedo." By Commander Murray F. Sueter. (Portsmouth: J. Griffin & Co.) 21s. net.

"Balancing of Engines: Steam, Gas and Petrol." By Archibald Sharp. (London: Longmans, Green & Co.) 6s. net.

A COMBINED SINGLE-PHASE AND CONTINUOUS-CURRENT SERIES AND COMPENSATED REPULSION MOTOR.*

BY E. DANIELSON.

The relative advantages and disadvantages of the series and the repulsion motor are now fairly well understood. If a good power-factor is to be attained with a series motor, the speed must be considerably above synchronism, while the speed of a repulsion motor should not exceed synchronism by more than about 50 per cent., otherwise sparking will become troublesome. Near the speed of synchronism the repulsion motor has a higher power factor than the series motor, while above synchronism the latter possesses a decidedly higher efficiency than the former. For the above reasons the author has thought that a combination of the characteristics of the two types in a single motor would be desirable, and has devised the arrangement described below.

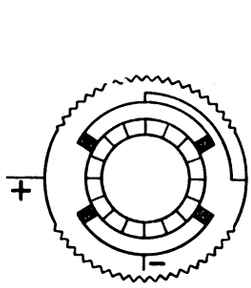

FIG. 1.—COMPENSATED REPULSION MOTOR, HAVING A PARTIALLY WOUND STATOR AND WITH THE LATOUR BRUSH ARRANGEMENT.

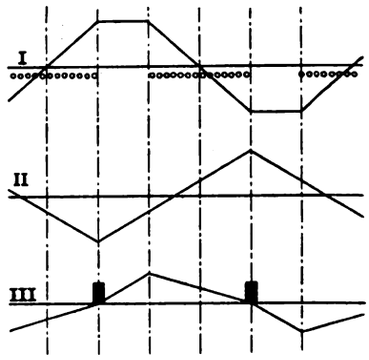

FIG. 2.—DISTRIBUTION OF THE FLUX IN THE MOTOR.

A type of compensated repulsion motor provided with two independent sets of short-circuit brushes, devised by Latour, is shown in Fig. 1. In order to restrict harmful magnetic leakage as much as possible, the stator in this type of motor should be wound over those portions only which are opposite the short-circuited sections of the rotor, as shown in Fig. 1. It will be immediately seen that if a pair of diametrically opposite brushes be disconnected or omitted the motor is transformed into a series motor, the resultant flux being determined by the vectorial resultant of the stator and rotor ampere-turns. If the number of turns be so chosen as to make the stator ampere turns equal to those of the rotor, the brushes will be found to be placed in the neutral zone. This will be evident from Fig. 2, in which I. shows the flux distribution due

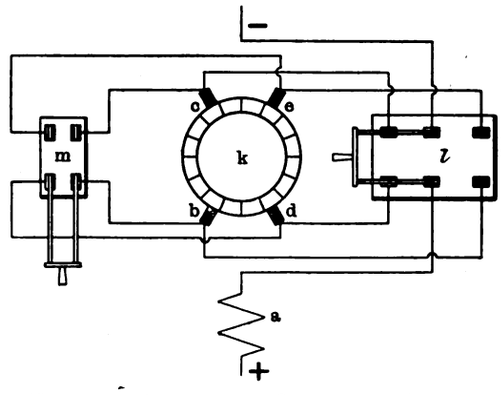

FIG. 3.—METHOD OF CHANGING THE COMPENSATED REPULSION MOTOR INTO A SERIES MOTOR.

to the stator winding, II. that due to the rotor winding, and III. the resultant flux distribution. In Fig. 3 are shown the switching arrangements for effecting the change in question, a representing the stator winding, l a reversing switch for reversing the direction of rotation, and m a change-over switch for converting the compensated repulsion into the series arrangement of connections.

A detailed comparison of a motor of this type (when used as a compensated repulsion motion) with one of the Winter Eichberg type shows that the same starting torque is obtained with a somewhat smaller number of volt amperes, the same copper loss in the rotor, and practically the same iron losses.

* Abstracted from the *Elektrotechnische Zeitschrift*.

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The motor combines the good qualities of the compensated repulsion motor in the neighbourhood of synchronous speed with those of the series motor for speeds above synchronism. Thus if, for example, a series motor has a mean power factor of 0·86 between synchronism and 50 per cent. above it—*i.e.* if it has a mean wattless component amounting to half the total current—in a motor of the new type, within this range of speed, the mean wattless component may be made to vanish entirely; while in contrast to the ordinary compensated repulsion motor, the new motor runs at still higher speeds quite as satisfactorily as the ordinary series motor.

The above qualities should prove of value in all cases where trains or single cars are required to run at a highly variable speed, as in the case of suburban railways or locomotives intended to be used for both passenger and goods service.

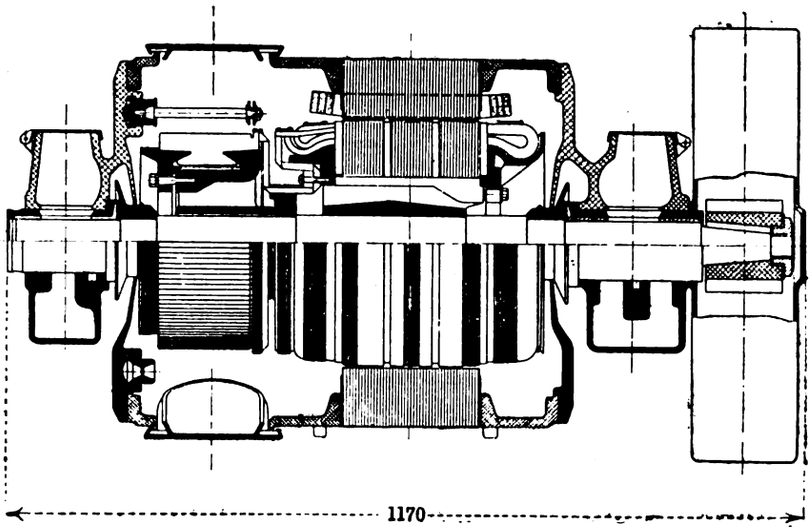

FIG. 4.—SECTIONAL ELEVATION OF THE COMBINED REPULSION AND SERIES MOTOR.
Scale 1 : 10.

In all cases where a compensated repulsion motor is required, the new motor may be used as such, and it may also be used as a continuous-current motor, thus offering the solution of a problem which had not hitherto been successfully attacked.

Although the motor is capable of running under three different sets of conditions, it is only provided with a single stator winding.

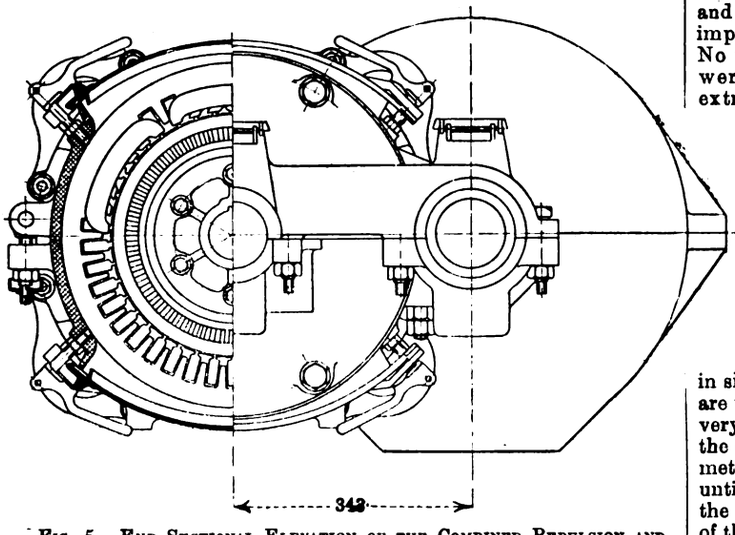

FIG. 5.—END SECTIONAL ELEVATION OF THE COMBINED REPULSION AND SERIES MOTOR.

It is, therefore, of very simple mechanical construction, and its stator may be divided into two parts hinged together, an arrangement which is not possible with certain other types of single-phase motor.

Experiments with motors of the new type have as yet been conducted on a limited scale only by the Allmänna Svenska Elektriska Aktiebolaget, of Westeras. The mechanical construction of the motors is shown in Figs. 4 and 5. They are 20 H.P. (one hour's rating) six-pole machines designed for a frequency of 25. When used as compensated repulsion motors, they have a power factor exceeding 0·9 at a speed of 400 revs. per min., and this practically reaches a value of unity at 800 revs. per min. On changing over to the series connections at 800 revs. per min. the power factor drops to about 0·9, and steadily rises with increasing speed. Thus at all speeds above 400 revs. per min. a power factor exceeding 0·9 may be maintained. The motors are at present in use on one of the experimental cars of the Swedish State Railways; they are running satisfactorily under varying conditions, and it seems reasonable to suppose that larger motors of this type would prove equally satisfactory.

It should be mentioned that the motors to which the above data refer were not specially designed to be used under the conditions stated. A more recent design should, according to the author's calculations, have a power factor of 0·99 with lagging current at 500 revs. per min., and a power factor of 0·99 with leading current at 750 revs. per min., when used as a repulsion motor. As a series motor it is expected to have a power factor of between 0·89 and 0·9 at 750 revs. per min., and of 0·94 at 1,000 revs. per min.

THE OCCLUSION OF THE RESIDUAL GAS BY THE GLASS WALLS OF VACUUM TUBES.*

BY A. A. CAMPBELL SWINTON.

Users of Crookes' tubes for Röntgen ray purposes have for long been aware that, apparently owing to a change in vacuum, the tubes become "harder" with use, and that it becomes necessary in the case of old tubes to heat the glass in order to get the discharge to pass. In a Paper read before the Royal Society in April, 1899,† the present writer pointed out that the vacuum actually increases in cathode ray tubes with use, even if repeated small doses of additional air be let in from time to time. Villard has also shown that the residual gas in a vacuum tube is driven into the glass, and that portions of the glass of a tube that has been used show bubbles if heated strongly. Again, in a Paper on the absorption of gas in a Crookes' tube by Dr. R. S. Willows,‡ a number of experiments relating to this subject are recorded.

The present Paper describes certain further investigations on this subject

The tubes first experimented upon were some of those originally employed by the writer in 1898 and referred to in his above-mentioned Paper. Since that date they have been lying undisturbed and open to atmospheric pressure, so that the gas now found to be imprisoned in the glass must have been there for some nine years. No note was taken in 1898 as to the amount of time that the tubes were used, but each was in operation for many hours and under extremely severe conditions, the alternating current employed having a volume of some 20 milli-amperes at about 8,000 volts pressure.

The condition of the glass walls of these tubes is now found to be as follows: When cleaned by rubbing they are quite transparent to casual inspection, though careful examination with the microscope shows that the inner surface of those portions that had been subjected to cathode-ray bombardment are materially roughened. When these portions of the glass are strongly heated in a blow-pipe flame, they immediately become clouded, the effect being due to quantities of minute spherical bubbles in the glass, which may clearly be seen with a microscope. The bubbles vary to some extent in size, but on the average are about 0·01 mm. in diameter. They are usually packed closely together in a single layer and are always very near the side of the glass that formed the inner surface of the tube. On measuring the thickness of the glass with a micrometer gauge, dissolving the inner surface with hydrofluoric acid until the bubbles had just disappeared, and then again measuring the thickness, it was found that, after making allowance for the size of the bubbles, the centres of these bubbles were about 0·122 mm. from the inner surface of the glass. A similar estimate was obtained by grinding the inner surface of the glass until the bubbles just disappeared and making micrometer measurements as before. It would, therefore, appear that the particles of gas must have been shot into the glass to about the depth stated.

In a typical piece of glass the number of bubbles per square centimetre of glass was found to be about 625,000, so that, allowing for

*Abstract of a Paper read before the Royal Society.

† "On the Luminosity of the Rare Earths when heated *in vacuo* by means of cathode rays," Roy Soc. *Proc.*, Vol. LXV.

‡ *Phil. Mag.*, April, 1901.

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the expansion of the gas, on heating the glass up to redness there was occluded about 0·000118 c.c. of gas at atmospheric pressure per square centimetre of glass, and as the amount of glass surface that was bombarded in each tube was about 400 sq. cm., the total amount of gas at atmospheric pressure occluded in each tube is nearly 0·05 c.c., apart from any further amount that may have escaped from the glass in the heating of the latter.

An interesting question arises as to whether the gas is merely mechanically mixed with the glass or whether there has been any chemical combination between the two. In the latter case, it seemed unlikely that mere powdering of the glass would cause the gas to come out, while in the former case it seemed probable that powdering the glass would have this effect.

In order to test this a number of pieces of the glass were placed in a chamber consisting of two slightly dished tinned plates some 15 cm. in diameter, which were soldered together all round the edges, with a metal tube inserted, so as to be air-tight. The chamber was connected with a mercury pump and a spectrum tube, and was then pumped until no electric discharge could be got to pass through the spectrum tube. An anvil was then placed under the chamber, and the latter was struck several blows with a hammer, so as to powder the glass, when there was an immediate fall of vacuum, and on examination with a spectroscope the gas that had been evolved was found to be mainly hydrogen. The chamber was then pumped out again, and on further blows being struck, so as to powder more glass, similar results were obtained; in fact, the process was repeated many times, the result being in each case to bring out more hydrogen.

It would appear, therefore, that the gas occluded in soda-glass vacuum tubes exhausted in the ordinary manner from air is almost entirely hydrogen, no doubt due to electrolysis of water vapour condensed on the walls of the tube prior to exhaustion, the oxygen of which is absorbed by oxidation of the aluminium electrodes.

In order, further, to determine whether the occlusion of the gas in a vacuum tube is in any way due to chemical combination of the gas with the glass, or whether it is purely a case of the gas being driven into the glass and mechanically held there, a suggestion made to the writer by the Hon. R. J. Strutt was followed, and experiments were tried with helium.

A spherical tube of soda glass about 7 cm. in diameter, with two electrodes consisting of aluminium plates, was employed. The tube was first exhausted in the ordinary way from air until the vacuum was so high that the discharge would not pass, and then, by an arrangement of stop-cocks, a small quantity of helium was admitted. The tube was then sparked and the vacuum was found to increase, showing that the helium was being absorbed. Further small quantities of helium were admitted at intervals, the process being continued intermittently for 20 days, the total number of hours of sparking being about 90, or 4½ hours per day, and the number of admissions of helium about 700, until about 1 c.c. of helium at atmospheric pressure had been absorbed.

During the process of sparking the tube gradually blackened, the deposit being afterwards ascertained to be aluminium from the electrodes. There thus seemed some doubt as to whether the helium was being absorbed entirely by the glass or perhaps partly by the very thin coating of aluminium, which, by the time the cubic centimetre of helium had been absorbed, had become a perceptible mirror.

On breaking up the tube, however, it was found that whether the glass was heated without further treatment, or whether the mirror of aluminium was first dissolved off its surface with dilute nitric acid, a plentiful supply of bubbles was produced in the glass, showing that at any rate some portion of the helium had found its way into the latter.

Similar experiments were made with the glass containing helium to those tried with the glass containing hydrogen, in the way of extracting the gas by powdering the glass in a vacuum chamber. It was found impossible to get rid altogether of the hydrogen spectrum and other faint lines, due, no doubt to impurities, but, on the glass being powdered, the helium spectrum was found to be clearly superposed. This was equally the case when glass that was still coated with the aluminium deposit was used as with glass from which this deposit had been dissolved off. Consequently, the occlusion appears to take place entirely in the glass, and, having regard to the inert character of helium, to be mechanical.

Test on a 3,000 kw. Steam Turbine.—The *Zeitschrift für das gesamte Turbinenwesen* gives an account of a test on a steamturbine which took place at the electricity works in Moabit, near Berlin. At full load (3,115 kw.), with steam at a pressure of 12·1 atmos., and at a temperature of 309°C., and with the turbine running at 1,500 revs. per min., the steam consumption was 12·95 lb. per kilowatt-hour, not including that used for the condenser, but including the excitation. The amount used for condensation purposes was 73 H.P. at full load.

CORRESPONDENCE.

WIRELESS TELEGRAPHY DURING DAYLIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Those interested in the development of wireless telegraphy will be interested to know that the writer has found it possible, by using a somewhat different type of impulse from that heretofore used, to cut down the absorbing power of daylight to a small fraction of its previous amount.

As regards the practical results, the National Electric Signalling Co. has lately succeeded in working from Brant Rock, Massachusetts, to the West Indies, during daylight, the distance being approximately the same as that from Newfoundland to Ireland, so that Trans-Atlantic wireless telegraphy during daylight is absolutely assured.

The new impulses are less efficient during night time than the old ones. I have only at hand numerical comparisons over a relatively short distance—*i.e.*, 400 miles—between Brant Rock, Massachussetts and Washington, D.C. The following is a sample quantitative result obtained between these two stations:—

June 1, 1907.

Type of impulse.	Strength of the signal received at Washington between the hours of 10 and 12 at night.	Strength of the signal received from 12 to 12:30 at noon.
Old impulse	1,200	80
New impulse	80	76

Unit intensity is the intensity at which telegraphic messages can just be clearly read without mistake, so that intensity 40 means that the signals are 40 times louder than that at which they can just be read.

It will be seen that with the new arrangement the impulses are practically of the same strength during daylight as at night. The fact that they are weaker at night time than the old type of impulse used by this company in telegraphing between Scotland and Massachusetts during night time is a matter of no consequence as, in the first place, daylight transmission is the important thing, and in the second place, even if it were not so, it would be preferable that it should be so, as the advantages obtained by having a fairly uniform strength of signal are very much greater than any advantage to be obtained by an increase of strength during night time.

Up-to-date rough measurements over distances above 1,500 miles seem to show that, while the new type of impulse is much stronger than the old, it also falls off from the intensity at night. The difference, however, is of an entirely different order from that which occurs with the old impulse, and, as mentioned before, the fact that these tests have actually been carried out over a distance equal, within a few per cent., of the distance across the Atlantic, during daylight and the summer months, renders it, I think, justifiable to say that there can be no further doubt as to whether wireless telegraphy is destined to become a rival and in time to entirely supplant cable telegraphy.

It is perhaps unnecessary to say that this communication is not based upon the results of one or two measurements, but upon measurements made daily for a period of over three months.—I am, &c.,

REGINALD A. FESSENDEN.

Brant Rock, Mass., July 2.

DOUBLE-CIRCUIT SINGLE-PHASE MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article in your issue of the 12th inst. contains, I think, a number of erroneous statements, to some of which I should like to draw attention.

(*a*) The machine referred to by Mr. Osnos as the compensated shunt motor (Fig. 1, p. 515) I prefer to designate as the "self-excited, compensated shunt induction motor." Terminology may be held to be a question of minor importance, but the same cannot be said of the torque conditions. Mr. Osnos comes to the conclusion that there are three torques in the machine, two of which, T_2 and T_3, cancel out so that the actual torque T_1 is simply proportional to $v_1 N_1$ and $i_3 z_4$. If that were so then the useful torque of the motor would be nil.

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Along the axis *aa* the machine is a transformer with z_1 primary and z_2 secondary turns; v_1N_1 is the flux of mutual induction due to the magnetising A.T. (i_0z_1) of the primary or to the difference of primary and secondary A.T. This transformer flux lags by very nearly 90 deg. behind E, the primary or supply E.M.F. It is, then, clear that N_2 can only be the secondary leakage flux and will be nearly in phase with i_2 whereas N_3 will be nearly in phase with i_3, the latter lagging by about 90 deg. behind the exciting E.M.F. (e_r) generated at the brushes *b* by rotation in v_1N_1. Now since e_r must be of same phase as v_1N_1 or of opposite phase to it, according to the direction of rotation, then this e_r must clearly be in quadrature with E, and we have the following approximate conditions and phase relations.

v_1N_1 lags 90 deg. behind E and is due to i_0z_1, and not to i_1z_1, as stated by Mr. Osnos.

N_2 is in phase with i_2 and, under normal working conditions, of opposite phase to E. This N_2 is only a leakage flux, and cannot compare in magnitude with N_3.

N_3 is in phase with i_3, and if e_r is of opposite phase to v_1N_1, then N_3 is of the same phase as E. In magnitude N_3 practically equals v_1N_1. i_3z_2 is consequently in quadrature with v_1N_1, from which follows that $T_1=0$. T_1 cannot therefore represent the main torque of the motor, as suggested by Mr. Osnos.

i_3z_2 is, however, of opposite phase to N_2, so that T_2 may have a certain value. This value must be a very small one indeed, because N_2 is small.

i_2z_2 is of opposite phase to N_3, therefore T_3 must have a certain value; in fact, T_3, *the* torque of the motor for N_3, which is the motor field, is large, and i_2, which is the armature current, increases with the load. T_2 is therefore not numerically equal to T_3, and does not cancel the latter, as stated by Mr. Osnos.

The same reasoning will show that in the case of Fig. 4, for instance, the main torque is not proportional to v_1N_1 and i_1z_2; this particular torque is, in reality, practically nil when the motor is running with a high power factor.

I have dealt very fully with the torque conditions of alternate-current motors generally in an original communication presented to the I.E.E. last May; if accepted, it will be published next session, so that I do not propose to go more fully into this question just now.

Mr. Osnos is also in error if he thinks that in Fig. 1 the exciting current passing the brushes *b* is supplied by the transformer *t*. This current is due to the exciting E.M.F. (e_r) generated in the motor itself by rotation in the transformer field—in fact, this is the very reason why I always refer to the machine in question as self-excited. If Mr. Osnos will short-circuit the brushes *b* in Fig. 1, and cut the transformer *t* out, he will not destroy the motor field and the machine will operate as before. The transformer *t* only serves to compensate the machine—*i.e.*, to improve its power factor. As to the winding z_4, disposed on the stator, this arrangement was patented by me in England and in seven other countries in 1902; in Germany, which at that time did not belong to the Convention, the same arrangement was patented by me in 1903 (patent No. 187,633). There is no material difference under normal operation between the motor shown in Fig. 5, p. 515, and that shown by me in Figs. 27, 28 and 29 of my Institution Paper of March 8, 1906. The line current i_1 in Fig. 5 is nearly in phase with i_3, and this line current flows almost entirely through z_4 in a direction opposed to that of i_3. This line current, therefore, in no way alters the mode of operation of the machine. The latter starts as a so-called "repulsion" motor—*i.e.*, a series induction machine, and operates as a compensated, self-excited, shunt induction motor, just as my old motors do.—I am, &c.,

London, S.E., July 15. VAL. A. FYNN.

[Mr. Fynn is quite correct in his statements; but so also is the author of the article in question. Mr. Fynn's opening sentence regarding the "number of erroneous statements" is a striking illustration of his utter inability to look at the matter from any other standpoint than his own. It does not seem to have occurred to Mr. Fynn that the symbols employed by Mr. Osnos may have a meaning other than that which Mr. Fynn, quite arbitrarily and unjustifiably, chooses to attribute to them. The v_1N_1 used by Mr. Osnos does *not*—as supposed by Mr. Fynn—stand for the "flux of mutual induction," but for a totally different quantity, viz., the *hypothetical* flux which would result from the current i_1 were the brushes *aa* open-circuited. Similarly, Mr. Fynn's N_2 denotes something totally different from Mr. Osnos's. We should have thought that any careful reader would at once have inferred the meaning of the symbols from the context, instead of rashly accusing Mr. Osnos of an amount of ignorance which exists in Mr. Fynn's imagination only.—Abstractor of the Article.]

TESTS OF CURTIS STEAM TURBINES.

We have received the following details from the British Thomson-Houston Co. (Ltd.) of tests carried out on a 9,000 kw. Curtis steam turbine, four of which have been installed at the Fisk-street station of the Commonwealth Electric Co. of Chicago. We understand that these tests were carried out by independent engineers with the greatest care.

The following table is a summary of the results:—

Load in kilowatts.	Gauge pressure, lb.	Vacuum, inches.	Superheat, degrees F.	Water rate, lb. per kw.-hr.
5,374	182	29·43	133	13·15
8,070	197	29·59	116	13·0
10,186	176	29·47	147	12·9
12,108	182	29·34	148	13·05
13,900	198	29·31	140	13·6

Results practically similar to those obtained at Chicago have also been obtained on a 5,000 kw. unit of similar design, installed in the station of the Boston Edison Co., and tested on January 29, 1907, the figures being as follows:—

Load 5,195 kw., gauge pressure 174 lb., vacuum 29·3 in.
Superheat 142°F., water rate 13·52 lb. per kilowatt-hour.

This difference from the Chicago figures is fully accounted for in the losses of the generator alone. When reduced to similar conditions these figures differ by only 0·3 lb. from those obtained at Chicago. The Boston tests were verified by three separate runs with different sets of instruments, some of which were specially calibrated for the purpose.

These figures appear to demonstrate that the large clearances which are characteristic of the Curtis turbine have no detrimental effect upon its economy.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

In the House of Commons on the 18th inst, the Prime Minister stated, in reply to questions by Sir Edward Sassoon and other members, that he could not reconsider his decision not to allocate time for a discussion of the report of the Radio-Telegraphic Committee. It was the intention of the Government to ratify the convention, and that they would do in the exercise of their own judgment and not merely because of the report of the Committee.

ELECTRIC SUPPLY CORPORATION BILL.

This bill came before the House of Commons Committee on Unopposed Bills last week. The bill, which authorises the transfer to the company of certain electricity undertakings and confirms five agreements with local authorities, has already been through the House of Lords. Evidence was given to show the financial strength of the company, the share capital of which is £250,000, £210,000 being paid up. Debentures issued represent about £100,000. The Committee found the preamble of the bill proved.

LEGAL INTELLIGENCE.

Dudley Corporation v. Dudley, Stourbridge & District Electric Traction Co. (Ltd.)

In the House of Lords on Tuesday their Lordships gave a considered judgment in this appeal by the plaintiff Corporation against a decision of the Court of Appeal reversing a judgment of Mr. Justice Swinfen Eady upon a special case stated for the opinion of the High Court declaring that the higher of two alternative sums mentioned in the case was the price payable by appellants to respondents for a certain light railway. The argument by appellants was, briefly, that the structure alone was to be valued; by respondents that in addition to the value of the structure the power and right attached to exclusively using the rails and of taking tolls was also to be included in the valuation.

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Mr. Balfour-Browne, K.C., and Mr. Vesey Knox were for appellants: while Mr. Cripps, K.C., and Mr. C. H. Sargent were for the respondents.

The LORD CHANCELLOR, in moving that the appeal be allowed, said the question to be decided arose in this way: In 1898 the company was promoting an order under the Light Railways Act, 1896, for constructing light railways. One of these (railway No. 5) was within the borough of Dudley and the Corporation opposed, but the order was granted by the Commissioners. On Oct. 17, 1898, an agreement was come to between the Corporation and the company under which the former withdrew their opposition to the confirmation of the order. The railway in question was to be constructed by the company to the reasonable satisfaction of the Corporation, and the Corporation were, at the expiration of four years from Aug. 11, 1898, to buy on the terms of the Tramways Act, 1870, all the tramways already existing in Dudley, and "the Corporation shall also purchase and the British Electric Traction Co. shall sell Railway No. 5 at a price to be settled in case of difference by the Board of Trade." That was Clause 3. Clause 4 ran as follows: "Upon the acquisition by the Corporation of the said tramways and railway they shall grant a lease thereof to the British Electric Traction Co. for 21 years from the date of the purchase upon terms to be settled unless otherwise agreed by lay arbitrators appointed by the Board of Trade." The time for purchase arrived, and by consent an arbitrator was substituted for the Board of Trade to fix the price. He found that if the railway was to be paid for "as a railway in situ capable of earning a profit" (as the Corporation contended), the price payable was £16,548. If, on the other hand, as maintained by the company, the proper basis of the valuation (to the company) of the railway as an income-earning concern, "then the price payable was £32,576." Mr. Justice Swinfen Eady decided that the lower sum was payable only, and in his lordship's opinion that decision carried out what seemed the real intention of the parties—namely, that the company should be reimbursed its outlay, with proper allowances for depreciation, and then be allowed for 21 years to enjoy under a lease the occupiers' profits of the undertaking. For it was clear that what the Corporation could lease and take rent for under Clause 4 of the agreement was simply that which it had bought and paid for under Clause 3. No doubt the Corporation must also give to its lessees the necessary powers of working, taking tolls and so forth, to carry out the purpose of the agreement. But the rent could only be for that which it had bought under the one clause and leased under the other, for the subject matter dealt with under both clauses was the same and described in the same words. Accordingly, this appeal must be allowed.

Lord ROBERTSON and Lord ATKINSON concurred.

Lord COLLINS differed, and said that his view accorded with that of the Court of Appeal. The subject matter of bargain was the railway "proposed to be authorised," with the powers of working it. It seemed to him unreasonable to suppose that the legislature would carry out this bargain by, in the first instance, making a free gift to the buyer of half the subject matter of the sale, and leaving the price of the residue only to be ascertained as provided and paid for by the buyer. It seemed to him that the *à priori* presumption here was that by "the railway" the undertaking was meant. They were dealing with a railway and not a tramway, and there was a presumption of permanence in the former which there was not in the latter. He agreed with the Court of Appeal that the word "railway" in its context was used as equivalent to the "undertaking" in the order itself. On that view the Court was relieved from the unpleasant duty of forcing the company to put up with what, in his opinion, would be something less than justice. For these reasons he thought the appeal should be dismissed.

By a majority the appeal was allowed, with costs.

The Electrical Ageing of Flour.—J. N. Alsop's Letters Patent 14,006 of 1903.

On Monday, Mr. Justice Parker commenced the hearing of a petition for the revocation of this patent.

Mr. CRIPPS, K.C., on behalf of the owners of the patent, said it was for a process of bleaching or ageing flour which was of great importance and commercial value, it being in use in some 1,200 mills, 60 or 70 of which were in this country. He thought the fight would not be as to utility or commercial value, but whether at the time the patent was brought out there was a patentable subject matter entitling them to the benefit of the grant. The process consisted of subjecting flour to the action of air which had previously been subjected to the action of electricity. The result of so treating the air was to produce a gaseous medium, which bleached or whitened the flour. In the old days millers had to keep their flour for months, but by this process it became prematurely aged and could be used at once. The patentee, an electrical engineer, was the first to subject flour to the action of a gaseous medium produced generally by the action of an arc or flame of electricity and he devised at the same time a practical method of apparatus by which it could be carried out, and the apparatus itself was a patentable novelty. There was some doubt as to what the gaseous medium was, but no gaseous medium had been before produced which in its action on flour had the same result. The main feature of the invention as regarded the apparatus seemed to be that a comparatively low potential was used. By this the risk was run of the arc being broken, as the electrodes were separated when they got a certain distance apart. As they got apart there was further resistance for the arc to get across.

Mr. WALTER, K.C. (for petitioners): The voltage is 500. The ordinary arc voltage is 50.

Mr. CRIPPS said he was going to compare it with machines of 5,000 to 10,000 volts. To counteract the tendency of the arc to break, an induction coil was employed, the effect of which was to increase the current just when it was wanted to be increased, and to allow the continuity of the arc even at a low potential. On the other hand, when the two electrodes were together, a short circuit was produced, the effect of which was to recharge the coil. The coil was, therefore, recharged and utilised automatically, and even with this low voltage they got an automatic continuity of the arcs which was essential for the working of the process, and, as a matter of fact, it worked with perfect success and without any practical difficulty at all. The patent was attacked on the grounds of prior publication and invention, and the petitioners, Messrs. Andrews & Andrews relied on patent granted to them for a chemical process in 1901, and on the specification of McDougall.

Evidence was given on behalf of respondents by Mr. J. SWINBURNE, who said that the gaseous mediums produced by the Andrews and McDougall processes were not the same as that prescribed and produced under the Alsop patent. He could not say in what way they differed chemically, but their effects were different.

The case was proceeding when we went to press.

Attorney-General v. Yorkshire (Woollen District) Electric Tramways (Ltd.)

Mr. Justice BRAY gave judgment in this case on Friday last.

The SOLICITOR-GENERAL, in opening the case, said the Inland Revenue sought to make the Company pay carriage duty on certain of their cars. The Company's answer was that they were not liable to pay the duty, as they were incorporated under the Light Railways Acts, and that their cars were not to be treated as ordinary tramcars, but as railway carriages. His contention was that the cars were propelled upon a track laid along public roads, and that the cars were liable to carriage duty. The Inland Revenue sought to make the Company pay carriage duty on 12 of the cars.

His LORDSHIP: You say that these cars are propelled upon a road or tramway?

The SOLICITOR-GENERAL: I say it is a tramway constructed upon a road and that it is not a railway at all; therefore it comes within the words of the section, "drawn or propelled upon a road or tramway."

Mr. DANCKWERTS, K.C., contended that the cars were not liable to the duty, as it was a railway constructed under an order granted under the Act of 1896. The Court of Appeal laid it down that tramways were things which were constructed under the Tramways Act.

His LORDSHIP, in giving judgment, said that to his mind it was obvious that the intention of Parliament by the Act of 1896 was that light railways should be treated as railways as distinct from tramways. The act and the authorities made it clear that the company's railway was a light railway, and he had nothing to do except to decide that it was a railway within the meaning of the section of the act, and those carriages not being propelled elsewhere than on a railway were not subject to duty. Therefore he dismissed the information, with costs.

Lynch v. Macartney, McElroy & Co.

On Monday the Court of Appeal (the Master of the Rolls, Sir Gorell Barnes and Lord Justice Kennedy) delivered judgment in this application of defendants for judgment or a new trial on appeal from the verdict and judgment at the trial before Mr. Justice Bigham and a common jury. The facts were given in our issue for May 3.

Lord Justice KENNEDY, who read the judgment of the Court, said they had come to the conclusion that the learned judge was right in leaving the question of libel or no libel to the jury, but they were clearly of opinion that the damages awarded by the jury were grossly excessive. There was no evidence of actual malice on the part of defendants. The alleged libel was only published in one newspaper in Malta, where plaintiff neither resided nor had any occupation. In these circumstances the case must go down for a new trial.

Subsequently it was announced that the parties had come to terms.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

There are vacancies for two premium pupils at Bedford Corporation electricity works. Particulars from the borough electrical engineer (Mr. R. W. L. Philips, A.M.I.E.E.), Cauldwell-road, Bedford. See also an advertisement.

An electrician is wanted to take charge, under works manager, in an old-established cable factory in England. Applicants should be young, energetic and good mathematicians and have had previous experience in testing both rubber and paper core made to Government specifications, and also be familiar with high-pressure testing apparatus. See an advertisement.

A junior shift engineer is required for a hydro-electric power station in the Snowdon district. Candidates must have mechanical and electrical training, and be conversant with e.h.t. three phase working, &c. Commencing salary 32s. 6d. per week. Applications to the Chief Engineer, North Wales Power & Traction Co. (Ltd.), Llanberis, R.S.O. See an advertisement.

A c.c. armature winder not less than 30 years of age is required by the Barrow Hematite Steel Co. (Ltd.) Applications to the electrical engineer to the company, Barrow-in-Furness. See an advertisement.

An electrical engineer is wanted to look after plant, consisting of two dynamos, water turbine and overhead mains. Wages not over

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35s. per week. Applications to Mr. F. R. Webb, Old Bleach Linen Co. (Ltd.), Randalstown, co. Antrim, Ireland. See also an advertisement.

A lecturer in electricity and physics is required in September next at the City of Birmingham Municipal Technical School. Commencing salary £140. Particulars from the secretary (Mr. George Mellor), Suffolk-street, Birmingham.

An assistant superintendent of telegraphs is required for service in Ceylon. Candidates must be qualified telegraph engineers and possess a thorough knowledge of Morse signalling. Engagement three years. Salary £300, rising to £350 per annum by annual increments of £25. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by July 29.

An assistant lecturer and demonstrator in applied mechanics and engineering design and drawing is wanted at the University of Liverpool. Salary, £100.

An instructor in wireman's work, for one evening a week, is required at the Municipal Technical Institute, West Ham. Commencing salary 10s. per evening. Further particulars from the Principal, at the Municipal Technical Institute, Stratford, E.

Two telegraph construction foremen are required in Southern Nigeria. Salary £20 and £25 a month respectively. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by 31st inst.

A professor of civil engineering (Rs.500 per month) and a professor of mechanical engineering (Rs.500 per month, rising to Rs.1,000, with a pension) are required at the College of Engineering, Madras. Applications to the Secretary, Public Department, India Office, London, S.W., by July 31.

Mr. Rogers, of Warrington, has been appointed chief assistant engineer at Dewsbury.

Mr. Mackenzie has been appointed power-house foreman at West Ham at £3. 10s. per week.

Mr. W. E. Hart, deputy town clerk of Sheffield, has resigned, having been appointed solicitor to the National Telephone Co.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne. See an advertisement.

City and Guilds of London Institute.—The entrance examinations of the Institute's Colleges are held in September. Particulars of the entrance examinations, scholarships, fees and courses of study may be obtained from the respective colleges or from the head offices of the Institute, Gresham College, Basinghall-street, E.C. The City and Guilds Central Technical College, Exhibition-road, W., is a college for higher technical instruction for day students not under 16 preparing to become civil, mechanical, or electrical engineers, chemical and other manufacturers or teachers. The College is a school of the University of London in the Faculty of Engineering. The City and Guilds Technical College, Finsbury, is a college for intermediate instruction for day students preparing to enter the engineering and chemical industries, and for evening students.

At the meeting of the Council on 22nd inst. the diploma of Associate of the City and Guilds Institute was awarded to the following matriculated third-year students of the Central Technical College who have completed a full course of instruction in electrical engineering as prescribed by the Council: J. W. Wheeler (Siemens Medal and Premium), C. H. Harvey, A. Collins, P. E. Hosegood, A. Kinnes, C. H. Toms, C. G. Barker, R. P. Abel, H. R. Rivers-Moore, H. E. Parry, L. N. Vine, J. O. Fraser, J. M. McG. Whellens, L. G. Dalais, C. A. Schurr, L. B. Sparks, G. E. W. Broade, E. H. Child, W. R. Harding, B. A. Tubini, C. H. Lauth, J. B. G. Northcott, C. Latham, L. T. Young, H. L. Bazalgette and J. McL. Donald. The diploma was also awarded to 55 students in civil and mechanical engineering and to six students in chemistry. In addition to the above, certificates have been awarded to 25 matriculated third-year students who have completed a full course of instruction at the Central Technical College and to 66 students who have completed a full course of instruction at the Technical College, Finsbury.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars as to fees, &c., can be obtained at the Institute, St. John's street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Hartley University College, Southampton.—The next session begins Sept. 25. At this college there are day courses in civil, mechanical and electrical engineering. Prospectuses, &c., from the Registrar.

Bath.—The Electric Lighting committee recommend the Council to accede to Mr. E. Schenk's request for a further extension of time (until March 8, 1908) for completing the purchase of the electricity undertaking, subject to Mr. Schenk's immediately paying a substantial deposit, which shall be unconditionally forfeited in the event of the scheme not going through.

Battersea (London).—The Lighting committee have informed the L.C.C. that, in accordance with the suggestions of their chief engineer, they are prepared to arrange for the electric cables in main thoroughfares to be laid at a minimum depth of 3 ft. 6 in., and in other thoroughfares at 2 ft. 6 in.

The committee have authorised the laying of additional feeders, distributors, &c., so as to provide for next winter's load, at an estimate of £2,830.

Beckenham.—Sanction has been received to a further loan of £5,460 for electricity supply.

Belfast.—On the recommendation of the city electrical engineer (Mr. Bloxam) a revised scale of charges for electric current has been adopted.

Mr. Bloxam estimates that the reduction will be equivalent to £2,000 per annum, but the anticipated increase in receipts is £10,000. Roughly speaking, the revised rate means a reduction of ¾d. per unit on each of the various scales.

Bideford.—A company has given notice of intention to apply for a provisional electric lighting order.

Birkenhead.—In future the charges for electrical energy for power and heating will be as follows: First 500 units per quarter, 2d. per unit; from 1,500 to 5,000 units, 1½d.; each additional unit in excess of 5,000, 1d.

Edinburgh.—Last week the Electric Lighting committee considered the question of the disposal of the year's surplus on the electric lighting accounts.

The convener (Councillor A. A. Murray) moved, and Bailie Carmichael seconded, a resolution that, after devoting £1,055 of the surplus to bringing the reserve up to its maximum, the balance (£9,920) be applied to the reduction of capital expenditure.

Councillor Cowan moved an amendment that the £9,920 be devoted to relief of rates.

After discussion the resolution was adopted by 5 votes to 3.

On Tuesday the Corporation decided to apply the balance to relief of rates.

Egham.—Woking Electric Supply Co. proposes to obtain a provisional order for this district.

Electricity in Small Urban Areas.—At Saturday's meeting of the Urban District Councils' Association, Mr. J. W. Benson, chairman of the Ilkley Gas and Electric Lighting committee, contributed a Paper on "The Supply of Electricity in Small Urban Areas."

Mr. BENSON said the acquisition of public undertakings by local authorities had had the effect of narrowing down the scope available for the speculative capitalist to such an extent that at present, where there appeared the slightest available opening, he at once came on the scene, no matter whether required or not. That was particularly the case with respect to electric lighting in small urban areas which from year to year formed the hunting ground of the capitalist anxious to discover fresh fields for investment. As the result of such speculative enterprise, the councils of small urban districts were continually being put to serious expense in defending their interests against promotors of electric lighting schemes, and, in some cases, in order to stave off invaders, Councils had no alternative but to take an electric lighting order themselves, or otherwise to permit outsiders to come in, and, if the council happened to own the gasworks supplying its own district, enter into competition with the ratepayers themselves. The result of a small urban council obtaining an electric lighting order was anything but satisfactory, for such small schemes could very rarely be carried out by a council except at serious loss, which was bound to fall on the rates. If local government were to maintain its position against private enterprise, and continue to maintain all public services for the public benefit, some way of avoiding this loss must be found, and he suggested as a possible solution of the problem that county councils should be vested with electric lighting powers for the whole of each county area controlled. By this means a county council would be in a position to link up two, three or more small urban districts, or even parts of rural districts, and supply the whole with electricity from one centrally-situated generating station. Such a scheme could be carried out far more economically and profitably than if each district had to provide its own site, buildings and generating plant, and it would obviate the continual cost and annoyance entailed upon small urban districts in endeavouring to prevent themselves being placed at the mercy of the speculative capitalist, whose sole aim was to obtain a foothold in any district for profit-making purposes. He moved a resolution accordingly.

An amendment proposed by Mr. LEES (Beckenham) and seconded by Mr. DANE (Ilford), that the resolution be altered so as to provide that local authorities be vested with powers to combine areas for electric light and power purposes, was accepted by Mr. Benson and carried unanimously.

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Farnborough.—The Woking Electric Supply Co. and the Mutual Electricity Supply Co. propose to apply for provisional orders.

Finchley.—Instead of borrowing £16,830, as recently decided by the Council, it has now been resolved to borrow £22,000—£12,000 for plant and £10,000 for extensions of mains.

The report of the consulting engineer (Mr. A. H. Preece) on the condition of the undertaking has been received. It is reported that Mr. Preece suggests the advisability of considering the question of taking energy in bulk from the North Metropolitan Electric Power Supply Co. or other authorised undertakers.

Fraud.—Last week Sheriff Robertson, of Aberdeen, committed Wm. Taylor (described as an "electrical engineer") on four charges of fraud and one of attempted fraud, alleged to have been committed between June 11 and 22.

It was alleged that he induced two firms in Aberdeen to supply him with 20 electric lamps (valued at £1. 1s. 8d.) and 50 electric lamps (valued at £3. 7s. 3d.), and two Glasgow firms to supply him with 250 and 93 electric lamps, under false pretences.

It was stated that Taylor, on getting out on ticket-of-leave a few weeks ago, obtained employment in the Aberdeen electricity department, but was only there about a week when his services were dispensed with. The accused then engaged in the alleged fraudulent practices.

Gloucester.—A special meeting of the City Council was held on Wednesday to consider the municipal light railway undertaking. Ultimately it was decided to appoint a special committee to inquire as to whether the tramways could be let on lease upon favourable terms.

Gravesend.—On Wednesday the Council again discussed the question of giving a supply of electricity in Northfleet, but it was decided by a majority of one to adhere to the former decision not to give such supply.

Grimsby.—An unopposed inquiry was held here last week into the Council's application for sanction to borrow £3,825 for extensions of the electricity undertaking.

Halifax.—As a concession to the working-class passengers, the Tramways committee have adopted a suggestion of the general manager of the tramways (Mr. F. Spencer) that half fares be charged on all 1d. stages before 8 a.m., afterwards the charge to remain as at present, the arrangement to be tried for 12 months.

Mr. Spencer's annual report on the tramways states that the total revenue during the past year was £77,995, and there was a nett loss of £1,677. The income had been seriously affected by the timidity of the public in consequence of the North Bridge accident and the strike of employés.

Hammersmith.—The Electricity committee have reported on the question of supplying electric current to the Franco-British Exhibition at Wood-lane.

The estimated maximum amount of current required will be 2,400 kw., and to supply the whole of this demand from the Council's own works would involve a heavy outlay (£27,770) for additional generating plant and extra mains. The committee did not think the Council would be justified in incurring this expenditure in view of the temporary character of the supply. The Kensington and Notting Hill Electric Lighting Companies had offered to supply the Council with h.t. current in bulk to the extent of 1,300 kw. to 1,400 kw. from May 1 to Oct. 1, the Council to guarantee a minimum quantity of 1,000,000 units. The charge to the Council would be 0·8d. per unit, which would be reduced to 0·75d. for any quantity over 1,000,000 units supplied. The estimated capital outlay in connection with this scheme, which would allow of a maximum supply of 1,200 kw. from the Fulham Palace-road Works, would be as follows: Augmenting two mains and additional feeders £5,577, less estimate of work required to meet ordinary requirements in Shepherd's Bush £920. Cost of mains from bulk station to exhibition grounds £1,000. In addition, there would be cost of providing static transformers for reducing the pressure of the alternating current, and of converters for transforming the alternating current taken from the companies into continuous current, estimated at £3,500, bringing the total estimated capital outlay to £9,157. The estimated working expenses of the Council in connection with the supply for one year, including the purchase of current, is £6,577. The committee think the Council could safely undertake to supply the required current upon the terms following: (1) The exhibition authorities to deposit as security £1,000; (2) the authorities to guarantee a minimum payment of £10,000 for current consumed between May 1 and Oct. 31, the rate of charge to be from sunset to sunrise 2d. per unit, from sunrise to sunset 1d. per unit; (3) current to be delivered in bulk at the boundary of the exhibition grounds, the whole of the distribution to be carried out by the exhibition authorities; (4) the maximum demand to be 1,200 kw. a.c. and 1,200 kw. d.c. The committee anticipate that the total income will be considerably in excess of £10,000, and that the Council will derive a fair profit from the supply.

The Executive committee of the exhibition had agreed to accept these terms, and the committee have, therefore, agreed, subject to the Council's sanction, to supply on the above terms, and to accept the offer of the Kensington and Notting Hill Electric Lighting Companies.

Herne Bay.—Messrs. Foote & Milne and Mr M. Parker notify their intention to apply for a provisional electric lighting order.

Liverpool and District Electrical Association.—The first meeting of the members of this Association was held on the 16th inst.

In the unavoidable absence of Mr. J. E. Lloyd Barnes, the chair was occupied by Mr. J. J. Richardson. The scheme of the association was explained by Mr. S. Frith, the promoter and hon. secretary, supplemented by remarks from the chairman. It was decided that the present committee should continue to carry on the business for three months, when the question would come up for further consideration. On Saturday week the association pay a visit to Formby power station.

London County Council.—On Tuesday the adjourned recommendation of the General Purposes committee was submitted, recommending that the Prime Minister be asked to receive a deputation to urge on the Government the necessity of securing the immediate establishment of a London Traffic Board on the lines indicated in the report of the Royal Commission.

Mr. SANKEY, in moving the adoption of the report, said it was argued that the Council was the proper body to carry out the duties of the proposed Traffic Board, but the fact that they were the owners of the tramways would make them biassed, and he thought the Council would not be a competent body to deal with the subject.

Sir JOHN W. BENN moved an amendment to refer the matter back, and contended that London was gradually emerging from its traffic difficulties. If the Council did its duty there would be no need for any advisory board.

The amendment was defeated by a large majority, and the recommendation adopted.

Tramway Buildings.—The Highways committee were authorised to obtain tenders from selected firms, together with sealed estimates from the Works committee, to be considered concurrently for the erection of (1) the first portion of the central car repair depot; (2) the Tooting tramways sub-station; and (3) the first portion of the Bow tramways car shed.

Surface-Contact System.—The adjourned report of the Highways committee was brought up, recommending the reconstruction of the Aldgate to Bow tramways on the "G.B." surface-contact system, the work to be carried out by Messrs. Dick, Kerr & Co. (Ltd.), and the entering into of an agreement with the "G.B." Surface Contact Co. for the payment of certain royalties.

Mr. GORDON moved the report be referred back, and said before the Council made such an experiment more information should have been supplied regarding running and maintenance expenses of the system. He had obtained figures from Lincoln which showed that the cars there weighed 10½ tons, and they consumed 1¼ units of electricity per car-mile. Their cars in London weighed 13½ tons and they would take 1·6 units of electricity against 1·4 units at present. In Lincoln live studs had been left which was a matter affecting public safety.

Mr. GOODRICH seconded the amendment.

Mr. N. COHEN pointed out that other systems of surface contact were at work in more populous towns than Lincoln and he would like to know that other systems had been properly investigated.

Sir J. W. BENN quoted from the report of the officers who visited the Continent in 1902 on surface-contact systems, in which they pointed out that there were various practical difficulties and dangers in their use. The "G.B." system was not, however, reported upon by the officers.

Mr. MCKINNON WOOD said they had to experiment to the tune of £72,000 because the local authorities objected to the use of the overhead system which was at work in hundreds of places. This was a matter which those associated with him would take no responsibility for.

Mr. WHITAKER THOMPSON said they felt the time had come when some experiment was necessary. Members had protested against the heavy outlay, but the committee felt that London, being a big place, required a substantial experiment, and that London would not be satisfied with an experiment in a hole-and-corner way. They felt that the surface-contact system should be tried under circumstances where there should be no doubt hereafter as to its success. The officers and committee had considered the matter for months, and the officers had examined all the systems at work in England, with the result that they reported that the "G.B." system was the only one they could conscientiously recommend for use in London. The "G.B." system was the only one in which the studs were flush with the road, and another advantage was that they lessened the quantity of metal used in the road. They would also do away with the expense of cleansing the conduits.

The amendment was defeated and the recommendation adopted.

Manchester.—The members of the Electricity committee made their annual inspection on Thursday last of the various works under the supervision of the Street Mains sub-committee.

Councillor ALLISON, who acted as guide, said that in addition to the three electricity generating stations in Stuart-street, Bloom-street and Dickinson-street, there were 20 sub-stations on Corporation premises in the city and in the various out-districts within the area of supply, besides transforming stations on the premises of a number of large consumers. There were over 322 miles of main conductors laid, exclusive of services. The present area of supply was approximately 23 sq. miles, and the total authorised area of supply 44 sq. miles. Extra high-pressure mains had been laid during the year in connection with three-phase supplies to a number of large works, and additional low-pressure feeders had been laid in the city to supply other firms. Distributing mains had been laid to supply the Denton Technical Schools. Traction feeders had been laid in connection with the tramway service to Sale and Altrincham. During the year about 600 new consumers had been connected, making a total of 6,989. The increase in connections of private consumers had been equivalent to 187,000 8 c.p. lamps, making the total to March 1,035,000. The sales of current during the year ended March last were: For tramways over

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24,000,000 units, for lighting over 12,000,000 units, for power over 10,000,000 units, and for public lamps 91,000 units, the total sales exceeding 47,500,000 units for the year. The total was 14,000,000 units in excess of the Liverpool figures, and, with the exception of Glasgow, was treble that of any other municipal electricity undertaking in the kingdom. He (Mr. Allison) claimed that the Electricity committee were efficient allies of that department of the Corporation which was trying to do away with the smoke nuisance.

Dr. A. W. Brightmore held an official inquiry on Tuesday into the application of the Council to borrow £112,850 for extensions of the electricity undertaking.

The deputy town clerk (Mr. T. Hudson) gave particulars of the progress of the electricity department. The loan was needed (he said) partly for new machinery at Dickinson-street, Bloom-street and Stuart-street stations. For these works £5,752 was required. With regard to Dickinson-street and Bloom-street, it was expected that the new plant would effect a saving of about £1,000 a year in the coal bill. For mains £60,498 was required for transforming plant at sub-stations and on consumers' premises £32,000, and for additional plant at distributing stations £14,600. The expenditure was necessary because the business was continually growing. The amount would be exhausted in three years. A new suspense account would be opened, and he undertook, when the expenditure was completed, to render a full statement as to the amounts expended, similar to that which was given in relation to the £72,000 the committee had previously been authorised to borrow. The electricity department had never been a charge upon the rates, and, as far as could be seen from present experience, it never would be. The committee had inserted in their last estimate £10,000 as a grant in aid of the rates. The terms of repayment proposed were for generating stations and mains 25 years, and for new plant at sub-stations or consumers' premises and additional plant at Corporation distributing stations 20 years.

The chairman of the Electricity committee (Councillor Howarth) also spoke in support of the application.

Mr. S. L. Pearce, chief electrical engineer, gave technical details of the work proposed to be done.

There was no opposition, and the application was supported by the Property Owners' and Traders' Associations.

Maryport.—Messrs. Foote & Milne intend to apply for a provisional electric lighting order.

Marlborough.—The Board of Trade have informed the Council that they intend to revoke the electric lighting order (1905) owing to the promoters having failed to make the necessary deposit.

Oxford.—The City Council have decided to accept the guarantee of Martin's Bank in £50,000 for the purchase of the old tramways.

Provisional Orders Revocation.—The Board of Trade have revoked the Ilkley Electric Lighting Order, 1901, as from July 16, and the Henley on-Thames Electric Lighting Order, 1906, as from July 18.

Provisional Order Transfers.—Tyldesley with Shakerley District Council give notice of intention to transfer their powers under their 1902 Electric Lighting Order to the Lancashire Electric Power Co., the pecuniary consideration being £480.

Little Hulton intend to transfer their powers under the 1905 Order to the same company. The consideration is £160.

Little Lever Council have given similar notice with regard to their 1905 Order and Kearsley Council with regard to their 1907 Order. The monetary considerations are £177 and £337 respectively. In all the above cases the Councils have power to repurchase at the end of the first seven or any subsequent seven years.

Rawtenstall.—The Council have applied for sanction to borrow £29,000 for electricity supply.

Messrs. Lacey, Sillar and Leigh have been instructed to prepare the necessary plans and estimates. It has also been decided to make an offer to the Rossendale Valley Tramways Co. for their undertaking, which is to be converted to electric traction by the Council. The proposal of Bacup Corporation that Bacup, Rawtenstall and Haslingden should combine in purchasing electricity in bulk from a private company has been rejected.

Sevenoaks.—The Mutual Electricity Supply Co. intend to apply for a provisional order.

Sheffield.—A special committee has been appointed to investigate the financial position of the electricity undertaking, with power to take all necessary steps to obtain advice and assistance in order to ascertain the position of the undertaking, financially and commercially.

The committee comprise the Lord Mayor (Ald. Styring), Sir J. Jonas, Sir Wm. Clegg, Ald. Franklin, Ald. Hughes, Councillors Neal, Kelley, Baker and Henderson.

Stepney (London).—A special meeting of the Council was held on Wednesday to further consider the question of the future extension of the electricity undertaking.

The Electricity committee reported that complication and differences of opinion had arisen owing to the reports presented by the Finance and General Purposes committees. They recommend the Council to rescind the several resolutions already passed and reconsider the whole matter. This was agreed to unanimously.

Councillor Gordon then moved "That the Council do forthwith proceed with the development of the Blyths Wharf scheme, the Electricity committee to prepare plans and specifications for submission to the Council." He said it was essential that they should enlarge their undertaking. For the past three years they had been in negotiation with all the companies who were prepared to supply them with current in bulk, but the terms offered were too high. The Council's officers would prepare the plans and no expert would be employed. The resolution was carried by 31 votes to 1.

Stoke Newington (London).—The Borough Council has received a cheque for £641 from the North Metropolitan Electric Power Supply Co. on account of deficit on the electricity undertaking.

Technical Libraries.—At the meeting of the board of directors of the Manchester Chamber of Commerce on Wednesday the following resolution was put forward on behalf of the chemical and engineering sections of the Chamber, and was adopted:—

"That representations be forthwith made to the Libraries committee of Manchester Corporation urging the committee to provide technical literature and—in addition to British and American patents—copies of foreign patents for the use of those engaged in the industries of this district, as such persons have not the means of obtaining otherwise the up-to-date information which is required."

The Board further appointed a committee, consisting of the officers of the chemical and engineering sections, to which was added Dr. Hutton, of the Victoria University, with authority to wait upon Mr. H. Plummer, chairman of the Manchester Free Libraries committee, to urge upon him the desirability of the plan suggested in the resolution.

Tewkesbury.—The Council have applied for an extension of their electric lighting order, with a view to its transfer to a company.

Messrs. Foote & Milne notify their intention to apply for a fresh order.

West Ham.—An order has been given for the delivery of the second turbo-generator, which had previously been ordered for July, 1908, and a bonus of £270 is to be paid for delivery in four months.

The borough electrical engineer (Mr. A. H. Seabrook) has reported that the maximum load is now 1,000 kw. above that of the same period last year, and is still increasing at a rapid rate. There was 600 kw. to go on before Christmas, and not sufficient spare plant in the event of a stoppage of the present turbo-generator to carry the load without serious risk of interruption of supply.

Willesden.—The electrical engineer (Mr. J. G. Bruce) has reported on the subject of additional means of supplying electricity to the Cricklewood and Willesden Green districts.

The requirements of the moment, he suggests, might be met by running a second feeder similar to the first, at a cost of £5,500, but as an alternative Mr. Bruce recommends the laying of high-tension feeders continuing with a smaller cable. The laying of the cables in this case would cost £4,800, whilst other plant would cost £400, total £5,200. The further cost of laying a feeder to meet certain special demands would be £350, and the plant would cost £300. The total cost, therefore, of relieving the existing feeder and bringing the Council into a position to supply the northern portion of the area would be £5,850.

Both schemes were submitted to Mr. E. T. Ruthven-Murray, who reported in favour of the scheme for the extension of the supply area in the northern portion of the district, and the Electric Lighting committee have, accordingly, decided to apply to the Board of Trade to sanction it.

There are 1,787 consumers, representing the equivalent of 86,749 8 c.p. lamps, connected to the mains.

Wolverhampton.—An inquiry was held on Tuesday into the application of the Council to borrow £35,000 for extensions of the electricity undertaking.

The town clerk (Mr. H. Brevitt) said the money was wanted to extend the generating station, including four new boilers and four generating sets, and to extend the mains. Recently an important contract to supply Messrs. Bayliss, Jones & Bayliss with energy had been entered into, and that would involve an expenditure of £16,000 for generating plant. In addition, they would have to cope with the general demand for electricity and the growth of the undertaking. Current would be transmitted to the works of Messrs. Bayliss, Jones & Bayliss, where it would be transformed.

Workhouse Lighting.—Chelmsford Guardians have appointed a committee to consider the advisability of adopting electric lighting at the workhouse.

Walsall Guardians have decided to ascertain the cost of wiring their workhouse.

York.—Last week the Tramways committee reported to the City Council on the question of the conversion of the local tramways to electric traction.

Certain routes were selected for conversion, and the committee's estimates of cost were based on their suggestions being adopted. It was recommended that a double track be laid on all the routes (comprising a total length of 5 miles 5 furlongs) with the exception of about 250 yds. The cost of equipping the lines on the overhead system was estimated to be £110,917, and on a surface contact system £119,959.

The adoption of the committee's report was moved and seconded, but the City sheriff (Councillor Meyer) moved an amendment that the report be referred back, with instructions to ascertain from the Light Railway Commissioners whether a clause could be inserted in an order for the construction of electric tramways in the city to the effect that the Corporation should not work tramways themselves without taking a poll of the citizens, and that they should be authorised to take such poll. This was adopted

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Outings.—On Saturday, July 13, the annual outing took place at Blackpool of the employés of Mountain & Gibson (Ltd.), Elton Fold Works, Bury (Lancs.).

The dinner (kindly provided by the directors) was partaken of at the Winter Gardens, in the Victoria Hall, where 215 sat down to a very enjoyable meal.

After dinner, Mr. WILKS, general foreman, proposed a vote of thanks to the directors, and this was seconded by Mr. STEAD, chief draughtsman.

Mr. MOUNTAIN (managing director and secretary), replying on behalf of the directors, met with a hearty reception, and said he was very pleased to meet so many of the men, as it showed good feeling between the employers and employes, and he hoped by next year they would increase in numbers, as they had done in the past year, there being nearly double the number present on this occasion.

Mr. GIBSON also received a hearty reception, and said he was pleased to meet all the men, as the firm was increasing so rapidly. He wanted them to feel they were sharing in the prosperity of the firm, as they (the directors) could not do without them. He was glad to say, as most of them knew, they had a lot of orders in hand; there was still more to come, and he hoped there would be double the number of employes present at next year's dinner, as there was every prospect there would be.

Mr. MOUNTAIN proposed a vote of thanks to the committee for the excellent arrangements in connection with the outing. This was seconded by Mr. HAMILTON (works manager).

Mr. TATTERSALL, cashier of the firm and hon. sec. to the Outing Committee, briefly responded.

In spite of the vagaries of the weather a very pleasant day was spent.

The first annual outing of the West Ham Corporation electricity department took place on Saturday to Stanstead Abbotts, in four four-horsed brakes, the party numbering 104, all employed in the various grades of the department.

Mr. A. H. Seabrook (engineer and manager) and Mr. Ald. Littler, chairman of the Electric Lighting and Tramways committee, were of the party, as were Messrs. W. Davis, J. Halsey, J. Storey and W. J. Woodward, members of the West Ham Electrical Contractors' Association. After a brief stay at Woodford, where the company was photographed, Stanstead Abbotts was reached and dinner was served. The speeches were short and to the point, and were made by Ald. Littler, Mr. Seabrook and Mr. Woodward. The weather was delightful, and a very successful outing resulted. It is hoped to make the outing a regular annual fixture.

The annual outing of the staff of the Harrow Electric Light Co. (to Streatley, Berks.) took place on the 17th inst. After lunch the party engaged in sports, and a cricket match was played between the works staff and the office staff, the latter winning by 29 runs.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Broughty Ferry.—The accounts of the electricity department for the past year were approved by the Council last week.

The convener of the Electricity committee (ex-Bailie Lindsay) said they began the year with a debit balance of £73. 5s. 6d., and ended with a credit balance of £53. 16s. 3d. The units generated had increased by 26,000; the revenue by £244. The cost per unit was 1½d., against 2·09d.

Coventry.—The accounts of the electricity department for the year ended March show a profit of £5,114. 14s. 1d., of which £1,000 has been voted to the relief of rates and the balance placed to reserve. A feature of the past year has been the increased demand for electrical energy for power.

Ealing.—The annual report of the borough electrical engineer (Mr. J. D. Knight) states that the price of current was reduced during the year, the average being 0·17d. per unit less than last year.

1,487,221 units were sold, against 1,378,334 last year. The year's income was £1,187 more than in 1905-6, amounting to £26,056. The collections from slot meters increased by £300, and meter rents increased by £100. £5,940 has been provided out of revenue for repayment of capital and £5,528 for interest. After paying all expenses the gross profit was £13,403. 9s. 7d., but after deducting interest and sinking fund the net profit was £1,768. 5s. 1d. The reserve fund amounts to £5,026. The total cost per unit sold was 3·87d., or, excluding interest and sinking fund, 1·993d. 370 new consumers were obtained, bringing the total to 3,271.

Gravesend.—The total expenditure on electricity supply to March 31 was £63,726, an increase of £3,387 on the year.

The total income was £8,986. Expenses were £4,769, leaving £4,029 to be carried to nett revenue account. Interest came to £2,049, instalments of principal and money borrowed £1,745 and payments to reserve £786, leaving £244. 15s. 6d.

Mansfield.—For the past year there was a gross profit of £3,867. 19s. 1d. on the electricity undertaking, against £2,249. 12s. 10d. in 1905-6.

After paying interest (£2,166. 2s. 5d.) and sinking fund (£1,180. 2s. 7d.) there was a nett profit of £521. 14s. 1d., of which £300 has been voted to relief of rates. There are 350 consumers, representing the equivalent of 20,517 8 c.p. lamps connected, increases of 68 consumers and 4,293 8 c.p. over last year. There are 57 motors of 200 H.P. connected. 919,551 units were sold, including 505,638 units to the tramways department, and 413,913 for private lighting, power, &c.

Motherwell.—During the past year 50 new consumers (representing 13,478 8 c.p.) were connected to the electric lighting mains, against 98 consumers and 15,572 8 c.p. in 1905-6. The total connections are equal to 74,464 8 c.p.

The units sold were 1,527,299, compared with 1,168,038, an increase of 359,261 units. (30 per cent.). The total works' cost amounted to £4,380. 14s. 9d. (0·68d. per unit), compared with £3,557. 16s. 5d. (0·73d. per unit)) for an output of 1,168,038 units. The total revenue expenditure was £4,813. 4s. 1d., compared with £3,937. 19s. 3d., an increase of £875. 4s. 10d. The total income was £10,138. 15s. 1d., compared with £9,264. 14s. 3d., an increase of £874. 0s. 10d., although the charges for lighting and power were reduced last year by 15 per cent. and 33⅓ per cent. respectively. After deducting expenditure, the gross profit was £5,325. 11s. Interest amounted to £2,295. 14s. 6d.; sinking fund to £2,300, leaving a net profit of £729. 16s. 6d.

The accounts have been passed and it has been agreed to clear off expenditure on free wiring amounting to £411. 4s. 4d. out of profit, and to carry the balance to reserve.

Oldham.—The accounts of the electricity department for the year ended March show a total capital expenditure of £281,079. 8s. 8d., an increase of £4,916. 0. 11d. on the year.

The gross revenue was £35,896. 9s. 6d. and the expenses £18,212. 6s. 9d., leaving £17,684. 2s. 9d. to meet interest, sinking fund, &c. The net profit was £1,459. 11s., and after deducting the deficit from 1906 there was a balance of £91. 12s. 2d. to be carried forward. The units sold (exclusive of traction) were 1,127,916, compared with 1,044,480, an increase of 83,436 (7·99 per cent.), the revenue being £13,902. 1s. 11d., against £13,185. 14s. 5d., an increase of £716. 7s. 6d. (5·43 per cent.). The units sold for traction were 3,453,038, compared with 3,089,135 last year, an increase of 363,903 (11·78 per cent.), the revenue being £21,581. 9s. 7d., against £19,307. 1s. 7d. last year, an increase of £2,274. 8s. (11·78 per cent.) The equivalent of 93,659 8 c.p. lamps is connected (an increase of 15,534 8 c.p.), the consumers being 858 (an increase of 81). The maximum demand (exclusive of traction) was 1,128 kw., and for traction 1,620 kw. The works costs were 0·708d. per unit (against 0.742d.) and the total costs were 0·949d. (against 0·985d.) per unit.

St. Anne's-on-the-Sea.—The annual accounts of the electricity department show that £43,355 has been borrowed and the capital expenditure is £42,058, an increase of £1,623, during the past year.

Revenue was £9,304 and expenditure £4,770, leaving gross profit £4,534. 0s. 9d., compared with £3,853 in 1905-6. After paying £1,436 for sinking fund and £1,358 for interest there was a net profit of £1,765. 13s. 6d., out of which £700 was voted in relief of rates, and £1,015 has been placed to reserve; 820,883 units were generated, 82,601 supplied to public lamps, 419,196 by contract and 215,802 to private consumers by meter. Arcs, Nernsts and incandescents, equivalent to 1,578 8 c.p. lamps, are in use for public lighting. There are 534 private consumers. The maximum supply demanded was 302 kw. for traction and 260 kw. for lighting.

West Ham.—In the annual report of the tramways department the manager (Mr. H. E. Blain) states that the net profit for the past year was £21,712. 5s. 2d, against £18,680. 10s 7d. for the previous year.

£7,722. 8s. 10d. has been carried to reserve and renewal funds, £9,668 (equal to 2d. in the £) has been voted in aid of rates, and the balance (£4,321. 16s. 4d.) carried forward. Capital expenditure is £501,885, and during the three years' existence of the undertaking the total receipts have been £288,002; gross profit £114,581, and net profit £50,485, of which £24,668 has been voted to relief of rates. Last year working expenses amounted to £72,418 (6·79d. per car-mile run) and the gross profit was £50,463 for the year. Contributions for interest and sinking fund were £28,750 (2·69d. per car-mile run), making the total expenditure per car-mile run 9·48d., against 9·70d. in the previous year. The total length of route open on March 31 was 14 miles 1,595 yds.; the passengers carried during the year were 35,502,836, and the car-mileage run 2,556,854, against 29,364,077 and 2,094,514 respectively in the previous year. The gross receipts for the year (including £3,106 for rentals) amounted to £122,881. The total electric energy used was 3,797,337 units, or 1·48 per car-mile.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Portsmouth Council invite tenders for supply, delivery and erection of one h.t. switchboard, and of steam, exhaust, circulating water and sundry other pipework. Specifications, &c., after 30th inst., at the Town Hall, Portsmouth. Copies of specification may also be inspected, but not obtained, at the offices of the consulting engineers (Messrs. Kincaid, Waller, Manville & Dawson), 29, Great George-street, Westminster, S.W. Tenders to the town clerk (Mr. Alexander Hellard), Town Hall, Portsmouth, by noon Aug. 14. See an advertisement.

Portsmouth Tramways committee invite alternative tenders for periods of 6 or 12 months for the supply of best large smokeless Welsh steam coal for their power station. Tenders to the Town Clerk, Town Hall, Portsmouth, by noon Aug. 5.

Barnes District Council invite tenders for two sets of mechanical stokers (for Babcock boilers) and feeder and distributor cables. Specifications, &c., from the electrical engineer, Mr. C. S. Davidson. Tenders, addressed to the clerk, Council House, High-street, Mortlake, by noon Monday, Aug. 12. See also an advertisement.

Grimsby Corporation invite tenders for supply, delivery and erection of one 500 kw. continuous-current dynamo direct coupled to a triple-expansion three crank high-speed double-acting engine. Speci-

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NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

fication, &c., may be obtained from the borough electrical engineer, Mr. W. A. Vignoles, Corporation electricity works, Grimsby, to whom tenders by first post Monday, Aug. 19. See also an advertisement.

Hull Electric Lighting committee invite tenders for ejector-type condenser, pump and pipework in connection with a 500 kw. high-speed engine at their Sculcoates-lane generating station. Forms of tender, &c., from the city treasurer, Mr. T. G. Milner. Tenders to the Chairman of the committee, Town Hall, Hull, before noon August 2. See also an advertisement.

Dublin Lighting committee invite proposals for the supply of motors to their consumers on the hire-purchase system. Conditions, &c., from the Secretary of the Lighting committee, 3, Cork-hill, Dublin. See an advertisement.

Tenders are invited for the lighting by gas, oil, electricity or other illuminant of the street, thoroughfares, &c., of the city of *Calcutta*. The city comprises approximately an area of 20 square miles, containing about 170 miles of main thoroughfares and 130 miles of smaller streets, besides several squares, markets, latrines, slaughter houses, &c., which are now lighted by gas and oil lamps. The new contract is timed to commence on May 1, 1911, and the successful tenderer will be required to have all arrangements completed and ready to begin and continue the lighting with effect from that date. Tenders should be for 10, 15 or 20 years. Further particulars are given in an advertisement, and tenders will be received by the Vice-Chairman of the Corporation up to 3 p.m. Jan. 2, 1908. See also an advertisement.

Tenders will be received by the *Postmaster-General* until noon Sept. 2 for supply of Swedish, Norwegian, Finland or Russian fir telegraph poles, to be delivered at one or more of the ports set out in an advertisement elsewhere. The poles to be felled during the winter of 1907-8 and to be delivered during the following summer. Forms of tender from the controller (Mr. S. C. Hooley), G.P.O., 17-19, Bedford-street, London, W.C.

The officer in charge of the Australian Commonwealth offices in London (Capt. R. Muirhead Collins, C.M.G.) will supply forms of tender, specifications, &c., relating to the following contracts:—Common battery switchboard and 3,000 subscribers' telephones for the Postmaster-General's Department, *Adelaide* (tenders by Jan. 8). Lead-covered paper-insulated telephone cable for the Postmaster-General's Department, *Brisbane* (tenders Sept. 9). Telegraph and telephone instruments, stores and material for the Postmaster-General's Department, *Brisbane* (tenders Sept. 9).

The time for receipt of tenders for the supply to the Postmaster-General's Department in *Western Australia* of a desiccating apparatus with motor-driven air pump for telephone cable work has been extended to noon, September 16.

Tenders are invited for supply of electric equipment for the Government power station at *Trollhattan* (Sweden), comprising three d.c. generators (each of 350 kw.), a storage battery of 4,800 ampere-hours capacity, four three-phase generators (each of a maximum of 11,000 k.v.a.), 12 transmitters (each of a maximum of 3,670 k.v.a.), connections, regulators and control tables. Tenders marked "Anbud a elektrisk utrustning for Statens kraftverk" to the Managing Director of the Royal Trollhattan Canal and Water-works, Trollhattan, Sweden, by noon Oct. 1. Delivery is to be completed by Sept. 1, 1909. Copy of the specification on deposit of 50 kronor.

Antwerp Municipality want tenders by Aug. 13 for the installation of electric lighting for the new North Dock at Antwerp. Tenders to the Bourgmestre, Hotel de Ville, Antwerp. Deposit of 7,000fr. (about £280) will be required to qualify tenders. Specifications can be obtained from the Hotel de Ville, Antwerp, at 0·50fr. each, and copies may be inspected at the Board of Trade, 73, Basinghall-street, London, E.C.

Tenders are wanted by Aug. 7 for supply of 1,300 tons of iron masts for power transmission to Sydsvenska Kraftaktiebolaget at *Malmo* (Sweden). Drawings, &c., may be obtained from the Sydsvenska Kraftaktiebolaget, Malmö, and copies may be inspected at the Board of Trade, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

On Tuesday London County Council adopted the recommendation of the Highways committee to accept the tender of Willans & Robinson for turbo-generators (including spare parts) for the Greenwich generating station at £43,195. The full list of tenders appeared in our last issue.

London County Council have accepted the tender of Higginbottom & Mannock for supply and delivery of two travelling cranes for the central car-repair depot at £1,208. The tender of Buck & Hickman for the supply of machine tools for the depot at £1,737. 18s. has also been accepted.

London County Council have accepted the tender of Johnson & Phillips for supply and erection of complete h.t. and l.t. switchgear equipment for eight tramway sub-stations, together with all cable for connecting machines.

For the supply of feeder pillars to London County Council the following tenders were received:—

British Insulated & Helsby Cables (*acc.*)	£1,896	3	0	Tramway Supplies (Ltd.)	£2,424	8	0
General Electric Co.	3,827	15	0	Universal Electrical Mfg. Co.	2,420	0	6
Kelvin & James White	3,290	13	8	Callender's Co.	2,355	13	0
Wenham & Waters	2,677	17	6	R. W. Blackwell & Co.	2,304	10	1
Western Electric Co.	2,569	6	6	W. T. Henley's Co.	2,304	2	9
Johnson & Phillips	2,535	1	3	Dick, Kerr & Co.	2,244	19	5
Brush Co.	2,521	4	0	J. E. Spagnoletti & Co.	2,178	15	0
Cox-Walkers (Ltd.)	2,470	9	0	T. L. Scott & Co.	2,154	17	6
Estler Bros.	2,444	13	0				

The British Insulated & Helsby cables are allowed to sublet to the undermentioned firms the following portions of the work: (i.) To Stirling Telephone Co., the telephones; (ii.) to Falkirk Iron Co., certain cast-iron work.

In connection with the proposal to reconstruct the Aldgate to Bow tramways on the "G.B." surface-contact system (dealt with in another column) the London County Council have agreed to extend the contracts with the Western Electric Co. and J. A. Ewart for supply of low-tension cables and the laying of cable ducts respectively, the sums involved being £9,000 for the cables and £4,000 for the ducts. It has also been resolved to accept the offer of the "G.B." Surface Contact Co. to fit 48 cars with surface-contact equipments at £70 per car. The contract with Bolckow, Vaughan & Co. has been extended so as to include 950 tons of track rails at an estimated expenditure of £8,466.

For the overhead electrical equipment of tramways in Woolwich and Plumstead the London County Council have received the following tenders:

Dick, Kerr & Co. (*accepted*)	£2,323	4	2	British Insulated & Helsby Cables	£2,652	16	9
Sydney G. Smith	2,962	0	11	R. W. Blackwell & Co.	2,413	19	3
Fry Bros.	2,811	18	6	Brush Co.	2,389	0	6

Messrs. Dick, Kerr & Co. have been authorised to sublet to the undermentioned firms the following portions of the work: (i.) Brecknell, Munro & Rogers, ears and hangers; (ii.) F. Smith & Co., trolley and other wire; (iii.) John Spencer (Ltd.), poles; (iv.) H. W. Johns Manville Co., insulators; (v.) B. C. Barton & Son, pole straps.

Handsworth Council have accepted the tender of Johnson & Phillips for supply and laying of tramway feeders and pilot-cable troughs, &c.

Eastbourne Corporation received the following tenders for extension of plant:—

Water-tube Boiler and Pipework.

Babcock & Wilcox	£2,030*	Clarke, Chapman & Co. (Woodeson's)	£2,152
J. Musgrave & Sons (Woodeson's)	2,412	Stirling Boiler Co.	2,054
Davies Patent Boiler (Ltd.)	2,290	B. R. Rowland & Co.	1,996

For extension to h.t. switchboard, Ferranti Limited tendered at £148. 4s. and Cowans Limited at £122. 10s. and £106. 10s. (not erected).*

Spray Cooling Plant.

J. H. Harrison	£257*	Korting Bros.	£250

* Recommended for acceptance.

Fleetwood Electric Light & Power Synd. have placed an order with Johnson & Phillips for cables.

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The Admiralty have placed an order with Johnson & Phillips for cables, conduits, troughs, boxes, glow-lamp pillars, &c., for H.M. coaling depot, Portland.

Chelsea Town Hall Extension committee received tenders from six firms for electric light fittings for the portion of the new buildings approaching completion. The designs accompanying the tender of Wright Bros. & Co. have been accepted, the prices being as follows: 37 two-light adjustable pendants (for offices) not exceeding 25s. each, 33 one-light adjustable pendants (for hall-keeper's rooms and offices) 5s. 10d. each, 15 two-light pendants (for corridors) 6s. 4d. each, 13 one-light pendants (for lavatories) 3s. 8d. each, 1 three-light electrolier (for Mayor's room) £2. 7s. 6d., 1 three-light pendant (for corridor) 6s. 9d.

The order for 61 disconnecting feeder pillars, ranging from 250 to 1,000 amperes capacity, has been placed with the Universal Electrical Mfg. Co. by Ealing Council. The pillars are constructed in accordance with the specification of the borough electrical engineer, Mr. J. Douglas Knight.

For the supply of special track work for the Woolwich and Plumstead tramways the tender of the Hadfield's Steel Foundry Co. (at £967. 5s.) has been accepted by London County Council. The other tenderers were Edgar Allen & Co. (£1,064. 5s.) and F. H. Lloyd & Co. (£1,295).

Lanark County Council have placed an order with Johnson & Phillips for supply and erection of motor-generator, booster, switchboard and machine, and also battery cables for Cambuslang.

Bury (Lancs.) Council have accepted the following tenders:—
Thos. Cass & Co., coking stoker for boilers; Switch Gear Co., switchboard extension; Davidson & Co., motor and fans for Wylde lavatories; and T. Cornall & Co., for wiring lavatories.

Hammersmith (London) Council have accepted the tender of the Phœnix Dynamo Mfg. Co. for a motor generator at £132, delivery in seven weeks. There were five tenders.

Out of 14 tenders Hammersmith (London) Council have accepted that of G. Hinchcliffe & Co. for Sgwborwen coal (to mix with 2,000 tons of Crynant coal) at 17s. 10d. per ton for six months.

The electric light department of Hankow have placed an order with Johnson & Phillips for arc lamps.

Bermondsey (London) County Council have accepted the tender of Johnson & Phillips for the supply of cables and boxes.

Bedford Council have placed an order with the British Insulated & Helsby Cables for 12 months' supply of cables.

Ealing Council have accepted the tender of Johnson & Phillips for cables.

Mouchel-Hennebique Ferro-Concrete.—We have received a list of contracts secured during the past month (June) for the execution of works in accordance with the Mouchel-Hennebique system of ferro-concrete. The list comprises bridges, marine work, foundations, flooring, roofs, factory buildings, &c., including the foundation slab for the storage battery at the Parkeston Quay extension (G.E. Rly. Co.) and foundation slabs for steam turbo-generators at the Sutton power-house of the South Metropolitan Electric Tramways & Lighting Co.

BUSINESS NOTICES.

W. F. Dennis & Co., 49, Queen Victoria-street, E.C., have been appointed sole agents in the United Kingdom for Heinrich Remy G.m.b.H., makers of steel magnets of all kinds, of Tiegelstahlwerk, Hagen-i.-Westphalia, Germany.

The Gilbert Arc Lamp Co. (Ltd.) have appointed Mr. H. G. Barrett, 209, Hope-street, Glasgow, to be their agent in Scotland for enclosed and open type arc lamps, flame lamps, raising gear, transformers, &c.

Foster & Co. have appointed Mr. David Alexander, 43, Mains-street, Waterloo-street, Glasgow, to be their sole agent in Scotland for arc lamps.

Mr. C. H. Rosoman has resigned his position with the British Thomson-Houston Co. and has joined the firm of W. F. Jones & Co., Dacre House, Victoria-street, Westminster.

The head offices of the Marconi International Marine Communication Co. (Ltd.) has been removed to Watergate House, York-buildings, Adelphi, London, W.C.

The partnership between Geo. F. D. Campbell, Stanley T. Isherwood and John A. G. Williams (trading as Campbell & Isherwood), electrical engineers, Raleigh street, Bootle, has been dissolved as regards Mr. Isherwood, who retires. Debts by Messrs. Campbell & Williams, who continue under the old style.

Catalogue Specialising.—Mr. H. Clifford Palmer writes us that he has recently resigned his position as advertising manager with the General Electric Co. in order to take an active part in the management of the Clifford Palmer Co., advertising and catalogue specialists, 6 and 7, Creed-lane, London, E.C. Mr. Palmer points out that during his connection with the electrical trade he has made a close and careful study of publicity methods, and is prepared to give his clients the benefit of this experience.

BANKRUPTCIES, LIQUIDATIONS, &c.

A summary of the statement of affairs in the failure of the British Electric Equipment Co. (Ltd.) has been issued showing 158 unsecured creditors estimated to rank for £7,724. 10s 8d.; gross liabilities £25,913. 9s. 10d. The total assets are estimated at £767. 3s, 7d.. A further sum of £1,314. 13s. 1d. is required to meet liability on debentures, making the estimated deficiency, subject to costs of liquidation, £10,342. 13s. 11d. The liability to contributories is £14,107.

The observations of the assistant official receiver are to the effect that the winding-up order was made on April 16 last and the statement of affairs was filed on June 22. The company was registered on Nov. 11, 1904, with a nominal capital of £40,000 in £1 shares, to acquire from Hugh Godfrey Nicholson (who has prepared the above summary of affairs) as a going concern the business carried on at 11, Queen Victoria-street, London, under the title of the British Electric Equipment Co. The board of the company throughout has consisted of Mr. Nicholson, as managing director, at a salary of £1,000 a year, and his brother, Victor Ralph Nicholson. In addition to his £1,000 a year salary as managing director, H. G. Nicholson was entitled to £50 a year as chairman and his brother to £25. The business above mentioned was acquired for a consideration of £15,215. 17s. 1d. payable as to £7,215. 17s. 1d. in cash and as to £8,000 in fully-paid ordinary shares, the company also undertaking to pay the liabilities of the business and a further £250 to H. G. Nicholson for commission earned by him while employed by the former owners of the business. The 8,000 ordinary shares still stand in H. G. Nicholson's name. 100 ordinary shares were allotted to V. R. Nicholson and one each to seven signatories, all paid for in cash. In addition 6,000 shares have been allotted as 5 per cent. cumulative preference shares, and have been paid up in full, bringing the total capital issued to £14,107. The 6,000 preference shares were allotted to John Cleland, the amount of his investment being guaranteed by Mrs. H. G. Nicholson, who charged certain of her property with the payment of the £6,000.

The original business of the British Electric Equipment Co., was, it appears, commenced at the end of 1902, by John Spencer, Sir Ernest Spencer, T. H. Spencer and H. S. Smallman, to whom H. G. Nicholson acted as chief engineer, and up to the time it was taken over by the new company (Nov. 11, 1904) had made a nett loss of £177. 12s. 3d. Work has been carried out by the company in connection with 20 electric tramways contracts. Upon 13 of these a profit varying from £1,779. 15s. 1d. (at Falkirk) to 18s. (at Canvey Island) is shown, and on the others a loss varying from £1,181. 18s. 6d. (at Dover) to 18s. (at Oxford) is shown. The company was financed throughout by Mrs. H. G. Nicholson, and the various charges given to that lady during the progress of the company's working are set out in the statement. It appears that these charges did not require to be registered at the Joint Stock Registry under sec. 14 of the Companies Acts, 1900, and consequently, persons who gave credit to the company could not ascertain the exact position of its affairs by inspection of the official file. Six days before the commencement of the liquidation (on March 20 last) 20 5 per cent. first mortgage debentures of £100 each were issued to Mrs. Nicholson, covering the whole of the company's assets, to secure an advance of £500 (made on March 23, 1907) and previous advances of £1,000 and £500 respectively, made respectively on April 30 and May 2, 1906. On April 9, 1907, Mr. C. F. Burton was appointed receiver and manager on behalf of the debenture holders (Messrs. V. R. Nicholson and G. T. Harley), to whom Mrs. Nicholson had in the meantime transferred the debentures.

After a careful investigation of the facts relating to the charges executed in favour of Mrs. Nicholson and the issue of the debentures, the Official Receiver intimates that he came to the conclusion that some of these charges could be upset and that the debentures in excess of £500 would be held to be invalid. After considerable negotiation an offer has been made on behalf of Mrs. Nicholson to obtain the withdrawal of certain claims and to pay, in settlement of all matters in dispute between the company and H. G. Nicholson and herself, a sum not exceeding £1,000 such as will be sufficient to provide for the costs and a dividend of 2s. in the £ on the claims of the unsecured creditors. The committee of inspection are of opinion that the offer should be accepted. The Official Receiver continues to act as liquidator with a committee of inspection of five creditors.

F. H. Rogers and L. F. Goodricke have been appointed joint liquidators of the Amalgamated Dry Batteries (Ltd.), under a reconstruction scheme, and creditors are requested to forward to Mr. L. F. Goodricke, Moorgate Station-chambers, London, E.C., a statement of their accounts against the company.

A receiving order has been made against Ernest Bohm, electric lamp manufacturer, 5, Boxworth-grove, Barnsley, London, N.

Claims against A. Blackburn and J. Walker (trading as Blackburn, Walker & Co.), electrical and mechanical engineers, Upperlane Mills, Cleckheaton, by Aug. 3 to Mr. W. Durrance, 29, Manorrow, Bradford.

Claims against G. Aaron Benton, electrical engineer, Shareshill, Staffs. (formerly of 8, The Exchange, Muswell-hill, London, N.), by Aug. 3 to Mr. S. W. Page, 30, Lichfield street, Wolverhampton.

On the application of the O.R. and liquidator (Mr. H. de V. Brougham), Mr. E. Marshall and Mr. J. W. B. Unwin (holding powers of attorney from the Union Electric Co. and the General Electric Co. respectively) and Mr. O. Krupka have been appointed a committee of inspection in the winding up of Improved Electric Supplies (Ltd.)

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Wolfram Limited is being wound up voluntarily. Claims by Aug. 17 to Mr. W. Barton, 8, Laurence Pountney-hill, London, E.C.

A meeting will be held on Aug. 26 at District Bank-chambers, Market-street, Bradford, to receive an account of the winding up of Edmondson & Purdom (Ltd.)

A winding-up order has been made in the case of Patent Exploitation (Ltd.), 8a, Lord-street, Liverpool.

Plant for Sale.—A Ferranti compound engine, direct coupled to a Ferranti single-phase alternator, with Parker dynamo exciter are advertised for sale by the Clydesdale Co., 1, Commerce-street, Glasgow.

A large 30 panel h.t. c.c. switchboard, complete with high-class instruments and all rheostats, is advertised for sale in another column.

Business for Sale.—Old-established electrical and general manufacturing works in London are advertised for sale as a going concern.

Improved Nernst Lamps.—The A.E.G. English Mfg. Co. write to say that they have during the past year been collecting statistics relating to the cause of premature failure of Nernst burners, and the results of these inquiries have shown the necessity of improving the heater circuit, which generally failed and in some cases caused breakage of filament.

Unfortunately (continues the letter) we are unable to dispense with the heater circuit, but have arranged that this circuit is perfectly controlled by improving the insulation and design of cut-out coils, which we are fitting free to all Nernst lamps of which we have a record. Since April 1 we have refitted 22,700 Nernst lamps in different parts of the country with these improved coils. Of the old coils returned to us, about 60 per cent. were entirely burnt out, and burners failed in consequence. We regret also that upon inspection of a number of installations of Nernst lamps used for street lighting, &c., we found polarity had not been strictly observed. In fact, the only towns which our expert visited and found every lamp inspected on correct polarity was Northampton, where 192 Nernst lamps are maintained by the company for a fixed charge per annum (80 ¼ amperes, 27 ½ amperes, and 83 1 amperes). The average number of renewals used from June 1, 1906, to May 31, 1907, for the above installation of 192 lamps was 338—only 2¼ burners per lamp per annum. These results are easily obtained if improved cut-outs and suitable burners are used and if polarity is strictly observed.

Electrical engineers and contractors are asked to communicate with the company and return all Nernst bodies, so that the company can fit improved type cut-out coils free of cost. Pamphlets giving full information as to how polarity shows on different type burners will be forwarded by the company on application to 4 and 5, New Compton-street, London, W.

Staple Driver.—Everyone who has attempted to drive small wire staples into corners knows the difficulty of doing so. This work will now be much facilitated by a small device brought out by Mr. T. Schoner, of Leeds. In consists of a staple holder with a central pin. When the holder is held in position the staple is driven home by hammering on the pin. The device is simple, appears to be effective, and is placed on the market at 1s.

Country House Lighting.—A revised edition of "Light in the Country" has been issued by R. J. Nicholson & Co., Macdonald's-lane, Manchester. The pamphlet describes and prices the "ideal" petrol electric set, and is designed to interest the householder himself.

Trade Directories.—There is no subject, we suppose, upon which greater differences of opinion may pardonably exist than that of the merits and demerits of a trade directory. The editor of the "Electrical Contractor," stepping in "where angels fear to tread," assumes he has sufficient experience in this particular branch of literary work to justify his assumption of the role of guide, philosopher and friend. He has recently discussed Electrical Trade Directories, and has told us all about what these books should be (which, of course, they are not). He tells how some remarks he was bold enough to make on the subject lately have involved him in a quite remarkable correspondence, and that not one-tenth of the letters he has received can he find room to publish, which is, of course, a most fortunate circumstance for the incompetent electrical directory compilers. It is notorious that everyone thinks he can "run a paper," and we suppose that, by the same token, compiling a directory is a simple matter. Those, therefore, who for a quarter of a century or more have endeavoured to cater for the electrical industry in the way of directories (and have, by the way, tried to carry on this work without serious loss to themselves) must stand down and marvel at this new Daniel come to judgment. For ourselves, who have had some experience, we would merely remark that all the large funds which doubtless the editor of the "Electrical Contractor" has at his command will be required to produce the "ideal" Big Blue Book which this worthy gentleman has created in his mind's eye. The directorial section of the Big Blue Book (and this doubtless applies to other publications of the kind) has always been, in the main, compiled from the direct instructions of those chiefly concerned in its utility, and we are satisfied that, so far as unsubsidised, non-philanthropic human effort can go, those responsible for the compilation of the Big Blue Book have striven for success, and, we respectfully urge, have deserved it. If those firms to whose absence or presence under certain headings exception is taken would give the same attention to the matter as the editor of the "Electrical Contractor" finds time to give, doubtless a more complete and perhaps more reliable work of reference would result. But this will involve a much more liberal support than has hitherto been given by the majority of those engaged in the electrical industry to such compilations, which, we venture to assure our critic, are wearying, worrying and at the same time costly productions.

We may, perhaps, be allowed to say here that the 1908 edition of the Big Blue Book is in active preparation, and that suggestions for improvements will, as formerly, be very carefully considered.

Tourist Guide to the Continent.—The G.E. Railway Co.'s new illustrated "Tourist Guide," edited by Mr. Percy Lindley, is just out, and to those who propose to spend their holidays on the Continent the booklet will prove a useful companion, as it is of handy pocket size and contains a great deal of information on the choice of routes, scenic attractions and historical notes, &c. There are particulars of new tours, via Holland, in North Germany, including the Harz and Thuringian mountains; in South Germany of the less-known side valleys of the Rhine; in Belgium, via Antwerp, of fresh tours in the Ardennes and among the old Flemish cities. A practical and useful feature of the Guide is the series of Continental maps. Copies can be obtained at 30, Fleet-street, London, E.C., price 6d., or at the company's stations and the bookstalls.

CATALOGUES, &c.

Dick Kerr Crane Motors and Controllers.—In the space of a few lines we cannot do justice to the excellent booklet, just issued by Dick, Kerr & Co., on the above subject. It is the latest addition to the firm's list of standard publications, and its arrangement and style are both neat and attractive. There are two distinct sections, devoted respectively to crane motors and crane controllers. The feature of the former is the overload capacity and the special shaft type of magnetic brake. The controllers are of the drum type, and are fitted with the now well-known metallic shield blow-out, the efficiency of which has been abundantly proved in practice. The controller section is completed by a number of useful diagrams of crane motor and controller connections.

Union Arc Lamps.—List No. C.C.1 is being issued by the Union Electric Co., Park-street, Southwark, London, S.E., and gives illustrations of Union arc lamps and prices and particulars of arc lamp carbons.

Electric Pulley Blocks.—The application of the small motor to hoisting apparatus has resulted in the standardisation of types of electric pulley blocks. S. H. Heywood, of Reddish, Stockport, is sending out a useful booklet, which describes and illustrates his standard range of pulley blocks, which are made in sizes from 10 cwt. to 5 tons lift.

Electric Capstans.—We have received from Appleby's Limited an illustrated pamphlet on electric capstans. These capstans are made in two main types—the standard box capstan and the turn-over capstan. In the former the capstan, body, motor and gearing are fixed to the underside of the cover plate and are enclosed in cast-iron machined water-tight case. The top-plate is fitted with hand holes and inspection covers to admit of easy examination of the working parts. In the latter type the case is semicircular in section and the cover-plate, which, as before, carries the machinery, is fitted with a spindle allowing the whole to be rotated through 180 deg., thus bringing the motor to the top for inspection purposes. This firm also manufacture a large number of different types of hand power jib cranes made either fixed or portable and comprising designs suitable for railway, dock and shop work.

Portable Tools.—A range of light portable electric tools is dealt with in a publication just to hand from S. Wolf & Co., Southwark-street, London, S.E. The motors for these machines are built for all standard circuits and voltages, and are either coupled direct or geared to the particular tools. Grinding and polishing machines figure among the types described in the list.

Steel and Iron.—The Consett Iron Co. are issuing a neat booklet giving particulars of its manufactures. The booklet has a good index and is punched for hanging.

Vulcanised Fibre—Messrs. J. Burns (Ltd.), of 189, Central-street, London, E.C., are issuing a sheet dealing with "Delaware" vulcanised fibre for motor-car parts, including gear wheels, various insulating parts, clamps and tubes for holding and carrying ignition wires, covers for magnetos, contact rings and covers, terminals, handles and switch covers, &c., &c.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone

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wire and materials, but not including electrical machinery, which is not separately specified) from July 17 to 23, with the ports of destination :—

Aden, £33 (including £20 telegraph material). *Africa*—Alexandria, £195; Cape Town, £84; Durban, £1,845 (including £30 telegraph material); East London, £96 (including £32 telegraph material); Port Elizabeth, £178; Port Said, £25. *Argentina*—Buenos Ayres, £2,322 (including £408 telegraph material); Rosario, £69. *Australasia*—Adelaide, £102; Blenheim, £115; Brisbane, £493; Fremantle, £200; Otago, £149; Sydney, £560; Wellington, £4,536. *Belgium*—Ostend, £58. *Brazil*—Rio Janeiro, £3,866 (including £3,736 telegraph material); Santos, £140 (telegraph material). *Canada*—Montreal, £25; Toronto, £2,225. *Ceylon*—Colombo, £53. *China*—Shanghai, £344. *Denmark*—Copenhagen, £21. *Germany*—Bremen, £134; Dusseldorf, £40; Hamburg, £192. *Holland*—Amsterdam, £79; Flushing, £42; Rotterdam, £72. *India*—Bombay, £729; Calcutta, £1,214; Madras, £31 *Italy*—Naples, £220. *Japan*—Kobe, £888; Moji, £84; Nagasaki, £382; Yokohama, £1,209. *North Atlantic*, £35,000 (telegraph material). *Portugal*—Lisbon, £3,704. *Russia*—Kureh, £88. *Straits Settlements*—Singapore, £636. *Sweden*—Gothenburg, £20. *West Indies*—St. Lucia, £9. Total £63,007, against £28,857 in the corresponding week last year (July 18 to 24).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

April 29, 1907.

9,865 ELECTRIC IGNITION Co. & HALL. Tremblers of induction coils.
9,866 LOUKS & NEWMAN. Speed-regulating devices for electric motor starters.
9,868 ELECTRIC & ORDNANCE ACCESSORIES Co. & HALL. Circuit breakers.
9,874 HOLT. Electric travelling pulley blocks or hoists.
9,892 LUXTON. Electric indicator.
9,913 HAWKINS. Devices for recording readings of meters.*
9,921 HOWELL. Electric water heaters. (Date applied for, 7/5/06.)
9,923 ROBERTS. Electrical impulse counting switches.*
9,950 MAVOR and MAVOR & COULSON. Control of alternating current generators and motors.
9,962 B.T.-H. Co. (G.E. Co., U.S.) Electrically operated signals.
9,963 B.T.-H. Co. (G.E. Co., U.S.) Electrically operated signals.

April 30, 1907.

9,991 ELLIOTT. Multiple sockets for incandescent lamps. (Date applied for, 18/5/06.)*†
10,007 SIEMENS BROS. DYNAMO WORKS & POYNDER. Means for altering working speed of polyphase motors.*
10,010 GALLOIS. Arc lamps. (Date applied for, 2/5/1905)*†
10,071 B.T.-H. Co. (G.E. Co., U.S.) Supports for filaments for incandescent lamps.
10,072 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control systems.
10,077 SMISSEN. Incandescent lamps for liquid hydrocarbons.*
15,154A/05 FERRANTI. Turbines. (Date applied for 3/7/06.)†

May 1, 1907.

10,091 SUTCLIFFE. Telegraphic apparatus.
10,115 BLAKE. Devices for closing or covering the slots or openings of the conduits of electric tramways.
10,119 NEWBERY & BRITISH PROMETHEUS Co. Controlling electric cooking and heating apparatus.*
10,120 HOLDEN. Time limit electric fusible cut-out.
10,126 THOMAS. Systems of electrical distribution by vapour electric apparatus. (Date applied for, 5/5/06.)*†
10,136 UNTERBERG & HELMLE. Magneto-electric ignition apparatus. (Date applied for, 11/8/06.)*†
10,142 HOBEL. Dynamo-electric coupling.*
10,152 SIEMENS & HALSKE A.-G. Conversation counters in telephone exchanges. (Date applied for, 3/5/06.)*†
10,161 LEITNER. Electric heaters.
10,169 MCNEIL. Electric fire alarms and thermo-indicators.
10,171 ALLGEMEINE ELEKTRICITÄTS-GES. Controlling devices for electric-winding engines. (Date applied for, 2/5/06.)*†
10,172 B.T.-H. Co. (G.E. Co., U.S.) Electric signalling systems.

May 2, 1907.

10,227 DALÉN. Turbines. Date applied for, 2/5/06.)*†
10,230 STEINER. Refining tin electrolytically. (Date applied for, 1/2/07.)*†
10,259 LE TALL. (Hewitt, U.S.) Wireless telegraphy.
10,261 WARWICK MACHINERY Co. (G.E. Co., U.S.) Bearings for vertical shaft machines.

May 3, 1907.

10,270 DOUGAN & BIBBY. Ships' telegraphs and the like.
10,293 COLLINS, HAYES and WATSON. Trolley heads of electric tramcars.
10,306 MURRAY & JACKSON. Telephone systems.*
10,328 GILLET. Determining the position of an object detected by Röntgen rays. (Date applied for, 4/5/06.)*†
10,356 SCHMIDT. Electrical commutator machines. (Date applied for, 3/5/06.)*†
10,360 WILDE. Electric jacquard loom.
10,367 COWPER-COLES. Electro-deposition of iron.
10,369 ATELIERS THOMSON-HOUSTON (ANCIENS ETABLISSEMENTS POSTEL VINAY). Dynamo electric machines. (Date applied for, 10/5/06.)*†

May 4, 1907.

10,391 STEEL & HATTERSLEY. Electro-magnetic coupling, driving and speed varying device.
10,406 W. T. HENLEY'S TELEGRAPH WORKS Co. & NICHOLS. Junction boxes for cables.
10,431 BIRNBAUM & WHITE. Single line intercommunication telephone systems.*
10,440 BROWNE. Microphones for telephones.*
10,450 B.T.-H. Co. (G.E. Co., U.S.) Electric resistances.
10,451 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control and apparatus.
10,452 ALLGEMEINE ELEKTRICITÄTS-GES. Systems of electric traction. (Date applied for, 4/5/06.)*

COMPANIES' MEETINGS AND REPORTS.

National Telephone Co. (Ltd.)

The fortieth ordinary general meeting of this company was held on Tuesday, at Hamilton House, Victoria Embankment, E.C., Mr. GEORGE FRANKLIN presiding.

The SECRETARY (Mr. Albert Anns) read the notice convening the meeting and the auditors' report.

The CHAIRMAN, after referring to the great loss sustained by the company by the death of their late general manager (Mr. W. E. L. Gaine), said the shareholders would welcome the news that their former colleague, Lord Balfour of Burleigh, had rejoined the board of directors. This was practically an interim report, for the accounts for the month of June were in the nature of an estimate. Continuing, he said: The report on page 2 shows what we have earned, what it has cost us to earn it, what there is left and what we propose to do with it. The income accrued in respect of the business of the half-year is £1,314,790, compared with £1,195,151 last year, an increase of £119,639—a record. Post Office royalties were no less than £125,311, compared with £113,348, an increase of £11,963. Net income is £1,189,478, compared with £1,081,803, an increase, after deducting royalties, of £107,675. Working expenses amounted to £753,207, compared with £691,737, an increase of £61,469, so that the net result of the half-year's working is £436,271, compared with £390,065, or an increase of £46,205. This large income represents the earnings of 428,703 stations, or an increase of 20,967 stations during the year. The increased income constitutes a record, and I think I can, perhaps, best convey its full meaning to you by giving a few figures. First we have an increase in the income of £119,000, an increase in the cost of earning it of £73,000, and this leaves us with £46,000. To that £46,000 we must add a diminished balance carried forward of £5,000, which gives us £51,000 over last year for distribution. Of this sum, £11,000 has already been absorbed in debenture and other interest, £30,000 more goes for dividends, and not merely in increased dividend, which is declared for the first time in the present half-year, and which I hope the shareholders will welcome, but in dividend upon the new capital which has been brought into the concern from time to time. That absorbs a further £30,000. Then we add £10,000 more to the reserve fund. A year ago I referred to the fact that, owing to the adoption of lower tariffs, the average income per station had for some time been gradually falling. In 1900 the average income per station was £7. 11s. 8d., and since that year it has gradually fallen, until last year it was only £6. 3s. 7d. I am glad, however, to be able to say that, for the first time in all these years, the average income has risen for the first five months of this year to £6. 4s. 5d. From this I think we may safely predict that the decline in revenue per station, owing to the adoption of these lower tariffs, has been overcome by the increased number of our subscribers; and, if that is so, there is no reason why the company should not look forward to a prosperous career during the remainder of our tenure. With regard to working expenses, they amount to £61,469 more than last year. That increase is smaller by nearly £7,000 than the figures for the corresponding half-year of 1905-6. The percentage of working expenses to net income has fallen from 63·94 to 63·32. The items of expenses—rent, rates and insurances—have absorbed about £6,500 more, administration and management expenses some £22,000 more, and maintenance of lines and instruments some £29,000 more.

The last item is a somewhat special one, upon which shareholders may possibly wish to have some information. The increase is largely due to the fact that we have to make certain payments to the Post Office in respect of underground wires, which have been put down by the department for the company under agreement and for the company's benefit, and for which we paid a rental amounting in the past half-year to no less than £31,000. The working expenses of the company are, therefore, loaded with this expenditure of £31,000, because had we ourselves spent our capital in expanding our own business, and had we not had to go to the Post Office for this expenditure, then the rent would, of course, have been absorbed in the dividend distribution, and the working expenses would have been correspondingly less.

The increased prosperity of the company has its reflex action in the dividend. For the first time we have been able to pay the dividend on the deferred stock at the rate of 6 per cent., or the same as on the preferred stock. Turning to capital account, the shareholders will see that the total capital expended, including £658,000 for land and buildings, is £13,659,777, raised by preferred and deferred stock and debenture stocks to the amount of £10,516,000, leaving a balance of £3,143,000, which is brought into the balance-sheet as an asset, representing the difference between capital expended and capital raised. Here, on behalf

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of the board, I can remark how pleased the directors have been that the issues of capital made from time to time have been so well subscribed by the shareholders. The shareholders have manfully shouldered the responsibility which is upon the company of finding capital to develop our business, always remembering, of course, that that capital has to be spent prudently, and must be such capital as can be reproductive to the shareholders of the company within the terms and the period of the company's licence.

Stock of materials stands in the balance-sheet at £395,766—about the same as at six months ago. The "special replacement" account stands at £129,895, compared with £189,473. It will be satisfactory to the shareholders to know that this item is being reduced. It represents, as shareholders may remember, sums which have been charged to revenue in respect of underground works undertaken in large towns. The sum represents the value of the plant replaced, and in order that it might not fall unduly upon the revenue of any particular year or half-year the directors instituted a scheme by which the amount could be spread over a period of years, and we are within measurable distance of seeing it wiped out altogether by the year 1909.

I think I can safely congratulate you upon the comparatively smooth water in which we find ourselves to-day. We are, as you know, face to face with great responsibilities; we have before us a somewhat anxious time when we reflect upon what might happen in 1911, but I think that if we adopt a policy of financial prudence all the time no undue alarm or unrest need occur among the shareholders. They may rest assured that the directors are fully alive to the responsibilities which rest upon them, and that they will see to it that the very best use is made of opportunities which may be presented to them from time to time. No body of shareholders can ask men to do more than that (applause). We have a staff of some 17,500 persons and shareholders numbering 16,600, which better perhaps than anything else indicates the extent of our business obligations, and shows the responsibility which rests upon both the directors and the shareholders. I now move the adoption of the report and accounts and the declaration of the dividends.

Mr. S. H. SANDS (vice-president) seconded the motion.

A discussion followed, in which the directors were congratulated upon the excellent results of the half-year's working generally.

In reply to questions the CHAIRMAN said that, if there was a surplus in 1911, after the result of the arbitration was ascertained, that surplus belonged to the shareholders, and no one could deprive them of it. As they were now within measurable distance of that time when their licence would expire, it would be most imprudent that they should do anything which would jeopardise the strength of their position when they went to arbitration. A big reserve fund was a great advantage to them. He did not consider it would be wise to show in the accounts the amounts set aside for depreciation. The company's position was never stronger, nor their prospects brighter, than at the present time.

The resolution was then carried unanimously.

The retiring directors and auditors were then re-elected.

A cordial vote of thanks to the chairman and directors brought the proceedings to a close.

Telegraph Construction & Maintenance Co. (Ltd.)

A half-yearly General Meeting of this Company was held at the offices on Tuesday. Mr. WILLIAM SHUTER (Chairman and Managing Director) presided.

The SECRETARY (Mr. E. Dickens) read the formal notice calling the meeting.

The CHAIRMAN said: Gentlemen, at our last meeting in February I had the pleasure to inform you that your Directors were quite satisfied with the financial position of the Company, and that they looked forward to the future with confidence. Since then everything has gone well, and nothing has happened which has caused us in any way to alter our views. We have carried out several contracts and have entered upon others which are still in hand. Perhaps the most important work of the half-year has been the making and laying of a cable between New York, Cuba and Panama, a length of over 2,300 nautical miles. The contract for this cable was made in January last with the Central & South American Telegraph Co. of New York. We undertook to complete the entire cable on or before July 15. Although the time was short considering the difficulty there has been in obtaining raw materials, and although the Central & South American Telegraph Co. increased the length of the cable and requested us to lay some harbour cables which were in addition to the work contracted for, I am glad to say we have received a telegram from our ship, the "Colonia," saying that the laying of the whole line from New York to Panama was completed at 8 p.m. on July 15, thus leaving four hours in hand before the expiration of the agreed time. I am mentioning these details of our work to the proprietors as I think it right they should understand that it has always been the policy of this company to respect its contract dates, and I am sure the shareholders will agree with me that it speaks well for the efficiency of our staff and of our organisation, both at the works and in our ships, that our contracts are carried out with such promptitude and success, and we all know that work done quickly and well is done cheaply. I have no resolution to submit to you as no report or accounts are presented to this meeting, but in accordance with our usual custom I have to announce that the Warrants for the Interim Dividend of 5 per cent. will be posted to-day. This concludes the business of the Meeting.

Mr. CROFT (a shareholder) observed that he had a very long experience of the Meetings of the Company, but the shareholders had never had, at what he might call an interim meeting, a more satisfactory report than that which they had just heard. He was quite sure that the shareholders had heard with great satisfaction that the cable referred to in the Chairman's speech had been laid within the contract time, showing, as the statement from the chair mentioned, the Company had again kept to its contract time, and this punctuality had nearly always been, he believed, the characteristic of the Company. He was aware that the Directors at the interim meetings did not, as a rule, make any lengthened report, but it was a long time to wait until the next general meeting, and, in these circumstances, he was sure that the Chairman would excuse him if he made a few observations and asked one or two questions. He wished to know whether the "Colonia" was the only ship the Company now possessed, or whether any ship had been bought to replace the "Anglia," which had been sold.

The CHAIRMAN: We have the "Cambria," which is a considerably smaller vessel.

Mr. CROFT said that his reason in asking the question was, because he saw from time to time reports of Telegraph Companies, whose cables, when damaged or broken, were apparently repaired by their own vessels. He had always been under the impression that their Company was primarily formed with the object of doing that class of work for such companies. He hoped the Company would always find good employment in that way. If the Telegraph Companies used their own ships, the Telegraph Construction Co. was deprived of work which legitimately belonged to it.

Mr. F. R. LUCAS (Managing Director) said they had the "Cambria" almost constantly employed in the repairing work referred to by the last speaker. The "Colonia" was a very large ship, with great carrying power, and they found that she could do her work so quickly that she could pretty well keep pace at the rate at which they could manufacture cable. The "Cambria" was at present employed in repairing and renewing certain cables in the Atlantic, and she was pretty constantly employed in that way. The Board had considered the question whether they should further add to the Company's fleet by building another ship, but there were considerations which they had to take into account. The present was rather an expensive time to build ships, and the Company did not wish to have more ships than they were likely to keep in constant employment. It was quite true that the large Telegraph Companies did, as a matter of course, their own repairs. They had a large fleet of ships in all parts of the world, and this did not leave very much work to be done by a Company such as their own in the way of maintaining cables.

In reply to Mr. ROWE,

Mr. LUCAS said the Chairman had referred to one large contract; they had several others running with it, and they had another large contract for the "Colonia" to carry out so soon as she got back. This involved a voyage to the Far East.

Mr. CROFT then proposed a cordial vote of thanks to the Chairman and his colleagues for the way in which they had managed the affairs of the Company. He would like to couple with that resolution the whole of the staff.

Mr. J. GIBSON seconded the resolution and said the skill of the Directors and Staff was such that the shareholders could entertain the strongest hope that the Company would continue to hold its own, although the times were somewhat hard.

The motion was then carried unanimously,

Sir JAMES PENDER having briefly acknowledged the compliment on behalf of the Chairman and his colleagues, as well as on behalf of the Staff, the proceedings terminated.

Buenos Ayres Grand National Tramways Co. (Ltd.)

The annual general meeting was held on Wednesday under the presidency of Mr. J. IRVING COURTENAY.

The SECRETARY (Mr. Fortescue Thursby) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, owing to transition of our system from horse to electric working not being the same in 1906-7 as in 1905-6, any detailed comparisons between the two years are of little or no value. The chief changes in the balance sheet are that, as regards to loan capital, the 5½ per cent. debentures are reduced by the amount redeemed (£1,700). The amount of conversion debenture stock issued is, in effect, reduced by the £700 redeemed of the second preference debentures and has been increased by £100,000 issued on Sept. 15, 1906. There remains now £100,000 not issued of the total of £700,000 at present authorised of this stock, but this £700,000 is liable to increase for the purpose of redeeming the £150,000 5½ per cent. preference debentures. The 6 per cent. debentures are also shown as reduced by the amount of £1,400 redeemed. On the other side of the balance-sheet, there has been expended during the year to March 31 in London and Buenos Ayres on electric construction and equipment £266,367. 12s. 8d. In the revenue account the chief differences are that the gross receipts for 1906-7 show an increase of £68,660, or 27·18 per cent., the working expenses £27,496, or 14·25 per cent., and the net receipts £41,163, or 68·95 per cent. The percentage of working expenses to gross receipts for 1906-7 was 68·60, against 76·36 in 1905-6, or a reduction of 7·76 per cent. The percentage of working the electric traction only for 1906-7 was 62·75 per cent. This last figure you will specially note. The number of passengers carried was, in 1906-7, 35,874,902, and in 1905-6 27,810,737, or an increase of 28·99 per cent. Passenger car-miles run were in 1906-7 7,014,999 and in 1905-6 6,676,738, or an increase of 5·07. The passenger gross receipts per car-mile were in 1906-7, 51·75 cents; in 1905-6, 42·36 cents, an increase of 22·17 per cent., while the expenses per car-mile in 1906-7 were 35·63 cents, against in 1905-6 33·03 cents, an increase of only 7·87. The net receipts for the year under review exceed those for the previous year by £41,163, or 68·95 per cent. Speaking on general matters, apart from figures, a most important step forward has just been taken, with the consent of the Municipality—that is to say, all the horse passenger service of the Company has been discontinued, and thus a source of unproductive expenditure has been eliminated. With the municipal authorities our relations, we are glad to say, continue to be quite cordial. The number of miles of single track now converted to electric traction is

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75¾ miles. Labour troubles have occurred in Buenos Ayres as elsewhere in the world, but these were occasioned by the operations of professional agitators, and in our particular case the majority of our men remained, I am glad to say, entirely loyal to us (cheers). For the manner in which the local committee and general manager dealt with these troubles—and they required delicate, but firm handling—and also for their skilful conduct of the administration of the Company, we are much indebted to them. Reviewing the whole situation, it is manifest that the position of the Company has vastly improved, and I am not aware of any cause why this improvement should not continue; on the contrary, there are valid reasons why the Company should advance in prosperity, for even if the great prosperity of Argentina during the last three years should not continue at the same rate, it is not probable that the tramway passenger movement in Buenos Ayres will be much, if at all, adversely affected. I now move the adoption of the report and accounts and the declaration of the dividends set out therein.

Mr. E. A. LAZARUS seconded the motion.

Mr. REED inquired the actual number of miles that remained to be converted to electric traction.

The CHAIRMAN: The difference is between 75¾ and 113 miles, which we take as the total length of the system as at present projected including the concessions applied for. The exact mileage at the present time under electric traction was 66½ miles. The resolution was then carried unanimously.

Mr. J. Irving Courtenay, Mr. W. H. Harris, Mr. E. A. Lazarus and Mr. H. A. Trotter were then re-elected to their seats at the Board, and the retiring auditors, Messrs. Monkhouse, Stoneham & Co. were re-elected auditors.

The CHAIRMAN: I now propose that we give a cordial vote of thanks to our local committee and to the staff in Buenos Ayres and the staff in London. They have all had a great deal of work to do, and I think they are entitled to a vote of thanks.

Mr. FRAME THOMSON, in seconding the motion, observed that from personal intercourse with the staff both in Buenos Ayres and in London, he could testify to the admirable way in which they had discharged their duties in difficult circumstances. The work of reconstruction of the lines and the new method of working had rendered their duties very complicated.

The resolution was carried unanimously.

Mr. REED proposed a vote of thanks to the Chairman and Directors for having brought the Company so happily, as he thought, through a strenuous and difficult period.

Mr. MONKTON seconded the motion, which was carried unanimously.

The CHAIRMAN briefly responded, and the proceedings terminated.

United River Plate Telephone Co. (Ltd.)

The twenty first ordinary general meeting was held on Tuesday, under the presidency of Mr. J. Irving Courtenay.

The SECRETARY (Mr. David Smith) read the notice calling the meeting and the auditors' report.

The CHAIRMAN said: Gentlemen, on my return from South America last year I gave you an account of my visit and stated my views upon the good prospects of the company. I am glad to say the results of the year's working have fully justified the anticipations then expressed. We are now actively engaged in Buenos Ayres in replacing our overhead lines by underground cables. The advantage to the company of a change of this kind can hardly be overestimated. Not only does it minimise the danger of loss and interruption through any large fire occurring, say, in a busy portion of the city, but it ensures a practical immunity from damage by storms, while the cost of upkeep of underground cables is not anything like so high as the upkeep of aerial lines. In Rosario and Cordoba also a considerable number of overhead lines have been replaced by underground cables, and it is the intention of the directors, as soon as the necessary arrangements have been completed, to make similar changes in the company's system in other important towns. A further improvement, as I have mentioned on a previous occasion, is being effected by the installation of common battery switchboards, equipped on the most modern principles, to work in connection with the underground plant. One large board has been erected and two others are in course of erection in Buenos Ayres. Already there is a marked improvement in the service, and I have no hesitation in saying that our service in Buenos Ayres will compare favourably with that given in any part of the world, with the possible exception of the United States. Another gratifying announcement I have to make is the opening of the Rosario line for public service. This line is about 220 miles long and connects the city of Rosario and its neighbourhood with Buenos Ayres. The line taps one of the richest grain-producing regions in the Argentine. The traffic is growing day by day and will ultimately be an important source of revenue to the company. We have thus, you will see, connected the two important provinces of Buenos Ayres and Santa Fé, and it is now not only possible for the company's subscribers as far north as Rosario, and even beyond that point, or as far south as Chascomus, to communicate direct with the Federal capital, but through our Buenos Ayres offices these extreme points can be put into communication with one another, and thus subscribers to the company's system can talk over distances not much short of 400 miles, which, I think you will agree, for South America is a creditable record.

Our relations with the Government and municipal authorities are of a friendly description, and as the country is becoming year by year more settled, I think we may look forward to a continuance of the prosperity with which Argentina is at present blessed. Of course there are minor troubles, but what land is free from them? There have been strikes in the Argentine, although I am happy to say our company has been singularly free from troubles of this description, and as population is more and more attracted to the Plate the labour question should undoubtedly tend to become less acute. Argentina is developing in all directions. New industries are constantly being started and new crops cultivated, and towns which a few years ago were villages are becoming important centres of industry. There is no reason why the company should not continue to share in this prosperity.

As to the future, a company like ours cannot stand still. As subscribers come forward we must provide for their needs. Some statistics I have prepared will interest you. In 1900 there were 675,000 telephone stations in use by subscribers of the Associated Bell Telephone Cos. in the United States; in 1907 there are 3,000,000. In the United Kingdom in 1900 there were 173,800; in 1907 there are 483,000. In Germany between 1900 and 1905, the latest year for which we have statistics, the increase was from 247,000 to 511,000. If we take it on the population basis the figures work out approximately: United States, 1 telephone for every 20 inhabitants; United Kingdom, 1 for every 90; Germany, 1 for every 120; and Argentina, 1 for every 200. That will show you the field we have to work. Regarding the conversion of the 5 per cent. debenture stock into 4½ per cent., this has been accomplished, and it is satisfactory to feel that the company is now in an infinitely stronger financial position than heretofore. Our borrowing resources will now keep pace automatically with any increase in our share capital. The extent to which in the future we may avail ourselves of these powers will be dictated by circumstances, but, at any rate, it is satisfactory to know that in case of need such powers are in existence, and this will constitute a great source of strength to the company. There will probably be an issue of ordinary shares in the late autumn of this year, and though I am not at the moment in a position to give you particulars I have no doubt the terms will prove to be agreeable to the shareholders.

You will have noted with pleasure that Sir John Gavey, C.B., late engineer-in-chief to the British Post Office, has joined the board of the company, and you will be glad to learn that he is going out to South America this autumn for the purpose of making himself acquainted with the business and affairs of the Company. The shareholders will agree with us in thinking that this visit will be productive of much benefit to the company.

With regard to the accounts, on the debit side capital has been increased by £100,000, by the issue of 20,000 new ordinary shares in July, 1906. There is a considerable increase in sundry creditors, accounted for by large purchases in connection with our underground work, the installation of the common battery system, and the general extension of our business. We are adding £10,000 to reserve and £25,000 to renewal of plant account. Capital outlay for the year, apart from real estate, has been £116,483. This is in connection with underground work, the installation of the common battery switchboards already referred to, and expenditure on new subscribers' lines and instruments. Sundry debtors are £313 down, although the business has increased, showing that our collections are kept well in hand. Real estate has increased by £13,824, owing to the purchase of certain new properties for stores and exchanges, and the erection of suitable buildings thereon. If we had to dispose of our real estate to-day it would realise considerably more than the price at which it stands in our books. Securities at cost are £8,167 less than last year, as we took advantage of a favourable opportunity to realise certain of our investments, the money being required in connection with our extensions. The prices at which the balance of the securities stand in our books is more than covered by their present market value. Receipts in the River Plate show an increase of about £35,000, while maintenance charges and general expenses are about £21,000 more. The increase in net profit for the year is £14,008. I think you will consider the results of our operations have been satisfactory. We recommend a final dividend of 5 per cent. on the ordinary shares, making, with the interim dividend, 8 per cent. for the year, tax free. I now move the adoption of the report and accounts.

Mr. F. GREEN seconded the resolution.

Mr. A. H. GAMBLE said he would like to know if they might anticipate any formidable competition? It was gratifying to see their reserve fund growing; was it invested in the business with the exception of the item, "securities at cost £58,391"?

The CHAIRMAN: The £58,000 odd is in good-class securities; the rest of the reserve is in the business. Monopolies are not tolerated in this age. The company has always had competition, and for anything we know may possibly have more in the future. The way to meet it is by giving the best possible service.

The resolution was then carried unanimously.

The retiring directors, Mr. F. Green and Sir John Gavey, C.B., were then re-elected, and the retiring auditors were re-appointed.

The CHAIRMAN: I do not think we should separate without according a vote of thanks to our local board, as well as to the manager and staff in Argentina and the staff in London. We have one of our Argentina staff present and are pleased to see him. We propose, in the future, to have more frequent communication between the staff there and on this side.

Sir JOHN GAVEY seconded the motion and said: To manage a concern like ours, in which the base of operations is several thousand miles from headquarters, the London board is very largely dependent on the local board and on the able and zealous officers who represent us in Argentina. I have had the pleasure of making the acquaintance of some of them, and I hope shortly to get into close touch with the whole of them. I can speak very warmly also of the manner in which the work in our offices here is conducted by our secretary and his staff, and it affords me the utmost pleasure to second the resolution that a hearty vote of thanks be accorded to the local board, manager and staff, in the Argentine and to our officers at home.

The resolution was carried unanimously.

A hearty vote of thanks was, on the motion of Mr. GAMBLE, seconded by Mr. KINGSBURY, accorded to the chairman and directors. The chairman having replied, the proceedings terminated.

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BOMBAY ELECTRIC SUPPLY & TRAMWAYS CO. (LTD.)—At the meeting on Wednesday the chairman said that three sections of their electric tramways were now open, making a total open of 5·61 miles. They expected to have the entire system running electrically before the monsoon of next year. The excess of expenses over receipts in the electricity supply department amounted to £1,639. 12s. 11d., which the directors considered it advisable to carry to suspense account. The lighting and power supply branch of the business had made excellent progress during the year.

BUENOS AYRES ELECTRIC TRAMWAYS CO. (1901) (LTD.)—The report for 1906 states that the gross receipts were £75,156, compared with £64,514 in 1905. The working expenses (inclusive of London administration charges) were £60,080, against £51,228 in 1905, showing a net profit of £15,076, compared with £13,286. After paying interest and transferring £1,731 to sinking funds for redemption of debenture stock, there remains (with £697 from 1905) £2,639 to be carried forward.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—At an extraordinary meeting on Friday it was unanimously resolved to increase the capital from £500,000 to £1,000,000 by the creation of 100,000 additional shares of £5 each. Col. A. J. Filgate stated that capital expenditure during the last five years had been £344,618, while the total capital expenditure to Dec. 31 last amounted to £544,353, the subscribed capital being £500,000. Their generating plant represented 5,817 kw., while the length of their feeders and mains was 171 miles. They had recently to order further generating plant, and the demand for additional mains continued. From Jan. 1 last they had added more than 300 customers, the additional lamps being equivalent to 25,780 8 c.p., the total being 289,174 8 c.p.

CENTRAL LONDON RAILWAY CO.—The directors recommend payment of the following dividends: At the rate of 3 per cent. on the undivided ordinary stock and at the rate of 4 per cent. on the preferred ordinary stock for the half-year ended June 30, providing also for a dividend at the rate of 2 per cent. on the deferred stock, this latter dividend only being payable when the result of the year's working has been ascertained. £25,890 is also carried forward.

CITY & SOUTH LONDON RAILWAY CO.—The report of the directors for the half-year to June 30 states that the receipts from all sources amounted to £82,456. 4s. 2d. and the cost of working to £36,592. 6s. 3d., leaving a profit of £45,863. 17s. 11d. Inclusive of the balance brought forward, the net revenue account shows a total of £52,516, 2s. 5d. After making provision for debenture stock interest and transfer to renewal fund of £1,500, £39,107. 5s. remains available for dividend. The directors recommend payment of the full dividend on the 5 per cent. preference stocks (1891, 1896, 1901 and 1903) and a dividend at the rate of 2½ per cent. on the consolidated ordinary stock for the half-year, leaving £1,857. 5s. to be carried forward. The dividend compares with 2½ per cent. in the corresponding half-year of 1906. The number of passengers, exclusive of season ticket holders, carried during the half-year was 10,048,780, and the receipts (including season-tickets) £77,519. 11s. 9d., against 9,104,293 passengers and £72,228. 2s. 4d. and 9,045,120 passengers and £72,454. 3s. 11d. respectively in the two preceding half-years.

Throughout the half-year the traffic on the old line and the old connections has shown a satisfactory increase, and the extension to Euston has brought in a considerable amount of new traffic. As will be seen, these receipts, added to what has come in from through bookings with allied systems, enable the directors to recommend an increased dividend. The three new trains had been delivered and are now running. The directors record with deep regret the death of the company's chief engineer, Sir Benjamin Baker, who had been associated with the company from its inception.

DUBLIN UNITED TRAMWAYS CO. (LTD.)—The report for the half-year ended June 30 states that after charging against revenue the balance of cost of reconstruction of portion of the Dalkey line (£3,157. 11s. 6d.) and the cost of alteration from centre to sidepole overhead construction (£998. 14s. 2d.) the amount available for division is £41,715. 6s. Dividends are recommended on the 6 per cent. preference shares, and at the rate of 6 per cent. (tax free) on the ordinary shares. These dividends will absorb £35,100, leaving £6,615. 6s. to be carried forward.

EAST LONDON RAILWAY CO.—At the meeting on Tuesday the chairman (Lord Claud Hamilton) said that he had obtained a rough estimate of the cost of electrifying the line from Mr. Firth, the electrical engineer of the Great Eastern Railway. He had mentioned two systems to that gentleman—the system in use on the Metropolitan and Metropolitan District Railways and the alternating-current overhead conductor system, but as the latter system was in its infancy as regarded railways in this country and they had had no practical experience of its working and cost, he had confined the estimate to the direct-current system. Mr. Firth's conclusions were as follows: To equip the 12 miles of single track would cost £32,000, but that would not include point-rodding, signal-wiring and other details comprised under the head of track alterations, but probably they would not amount to much. If power could be obtained from outside sources both north and south of the Thames, the track-work for that purpose would cost another £20,000, and if, owing to the difficulty of obtaining a supply from the southern section, a sub-station had to be erected south of the Thames, there would be a further cost of £18,000, or £70,000 in all. He imagined, however, that a direct supply could be obtained, but even in that case the cost would be £52,000.

EDMUNDSON'S ELECTRICITY CORPN. (LTD.)—For the year to March 31 the net profit, after payment of interest, was £16,595, added to £15,211 brought forward. Deducting the preference dividend paid to Oct. 30, 1906, (£14,000), there is a balance of £17,806 to be carried forward. The directors regret that, owing to the slow development in the demand for electric light during the past year, the results have been so disappointing. The net profit on trading account, after providing for all standing charges, is only £4,059, compared with £27,710 last year. A schedule is given in the directors' report showing the earnings of each of the subsidiary companies. The parent company's income from its investments in these companies was only £31,136, against £32,182 last year. An improvement in this respect during the current year may be looked for.

ELECTRIC SUPPLY CORPN. (LTD.)—The directors' report for the year 1906 states that the gross revenue shows a steady and satisfactory improvement, and (including the dividend from the Chelmsford company) amounted to £7,285. 2s. 6d. After providing for interest, &c., there remains a net profit of £151. 9s. 2d. During the past year electricity supply was commenced in Dumbarton, Hitchin and Falmouth, the equivalent of 6,853 8 c.p. lamp shaving been connected to the mains in those towns. The six towns (Jedburgh, Melrose, Dalkeith, Dollar, Exmouth and St. Andrews) produced a gross revenue of £3,730. 7s. 1d., compared with £2,060. 12s. 9d. in 1905. The Totnes undertaking is now working at a profit. The directors consider the growth of the business satisfactory. In each town there has been a substantial increase in the number of lamps connected to the mains.

The tramway within the burgh of Dumbarton has been completed and the line is now opened for traffic. The provisional order for the tramway from Clydebank to Dumbarton and from Dumbarton to Balloch has been confirmed by Parliament, and it is proposed to transfer this order and the burgh tramway to a company which has been registered under the title of the Dumbarton Burgh and County Tramways (Ltd.). A bill authorising this transfer has been presented to Parliament. The new company will repay to the Corporation the costs incurred, together with the outlay on the burgh tramway, and will contract to take its supply of electrical energy from the generating station at Dumbarton at satisfactory prices. The bill in Parliament for vesting in the Corporation the various undertakings constructed and worked by the Corporation is unopposed and will give legal effect to certain agreements with local authorities, and will put an end to the existence of separate companies for Chelmsford and Totnes. The final dividend for 1906 was paid in January, and the guarantors will now provide the amount sufficient for the payment of an interim dividend at the rate of 5 per cent. for the six months ended June 30.

GENERAL ELECTRIC CO. (LTD.)—The annual report of the directors to March 31 last states that the net trading profits and income from investments, &c., amounted to £68,545. 13s. 6d. After deducting depreciation and debenture interest (£25,951. 7s. 1d.), there remains £42,594. 6s. 5d., out of which the dividend on the 5 per cent. preference shares has been paid (absorbing £12,500), leaving an available balance of £30,094. 6s. 5d., which the directors recommend should be appropriated as follows: Provision for managing directors' and employés' bonus, £3,009. 8s. 7d.; dividend on ordinary shares at the rate of 5 per cent., £17,293. 10s.; and placing £9,791. 7s. 10d. to reserve. The prices of raw materials have continued to advance throughout the year, and have been the main cause of reduced trading profits. The factories at Salford, Witton, Birmingham and London have again been increased by new buildings and more machinery. They have been maintained at high efficiency and are well filled with orders. The directors have recently concluded arrangements for working in Great Britain and Colonies the Osram tungsten metal filament lamp, from which they expect good results. Further ordinary shares (1,465) have been allotted, during the period covered by the accounts, to the directors and staff at par.

METROPOLITAN RAILWAY CO.—In the report for the June half-year the directors state that the total receipts (deducting proportion of revenue of City lines and extensions) were £345,519. 9s. 4d., and the expenses £193,361. 4s. 3d., leaving a profit of £152,158. 5s. 1d. Compared with the corresponding half-year of 1906, the receipts show a decrease of £43,494. 14s., and the expenses a decrease of £19,670. 19s. 11d. After providing for debenture interest, &c., £17,624. 4s. 4d. is available, and the directors recommend a dividend on the ordinary stock at the rate of 10s. per cent., carrying forward £3,294. 1s. 3d. The falling in revenue is attributed partly to the competition of tube railways and motor omnibuses. Throughout the half-year the working of the electrical plant and machinery has given every satisfaction and current is being produced at a very low cost per unit. The increased services of trains on the circle and on the St. John's Wood line have been greatly appreciated by the public, and in the latter case have assisted the company materially to meet the motor omnibus competition.

The chairman (Sir Charles MacLaren) stated at the meeting yesterday that the company still felt the effects of the motor omnibus competition, although they anticipated, with confidence, that those companies would abandon the policy of cutting fares and adopt more remunerative rates. The total number of passengers carried (including season ticket-holders) showed a falling off of 745,432.

SHANGHAI ELECTRIC CONSTRUCTION CO. (LTD.)—Sir Alfred Dent stated at the meeting of this company that an agreement had been made with the company which obtained the tramway concession in the French Settlement for mutual running powers. The French company expected to be ready early in 1908. Their cars were under construction in this country, and were exact replicas of the English company's. The negotiations as to the tramways on the Chinese Bund and in the Chinese quarter round the native city were at a standstill, but there seemed every probability, when the Chinese authorities saw the tramways running successfully in the English and French settlements, that they would desire to have them extended to the streets under their own jurisdiction. It was probable that the whole of the undertaking would be ready by Oct. 10.

THOMAS PARKER (LTD.)—The directors' report for the year ended April 30 states that the profit was £18,033. 6s. 2d. It is proposed to add £5,000 to general reserve and £5,000 to depreciation reserve, to write £3,500 off suspense development account, and to carry the balance (£4,533. 6s. 2d.) forward. The report states that the patent C type dynamos and motors which were put on the market last year have

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proved very successful and have become the company's standard type, replacing all previous designs. The orders for electrical work have increased by nearly 50 per cent. over the previous 12 months, but owing to the continued competition and over-production, prices for electrical machinery have shown little tendency to rise, whereas the prices of raw material, especially copper, have been maintained at a high figure. The Rees Roturbo Development Synd. is (it is stated) now a very valuable property. The result of the agreement with the syndicate secured the full manufacturing rights in Great Britain for the company in all classes of pumps, turbines and machinery under the "Roturbo" patents. The result of the sale of the patents to the Rees Syndicate is a profit balance of £17,737 11s. 7d. after writing off the whole of the formation expenses and the preliminary expenses of developing the business in the works. The directors not only consider that the prospects of the company are very satisfactory, but owing to the development of sales and margin of profit in the Roturbo business are more than satisfied that the company can look forward to occupying a place in the front rank of successful manufacturing concerns in the country. In order to realise fully the advantages secured by the patents it is desirable to increase the capacity of the works so as to standardise rapidly and manufacture all the Roturbo machinery without interfering with the electrical output. An extraordinary meeting of shareholders will be called to authorise the issue of fresh capital with the object of paying off the bank overdraft, redeeming the debentures and providing further working capital.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

ASSOCIATED BATTERY CO. (LTD.) (94,179.)—Reg. July 15, capital £25,000 in £1 shares, to acquire the business carried on by the Amalgamated Dry Batteries (Ltd.), to adopt an agreement with C. H. Elliot, and to carry on the business of manufacturers and vendors of electric batteries. First directors, A. J. Aitkens, C. H. Elliot and F. H. Rogers. Reg. office: 16 and 17, Devonshire-square, London, E.C.

BRITISH ELECTRICAL FEDERATION (LTD.) (94,252.)—Reg. July 19, with 100 members, each individual member being liable for 5s. and each company which is a member being liable for 5s. for every £1,000 of its authorised share capital, to encourage, promote and protect the interests of the electrical and general engineering, carrying, contracting, tramway, railway, electrical, magnetic, mechanical and chemical engineering industries, &c. The subscribers are Sir C. Rivers Wilson, G.C.M.G., E. Garcke, E. Hopwood, C. J. Tegetmeier, W. G. Bond, J. Renwick and C. H. Dade. The management is vested in a Council, the chairman for the time being of the British Electric Traction Co. to be president of the Federation and also president of the council and chairman of all committees.

GUERNSEY ELECTRIC LIGHT & POWER CO. (LTD.)—Reg. in Guernsey July 20, capital £100,000 in £1 shares (50,000 pref.), to acquire the business and property of Edmundson's Electricity Corpn. (Ltd.) in Guernsey, and to carry on the supply of electric light and power in that island.

PYRENEES ELECTRICAL SOCIETY (LTD.) (94,225.)—Reg. July 27, capital £60,000 in £1 shares, to promote, construct, equip, maintain, work and control tramways, railways, motor ways, telegraphs, telephones, cables, harbours, mills, smelting, hydraulic, gas, electric light and power supply works, &c. Reg. office, Parliament-mansions, Victoria-street, Westminster.

STATUTORY RETURNS.

INDO-EUROPEAN TELEGRAPH CO. (LTD.)—The capital in return to May 13 is £450,000 in 18,000 shares of £25 each, of which 17,000 have been taken up. £425,000 has been received. Mortgages and charges, nil.

W. LUCY & CO. (LTD.)—Return to June 7 gives a capital as £15,000 in 250 preference and 1,250 ordinary shares of £10 each, of which 250 preference and 1,030 ordinary shares have been taken up. £10 per share has been called up on 250 preference and 781 ordinary, and £10,310 has been received. £2,490 is considered as paid on 249 ordinary. Mortgages and charges, £7,000.

NATIONAL ELECTRIC CONSTRUCTION CO. (LTD.)—In return to May 20 capital is £250,000 in £1 shares, of which 170,000 have been taken up. £1 per share has been called up on £151,149, resulting in the receipt of £151,149. £18,851 is considered as paid on 18,851 shares. Mortgages and charges, £75,000.

NORTHWOOD ELECTRIC LIGHT & POWER CO. (LTD.)—In the return to June 27 the capital is £30,000 in 15,000 ordinary and 15,000 preferred shares of £1 each, of which 12,357 ordinary and 2,260 preferred have been taken up. £1 per share has been called up on 8,132 ordinary and 2,260 preference, and £10,392 has been received. £4,225 is considered as paid on 4,225 ordinary. Mortgages and charges, nil.

WEST COAST OF AMERICA TELEGRAPH CO. (LTD.)—Return to May 28 gives capital as £132,520 in 53,008 shares of £2. 10s. each, of which 45,008 have been taken up. £2. 10s. per share has been called up on 8 shares and £20 has been received. £112,500 is considered as paid on 45,000 shares. Mortgages and charges, £170,000.

MORTGAGES AND CHARGES.

BRYANT TRADING SYND. (LTD.)—£5,000 8 per cent. debentures, created June 21, 1907, charged on company's undertaking and property (present and future), including uncalled capital, but excluding any property abroad, have been registered. No trustees.

NEWQUAY ELECTRIC LIGHT & POWER CO. (LTD.)—Issue of £300 5 per cent. debentures, part of series, to secure £4,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued, £3,700.

NORTH-EASTERN ELECTRICAL STORES (LTD.)—A first debenture dated July 10, and a second debenture dated July 12, 1907, securing £175 and £165 respectively (both with 5 per cent. interest), charged on company's undertaking and property, present and future, including uncalled capital, have been registered. Holder, A. Dunbar.

W. R. SYKES INTERLOCKING SIGNAL CO. (LTD.)—A trust deed dated July 9 to secure £15,000 debenture stock, has been registered. Property charged: Certain leasehold land with premises thereon in Clapham, and company's other assets, present and future, except uncalled capital. Trustees: J. E. Nichols and A. H. Johnson.

CITY NOTES.

MEMORANDA (July 25).—Bank rate 4 per cent. (since April 25, 1907), Price of silver 31⅛d. per oz. Consols $83\frac{5}{16}$—$83\frac{7}{16}$ for money, $83\frac{5}{16}$—$83\frac{7}{16}$ for account; 2½ per cent. annuities 81⅛—82. Consols Pay Day, Aug. 1; Stocks and Shares Continuation Days, July 29 and Aug. 13; Ticket Days, July 30 and Aug. 14; Pay Days, July 31 and Aug. 15; Mining Share Carry-over Day, July 26.

BRISTOL TRAMWAYS & CARRIAGE CO. (LTD.)—The directors have declared an interim dividend at the rate of 8½ per cent. for the half-year ended June 30.

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The number of units delivered to consumers during the five weeks ended May 31 were 704,888, compared with 687,460 units in the corresponding five weeks of 1906; and for the four weeks ended June 28 the units delivered were 577,338, against 538,356 in 1906.

ELECTRICAL DISTRIBUTION OF YORKSHIRE (LTD.)—This company is about to invite subscriptions for 22,945 ordinary shares of £1 each.

IMPERIAL TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend at the rate of 8 per cent. for the half-year ended June 30.

LIVERPOOL OVERHEAD RAILWAY CO.—The accounts for the past half-year show an available balance of £8,128. 5s. 1d. The dividend on the 5 per cent. preference shares will absorb £3,675. 17s., the balance (£4,452. 8s. 1d.) being carried forward.

MANUFACTURING PROFITS.—We have received the following letter on the subject of manufacturing profits and the prevailing low prices:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read your report of the Electric Construction Co.'s meeting in the current issue, and would point out a mistake made by the chairman in his speech. We take considerable exception to this statement, which reads as follows: "It is but small consolation to know that such absence of profit is not exceptional nor confined to this company, for I cannot find any electrical manufacturing concern of importance, carrying on a purely manufacturing and competitive business similar to ours that can show any better result, and some show a great deal worse."

We may say that the average dividend which we have paid on our ordinary shares for the last six years is 8½ per cent.; during 1906 we made more profit than in 1905. These dividends were paid after a substantial depreciation was allowed for. Our profits were stated in the prospectus issued a few weeks ago. We maintain that our business is practically similar to that of the Electric Construction Co., as it is purely manufacturing, and we have over 800 employés. We have, of course, a few specialities, but the bulk of our profits are obtained from standard d.c. and a.c. motors and generators. The average size of our productions is probably somewhat smaller than those of the Electric Construction Co., but we make a range of machines from 1 to 1,000 H.P.

We would also draw your attention to Messrs. Crompton & Co.'s report (which is printed on the next page to that of the Electric Construction Co.), in which they declare a dividend of 5 per cent., and place a substantial sum to reserve.

We must say, however, that we consider the prices obtained at the present time are much too low, and we entirely sympathise with the remarks made by the chairman re the failure of the co-operative scheme.

It may interest you to know that at the present time we are exporting a considerable number of machines to Italy, France and Germany, notwithstanding the high import tariff.—Yours faithfully,

THE LANCASHIRE DYNAMO & MOTOR CO. (LTD.).
Trafford Park, Manchester, July 22. A. P. Wood, General Manager.

MONTREAL LIGHT, HEAT & POWER CO.—A dividend has been declared for the quarter ended 31st inst. at the rate of 6 per cent.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend of 2½ per cent.

ST. JAMES' & PALL MALL ELECTRIC LIGHT CO. (LTD.)—The directors have declared an interim dividend on the preference shares at rate of 7 per cent. and on the ordinary shares at rate of 10 per cent. for the half-year ended June 30. The share transfer books will be closed from July 25 to Aug. 7 inclusive.

The amount of electricity sold for the half-year ended June 30 is returned at 4,561,897 units, estimated to produce £60,427, against 4,072,810 units, which produced £56,474 for the corresponding period of last year. This return is for the half-year instead of for the last quarter only. Future returns will be made half-yearly

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have been asked to allow a further issue of £616,425 deferred stock of the *National Telephone Co. (Ltd.)* to be quoted.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 17	2,034	+ 371	7	10,449	+ 81
Airdrie	,, 12	250	- 3	27	6,105	- 11
Anglo-Argentine	,, 22	16,533	+ 2,281	29	477,960	+ 48,857
Ashton-under-Lyne Corp	,, 20	415	+ 87	17	6,665	+ 693
Ayr Corporation	,, 13	445	- 9	10	3,720	- 171
	,, 20	981	- 38			
Baker St. & Waterloo Ry.	,, 20	2,320	+ 968	3	7,700	+ 3,462
Barnsley	,, 12	162	+ 2	27	4437	- 16
Barrow	,, 13	316	- 4	27	6651	- 103
Bath Electric Trams, Ltd.	,, 17	935	- 72	29	2 774	- 422
Birkenhead Corporation	,, 21	1,143	- 26	3	3,386	+ 62
Birmingham Corporation	,, 20	5,399	...	16	95,550	...
Birmingham & Mid.	,, 5	817	...	26	20,629	...
Blackburn Corporation	,, 17	1,175	+ 101	‖16	18,116	+ 662
Blackpool Corporation	,, 18	1,792	- 199	15	15,869	- 1,656
Blackpool and Fleetwood	,, 20	1,270	- 42	3	3,098	- 102
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 21	2 582	+ 376	16	36,446	+ 1,319
Bournemouth Corporation	,, 17	1,933	+ 197	¶15	25,881	+ 42
Bradford Corporation	,, 20	5,321	+ 704	16	71,713	+ 233
Brighton Corporation	,, 21	1.081	+ 2	16	14,469	- 1,389
Bristol Trams & Carriage	,, 19	5,573	+ 173	2	11,032	- 170
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 20	1,282	+ 203	16	18,358	- 25
Burton Corporation	,, 21	415	+ 78	16	4,706	- 236
Bury Corporation	...	...	...	...	...	...
Calcutta Tramways Co.	,, 20	R48,780	+ R5,040	2	R95,886	+ R7,897
Camborne-Redruth	...	...	...	...	...	...
Cardiff Corporation	,, 20	2,680	+ 572	16	31746	+ 451
Cavehill	,, 12	156	- 77	27	2,153	- 120
Central London Railway	,, 20	5,138	- 609	3	16,627	- 1,117
Charing C., Euston & H'stead	,, 20	2,585	...	3	7,930	...
Chatham & Dist. Lt. Rys.	,, 18	884	+ 115	‡29	19,914	+ 1,658
City & South London Rly.	,, 21	3,188	+ 689	3	9,624	+ 2,196
City of Birmingham	,, 12	2,873	...	27	75,500	...
Colchester Corporation	,, 17	248	+ 10	3	685	- 32
Cork Electric Trams Co.	,, 18	578	+ 4	29	13,033	- 432
Croydon Corporation	,, 19	1,569	+ 31	16	22,943	- 1,501
Devonport & Dist. Trams	,, 12	511	- 40	27	12,210	- 5
Dover Corporation	,, 20	256	- 40	16	3,679	- 476
Dublin & Lucan Railway	,, 19	172	+ 12	3	392	+ 2
Dublin United	,, 19	8,122	+ 2,321	‡3	20.261	+ 5,261
Dudley Stourbridge	,, 12	904	- 63	27	22,556	- 503
Dundee Corporation	,, 17	1,214	+ 107	9	10,272	+ 407
East Ham Council	,, 20	988	+ 56	16	14,721	- 395
Exeter Corporation	,, 19	392	+ 20	16	5,108	+ 466
Falkirk and District	...	...	...	...	...	...
Gateshead & Dist. Trams	,, 12	1,006	- 268	27	27,129	+ 645
Glasgow Corporation	,, 20	15,638	+ 2,873	7	125,213	- 667
Glossop	,, 20	150	+ 15	29	3,920	+ 58
Gravesend—Northfleet	,, 12	276	+ 3	27	6,361	- 14
Great Northern & City Rly.	,, 20	1,654	+ 25	3	5,110	+ 85
Gt. Northern, Piccadilly, &c.	,, 20	4,115	...	3	12,960	...
Greenock & Port Glasgow	,, 12	639	- 32	27	17,751	- 244
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 12	320	- 50	27	7 398	- 461
Hastings Elec. Trams Co.	,, 18	1,350	+ 530	3	2,561	+ 1,151
Hong Kong	,, 20	$7,453	+ $163	16	$223,145	+ $33,541
Huddersfield	,, 20	1,714	+ 127	16	25,442	+ 910
Hull Corporation	,, 20	2,412	+ 85	16	38,131	+ 1,974
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 17	158	+ 17	16	2,273	+ 158
Ipswich Corporation	...	...	...	...	...	...
Isle of Thanet Co.	,, 20	1,188	+ 45	42	16,859	- 278
Jarrow	,, 12	108	...	27	3,224	...
Keighley Corporation	,, 18	177	+ 20	3	420	+ 15
Kidderminster & District	,, 12	134	- 52	27	2.952	- 165
Kilmarnock Corporation	,, 20	194	+ 11	9	1,560	+ 10
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 18	1,895	+ 866	29	32,887	+ 7,762
Lancashire United	,, 17	1,426	+ 241	29	31,787	+ 9,150
Leamington	,, 12	176	- 77	27	4,085	- 677
Leeds Corporation	,, 20	7,030	+ 772	16	104,709	- 4,228
Leicester Corporation	,, 20	2,353	+ 41	3	6,757	- 208
Leith Corporation	,, 20	690	+ 88	‡10	5 365	+ 71
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 21	1,975	+ 374	3	5,192	+ 473
Liverpool Corporation	,, 13	11,351	- 20	28	298,706	+ 3,370
•London County Council	,, 13	32,160	+ 5 800	15	165,767	+ 69,686
London United	,, 19	8,473	+ 1,191	‡29	177,723	+ 3,923
Lowestoft	,, 20	275	+ 7	12	7,003	+ 927
Maidstone Corporation	,, 20	125	+ 3	16	1,723	- 105
Manchester Corporation	,, 20	16,156	+ 2,340	16	235,571	+ 18,853
Mersey Railway	,, 20	1,726	+ 12	3	5,597	+ 603
Merthyr	,, 12	213	+ 5	27	5,615	+ 2?0
Metropolitan Dist. Railway	,, 21	7,633	- 137	3	23,972	- 10
Metropolitan Elec. Trams	,, 12	5,265	+ 1,392	27	118,707	+ 27,204
Middleton	,, 13	382	- 49	27	9,320	- 214
Nelson Corporation	,, 20	168	+ 11	17	2,461	+ 7
Newcastle-on-Tyne Corp.	,, 20	4,126	+ 251	16	67,146	+ 538
Newport (Mon.)	,, 20	739	+ 83	16	11,678	+ 1,512
Northampton Corporation	,, 19	494	+ 5	‡16	6,950	- 311
Oldham, Ashton & Hyde	,, 12	608	- 23	27	16,157	+ 721
Oldham Corporation	,, 21	2,261	+ 311	17	32,898	+ 2,552
Perth (N.B.) Corporation	,, 17	191	+ 16	9	1,514	+ 33
Perth (W.A.) Elec. Trams	,, 19	1,380	- 115	29	41,561	- 1,468
Peterborough	,, 12	238	- 21	27	3,260	- 118
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 20	2,114	+ 45	16	31,704	- 1,315
Potteries	,, 12	1,838	+ 97	27	50,836	+ 1,267
Preston Corporation	,, 17	795	+ 31	16	12,141	+ 111
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 18	601	+ 98	‡16	9,262	+ 1,387
Rothesay	,, 12	459	- 61	27	3,862	- 503
Salford Corporation	,, 22	5,034	+ 323	16	76,056	+ 1,566
Sheerness	,, 10	63	- 6	27	1,470	- 38
Sheffield Corporation	,, 21	5,880	+ 431	17	93,924	+ 4,063
Singapore Trams	,, 20	$8,908	+ $1,105	16	$153,491	+ $20,092

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	July 17	507	- 9	16	5,825	- 354
South Metropolitan	,, 12	860	+ 341	27	20,271	+ 2,105
Southport Tramways	,, 12	390	+ 13	27	7,490	- 488
South Staffs	,, 12	886	+ 31	27	24,076	+ 1,702
Stalyb'dge, Hyde, &c., Jt. Bd	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 21	1,601	+ 41	16	22,908	- 120
Sunderland and District	,, 17	546	+ 121	29	12,573	+ 1,598
Swansea Trams	,, 12	970	+ 51	27	22,859	+ 689
Swindon Corporation	,, 17	154	+ 6	...	...	...
Taunton	,, 12	44	- 5	27	1,120	- 84
Tynemouth and District	,, 12	313	- 74	27	5,610	- 810
Tyneside Trams Co.	,, 17	507	+ 75	29	13,229	+ 630
Victoria, Elec. Supply Co. of	June 16	668	+ 15	12	10,540	+ 957
Wallasey District Council	July 20	1,019	+ 109	17	13,476	+ 275
Walsall Corporation	...	...	...	...	...	...
Warrington Corporation	,, 18	387	+ 16	16	6,006	+ 230
West Ham Corporation	,, 18	2,480	+ 128	16	38,112	+ 1,059
Weston-super-Mare	,, 10	225	- 104	27	2,323	- 397
Wolverhampton Co.	,, 12	513	+ 30	27	12,054	+ 540
Wolverhampton Corpn.	,, 17	983	+ 78	26	13,233	...
*Worcester	,, 12	309	- 25	27	7,227	+ 220
Wrexham	,, 13	98	- 7	27	2,691	- 40
Yorkshire W.R. Trams	,, 21	1,222	+ 364	29	32,448	...
Yorkshire Woollen District.	,, 12	961	+ 22	27	25,681	+ 1,397

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., July 24.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to July 24. Highest.	Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	Anglo-Argentine Ord. Shares	8½—8¾	4 12 6	Ap, Oct	8⅝	8⅜
5	2/9	Do. 5½ per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	6⅛	6⅛
St.	6¾	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5¾	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	2½—3⅛	3 2 6	May ..	3⅜	3⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	My, Nv	4⅞	4¾
St.	4¼%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	97⅛	..
St.	7%	British Columbia El. Ry. Df. Ord.	123 —123	5 8 6	Mr, Spt	..	..
St.	4%	Do. Pref. Ord. Stock	108 —112	4 8 9	My, Nv	111½	..
St.	5%	† Do. 5% Cum. Perp. Pref. Stock	101 —104	4 16 0	Ja, Jul	102½	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	..	..
100	4½%	† Do. Vancouver Power Debs.	101 —103	4 7 3	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4⅛ - 4⅜	8 11 0	Ap, Oct	4⅛	4⅛
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4¾—5¼	5 14 0	Ap, Oct	..	..
5	3/0	Do. "B"	4¾—5¼	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 —97	5 3 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 —103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	101 —105	5 14 0	Ap, Oct	1 2½	101
5	4/6	Calcutta Tramways (1 to 137,610)	7⅞—7⅞	5 5 0	Mr, Spt	7⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ - 5⅜	4 13 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —106	4 5 0	Ja, Jul	104⅜	..
St.	..	Cape Electric Tram Shares	.. ..	.. ..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 — 98	5 2 0	My, Nv	..	..
1	5%	†Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	83 - 88	5 14 0	Fb, Aug	83	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 —82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅛	3 16 0	July .	1⅛	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	4 10 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb	95 - 98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —99	5 1 0	Ja, Jul	96	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	..	..
St	4%	Perth E. Trams. 1st Mt. Db. Stock	100 — 104	4 13 0	Ja, Jul	..	..
..	6%	Sao Paulo Tramway, Light & Power Co. $100 Stock	113 - 122	6 7 0	..	1 0½	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92½—94½	5 6 0	Ju, Dec	94⅜	94
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½- 5½	5 14 0	Mr, Spt	..	..
10	3/1⅛	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8⅜	5 15 0	..	8	..
St.	4¼%	Do. 4½ per Cent. Deb. Stk. (red.)	95 - 97	4 12 9	Ja, Jul	96½	96
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6¾ 7⅜	5 3 3	Ap, Oct	..	..
5	2/3	Do. (80,001 to 140,000)	6½—7¼	.. ..	..	7⅛	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 — 53	4 11 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½—2¾	.. ..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	8 ½—9½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ 96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —1 6	5 13 0	Ja, Jul	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	96	..
1	0/3	River Plate Electricity Co. Ord.	⅝ - ¾	3 6 9	April ..	..	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	⅞—1	6 0 0	May	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 —98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101¾	4 19 0	Ja, Jul	1 ¼	100

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 24.	RATE % YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 24. High-est.	Low-est.
		ELECTRICITY SUPPLY.					
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 – 11	6 6 0	Mar, Sept,	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9¾ – 10¼	4 8 0	Feb, Aug	10⅛	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ..	1 ¼ – 10⅜	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	£9 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	£8 – 100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞ – 8⅞	5 14 6	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	7⅛ – 7⅜	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	£9 – 102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W.End & City) El.Sup.Co.	3½ – 4	6 5 0	Feb, Aug	4	..
5	2/3	Do 4½ per Cent. Pref.	4⅛ – 4⅜	5 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 – 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	8⅜ – 8¾	6 9 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	8½ – 4¼	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 104	4 6 6	June, Dec	10⅜	..
10	5/0	†City of London Electric Lighting Ord...	9 – 9½	6 6 0	Feb, Aug	9	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11½ – 12½	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.),.....	120 – 123	4 1 3	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 – 99	4 11 0	Jan, July	98⅛	17⅛
5	5%	County of Durham Elec. P.D. Ord.	3¾ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 4⅝	5 4 11	April, Oct	..	..
10	6/0	County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	7⅜	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10½ – 11½	5 4 0	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)...	106 – 109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	94 – 97	4 12 6	May, Nov	£5	94
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜ – 5⅜	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅜	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	98 – 101	4 9 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ – 7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ – 9¼	5 5 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½ – 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 – 99	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	100 – 103	3 17 9	April, Oct	..	..
3	2/4⅔	London Electric Supply Ord.	1⅞ – 2⅛	5 12 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅞ – 5⅛	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 – 96	4 3 8	Jan, July	98⅛	93
5	4/0	Metropolitan Electric Sup. Ord.	5⅜ – 6⅛	6 8 0	April, Oct	6⅛	6 1/16
5	6/3	Do. 4½ per Cent. Cum. Pref.	4⅞ – 5⅛	4 9 0	Jan, July	5⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 – 1 7	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	78 – 81	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 – £8⅞	4 11 9	June, Dec	96⅛	96
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9⅝ – 9¾	4 15 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	93 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6¾ – 7	5 16 4	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	7⅛ – 5½	4 16 0	Feb, Aug	..	..
100	4%	† Do. 4 per Cent. Mort. Deb. red. 1907.	97 – £8	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	! Do. 4½ per Cent. Deb.	97 – £9	4 11 10	Jan, July	..	..
10	£/0	†Notting Hill Electric Ord.....	17½ – 18⅛	6 0 0	March ..	..	..
5	4/6	Oxford Electric Ord.	6⅜ – 6½	5 12 0	March ..	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock	£5 – 97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	8 – 8⅛	5 17 6	Feb, Aug	8 1/16	..
5	3/6	Do. 7 per Cent. Pref.	6⅛ – 7⅛	4 18 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.)	£6 – 91	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	⅜ – 1½	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	73 – 77	5 4 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	1⅜ – 2¼	7 7 0	April	2⅜	2 1/16
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜ – ⅝	3 6 9	..	..	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 – 103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅞ – 2¼	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
5	6/6	Westminster Elec. Sup. Ord.	9¼ – 9⅝	6 8 0	Mar, Sept	9⅝	9⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 2 0	Jan, July	5 1/16	5⅛
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	†Baker St. & Waterloo 4% Perp. Db. St.	£8 – £3	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ – ⅝	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	1⅛ – 1⅜	4 17 6	Jan, July	1⅜	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 99	4 11 0	April, Oct	£4⅛	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 – £7	4 13 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14½ – 14¾	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	£4 – 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 – 99	4 0 0	Feb, Aug	5⅞	..
10	..	British Electric Traction Ord.....	2⅝ – 3	..	June, Dec	2⅞	..
10	6/0	Do. 6 per Cent. Cum. Pref.....	7½ – 7¾	7 15 0	Feb, Aug	8	7⅞
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 103	4 17 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	£8 – 81	5 11 0	May, Nov	71⅞	..
St.	4%	Central London Ordinary Stock.....	£3 – 75	5 6 9	Feb, Aug	7⅝	..
St.	4%	Do. 4 per Cent. Pref. Stock	£2 – 94	4 5 0	Feb, Aug	93⅜	93
St.	4%	Do. Deferred Stock	£3 – 56	7 2 8	Feb	£4	55⅜
100	4%	† Do. 4 per Cent. Debs.	104 – 105	3 16 0	Jan, July	..	..
St.	4%	Charing X. Euston & Hmpstd Per. Db Stk.	81 – £4	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	£8 – 101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ..	47 – 49	4 1 6	Feb, Aug	5⅛	4⅞
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 – 121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent, Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½ – 14½	4 2 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	13 – 14	4 5 9	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	2 – 2½	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Lb. St	98 – 101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	11½ – 12½	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10½ – 11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 – £9	4 10 11	Jan, July	£5	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1½	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	£6 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5 Prior Lien Db. St.	98 – £6	5 4 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅛ – 1⅜	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6⅞ – 7⅛	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 – 86	4 13 0	Jan, July	..	..
10	5/0	London United Trams. 5% Cum. Pref. ...	7⅜ – 7⅝	5 14 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 88	4 11 0	Jan, July	..	..
St.	..	Mersey Con. Old Stock	9 – 4	—	Feb, Aug.	..	..
St.	..	Do. 8 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	3/16 – 5/16	—	April ..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3/16 – 5/16	5 3 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜ – 1⅜	..	May	..	..
1	8/0	Potteries Electric Traction Ord.	7/16 – 9/16	7 3 0	April, Oct	..	..
1	5%	Do. 5 per Cent. Cum. Pref.	7/16 – 9/16	6 3 0	Feb, Aug	9/16	5
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 – £8	4 11 9	May, Nov	..	..
1	3·56d	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	3/16 – 1 3/16	5 16 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£0 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	£4 – £8	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	£4 – £7	7 9 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord. ...	1 – 1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3/16 – 5/16	..	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	£5 – 91	4 19 0	Jan, July	£3½	..

SHARE	LAST DIVIDEND	NAME.	Price Wed., July 24.	RATE % YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 24. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	5/16 – 7/16	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜ – ½	8 0 0	April, Oct	..	..
1	2/4⅔	Babcock & Wilcox Ord.	3⅞ – 4⅛	6 1 6	April, Oct	4	3⅞
1	0/7½	Do. Pref.	1⅜ – 1⅝	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅞ – 7⅛	6 18 0	July, Feb	7 1/16	..
5	3/0	Do. 6 per Cent. Pref.	5⅛ – 6⅛	4 16 0	Jan, July	6	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 104	4 6 6	Jan, July	103	102½
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	87 – 91	4 19 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£9 – 64	6 5 0	Jan, July	..	..
5	..	Brush Electrical Engineering	⅜ – ⅝	..	March ..	⅝	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅝ – 1⅛	5 7 0	Mar, Sept	1⅛	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 – 74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9½ – 10⅛	7 2 6	Jan, July	10⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅝ – 5⅞	4 9 0	Jan, July	5⅞	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105⅝ – 107½	4 3 6	Nov, May	..	..
1	0/9⅔	Castner-Kellner Alkali Co.	1⅝ – 1⅞	5 12 6	May, Nov	1⅝	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 – 102	4 8 0	Feb. Aug	99⅜	..
1	1/2⅔	Chadburn's (Ship) Telegraph Ord.	1⅝ – 1⅞	7 10 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅞ – 1⅞	5 4 0	April, Oct	..	..
3	1/6	*Crompton & Co. (Nos. 1 to 64,000).....	1½ – 2⅝	3 9 0	Jan, July	2⅜	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	93⅛ – 96⅜	5 3 6	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝ – 1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1½	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" £h.) (£3 ½ d.)	1⅜ – 1⅝	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼ – 2⅝	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (red.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅛ – 1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1 – 2	..	May, Nov	2⅛	..
St.	4½%	† Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	77	..
2	..	Electric Construction Co.....	1/16 – 1/8	..	Jan, July	..	..
2	2/6⅔	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	8 18 0	July	..	..
St.	4%	† Do. 4 per Cent. Perp. 1st Mort. Deb.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 8⅛	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅜ – 12⅜	6 0 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5⅛	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½ – 107½	4 3 6	Mar, Sept	106	1 5⅛
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	15 – 16	6 5 0	Feb, Aug	15	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April. Oct	..	..
1	1/2½	Richardsons, Westgarth & Co., Ltd. Ord.	3/4 – 1⅛	7 6 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞ – 1	6 0 0	May, Nov	1 1/16	..
St.	4½%	To. 4½ per Cent. Perp. Deb. Stock ...	94 – £7	4 18 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	24/0	Telegraph Construction & Maintenance	32 – 33	5 9 6	Mar, July	31⅛	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	£9 – 102	3 18 3	Jan, July	..	..
1	2/0	Vickers, Sons & Maxim, Ltd., Ord.	2 3/16 – 2 7/16	5 16 0	..	2 5/16	2 1/16
1	0/6	Do. 5 per Cent. non-Cum. Preference	1 3/16 – 1 5/16	4 1 0	..	1 5/16	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	112 – 115	4 7 0	..	114	113½
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 – 104	3 17 0	June, Dec	1 2⅜	102½
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	1 1⅛ – 107⅛	4 4 0	June, Dec	106⅜	..
10	8/0	†J. G. White & Co. 6 per Cent. Cum. Prf. xd and bonus	£1 – £3	6 8 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1¼ – 1⅜	..	Apr, Oct	..	..
£	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	£¼ – 4	..	Apr, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3½	—	June, Dec	..	—
100	5%	Do. 5 per Cent. Debs. (red.)	85 – 88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	£3 – 66	5 18 0	F.My.Ag.N	..	..
St.	30/0	Do. Preferred	109 – 110	5 9 0	F.My.Ag.N	110	109
St.	12½%	Do. Deferred	£6 – £7	8 8 0	F.My.Ag.N	£1	2 1/16
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 – 94	4 4 6	Jn.Ap.Jy.O	..	..
10	5/0	Cuba Submarine Ord.....	7⅛ – 8⅛	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞ – 16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅞ – 3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	8⅝ – 9⅛	5 8 0	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝ – 103⅜	4 7 8	Jan, July	..	..
20	4/0	Direct United States Cable	15⅛ – 16	5 16 6	Ja.Ap.Jy.O	15⅞	15⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (red.)	98⅛ – 100⅜	4 9 6	June, Dec	..	..
St.	25/0	†Eastern Ordinary	135 – 138	5 1 6	Ja.Ap.Jy.O	137⅛	136⅛
St.	17/6	† Do. 3½ per Cent. Pref. Stock	88 – 90	3 17 9	Ja.Ap.Jy.O	89⅛	88
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 – 105	3 16 6	May, Nov	..	..
10	2/6	†Eastern Extension	13 3/16 – 18 7/16	5 4 0	Ja.Ap.Jy.O	13 5/16	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock	104 – 106	3 15 6	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	99 – 102	3 18 6	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	99⅛ – 100 4/8	3 19 6	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71...	34 – 36	6 19 0	Jan, July	37⅛	34⅛
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.	98½ – 100⅛	4 9 6	June, Dec	..	..
25	£2/6	Indo-European	56 – £8	5 12 0	May, Nov	..	..
100	$1	Mackay Companies Common	6⅜ – 6⅝	5 18 6	Jan, July	..	..
100	$1	Do. Preference	67 – 69	5 16 0	Ja.Ap.Jy.O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅝ – ¾	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Debs. (red.)	£9⅛ – 100⅜	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10⅜	8 16 0	June, Dec	..	..
2½	1/8	West Coast of America	1⅛ – 1⅜	3 2 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 – 101	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅛ – ⅜	..	May, Nov	⅜	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅝	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6⅜ – 7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	100 – 103	4 17 6	Jan, July	..	..
10	3/0	Western Telegraph	13⅜ – 14	5 0 0	Mr.Jn.O.D	13½	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 – 92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 – 104	4 16 0	Mar, Sept	..	..
5	3 0	Chili Telephone	6⅝ – 7⅛	5 11 0	August ..	..	..
1	0/4⅓	Monte Video Telephone Ord.	¾ – 1 1/16	4 14 0	Nov	⅞	..
1	0/6	Do. 5 per Cent. Pref.	¾ – 1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	109 – 111	5 8 0	Feb, Aug	109⅜	109
St.	5½%	Do. Def. Stock.....	106½ – 109⅛	5 0 6	Feb, Aug	109⅛	108
10	£/0	Do. 6 per Cent. Cum. 1st Pref.	13½ – 13⅝	4 9 0	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	1⅛	10⅜
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛ – 5⅜	4 9 0	Feb, Aug	5⅜	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	95⅛ – 96⅛	3 12 6	June, Dec	96⅛	96
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 6	Jan, July	102	100⅜
1	£/0	Oriental	1⅜ – 1⅝	5 2 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜ – 1⅝	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	90 – 96	4 3 3	Jan, July	..	..
St	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	18 – 101	4 9 0	Jan. July	..	..
1	5/0	United River Plate.....	7 – 7½	5 6 6	July	7⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5¼	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	£/0	Elec. & Gen. Investment 6% Cum. Pref.	5⅝ – 6	6 6 3	Jan, July	..	..
10	6 2	Globe Telegraph & Trust.....	10⅝ – 11	5 0 0	Ja.Ap.Jy.O	11	10⅜
10	4/0	Do. 6 per Cent. Pref.....	13⅛ – 13⅜	4 8 0	Ja.Ap.Jy.O	13 1/16	12⅝
100	6%	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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Combinations of Power Sources.

IN countries, such as Great Britain, where coal is plentiful and railway service efficient, it has become the practice to generate electric power by means of steam. The steam boiler and prime mover equipment of a modern electric power house is a vast improvement on that employed in the early eighties. In fact, such a marked advance with steam units has been effected that power generation at and transmission from the coalfields is now no longer talked about; it is being done both here and abroad. While we in this country rely entirely on steam, in other places, where coal supplies are irregular and freight traffic spasmodic, the steam plant is supplemented by water power and a constant electric supply is, by the combination, maintained. The situation is more often than not reversed—that is, the water power is inadequate during the whole year and must, during regular shortage or times of drought, be supplemented by steam. The many steam-hydro-electric plants in operation appear to operate satisfactorily, and no difficulty seems to be encountered in giving a constant service. Sometimes the stand-by plant is gas-engine driven, and this combination also has proved valuable and efficient. The point to be observed is that combined plants are justified where the local conditions admit of nothing else. Rather than be without an electric service, or give a supply during part of the year only, a combination of prime movers is desirable.

We have already referred to the most usual power combinations of which actual examples exist, but cannot trace any instance in which wind and water have been used in conjunction. These power sources lend themselves to use in combination more frequently than not, and probably only a preliminary investigation would be needed to furnish evidence in support of their use. We think this statement applies more to this country than to any other. The coast line is most extensive, there are many rivers running east and west into the sea, and most of the estuaries are contiguous with low-lying country which is wind-swept the greater part of the year. The wind itself could not be entirely depended upon, but it could with advantage be supplemented by a hydraulic power plant utilising the rise and fall of the tide in the adjacent river. The elements for such a scheme are all available: standard windmills, water turbines and dynamo electric machinery, each and all complete as to design and of proved efficiency. Transmission inland is probably the only item which might need more than ordinary consideration. The distances required would not, however, be great, and would present no new problems in transmission of electrical energy. The operation of a number of stations in conjunction would be one of the chief factors in this portion of the scheme.

The matter is not one for private enterprise; at least it does not appear so on the surface. If plans for such an undertaking materialised they would naturally require to be of the broadest possible character, as the scheme might present a possible solution of a difficulty which while yet many years ahead will certainly come up for consideration: we refer to the period when coal shortage will remove the possibility of making use of steam or gas as power agents for electric power generation. In Great Britain this probability will require to be taken into account in view of the serious consequences involved. Industries dependent hitherto upon steam have been operating under electric power conditions for some time, but the electrical energy is now, and will be to a greater extent later, dependent on coal, so that the failure of the supply of this product would compel attention to other natural power sources which could be tapped to maintain the service. Wind and water combined would probably be the only undeveloped power sources remaining to be utilised.

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The Electric Equipment of a Paint Factory.

THE list of industries in which electric motors have displaced other power agents for machinery operations is constantly being added to. It is, in fact, difficult to indicate in what branch of industrial effort these motors may not appear, and with a like degree of success as has so far marked their application to the manufacturing arts. The great majority of mechanisms requisitioned for productive purposes are based in principle upon rotary motion, a circumstance which seriously handicaps reciprocating power agents in comparison with a purely rotatory machine. Many instances could be given of industrial appliances which consist of a number of simple rotating members, but for the purpose of the present article the machinery in a modern paint works may be taken as typical.

Into the manufacture of paint on a large scale numerous devices are introduced, which require a system of driving affording regularity and control of speed. Paint mixers, rollers and mills need to be run at a variety of speeds, but each and all of these must be constant and steady when once fixed. The differences in speed required can be more conveniently carried out with a variable speed electric motor than with stepped pulleys or speed cones. This, combined with the fact that both mills, rollers and mixers are rotary machines, fully justifies the use of electric power in the paint-making industry.

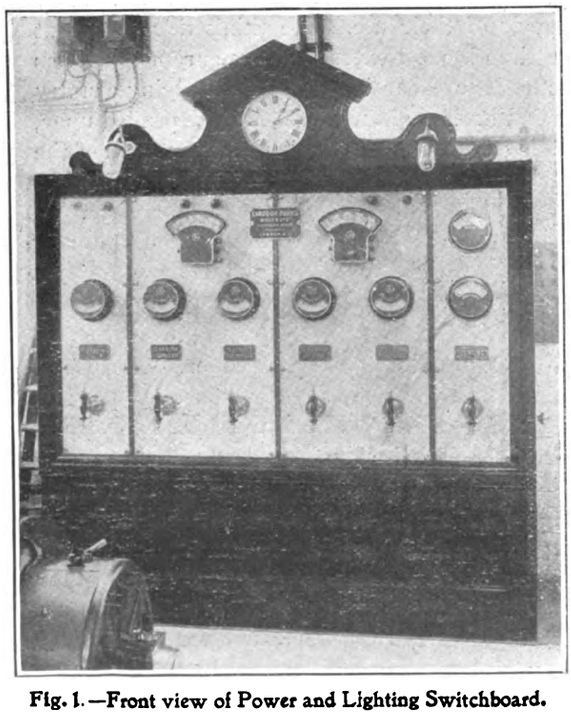

Fig. 1.—Front view of Power and Lighting Switchboard.

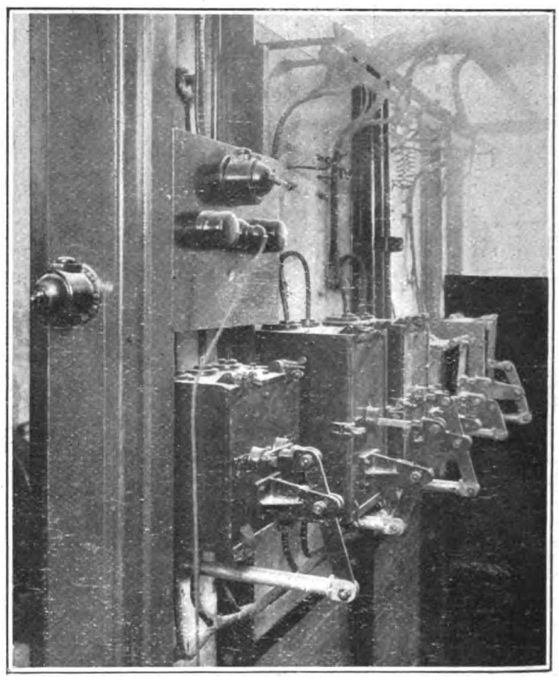

Fig. 2.—Rear view of Power and Lighting Switchboard.

An example of electric driving, which may be regarded as representative of modern practice in paint works, has recently been installed and put into operation in the works of the Suter Hartmann & Rahtjens Composition Co. (Ltd.) at Silvertown, Essex. The staple product of this company is an anti-fouling composition for ships' bottoms which is widely known and used. It has been manufactured in large quantities for many years past in extensive works driven by steam, but as the demand has outgrown the supply additional plant was required to keep pace with it. A new building was erected on a site adjoining the existing works,

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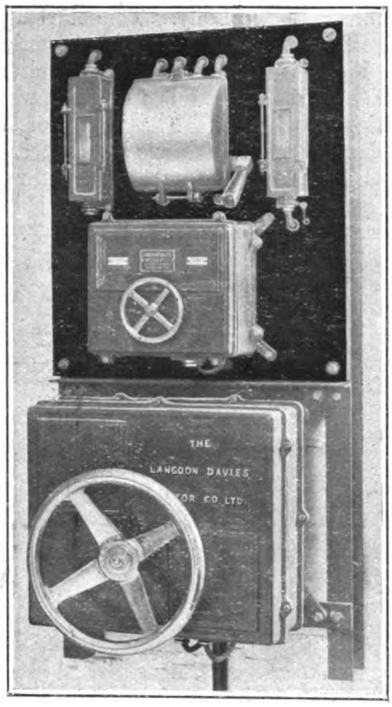

Fig. 3.—Gas-tight Motor Starting Panel, with Main Switch, Fuses, and Speed Regulator.

and modern machinery, driven electrically, was recently installed by the Langdon-Davies Motor Co., for the manufacture of the composition.

It may be noted here that the operating conditions of the works require the complete enclosure of all spark-producing portions of the electrical circuit, so that fuses, switches and motors must be absolutely enclosed. This stipulation has been complied with throughout the entire installation.

The conductors, from the insulators on the outside wall of the new factory, are steel-armoured V.I.R. cables, cleated to the brickwork, and they enter the building at a point on the ground floor. After passing through two meters the cables are run to the main switchboard, which controls the lighting and power circuits. Front and rear views of this are given in Figs. 1 and 2. The board is built of iron framework and marble slabs, the front being faced with polished teak, and all switch handles and instrument cases are nickelled and give the gear a handsome appearance. It will be noticed that for the motor circuits separate switches and instruments are provided, the latter being calibrated in horse-power for convenient reading. The main switches are the Berry enclosed pattern, operated from the front of the board by pull-rod and lever. These switch fuses are clearly shown in the rear view of the board. A main ammeter and voltmeter complete the instruments, and a useful item is a diagram of all the connections in celluloid on the left panel of the board.

The lighting and power cables are run in steel conduit throughout the building. The motors are controlled from separate ironclad switch panels which conform to the stringent requirements as to enclosing of the contacts.

Fig. 3 depicts one of these panels complete. At the top are d.p. switch, two s.p. enclosed fuses and shunt regulator, all mounted on a stout slate panel. Below these is the main motor starter, also enclosed and bolted to iron supports across the two main girders. The cables and handwheel spindles pass through stuffing boxes in the different pieces of apparatus to render the gear completely gas-tight.

The power installation is arranged for group driving, and at present a number of both large and small motors are in use. The switchboard, however, has controlling gear for additional motors. A view of one of the floors with one of the motors and machinery is shown in Fig. 4. The

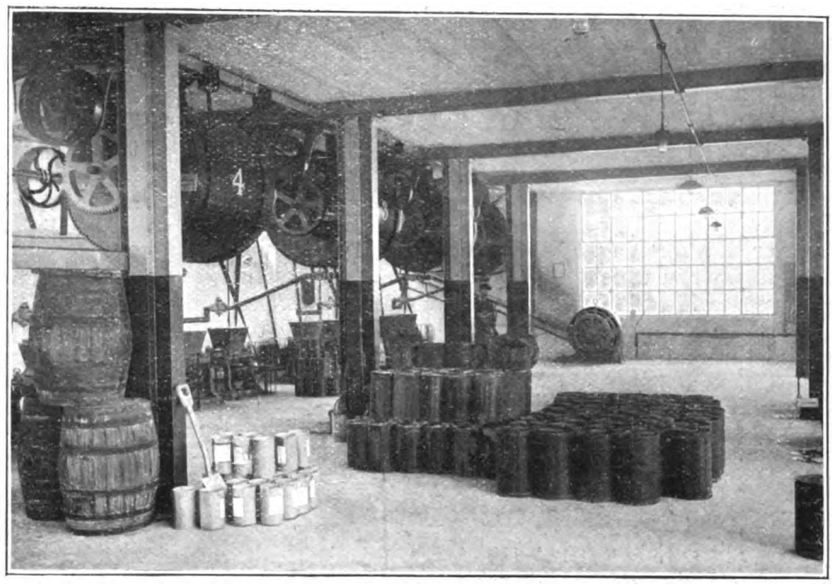

Fig. 4.—Paint Mills, Mixers and Motor Equipment on first floor.

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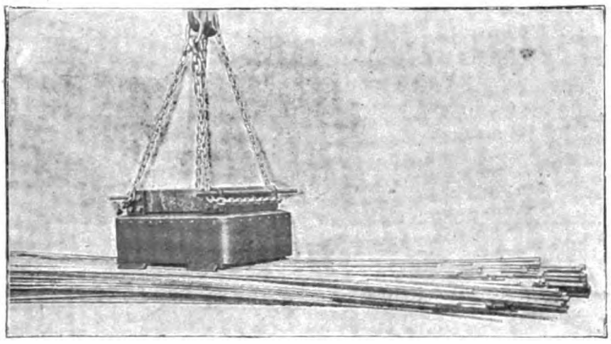

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motor shown in Fig. 5 is a 35 B.H.P. motor. This indicates the manner in which the machine is completely enclosed. The speed is variable between 340 and 400 revs. per min.

In the laboratories small motors are used to drive miniature mills and mixers for experimental purposes. Figs. 6 and 7 depict two of these machines. The first

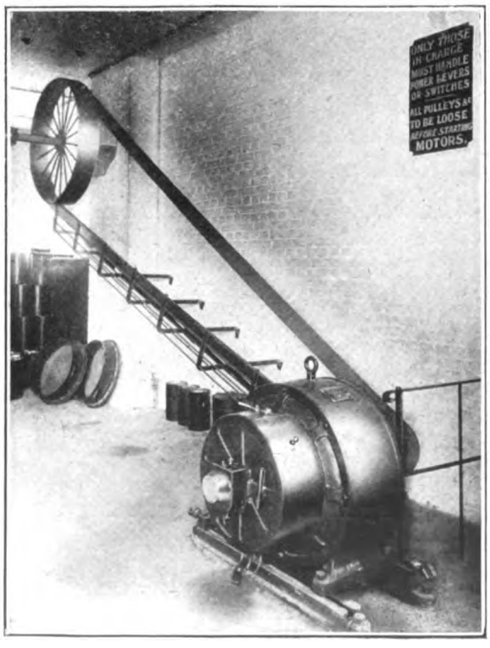

Fig. 5.—35 H.P. Enclosed Motor driving Mixers on ground floor.

mentioned is a ½ H.P. motor geared and belted to a mill and rotary mixer respectively. The starting switch and resistance are fixed above the bench conveniently close to the motor. Fig. 7 is a view in the main chemical laboratory, in which a motor has been put down for driving various testing machinery. The speed of the motor is reduced to that of the machinery by counter-shafting and belts. In addition to the number of motors used for the

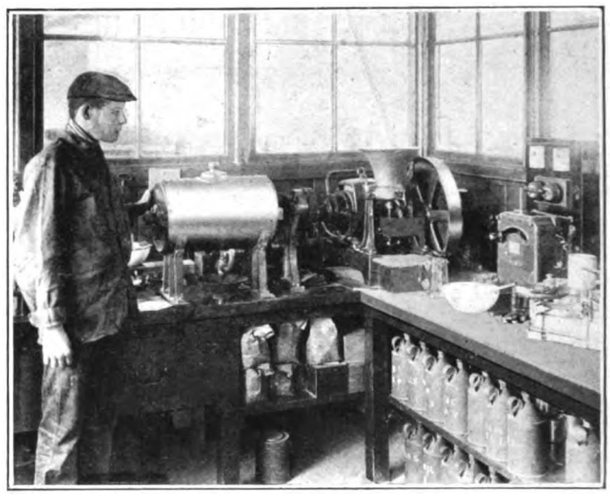

Fig. 6.—Mill and Mixer in Test Room, driven by ½ H.P. Motor.

paint machinery proper, a 3-ton hoist is fixed to the first floor of the new paint works, and is worm-driven by a 17 H.P. motor mounted on the same bedplate as the hoisting drum. The hoisting speed at full load is 120 ft. per minute, and the motor speed is 660 revs. per min. The hoist serves both the first and second floors, the rope sheave being fixed at the top of the building.

The lighting installation calls for no special comment, except, perhaps, that the fittings are double enclosed to

Fig. 7.—Chemical Laboratory, with equipment of Paint Mills driven by 3 H.P. Motor.

exclude gas from the incandescent lamps. There are about 250 lights supplied at 220 volts from either side of the three-wire network.

The installation is an interesting example of up-to-date electric equipment of a factory, and has been entirely carried out by the Langdon-Davies Motor Co., Ltd., who specialise in motor construction and power installations.

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Industrial Electrical Undertakings.—VII.

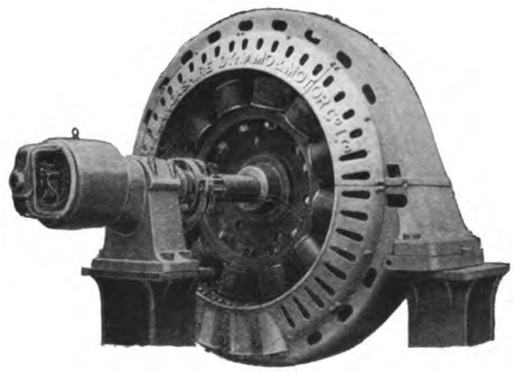
The Lancashire Dynamo & Motor Co., Ltd.

THE success of electric power applications to industry is almost entirely dependent upon the design and construction of efficient dynamo electric machinery. The power specialist must rely on the motor and the power supplier has equally to place confidence in the dynamo. In each case the responsibility rests with the makers of these, and when the widening sphere of electrical utilities is considered this responsibility is far from being light. The history of generator and motor production supplies evidence in support of two important facts—that specialisation has introduced the most efficient machines, and that in both old and new industries electric power applications have been fully justified by results.

The records of the Lancashire Dynamo & Motor Co. support these two facts in every particular. As dynamo and motor specialists for the past eight years they advanced both organisation and product to a point which would appear to admit of little further improvement. Standardisation has been kept prominently in view and wherever possible has been practised. The shops were laid down for the production of both standard and special types of generators, motors and allied machines and a works system evolved which gave the most economical results.

Standard Vertical Pattern D.C. Motor for special work.

Since their erection in 1899 the shops in Trafford Park have been extended considerably, and they now give employment to upwards of 800 men. The works are served by the railway and the Manchester Ship Canal, both of which afford excellent traffic facilities. Electric power, purchased from the Trafford Park Power Supply Co., is used throughout the shops, and arc and incandescent lamps are employed for lighting both shops and offices. The company early recognised that its business was not electricity production and elected to obtain its power from outside rather than generate on the works. This example might well be followed elsewhere, as might also the practice of the company in driving its machine tools by individual motors. Unlike many makers of nostrums the firm has exemplified its faith in its own products by the wholehearted manner in which it has adopted the electric drive in its shops.



300 Kw. Three-Phase Alternator with Direct-Coupled Exciter.

The works are divided into four main sections: the machine department, the winding department, the assembling department and the testing department. The machine shop comprises a large main aisle, two bays and a wide

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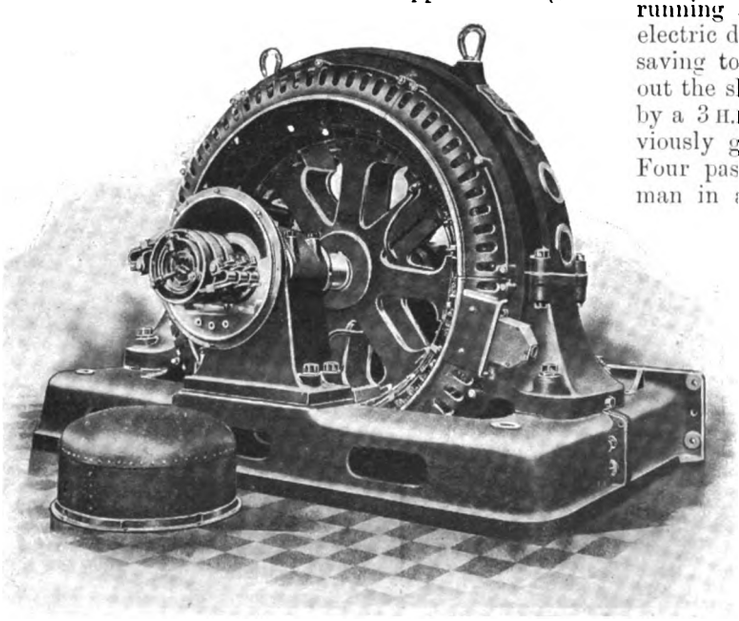
gallery extending round three of the walls. There are many fine examples of machine tools in this shop, notably boring mills, radial drills, multiple drills, planers and large lathes. These are mostly driven by separate motors, which, in the main, are placed to form an integral part of the tool, a method which greatly economises space. To a number of these machines the Renold chain has been applied during the last year or two, with very satisfactory results. The chain drive is fitted between the motor pinion and the first reduction shaft, and high speeds are the rule. Among the lathes is one of 14 in. centres, driven by a 15 H.P. shunt motor through a 3 in. Renold chain. The speed of this machine can be varied by shunt regulation alone between 500 and 1,500 revs. per min.



400 H.P. Induction Motor with Enclosed Slip Rings for Colliery and other Work.

An interesting instance of the motor drive is a side planer, for planing motor cases and similar work. The motor is direct coupled to the screwed shaft operating the table, and is reversed at each reversal of the table. Once started the motor continues to reverse at the end of each stroke of the table. On approaching the end of its travel in each direction the table moves over tappet levers connected by rods to a reversing switch operating a solenoid controller. A double tool-holder is used so that cutting takes place on each stroke. Another large planer is operated by a 25 H.P. motor, the table measuring 18 ft. by 6 ft., and the drive is by belt. In the same shop are several large boring mills, one of these, 20 ft. diameter, being gear-driven by a 15 H.P. motor. For drilling motor cases and end plates the multiple drill is a handy tool, and three of these are in use. One is a six-spindle machine, driven through gearing by a 3 H.P. motor, and the other an eight-spindle size, operated by a 15 H.P. variable speed motor. The feature of this machine is the mounting of the motor directly above the multiple drill box. In another case a vertical spindle motor is used mounted on the top of the tool. This is a departure initiated in the works and one which conduces to economy in space and the reduction of gearing losses. The drill table in this case is traversed by a 1 H.P. motor which proves very useful when heavy weights—which are frequently handled—are placed under the drills. Another interesting tool is a milling cutter in which both the cutters and the table are driven by separate motors. The cutter spindle is operated by gearing by a 6 H.P. motor, and the table is moved by a 1¼ H.P. machine. Both these motors are mounted as part of the tool base. Adjoining this tool is a machine for tapping the holes in pole-pieces for the reception of the screws holding on the laminated tips. The tool resembles a radial drill, and only differs from it in the special tap holder employed. This is fitted with a powerful spring which absorbs shocks during tapping operations. The motor used is a 3½ H.P. machine running at 500 revs. per min. A number of portable electric drills are also used in this shop. A handy labour-saving tool is an electrically-driven broacher for opening out the slots in rotor and armature cores, which is driven by a 3 H.P. motor. These tools save much of the time previously given up to hand-filing of the slots referred to. Four passes are made with the tools provided, and the man in attendance cannot make a mistake, as only the tools for the particular job are served out to him.

In the machine shop the bulk of the work required to be done on motor cases, armature shafts, end plates, pole pieces, core plates, &c., is carried out. Jigs are used almost everywhere for drilling purposes, as they tend to eliminate errors which usually occur when the skill of the workman is depended upon.

The system of gauges is also very complete, limit gauges being in use which are checked against an exceedingly accurate standard. This system ensures interchangeability between parts of standard machines in the same class and, where a power installation is equipped uniformly with "Lancashire" motors, is likely to prove

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valuable in cases of emergency. The number of spare parts carried can also be made smaller.

The general routine of the machine department is supplemented with grinders, slotting machines, metal saws and other tools, mostly driven from overhead shafting belted to a large motor. The shop is served by large overhead electric travelling cranes. Twelve cranes are in use in the works, these including one 20-ton, three 10-ton and eight 5-ton, all these being equipped with three motors. The gallery is set aside for small work on brush-holders and light fittings. At right angles to the machine shop is a wide shop divided into six bays by columns supporting the roof principal. This construction provides a roomy and well-lighted shop with freedom of access between the bays. In this part of the works sections are set apart for field and armature coil winding, commutator building and turning, armature winding, mica iusulation making, and the general assembling of machines from parts furnished by every department. The field coil winders are small machines driven by $1\frac{1}{4}$ H.P. motors running at 750 revs. per min. and driving through two discs at right angles to each other. The movement of the smaller of these, which is on the motor shaft, towards the centre of the larger disc, gives the necessary speed variation.

In the armature coil winding department taping machines are in use which save much valuable time and enable the material to be laid on more evenly. The ends of the coils are tinned previous to their insertion in the commutator bars. When assembled in position the sweating in of these ends is performed at one operation. The complete armature and commutator, of all but very large machines, is raised vertically and the parts to be soldered are dipped into an annular bath of molten metal, kept hot by a gas ring. This is another labour and time-saving device in use at the works. In the same shop is a vacuum drier for coils of all kinds, and also a vacuum impregnating tank in which varnish is forced into the interstices of coils and windings, subsequent to the extraction of moisture. The vacuum and force pumps of this apparatus are electrically driven.

The assembly of the various parts to form complete machines is regulated by a stores, into which all items of work as completed are sent. These are again delivered by the stores to the assembly benches. Complete check can be kept upon the progress of all work done and each department can be treated as a separate unit. Naturally in works of the size and importance of those we are describ-

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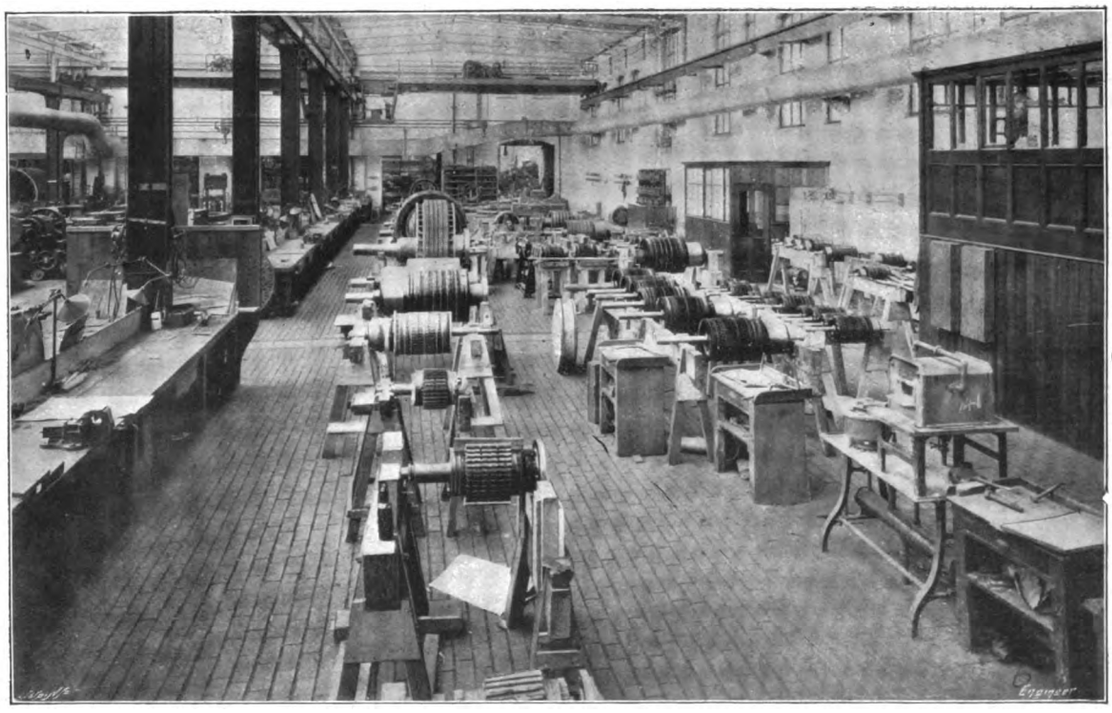

Interior View in Armature Winding Shop.

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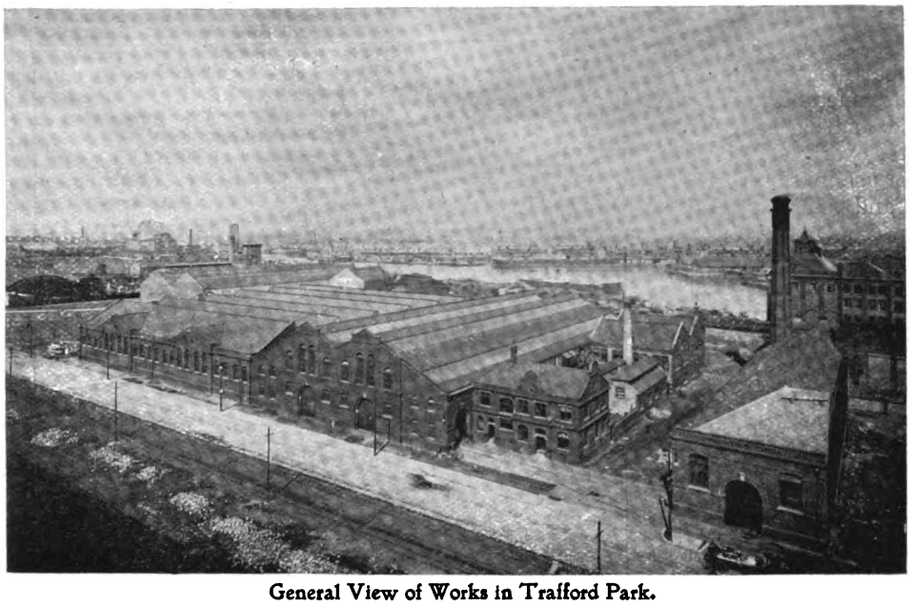

General View of Works in Trafford Park.

ing, more than ordinary care is required with tools. For the treatment and control of these a separate department has been organised, equipped with special tools, gauges and stores, in charge of an expert tool-maker. A check system is in use by which any tool can be traced to the man using it. The fact that the machinist is required merely to use the tools and not to keep them in cutting order relieves him of undue responsibility and ensures greater attention to the work he has in hand. It also makes for greater accuracy of work in that each tool receives the attention it requires at the hands of a competent man.

The testing department is in a separate building from the two main shops, but is connected therewith by a line of standard gauge railway. Heavy machines are hauled across the space between the two shops by an electric capstan. A large test plate has been laid down in this shop, and the equipment in the way of motor-generators, instruments and load resistances is very complete. The switching gear and instruments have been erected on slate panels mounted on an iron framework, which also serves to support and enclose all the resistances needed. Complete testing units are by this means obtained, and they are placed in a row by the side of one of the main test plates. The high-tension gear for the control of pressures up to 30,000 volts is erected in a separate enclosure. All machines are submitted to the usual load and pressure tests before being passed finally for shipment. Space does not permit us to deal with this department in detail, but, from the precautions taken and observations made, any errors in design or manufacture are eliminated before the particular machine is allowed to leave the works.

The standard products of the works are generators and motors for direct-current and alternating-current circuits, and a speciality is made of reversible boosters for tramway and lighting purposes. The standard direct-current machine is built up in steel field casing with solid poles and laminated tips. The armature core is assembled on a cast-iron spider through which the shaft passes and on which the commutator bush is also fixed. The armature is slot-wound, the windings being shaped on formers and put into the slots after they have been lined with insulating material. The brush holders are made of brass stampings and are shaped to carry a carbon block. The design makes up a neat and efficient holder for all sizes of machines. Among the later designs are motors fitted with commutating poles which allow of a wide speed variation with shunt regulation alone. The alternating-current machines include engine type alternators of the revolving field type for one, two or three-phase currents and any standard or special voltage. The field coils are wound with copper strip on edge and the magnet limbs are dovetailed into a central boss shrunk on to the steel shaft. The stator windings are placed in slots with mica tube insulation, and are brought out to cable terminal boxes at any desired point on the machine.

The alternating-current motors are all of the induction type and are fitted with or without slip-rings. The stator windings are placed in partially-closed slots, and the carcase is provided with large spaces which allow of free access of air to the core and windings. The rotor is either bar or wire wound, according to the size of the machine, and the core plates are built up on a cast-iron spider which is keyed to the shaft. These machines are made in a standard range of sizes to meet the conditions of voltage and periodicity in regular vogue. For colliery work or running in explosive atmospheres the slip-rings are totally enclosed in a gas-proof case from which all access of the surrounding air is excluded.

The McLeod & Turnbull reversible booster is one of the special machines which the company builds. It has already been installed in many important tramway undertakings, and we understand that there is a considerable demand for the machine. Its chief features are well known, but we may here remark that it is not dependent on any balancing

Main Aisle of Large Machine Shop.

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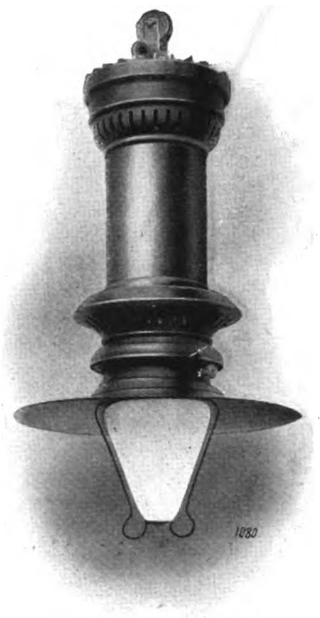

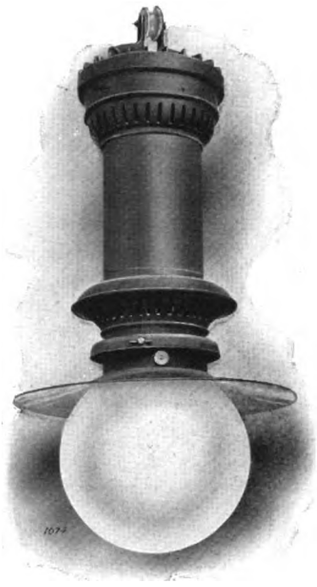

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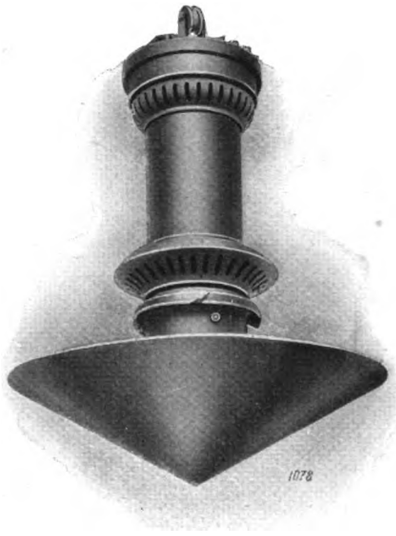

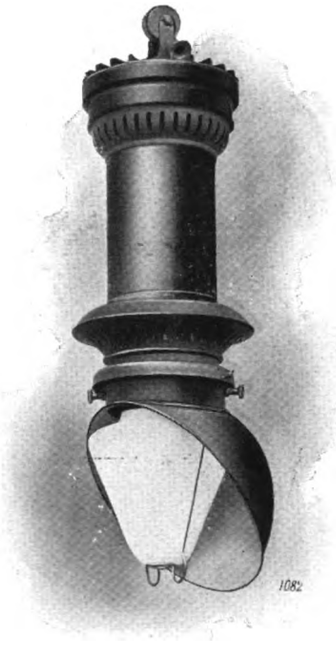

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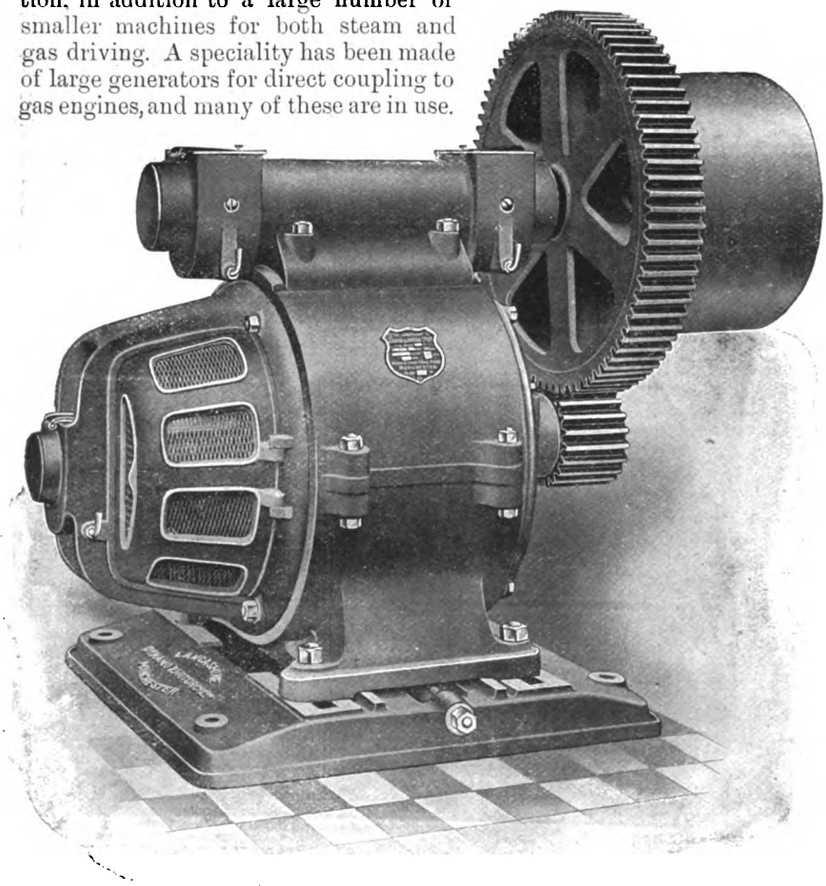
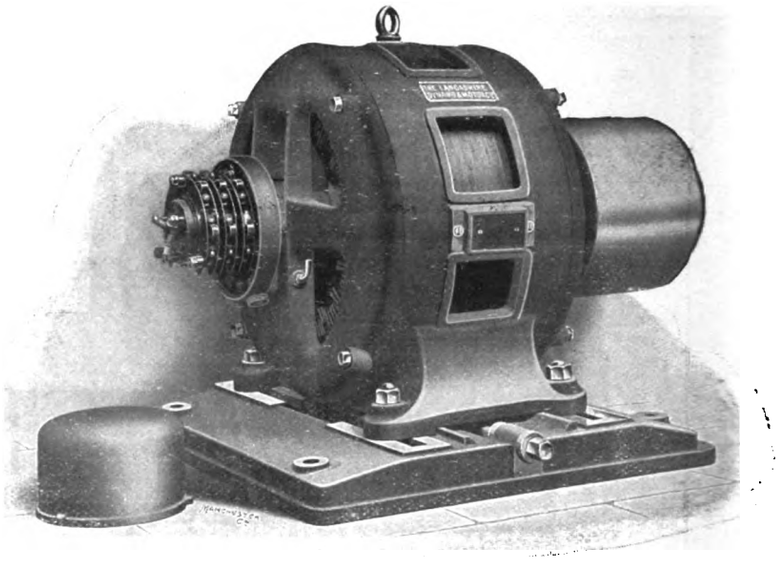
of the dynamo characteristic. The voltage at the switchboard can be raised without any readjustment of the booster regulators. The booster can be adjusted so that the generators will take a certain percentage of the overload, the battery doing the remainder, or it can be adjusted to give a constant load on the generator. There is no possibility of current returning from the battery to the generators, as even a small reduction in the current, at which the demands are set, causes the booster to give a heavy charging voltage. This effect will get far more pronounced long before the generator falls to nothing, let alone reverses. Another property is the ease of paralleling, it being very simple to get the booster in again after a circuit-breaker has opened; it may be put in at a considerably different voltage from the line.

The range of dynamo and motor specialities of the company is, it will be gathered, an extensive one, and with their well-equipped works they are in a position to meet both standard and special requirements for machinery of this class. They also specialise in the industrial application of motors, having numerous branch offices in the great manufacturing centres from which technical advice on electric driving is given.

Amongst the work going through the shops we noticed a large number of motors for Chatham, Sheerness, Malta and Gibraltar Dockyards, in addition to a number of battleship generators and motors. Also generators and about 100 motors for the Government factories and State Railways of India. Among other generators under construction are the following, of 500 kw. output in each case:—Three for Hankow Native City, China; three for Bradford Dyers' Association, Ltd.; one for Darlington Corporation, one for Long Eaton Urban District Council, two for Messrs. Steiners' Works, of Accrington, one for Stockport Corporation, in addition to a large number of smaller machines for both steam and gas driving. A speciality has been made of large generators for direct coupling to gas engines, and many of these are in use.



D.C. Ventilated Motor with Back Gearing.



Standard Type Slip Ring Induction Motor with Wound Rotor.

An imposing 400 H.P. three-phase slow speed 2,000-volt motor has just been completed; also a 300 kw. three-phase 2,000-volt generator, both for colliery service. Induction motors are being manufactured in large quantities for collieries and industrial works of all kinds, and there are machines going through for export to Japan, China, India, South America, Germany, Italy, France and Spain. A large repeat order has just been received for interpole variable speed motors for one of the largest steel works in Germany. This is rather interesting, in view of the somewhat alarmist reports of German competition. We understand that the orders for power installations include a cotton mill and several metalliferous mines in Cornwall.

Business has proved so brisk that a night shift is being worked in the shops. The firm has, however, had various departments working night and day for several years, but at present the whole works is being run during the twenty-four hours.

We cannot conclude this necessarily brief survey of a flourishing industrial establishment without a word of thanks to Mr. A. P. Wood, the managing director, for permission to go through the works and for the data and illustrations which make up this description.

Notes and Observations.

X.—Textilities Again.

"IN spite of all the talk about triple-expansion engines and modern rope drives, textile mills are not in such a bright state as you want to make out," I remarked to the chairman of directors, who sat at the head of the table.

"What am I to infer from that remark?" came from the chair.

"Simply this, that the bulk of the mills in this part of the country are driven from beam engines through the medium of wheel gearing," I answered. "And, further, that they would profit enormously if they put in the electric service."

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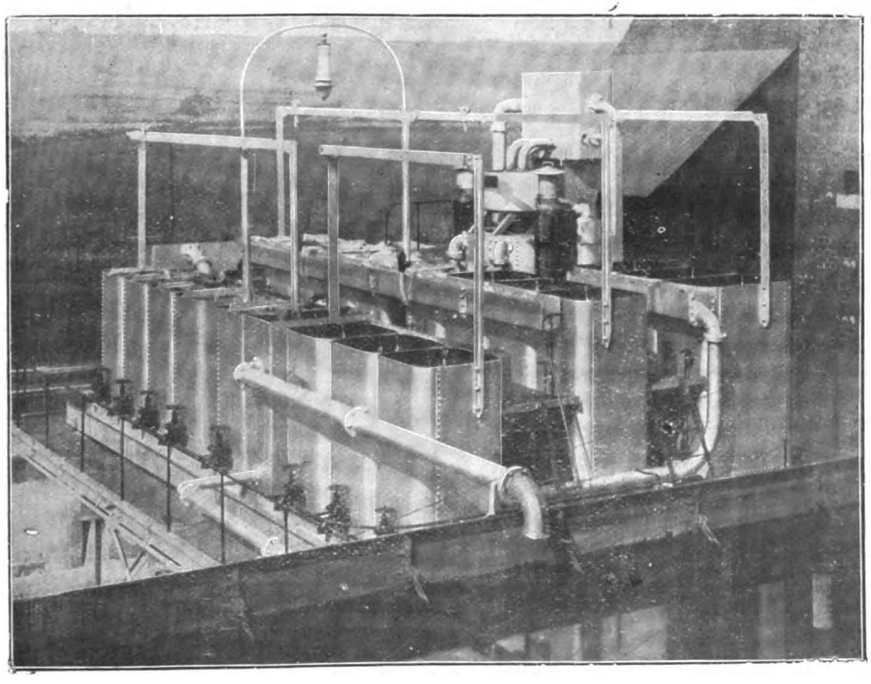

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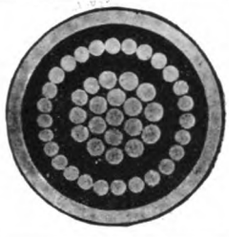

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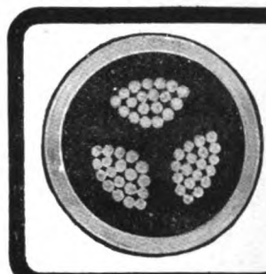

"How do you know that?" said the chairman.

"It's our business to get to know," I replied. "Besides, we can get into your competitors' mills, whereas you can't."

"We'll leave that for the moment and come to the object of this interview," he said suddenly. "How you get hold of certain information I do not know, but your letter here says 'you understand the engine makers cannot deliver until six months after the mill is completed, and the machinery will be hung up that length of time. I can save you that six months' loss.' Now how do you propose that this shall be done?"

"I noticed as I passed the mill yesterday——"

"Passed the mill yesterday!" he interrupted; "why no one knows we are——"

"But we find these things out," I went on. "I noticed the engine and boiler rooms were not started above ground and the stack is not even begun."

"Well, you see," continued the chairman, "we were hung up by the engineers. They have got into difficulties, and we suspended the boiler contract until something else was settled. We now find that the best makers cannot deliver under six months, and, as your letter says, 'the machinery will be hung up that length of time,' unless we can do——"

"Just so," I interjected.

"You have a suggestion to make, I believe, and it is that I wish to lay before my colleagues—assuming, of course, that it is any way practical."

"I concluded you want to save those six months when I got your letter," I continued.

"The fact is, you're quite right. We want to start before the Buffalo mill down the river. They are rather better off, and they can be running in another three months, which will then give them a big lead." He leaned forward in his chair and confided this news in a whisper.

"Well, you can beat them by nearly three months if you agree to our suggestion, and if the rope race is already built in the new mill," I answered.

"And your proposal is?" he queried.

"To place electric motors on to the pulley supports in the rope race and drive each floor by either rope or direct from separate motors," I replied promptly.

"Where is the power to come from? We have no boilers and engines," he said.

"Oh, we look after that at our power house. Our mains are only a mile away over the hill," I responded with energy. "A week will see the cable at the mill lodge."

"A motor for each floor?" he said. "Why not a large motor to temporarily replace the steam engine."

"Because this proposal is based on the loan of motors just big enough for the job. If you want this mill to start up you must leave things to me," I urged.

"And what about the stack, the boilers and the engines?" said the chairman. "The contracts are pending and will have to be let. The engine we do not mind so much, as we are not yet committed since the first concern failed, but from the boiler and stack agreements we can make no withdrawal."

"That's your funeral," I said. "Besides, this is a six months' job. When the engine can be delivered you make your own arrangements about the steam. We shall run the mill till the engine is ready; then we come outside."

"But suppose we don't want you to do so?" said he.

"Say that six months hence," I answered. We claim to do with electric power what cannot be done with steam, oil, gas or petrol."

"And what's that?" he asked.

"Start this 100,000 spindle mill of yours in four weeks and run it efficiently, with temporary power agents, for six months. That's what I wrote you about, and I am simply waiting for you to say, 'Go!'" was my answer.

"And the price for power? what must we pay for the convenience?" was the next question.

"We shall not charge for power."

"What then? Do you want a commission?"

"Yes. We ask 25 per cent. of the revenue during the six months. You can take it or leave it. There's no alternative."

"And at the end of six months ——," he commenced.

"We will talk about that then. It's worth the other 75 per cent. to you to run rather than stand idle. If it wasn't such a real good advertisement for electric driving I should want a third."

"Well, I'll put the proposal before the directors," he said, after some deliberation. "It sounds feasible enough, but they must decide."

Within a week I was summoned again and requested to proceed.

"But our difficulty is still the engine and steam plant," said the chairman at the close of the meeting.

"In another six months you will have made up your minds," I suggested. "Hang up the contracts for a time, and then decide whether we shall remain a 'permanent temporary.'"

"It may be costly, but we shall have to risk it. We want to be ahead of the Buffalo at all costs," he replied.

"I have promised you that," I said.

And I kept my word, though I know he did not expect me to do so.

The steam engine is not ordered yet, and that same temporary motor rig is driving the mill. W. E. W.

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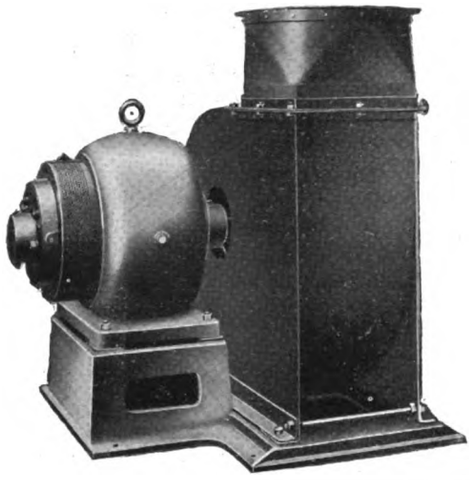

PRESSURE.

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Copy for text or advertisement pages for next issue should reach the above address not later than August 18th.

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms ; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations ; to any firm of Merchants or Agents ; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings ; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Lifting Magnets. On another page will be found some illustrations of lifting magnets for industrial establishments which bear out the approval we have previously expressed of the value of this useful device. It is important to note that the element of danger attaching to lifting magnets in case of current failure is considerably minimised, if not entirely removed, by a safety grab which supports the load if the magnet fails from any cause. The use of this attachment should remove any prejudice against the lifting magnet and bring it into greater use. There seem to be many instances in which this device could save much valuable time in engineering workshops, not only for the transport of heavy masses of iron and steel, but also for light parts which require handling about machine tools and over short distances in a shop. Light trolley cranes are used in the majority of shops, and pieces which needed an awkward sling might frequently be lifted at once by the aid of a magnet. The lifting magnet only requires to be better known to be more widely appreciated.

Cotton Mill Driving. The extension of electric driving to the cotton mills of Lancashire, more particularly the newer mills, seems to be proceeding apace. Every mill so driven creates a new interest for the cotton spinner, even though he may not, often enough, get into his competitor's mill to see the equipment. Naturally the doors of certain mills are rigidly closed to the heads of a rival management, because in addition to the electrical equipment there may be methods in vogue which confer advantages over other factories lacking such improvements. The electric power expert frequently suffers on this account, as he cannot take the head of a similar establishment to view an actual installation of plant the inspection of which might prove immediately convincing and result in business for himself. Photos and press descriptions are useful in their way, but they cannot take the place of personal examination. The same applies to many other industries. Before many months have elapsed we should be in possession of data regarding the running costs of these electrically equipped mills, and also information as to the difference in the quality of yarn spun or cloth woven. To cotton spinners the results must be presented in terms which they will readily appreciate and not in the form which may seem most convenient to the electrical engineers. The relation of coal consumed to yarn or cloth produced will appeal more to a textile man than talk of coal consumption per kilowatt-hour or the many cost items of power generation which interests electrical experts only. We shall welcome the publication of such data, and hope that it will be made up from the standpoint of the textile engineer for whom it is primarily intended.

Water Power as a National Asset. The importance of water power to any country in which industrial operations can be conducted is apt to be overlooked in a land of coal and steam. The possibility of turning any other natural power sources to account than coal, for instance, is seldom seriously discussed in this country. The *Electrical Review*, New York, makes the following comments on the subject: "The general public does not seem to realise the value of the water powers existing within any country. These are certainly to be considered as much a resource of the country as its coal mines or forests. They are capable of producing a commodity as saleable as coal and wood, and certainly, if properly guarded, they are inexhaustible in the sense that they will continue for ever; and this cannot be said of the other two sources of power—the mine and the forest. The significance of this is that utilising them does not consume anything that can not be replaced. On the other hand the coal supplies will eventually be exhausted, the forests also will disappear unless they are properly protected, which merely means that the production of lumber will be reduced to a certain maximum. After the art of transmitting electrical energy over considerable distances had been brought to a satisfactory condition commercially, water powers assumed a new value, at least in the eyes of those who understood what the new development signified. We have seen since then nearly every large water power in this country harnessed ; we have seen companies formed for gathering in the water powers of certain districts and developing them for producing and selling electric power.

"But it is not only in the younger countries that the water powers are being utilised, for even in India and the other countries of Asia the waterfalls which have hitherto been unmolested are now employed for generating electric power, which, in turn, is used for doing the work formerly done by hand. This work of development is going on practically throughout the entire world. The engineer appreciates it, the developer and the man who buys the power realise its importance; but the layman shows little interest in the matter. He knows, in an indefinite way, that the water powers are being developed to generate electricity, yet he has no idea of the revolution in the industrial world which is thus being brought about."

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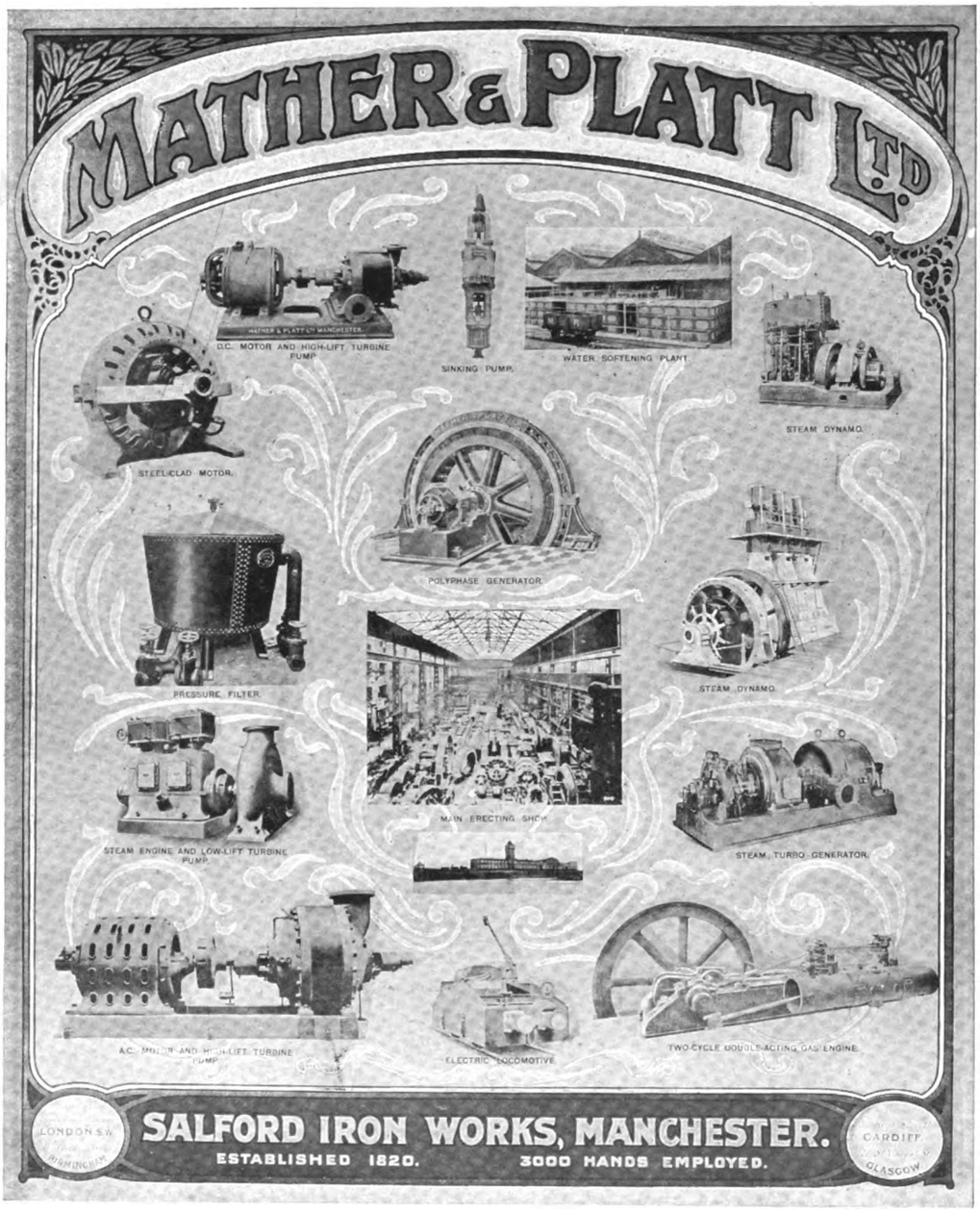

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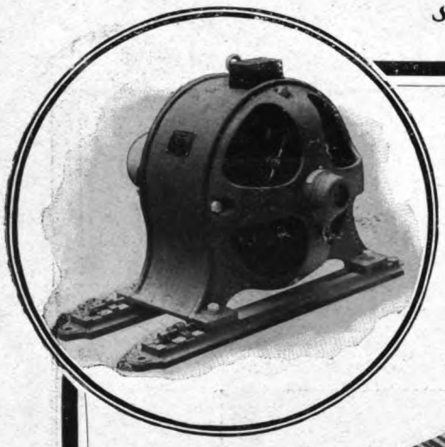

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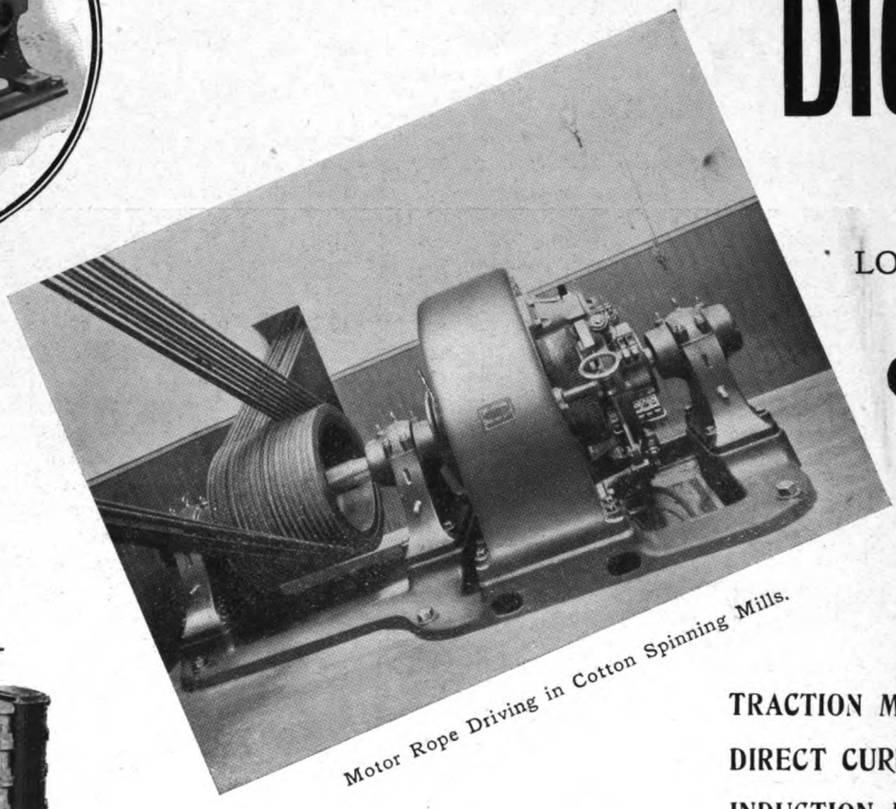

Motor Rope Driving in Cotton Spinning Mills.

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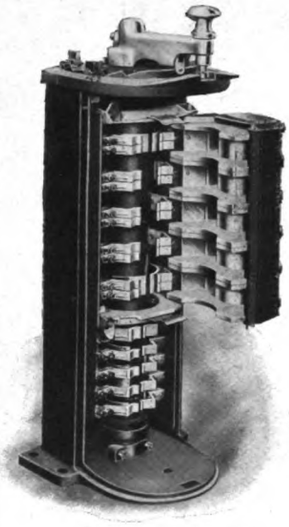
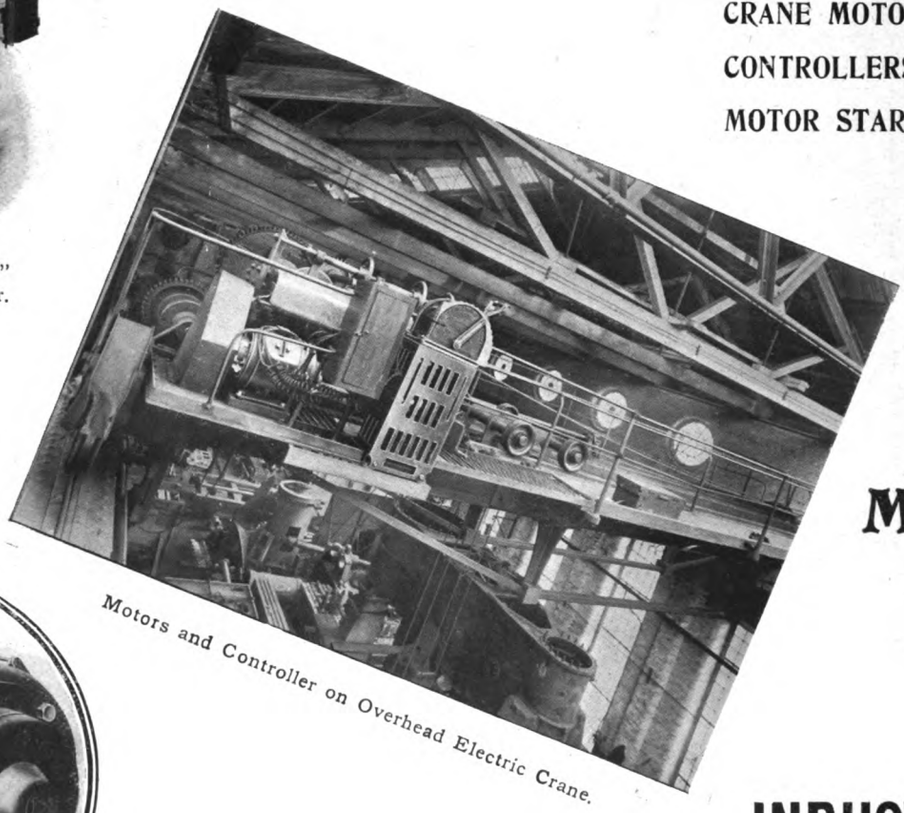


Interior View of "R" Type Crane Controller. Solenoid swung back.



Motors and Controller on Overhead Electric Crane.

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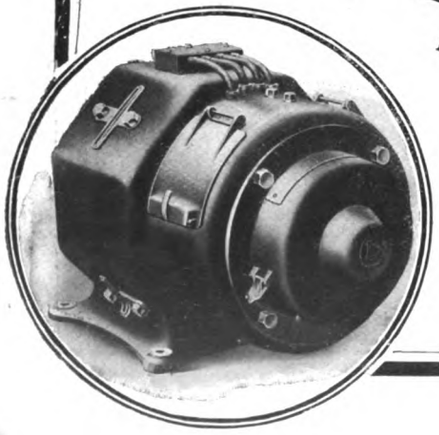

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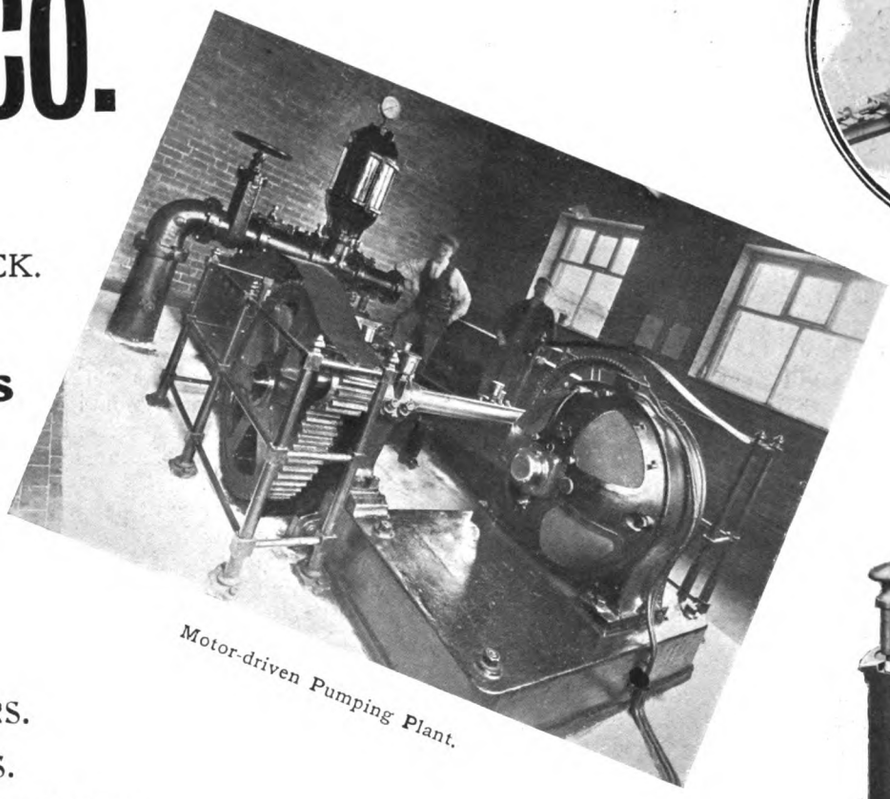

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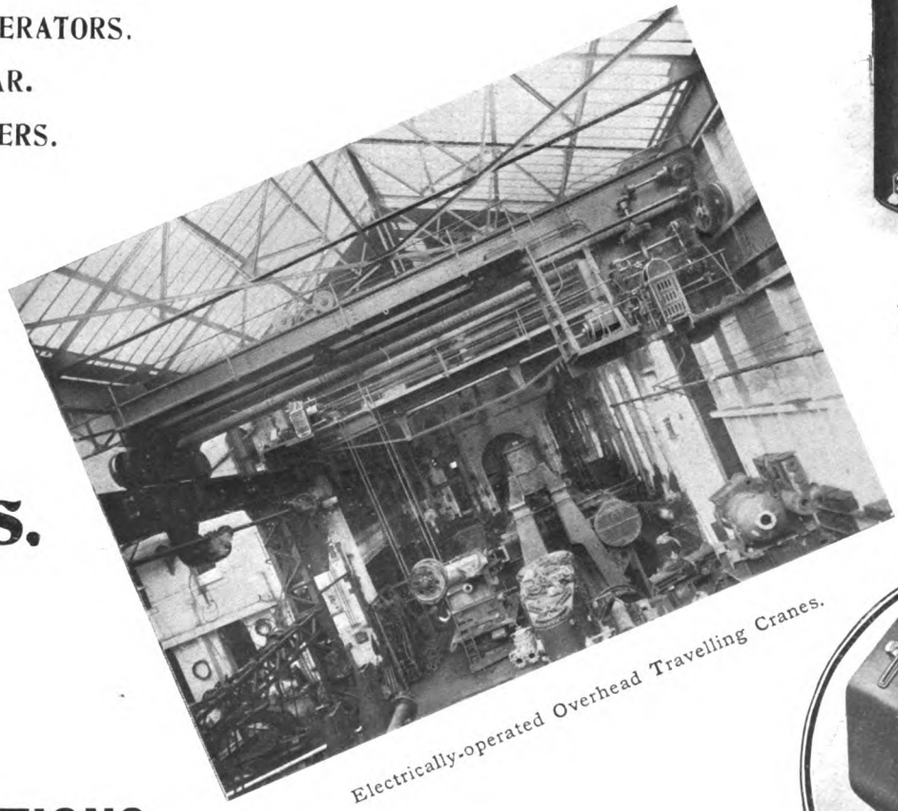
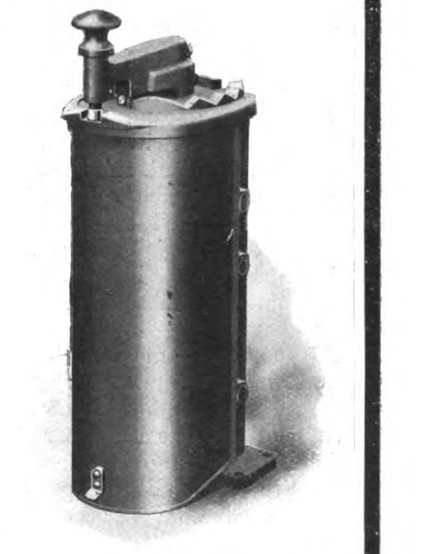


Electrically-operated Overhead Travelling Cranes.



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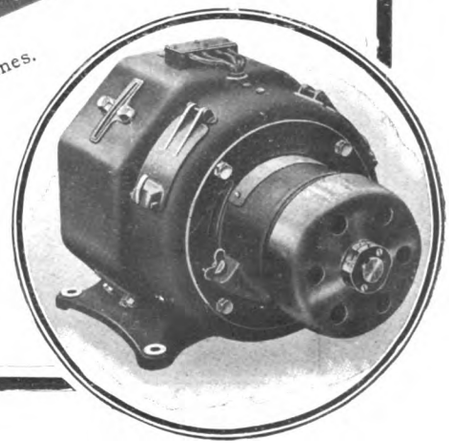

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Specialized Switch Manufacture.

Products of Eckstein, Heap & Co.

SWITCHES and switch gear are peculiarly adapted to specialization, and the best results in switch construction have been obtained by separate and distinct organisations devoted solely to the design and production of such apparatus. More particularly does this statement apply to the production of controlling apparatus for both large and small power supply circuits. The future of industrial power supply is as much bound up in the problem of efficient switchgear for the purpose as in the design of the motors themselves. It is a mere platitude to state that with a bad controller the motor is useless, but it is none the less true. Further specialization, while in no way affecting quality, tends to bring price to a level commensurate with the value of the controlling device in comparison with the motor itself.

We were recently afforded an opportunity of inspecting the works and products of a firm of switchgear specialists, Messrs. Eckstein, Heap & Co., Waverley Mills, Salford. This firm has laid down a quantity of modern machine tools and other plant for the production of switching apparatus, and more particularly those types of gear now in vogue on the premises of power consumers. The shops are all arranged with a view to economy of time in the handling of material, and the store system is very complete. The progress of each shop order is closely followed by a carding system, and it is possible to quickly arrive at the works cost of any job going through. The small parts for each job are placed in numbered trays in the stores, and, when required, are sent in the tray into the assembling department.

The tools in the machine department are placed in transverse rows down the shop, as in this position the best light from the side windows is obtained (*see* Fig. 1). The tool equipment includes a number of large lathes, vertical and radial drills, milling machines, automatics, &c. The small lathes are of the Pittler pattern, these being renowned for the production of accurate work. In this department, which is on the first floor, the metal turning and drilling for all switch parts, &c., is carried out, as well as a quantity of fitting work. The drilling of marble and slate is done on special radial machines. On the ground floor the complete gears are assembled (*see* Fig. 2), the requisite parts being delivered from the machine and fitting shops. The testing department is on the top floor and contains apparatus for testing circuit-breakers, switches, relays and instruments. The equipment includes a 500-volt battery, a motor generator and a motor alternator. The larger types of circuit-breaker can be tested under working conditions both as regards current and voltage.

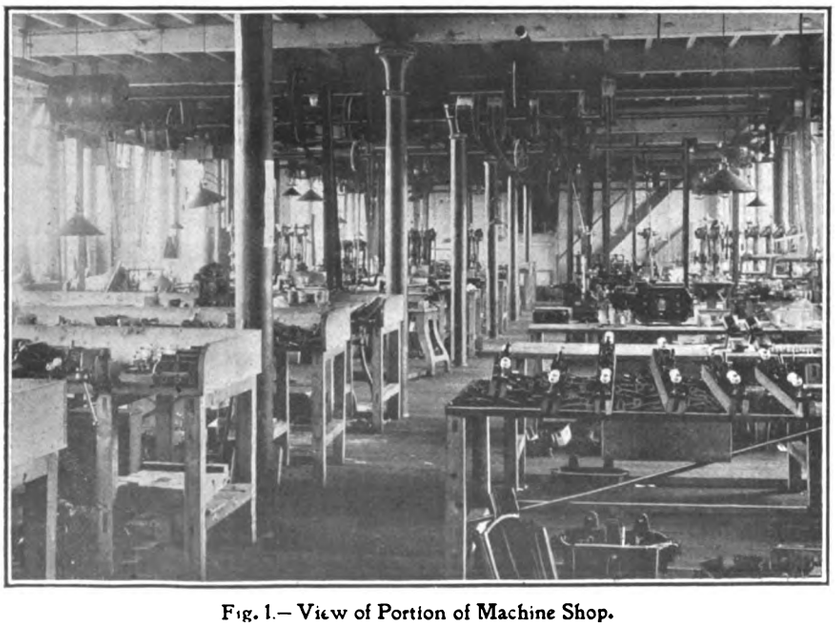

Fig. 1.—View of Portion of Machine Shop.

The principal products of the works are knife switches, oil switches, ironclad switches and circuit-breakers for direct-current and alternating-current circuits. As most of these possess distinctive features we propose dealing with them in some detail.

Knife Switches. A common trouble with knife switches is the tendency of the blade to move out of alignment and cause heating or give trouble in switching. The "Waverley" knife switch has been designed to obviate this difficulty. The blade is fixed in a rectangular iron carrier, fitted at one end with a hinge and at the other end with an insulated handle. The blade is supported by two pins, passing through bosses in the carrier, so spaced as to leave the ends of the blade to enter the contact clips. The breaking tips are also hinged to the blade, and two side-springs give the necessary quick break. The design (as will be seen from Figs. 3 and 4) has the advantage of dispensing with hinged contacts, which are not unusual with knife switches. The two clip contacts can be accurately lined up, and the blade being rigid in its carrier preserves the alignment at all times. This switch is made in sizes,, from the smallest of 30 amperes to 3,000 ampere capacity and, from our inspection of it, appears an advance in design on switches of its class. The larger sizes are built of two parallel units, as shown in Fig. 5, the blades being fixed in a common hinged frame. The switch shown has a capacity of 3,000 amperes; a single bladed switch to control this amount of current would require considerable force to close and open. We tried a "Waverley" switch of the capacity illustrated, and noticed its smooth, almost "velvet"-like action both in opening and closing. The parallel arrangement of the contacts is also convenient, as with very large switches two or more cables are usually run, and several sweating thimbles are required. In this case the provision of two clamping nuts at each switch terminal ensures better contact and reduces the difficulty of making a sound job of the cable connections.

Carbon Break Switches. The "Waverley" laminated edgewise switch is a pattern which is intended to furnish an efficient carbon break switch, more especially for ironclad purposes. From the smallest to the largest sizes, laminated bridge contacts, are fitted. The main contact is carried in a hinged frame linked up by outside links with a carrier, hinged to the base and fitted with the operating handle. This carrier is provided with slots in the small sizes and

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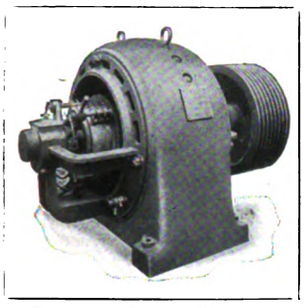

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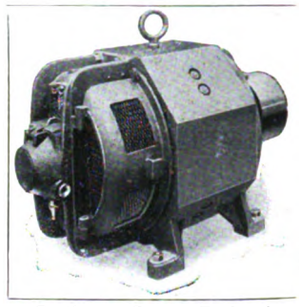

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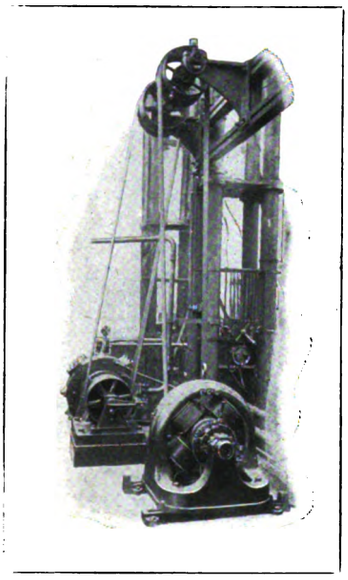

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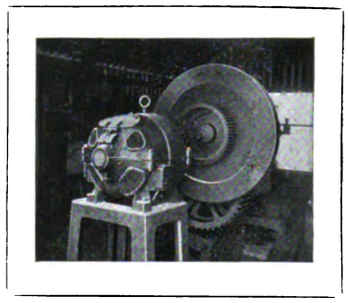
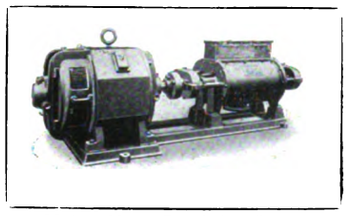


Motor Driving Cold Shear in Steel Works.



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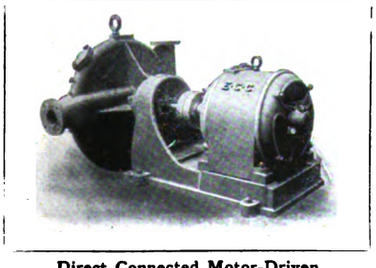

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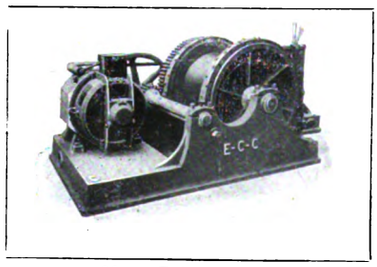

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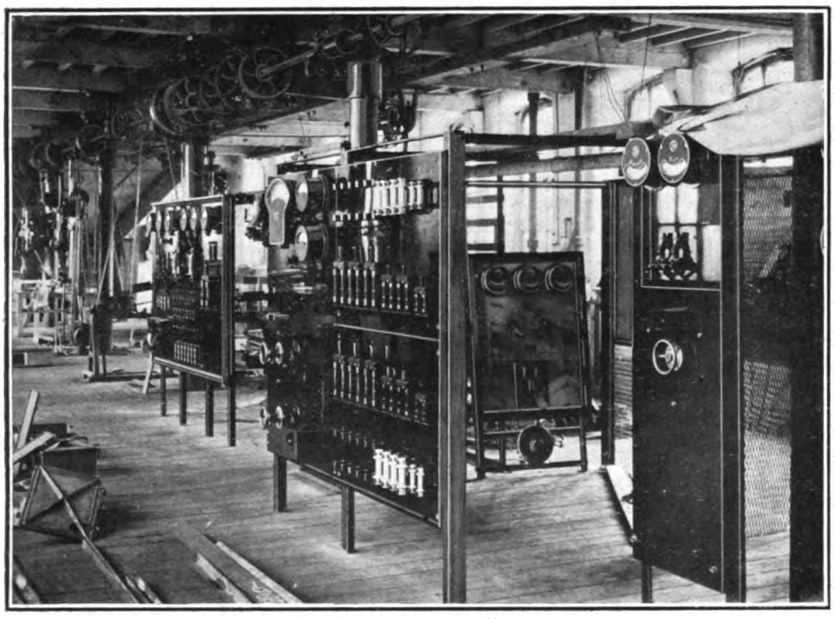

Fig. 2.—A Corner of the Erecting Shop.

internal links in the large sizes, which engage with the internal frame during the off motion, and also tension is put upon side springs, the ends of which are attached to the switch frame. This frame is locked on by a knuckle action of the links referred to, and this knuckle is broken by the handle carrier when switching off, the side springs together with the released compression on the main and auxiliary contacts giving the final quick break. The switch motion is quite smooth, and the on and off positions are positively taken up without jar. The general design of the carbon break switches will be gathered from Fig. 6, which shows the smaller pattern of switch in the off position. The same pattern is shown in Fig. 7 as a double pole switch with enclosed fuses, made up in cast-iron case. There is a slot in the hinged cover through which the handle projects. Any number of the switches can be linked together and operated in tandem or parallel. The main brush contact is protected by copper-tipped beading spring and the final break is taken on carbon buttons

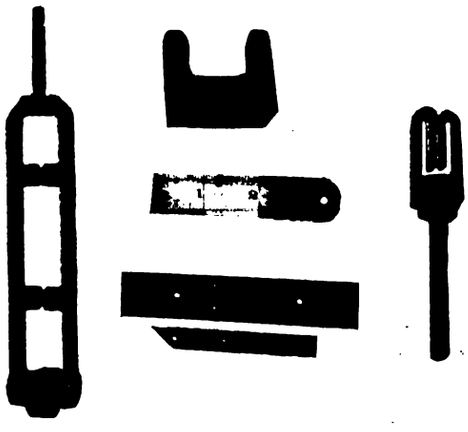

Fig. 3.—Parts of Waverley Knife Switch.

or blocks, according to the size of the switch. A gas and water-tight pattern, which, we understand, has the approval of the War Office, is also manufactured. In this type the motion of the handle is communicated to the switch by levers coupled to a rod passing through a gland in the side of the box below the line of the lid. The latter and the cable bushes are made gas and water-tight with rubber insertion and packing glands respectively.

Circuit-Breakers. A line of circuit-breakers for direct-current control is also included in the switch products of Waverley Mills. A standard 400-ampere single-pole laminated pattern is depicted in Fig. 8. The features of the breaker are the link operating motion and the carbon and magnetic blow-outs. The handle is free of the main contact motion in cases of overload or no load as the case may be. It is coupled to the hinged laminated brush by a set of three roller links. The knuckle between two of these is broken by the overload tripping or no-volt coils and a single spring throws out the switch. In case of an overload occurring while switching-in, the links are moved out of alignment by the coil and the handle is worked loosely without operating the main contacts. The magnetic blow-out is fitted in addition to the carbon break, to comply with certain specifications rather than as any additional precaution. The carbon break is the firm's standard and has been found to give complete satisfaction for all capacities both of switches and circuit-breakers. A similar design of circuit-breaker to the above but fitted with maximum and no-volt release coils and mounted in cast-iron case is illustrated in Fig. 9.

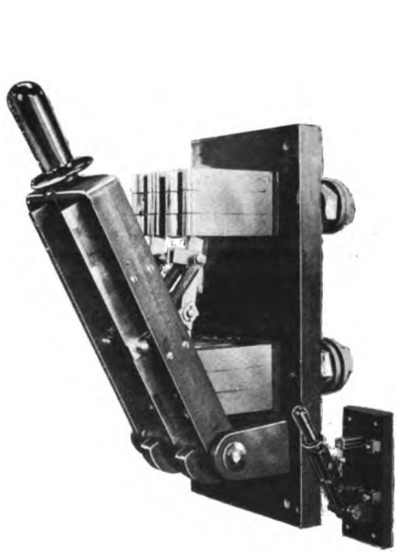

Fig. 4.—30 and 3,000 amp. Waverley Knife Switches in breaking positions.

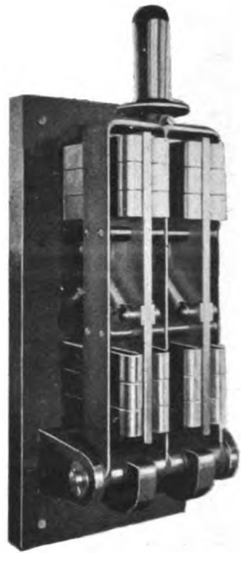

Fig. 5.—3,000 amp. Knife Switch, closed.

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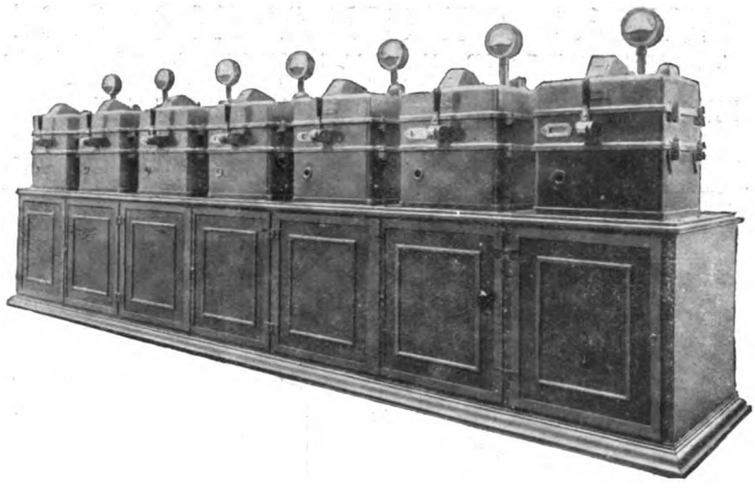

Should not only be well protected mechanically and electrically, but should also be capable of easy dissection so that all parts may be supervised and, if necessary, adjusted without expense.

The seven elements of the Distribution Switchboard illustrated above are all fitted with adjustable overload releases operated by the H.T. current. They have also no-voltage releases, safety fuses, ampere-meters and reliable indicators; the oil-break switches have our vertical quick-break action and the cables pass into terminals under the oil tanks. By simply lifting the upper section, the parts may be inspected; by lifting the middle section, the working parts are all available without disconnecting any cables.

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A.C. Oil Switches. To meet the demand for a reliable low voltage switch or circuit-breaker a solenoid operated oil switch is manufactured for the control of alternate-current motors. The general arrangement of the complete switch may be gathered from Fig. 10 which shows the oil tank and lid removed to expose the solenoid and contacts. The solenoid is energised from a small control board containing two push buttons and an indicator, which may be placed in any desired position. The buttons are marked "on" and "off," and serve to open and close the solenoid circuit. At the same time an indicator drops before a window below the push-buttons showing that the switch is on or off.

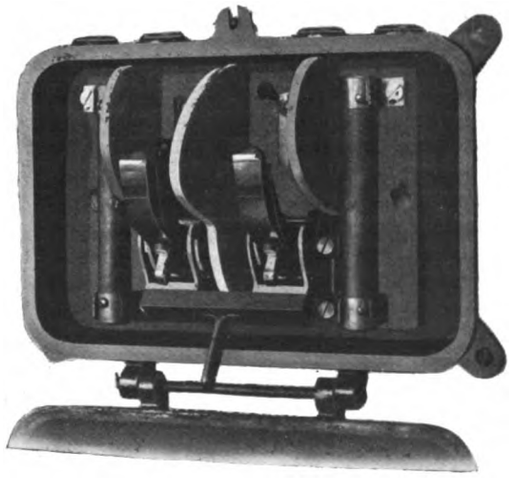

Fig. 7.—D.P. Laminated Carbon Break Switch and Fuse in Cast-iron Case.

Fig. 6.—S.P. Laminated Carbon Break Switch.

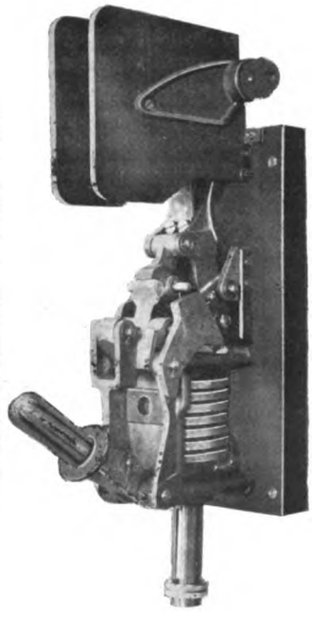

Fig. 8.—S.P. Overload Circuit-breaker with Carbon Break and Magnetic Blow-out.

The solenoid and its plunger are placed vertically over the switch contacts, and the plunger is connected to a link motion which mechanically locks itself by toggle action when the switch is on. The solenoid remains in circuit holding up the plunger, which is slotted to give a lost-time action, which ensures a hammer blow being given to the toggle levers when the plunger falls, due to

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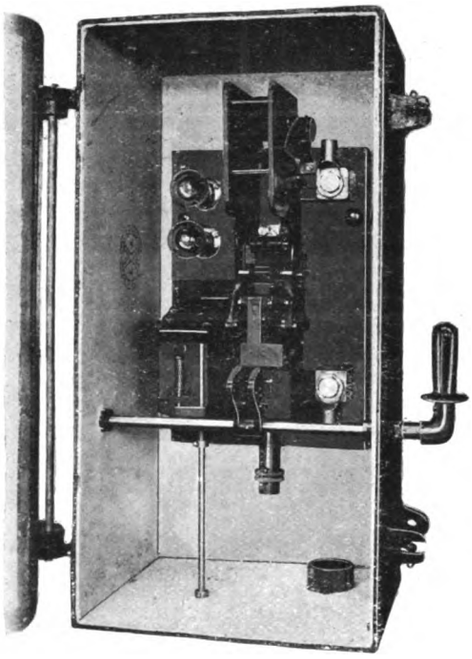

Fig. 9.—S.P. Circuit-breaker in Cast-iron Case.

the de-energising of the solenoid. The no-voltage and minimum-voltage release of the switch is obtained by placing the solenoid in the main circuit, the full pressure of which keeps the solenoid energised. Overload release is obtained from a separate relay. In this case, the switch being three-phase, a triple-pole relay is employed. There is a small coil in each phase, with a loose plunger, which rises, in case of overload, and opens the solenoid circuit. For one and two-phase circuits single and double pole relays respectively are used. Fig. 11 depicts the form adopted for three-phase working, the relays being put up in a cast-iron case. The use of a relay in each wire, with three-phase circuits, allows of the switch being employed where the neutral is grounded. All the parts of this switch combination are placed in cast-iron cases fitted with suitable glands for lead-covered or armoured cables to admit of the continuous bonding of the lead or armour in accordance with Board of Trade regulations.

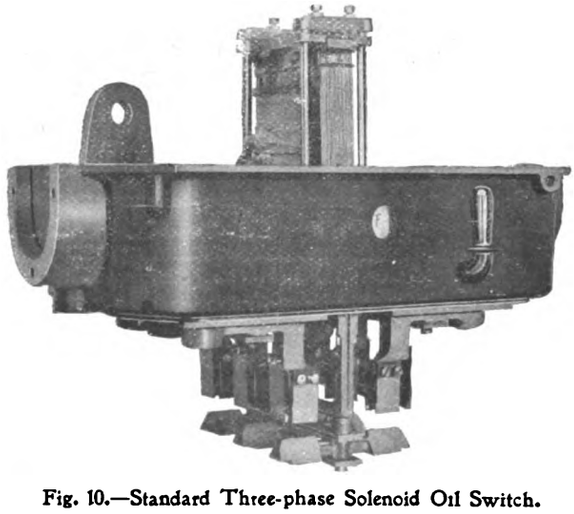

Fig. 10.—Standard Three-phase Solenoid Oil Switch.

Switch Panels. The growth of power supply has created a demand for complete switch panels upon which are mounted the accessories for the main feeder control or for the operation of motors. All standard requirements in this particular can be met by Messrs. Eckstein, Heap, who have already supplied a large number of such panels for alternating-current and direct-current circuits. An alternating-current control panel for use with the solenoid operated oil switch already described is made up in standard sizes. It comprises push buttons and indicator in iron case and star-mesh or autotransformer oil type controller mounted together on iron supports.

Porcelain Fuses. Despite the prevalence of the circuit breaker there is still a wide field of utility for the switch fuse. For the control of certain low-capacity circuits and for distribution boxes it enjoys considerable vogue and is generally reliable in practice. In the construction of these fuses one of the chief troubles is the fixing of the contact blades to the porcelain. Sulphur compound or cement has been mostly employed, but in case of overheating is liable to melt out. Fig. 12 illustrates a type of replacement fuse in which the knife blades are secured mechanically without resort being had to compounds of any kind. Between the ends of the porcelain tube and the flanges slots are moulded, through which the copper strip forming the contact is passed. At right angles to the slots is a countersunk hole through which a brass screw enters a tapped hole in the copper blade. The countersunk hole has a brass washer, against which the shoulder of the screw presses and draws the contact firmly against the slots in the handle. No more simple or effective method of securing the contacts could well be imagined. The fuse is made for capacities up to 400 amperes, in 100 ampere units, and pressures to 600 volts. Ordinary asbestos tube is used to

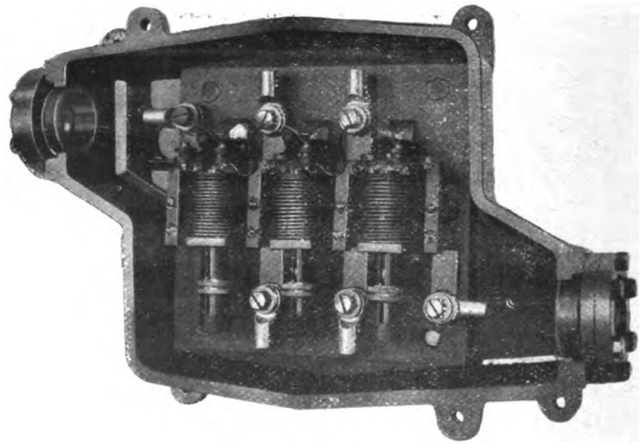

Fig. 11.—Three-phase Overload Relay for Solenoid Oil Switch.

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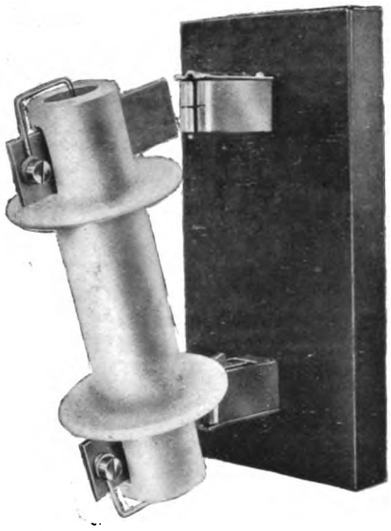

Fig. 12.—Standard Porcelain Handle Replacement Fuse.

cover the fuse wire passing through the handle. Fuses of this type are assembled in iron cases to form distribution boards as shown in Fig. 13, for the control of power circuits in shipyards, pithead works, engineering shops, &c.

Fig. 13 also shows, combined with the fuse box, a trifurcating and sealing chamber for use with lead-covered paper cables.

We may here remark that Messrs. Eckstein, Heap & Co. have already carried out a number of important contracts for large switchboards for central and sub-station service, and have laid themselves out specially for work of this kind. The orders at present in hand include some large switchboards for collieries and power supply companies, fitted with remote control, no-voltage and overload release, oil-break switches as described above, high and low-tension switchboards of various types for use in this country, also some important installations abroad.

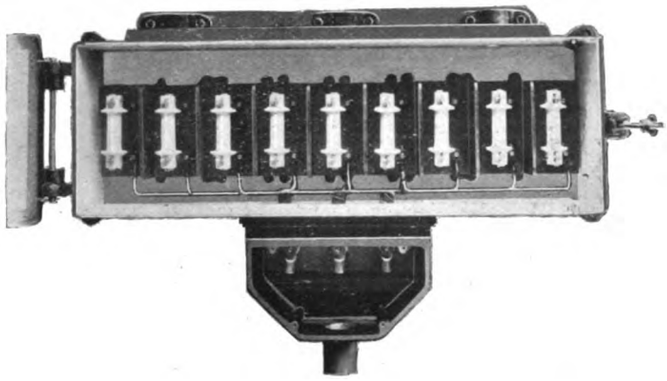

Fig. 13.—Replacement Fuses in Cast-iron Distribution Box for Three phase Circuit.

In addition, the works are kept busy meeting the regular demand for the standard types of switches and fuses to which we have already referred.

In concluding this description we would give our thanks to Mr. A. C. Heap for his courtesy in conducting us through the Waverley Mills and explaining the details of the various departments under his control.

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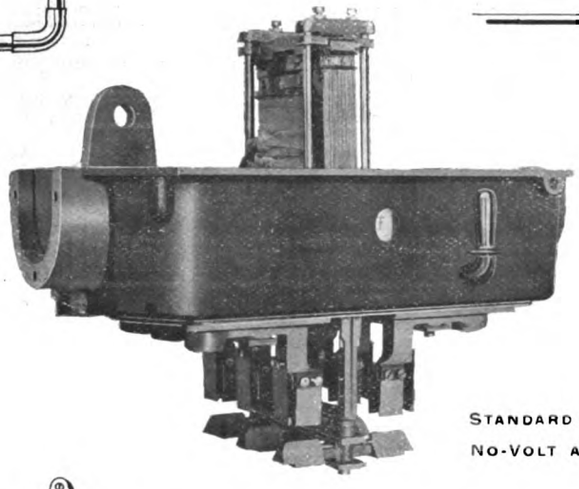

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The Union Electric Co. is supplementing its standard types of dynamos with a line of open and enclosed steam engines suitable for direct coupling to these machines. Both patterns are vertical double-acting engines built simple or compound according to the output. In the enclosed engine the crank slides and connecting rod run in an oil bath which retains the oil used by the engine, there being practically no leakage. The steam valves are of the piston type and at each end of the cylinder relief valves are also fitted. Two doors are provided, one at each side of the crank case; and these allow of free and convenient access to the piston rod, slides and other reciprocating parts. The valve gear is so fitted that the valve is free to "float" on the eccentric rod, so that it can take up a central position in the valve cylinder. The setting of this valve can be examined through holes in the casing. A crank shaft governor of the balanced type is usually supplied with the engine, but a "Pickering" pattern can, if desired, be substituted for this.

The open type engine is somewhat similar in design, except that a centrifugal throttle governor is fitted and the crank case is merely enclosed by a splash guard. Lubrication also is by drop feed from a central oil reservoir. We illustrate a two-cylinder high-speed engine coupled to a DEW dynamo. The units are supplied in sizes from 3¼ to 86 kw., and the standard dynamos are shunt or series wound. The engines are built to run on 100 lb. steam pressure.

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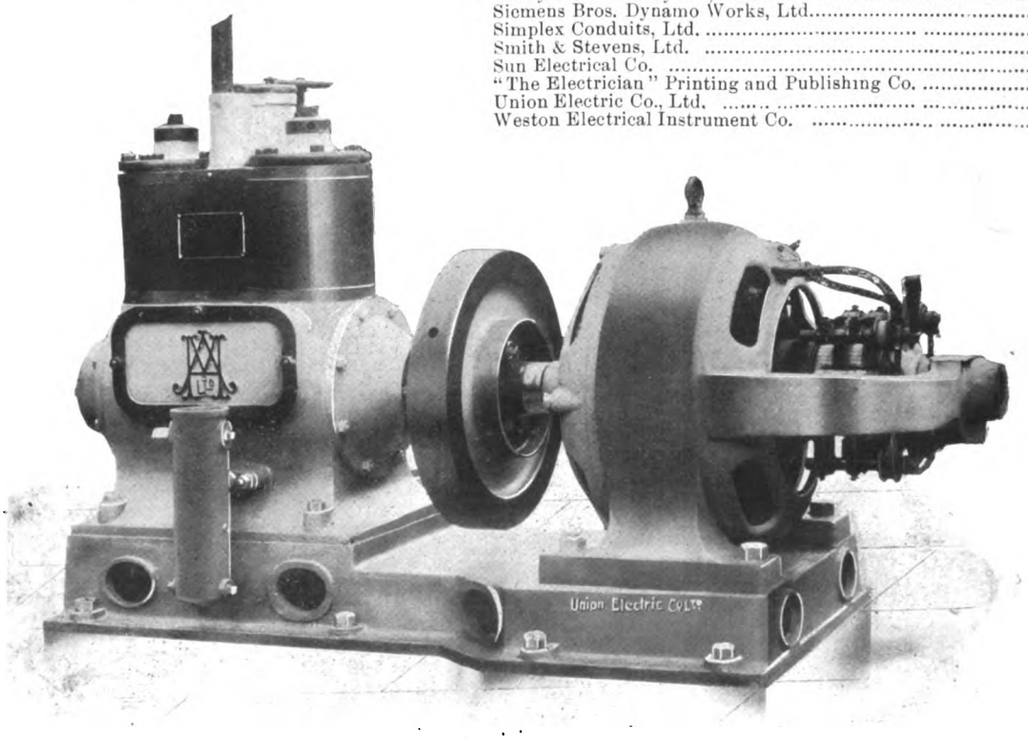

Two-cylinder High-speed Engine and Union DEW Dynamo.

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Electric Power in Textile Mills.

WE find that some discussion has arisen from our treatment of this subject in the past few issues and that the matter is generally exciting considerable comment in textile districts. This in itself cannot fail to do good, as the man chiefly interested will become familiar with the fact that there is such a thing as an electric motor and that it can be used in a cotton mill, with certain advantages to the owner. Electrical engineers as a rule are apt to be too sanguine both in their statements of what electric power can do and in arguing the undoubted merits of the electric drive in one industry into another totally different. This is, of course, unwise, and continued experience tends to pile up practical evidence in refutation. For instance, the electric motor has pre-eminently proved its superiority to all other power agents, steam, gas and oil, in the driving of large engineering workshops. These industrial establishments are conducted upon what may be termed "piecemeal" lines. That is, although the works organisation as a whole contributes towards a definite result—namely, the completion of the work in hand—all the details are themselves made up separately and at times which do not directly coincide. The lathes, milling machines, planers, drills, slotters, &c., in a machine shop, though apparently working together, are started and stopped independently, but, of necessity, they furnish their respective parts for the assembly into the complete machine. In a case like this electric driving by individual motors is ideal. Each large, even each small, tool receives its driving power independently, and any section can be run without the others. In fact, necessity demands that there should be this independence of action, particularly when working overtime.

Although we have taken this instance of an engineering workshop it is not difficult to understand that the majority of the industries and trades in which electric driving has been adopted possess remarkably similar features as far as the driving unit is concerned. The only limit to the use of the individual motor is the capital expenditure. There are practically no single machines to which small motors could not be applied.

Having regard to this predominating feature of electric driving in most industries it is only natural that in approaching the subject of textile mills the electrical engineer should be strongly biassed in favour of the subdivision of the power units as much as possible. Indeed, it is not surprising that he should endeavour to persuade the textile manufacturer that for his purpose a motor for each machine would be ideal. In this contention he is not in the wrong, nor is he without practical evidence to support his claim. On the Continent certain types of textile machines are in operation driven by separate motors. These include spinning mules and looms, the latter, as far as we can ascertain, being carpet-weaving machines. Although definite data is difficult to obtain, the chief matter we wish to emphasise is that the operation of individual textile machines by small motors is not impossible of accomplishment, as experience can testify. With this evidence to go upon, the electric power expert were foolish did he refrain from impressing it strongly on the mind of the textile manufacturer.

Now, up to the present the electrical equipment of cotton mills in this country has been confined to group driving. A motor is usually installed to drive each room, or a set of machines, and no attempt has been made to subdivide the power units beyond this limit. The operating conditions of a cotton mill do not appear to justify further subdivision. The various processes are largely co-dependent, and the running of one room without the others at any time is the exception rather than the rule. This fact goes to show that the whole of the mill machinery is run at the same time, and consequently the power plant may always be operated at full load, or the most economical load for which it is built.

The textile industry, then, would appear to be one of those extensive and important industries in which the factory equipment, considered as a whole, is run regularly during the hours of working, and little if any overtime is put in. This is a matter which electric power experts will require to carefully consider, and rather than argue from other industries in which the individual drive is a distinct success, the case of textiles will need distinct and detailed treatment. Obviously, the peculiar conditions under which textile machinery is run do not preclude the possibility of developments which would admit of the greater subdivision of the power units among the machines employed. An economical and cheap motor or some radical alteration in the design of certain textile machines may render individual driving not only desirable but necessary. Consequently, it is unwise to make any definite statement that group driving of textile mills is the only method by which electric power can be applied. We are persuaded, however, that electrical operation will become more general and that experience will accumulate in its favour in a very few years. The number of electrical manufacturers, their persistent advocacy of the electric drive, the establishment of power supply schemes—these and other factors will contribute to the existing abundance of evidence in support of electrically-driven textile mills, and out of this experience material will be supplied for yet another advance towards an even higher power ideal.

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Electric Passenger and Goods Lifts.

THE electric passenger lift has attained popularity because it has proved superior on all points to all other forms of lifts. There are thousands of these lifts in use in all parts of the world to-day under an infinite variety of conditions both as regards load carried and speed run, but one does not need to go outside the United Kingdom to find many excellent and important installations. The standardisation of the electric motor has been speedily followed by the production of standard pattern motor-operated lift gears for various requirements. There are engineers in the field who are capable of advising on the installation of a complete lift equipment, and of building and erecting all the apparatus necessary for its successful operation.

The Lift Gear. The gearing required for an electric lift is too simple to need detailed explanation. On a common iron bed-plate is mounted the electric motor of suitable size, which drives by worm gearing the shaft carrying the winding drum round which the lifting rope is placed. Attached to the same bed-plate is the electrical starting apparatus, all the switches for which are mounted on suitable supports and neatly connected together. This complete gear is placed either at the top or bottom of the lift well, or in any other position which may be considered convenient. In the well itself are fixed the guides for the cage, this latter being suitably suspended to run freely at all times. The steel rope system is arranged to carry the cage at one end and balance weights at the other, various pulleys intervening to give both the cage and the weights a vertical travel. The cage itself carries the necessary apparatus for control of all movements.

Control Methods. The switching apparatus attached to the lift gear can be actuated in several ways. The simplest is a rope passing through the car and connected to a small pulley fixed on the spindle of the controller. An upward or downward pull of the rope causes the motor to operate the cage in either direction, and its motion can be at once arrested by a slight further pull on the rope. The motor can also be electrically controlled from a special car switch or controller, to which is connected a number of small wires carried in a cable hanging from the bottom of the cage. Movement of this controller energises a number of magnet switches attached to the lift gear, these closing the circuits which give the direction required according to the position of the controller handle. This is a simple and convenient method of control, and one which is applicable to the majority of lifts. Magnet switches are also used in conjunction with push buttons for the control of the lift by the passengers themselves. This method is sufficiently interesting to merit separate notice.

Push Button System. The arrangements provided are very complete, as it is necessary to safeguard the passengers in every possible way. Electrical contacts are fixed to all doors or gates to ensure that the cage cannot be set in motion with any doors open, and also that it shall at once come to rest if at any time a door or gate should be forced open. The usual method is to electrically lock all openings on to the lift well, as soon as the cage is started. The control buttons are provided to correspond to each floor, and upon pressing one of these the cage will at once ascend to the desired floor and stop directly opposite to it. Should the wrong button be pressed the passenger will need to correct his error, and this is arranged for by a special emergency stop button. When this is pressed the cage stops, and the right button may then be pressed in order to proceed to the floor required. This form of electrical control is perfectly simple, and there is little if anything to get out of order. The pressing of the various buttons in the lift closes the circuit of the magnet switch controlling the direction of the motor corresponding to the button pressed. In the majority of cases there are few, if any, sliding contacts in the lift well, and such switches as are necessary are usually accessible from the staircase.

Speed. There is practically no limit to the speed at which an electric lift can be made to operate, except it be the comfort of passengers. Hydraulic lifts are notoriously jerky at starting, because it is difficult to control the supply of water to the rams. With electrical operation very rapid acceleration can be obtained, but in such a way as not to be noticed by the passenger. A speed as high as 450 ft. per minute is attained without damage to the apparatus, and without the least feeling of unpleasantness.

Power Regulation. The electric lift only takes power while the hoist is in operation, and the consumption of energy by the motor is directly proportional to the load which it sustains. That is to say, if the lift is only working at half load, only half the energy is needed to operate it. With hydraulic lifts the consumption of water is the same, no matter what the load on the ram, so that there is no economy in working the lift lightly loaded. This self-regulating property of the electric motor is one of its most important and peculiar features. It is, moreover, one that it shares

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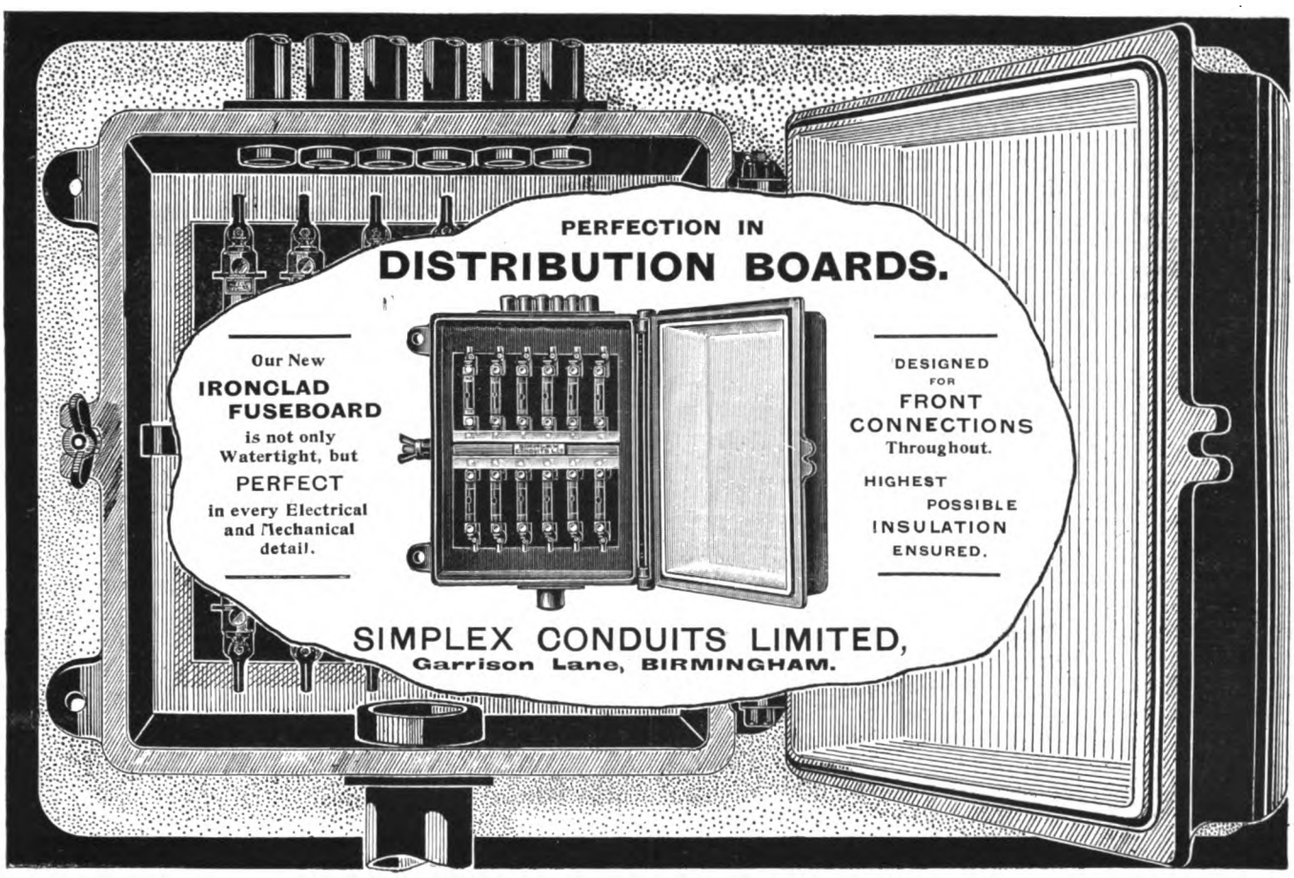

with no power agent. No better testimony to the value of electric lifting appliances is to be found than that afforded by the action of the Admiralty in adopting such apparatus on the latest types of battleships. It is hardly necessary to point out that the utmost reliability is required in the operation of such mechanisms as ammunition hoists, tilting tables, gun carriages, bulkhead doors, &c. In the latest Admiralty practice the electric motor is employed for actuating all of these.

In Business Houses. The competitive conditions under which business houses of almost any kind are now conducted practically compel attention to the comfort of clients. A large shopping establishment, for instance, with more than two floors of departments will encourage custom if an electric lift is installed to take customers to the upper floors. Even medium-sized houses would reap considerable benefit by the introduction of a lift, more particularly as the cost of operation is remarkably low. It can be put in charge of a boy, and needs practically no attention or repair. The modern business house also will benefit by the introduction of cheap and convenient means of transport between the various floors. The disadvantages of high buildings are almost entirely eliminated by the use of lifts. With the push-button type the need for an attendant is dispensed with, so that officials and other persons can save much valuable time in getting from one department to another.

Goods Lifts. There are already in satisfactory use many electric goods hoists and lifts, and this fact should encourage those contemplating the introduction of such apparatus to proceed with its installation. Electric lift makers now have varied and extensive experience at their command, and the requirements of every class of load can be met without the least difficulty. In the majority of cases lift gears can be supplied at short notice for all the ordinary requirements of commerce and industry. Instances are on record in which other power lifts have broken down, and serious loss has threatened the proprietors of the particular establishments. Electric motors have been requisitioned at short notice, and the lift has been doing its normal duty within a few hours of the first interruption of service. This fact speaks for the simplicity and reliability of all electrical power methods.

Wherever an electricity service is available lifts operated by electric motors can be installed and worked from the distributing mains. Types are now standardised for connection to the various systems of supply throughout the country, so that no difficulty need be experienced as regards the necessary electrical energy.

In the cost of operation the electric motor has a very favourable record to present. The power rates of the majority of the electricity supply concerns in the country are, comparatively speaking, very low. The average price of 2d. per unit might be taken as representing a very fair mean. With energy supplied at this rate a 7 cwt. lift will make 14 journeys of 50 ft. fully loaded for 1d. The total annual expenditure for repairs and renewals to a lift of this kind would not exceed about £3.

The table below, compiled by Smith & Stevens from data derived from an extensive experience, gives an idea of the cost of operating various types of lifts:—

Pattern of lift.	Load.	Travel.	Average cost power per an.
Electric private passenger lift	6 cwt.	40 ft. to 60 ft.	£2 14 0
Ditto, alternate current	6 to 10 cwt.	40 ft. to 60 ft.	3 14 0
Electric factory or warehouse lift	6 to 30 cwt.	40 ft. to 70 ft.	5 9 3
Electric office lift.....	6 to 12 cwt.	40 ft. to 80 ft.	8 17 7
Electric hotel lift.....	9 to 12 cwt.	40 ft. to 80 ft.	29 9 5
Electric lifts, all classes....	6 to 30 cwt.	40 ft. to 80 ft.	8 5 4
Hydraulic lifts, all classes (London)	—	—	15 11 0

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The chief points of the electric lift may be summarised as follows:—

1. Compactness.
2. Ease of control.
3. Higher speed.
4. Absolute safety.
5. Low cost of installation.
6. Great economy in working.

To these may be added the extreme simplicity and reliability of the electric system, the capacity for constant hard work under severe operating conditions, and the ability to stand heavy overloads over even extended periods. These items must all be placed amongst the many advantages which the electric lift can confer in comparison with other power types on the market.

Steam Turbines for Cotton Mill Driving.

SINCE the publication of our comments on the correspondence on the above subject in the "Manchester Guardian" further interesting contributions to it have been made and call for some notice. The controversy has at no time descended to a personal level, and the correspondents do not appear to have "let themselves go" on any occasion. Still it has not lacked spirit, and the champions of the respective merits of steam and electricity are not wanting in ammunition.

The appearance, in the same paper, of a serial on "Steam Turbines for Cotton Mills" has also added interest to the discussion and supplied useful information to textile men in regard to this prime mover. Cotton-mill engineers have always been on the side of slow speeds, a fact to which the existence of many beam engines furnishes abundant testimony, and the recommendation of an engine whose speed is far in excess of any limit they have hitherto reached will doubtless come as a surprise to them. The writer of this article makes some instructive comments on the combination of the turbine with an electric generator. Previous to doing so, however, he points to the comparative futility of applying the turbine direct without any reduction of speed other than by different sized pulleys for rope driving. He says: "If the rope speed were increased to 6,000 ft. per min., a turbine running at 2,000 revs. per min. would require a fly-rope pulley of rather less than 1 ft. in diameter. According to the usual rule as to the relation of rope diameter to least pulley diameter, the ropes for this pulley would be $\frac{1}{2}$ in. in diameter, and would each transmit about 4 H.P. For a 1,600 H.P. turbine this would mean that the main pulley would be grooved for about 400 ropes, and would be not less than 30 ft. wide. Even if the ropes were made $\frac{7}{8}$ in. in diameter there would still be about 150 of them requiring a pulley about 18 ft. wide. And it must be remembered that this pulley would be only 1 ft. in diameter. Clearly, then, direct rope driving cannot be adopted for large powers."

The writer then proceeds to state that the value of the turbine lies in its combination with a generator. "In many cases this method has no rival, but in cotton mills the conditions are specially favourable to the direct drive. The electrical drive is at its best when the points of application of the power are scattered, when heavy momentary fluctuations of load are experienced, and when rapid acceleration in speed is desirable, as in tramway service. Where, however, turbines are adopted the cotton manufacturer has at present no alternative but to adopt the electric drive for his mill."

Various comments are then made on the merits of the turbine compared with reciprocating engines, and the conclusion drawn is that there is very little to choose between them. The employment of a low-pressure turbo-generator is, however, suggested, and this is certainly to be recommended. To use the writer's own words: "A low-pressure turbine might often be advantageously combined with a reciprocating engine. The latter would expand the steam down to about, or rather less than, atmospheric pressure, the remainder of the expansion being completed in the turbine. By means of this arrangement the coal consumption could be reduced by from 15 to 25 per cent. The reciprocating engine would drive part of the mill by means of ropes. The turbine could drive a generator which would supply power to the more distant and awkwardly situated parts of the mill, and also supply current for lighting. Although this arrangement would be somewhat more costly than the simpler all-turbine or all-engine plant, yet it would be much more economical, and the turbine would be less liable to breakdowns than a high-pressure turbine. The future of the turbine in cotton-mill work is thus seen to be intimately connected with that of the electric drive. When combined with a high-pressure reciprocator, as outlined above, it operates under the most favourable condition as regards both efficiency and reliability. That it will seriously menace the reciprocator is unlikely, unless satisfactory high-speed gearing can be made for large powers. Even in such an event the turbine is probably destined to be a partner rather than a rival to the reciprocating engine."

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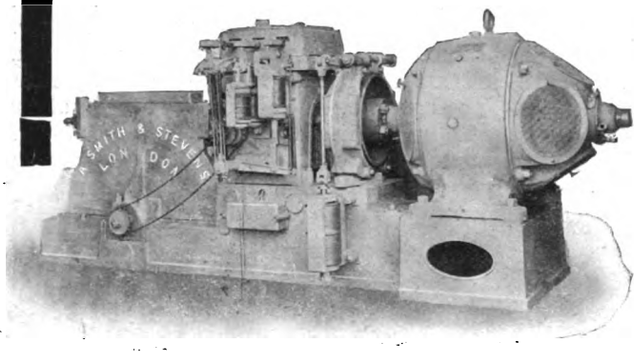

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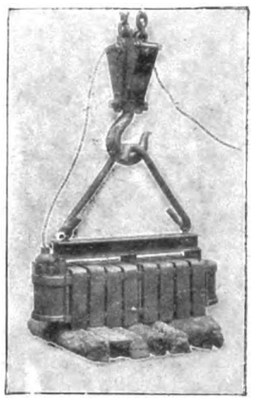
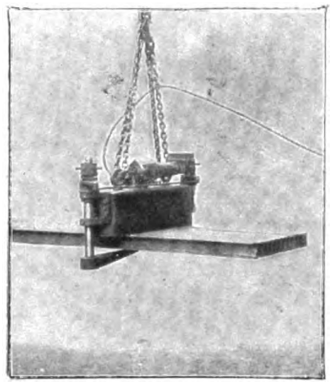
Practical Lifting Magnets.

WE have frequently pointed out that lifting magnets offer an expeditious means of transporting blocks, bars, rails, forgings, plates, tubes, castings, filings, &c., of steel, cast iron or wrought iron. The lifting power of the magnets is but little affected by the temperature of the load up to 300°C., but beyond this point it diminishes at an accelerated rate, and ceases altogether at a temperature of from 600°C. to 709°C. To suit various conditions, magnets are supplied with fixed, movable or adjustable pole-pieces. Magnets with fixed poles are provided either with wound or oblong poles. The round form is particularly suitable for lifting solid blocks of iron, complete machines, iron sheets, armour plates and so on, while the oblong form offers special advantages in connection with the lifting of a number of iron bodies, such as billets, rails, angle iron, channel iron, and so forth. Long bodies are preferably handled by means of two or more magnets suspended from the crab of the crane. Long magnets are provided with movable poles of ⌐¬ shape or ⌐⌐ shape. In the latter case each pole can be separately adjusted, so as to obtain as large a contact area as possible on bodies of curved or irregular shape.

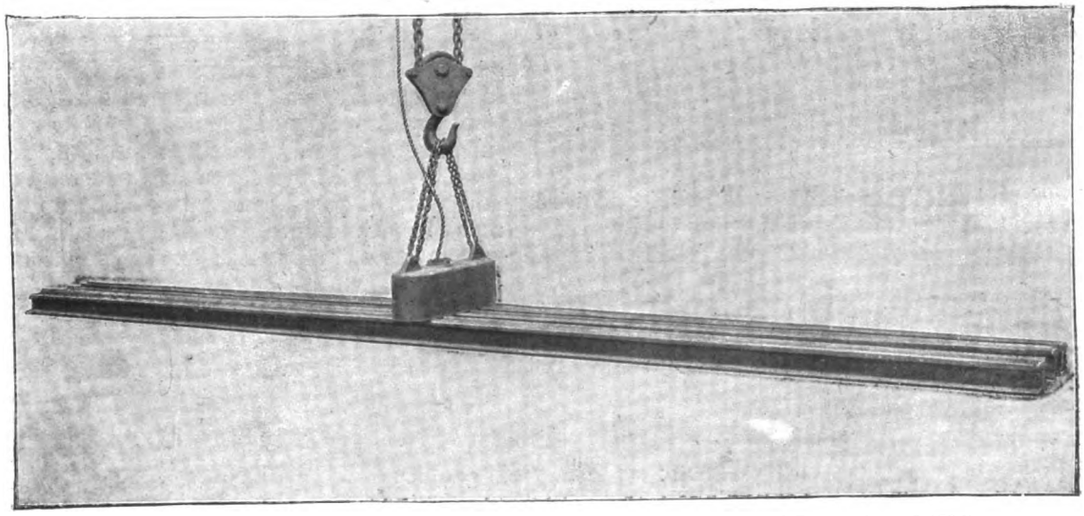
For places where the material is to be conveyed above the heads of workmen, Siemens Bros.' Dynamo Works (Ltd.) supply lifting magnets with an electrically-operated grab, which embraces the material and prevents it from falling in the case of anything going wrong with the lifting magnet. The lifting magnets are energised by continuous current. In the case of an alternating-current supply continuous current is obtained from a small motor-generator installed for this purpose. It is necessary to use magnets with adjustable poles in those cases in which the surface of the material is so uneven that the distance between it and the fixed pole would exceed a certain value. It is not possible to state definitely what loads a given lifting magnet is capable of dealing with, as this depends to a very large extent on the nature of the material to be transported. It may be mentioned, however, that the firm has carried out a great



Lifting Magnet with Movable Poles, carrying a number of Cast-iron Bars.



Lifting Magnet, with Safety Grab.



Lifting Magnet Carrying 6 Rails, each about 21ft. long. Total weight of Rails about 2,650lb.

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Lifting Magnet carrying Wrought Iron.

number of tests with different types of magnets and a variety of goods, such as are to be found in every workshop, including blocks of cast steel and cast iron, both planed and unplaned, rolled iron of various sections, gas tubes, iron sheets, and so on. Space prevents us from giving a detailed account of these tests, but an idea of the capabilities of these lifting magnets will be obtained when it is mentioned that some of the larger sizes of magnets are capable of lifting steel or cast-iron blocks, bars, angle iron &c., weighing many tons. The types illustrated herewith offer practical examples of magnets designed to meet a variety of working conditions and which may be taken as covering almost the entire field of utility for this useful electrical device.

Motor Starter Specialities.

THE motor starter specialities of E. P. Allam & Co, Clerkenwell-road, London, E.C., include several interesting types of this class of apparatus. A complete line of starters for all kinds of direct-current motor control is made by this firm, and we take the adjoining illustrations from its latest pamphlet file. The starters are designated the "Premier," and they range from small ¼ H.P. sizes to 50 H.P., and are suitable for standard pressures between 100 and 600 volts. They are made in plain open

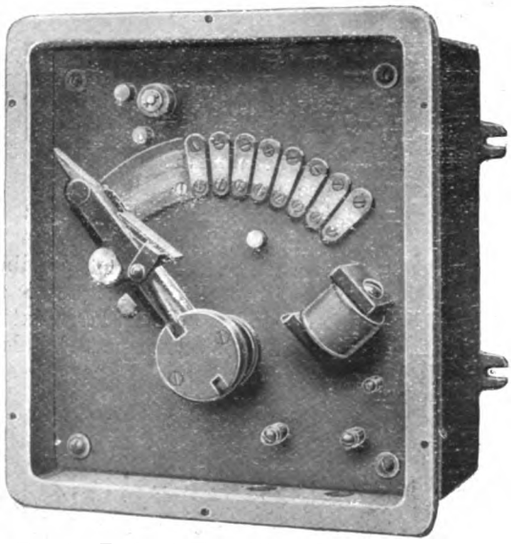

Fig. 1.—Premier Enclosed Type Motor Starter, Cover Removed.

semi-enclosed and totally enclosed cases, and, in addition to starting the motor, certain types are fitted with speed-regulating contacts. Fig. 1 depicts the "One Minute" pattern starter in iron case for total enclosure, the cover being removed. The resistance units which are made up behind the contact base are of wire, of a special alloy, wound on asbestos tubes, treated so as to be non-hygroscopic. These tubes are fixed on insulators of English porcelain, and the slate slabs are also bushed where the contact studs pass through. The operating lever is attached to the cover and pins engage with slots in a disc attached to the starter arm. The keeper engaging with the poles of the hold-on coil is mechanically locked so that it is not shaken loose by vibration nor any weakening of the field strength due

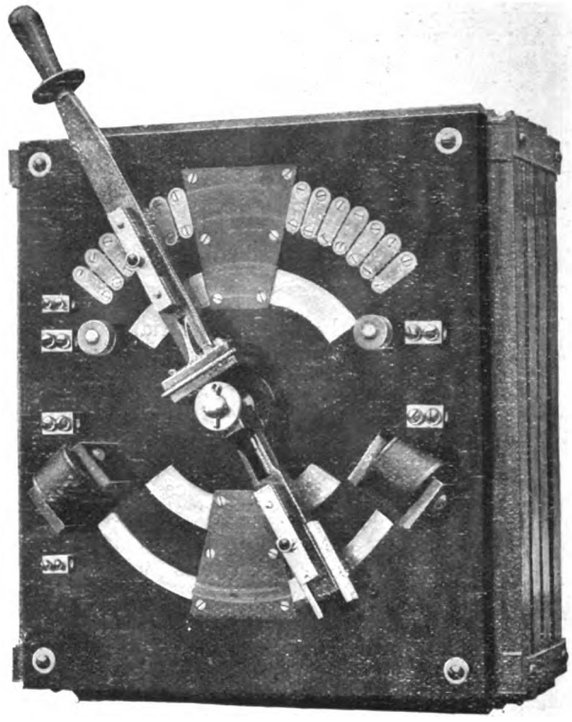

Fig. 2.—Premier Reversing Motor Starter.

to increasing the speed of the motor by shunt regulation. The cover joints are made with rubber insertion, and the cables enter the case through suitable glands.

Fig. 2 illustrates a Premier reversing starter built for the control of direct-current motors ranging from ¼ H.P. to 50 H.P. As will be seen from the illustration, no current is carried through the moving arm, laminated brushes, insulated from the arm, being used to bridge the contact pieces on the slate base. The resistance stops are of the radial pattern and can be renewed from the front when burnt. The design of the controller ensures that all resistance is re-inserted in the armature circuit before the motor is reversed. The design shown is an open type starter, but semi-enclosed covers can be fitted if required. The same company also supplies its motor-starting apparatus in conjunction with fuses and switches, to form complete motor-control panels, either of the open or totally enclosed types. Any form of panel can also be built up to meet special requirements. Among the Premier starters we may also mention those for small motors ranging from ⅛ to 3 H.P.

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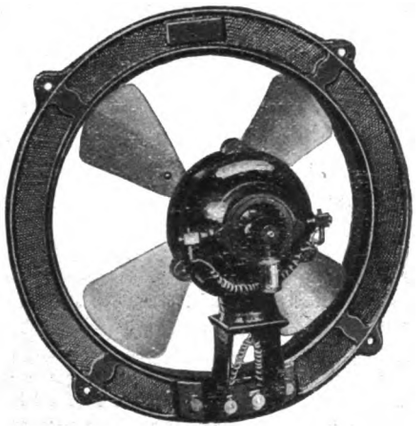

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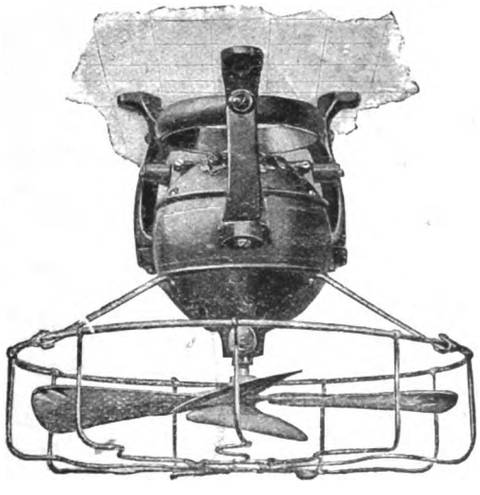

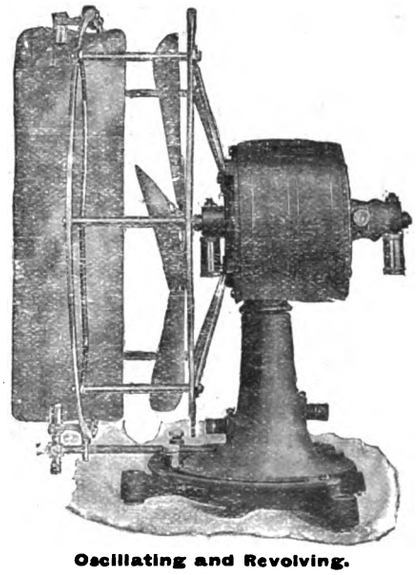

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THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

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NOTES.

The British Association.

THE annual meeting of the British Association opened at Leicester on Wednesday, under the presidency of SIR DAVID GILL, K.C.B., F.R.S. Admirable arrangements have been made by the local committee, and considerable assistance has been rendered by the Corporation. Many municipal buildings are being used for meetings, and officials of the town are giving their services. Section G (Engineering) is presided over by Prof. S. P. THOMPSON, F.R.S. who delivered an excellent address, which we give in abstract elsewhere. The number of visitors is somewhat smaller than is often the case, the number registered yesterday afternoon being only 1,600. Mr. FRANCIS DARWIN, reader in botany at Cambridge, and son of the celebrated CHARLES DARWIN, is to be president next year.

Relieving the Ratepayer.

WE must say we feel some sympathy with the Edinburgh ratepayers who are objecting to the distribution in relief of the rates of the surplus of £10,000 profit made by the electricity undertaking during the past year. In the *Scotsman* an irritated electric light consumer puts the case very clearly when he says that he strongly objects to making a present to Mr. Jones round the corner who uses nothing but gas for his lighting and coal for his cooking, such present being provided by the too high rate at which the electric light consumer has to pay for his electrical energy. If a surplus of this kind is used for reducing the rates, evidently the minority, formed of the electric light and power consumers, are paying something for the benefit of the majority who care nothing whether electric light and power exist or not. Theoretically, there should be no profit at all, and to the lay mind this is quite a simple matter; but actually, of course, it is impossible to so adjust expenditure and revenue that no profit shall result. If such a course is attempted there is likely to be a loss at times, and then there will be indignation among the ratepayers generally, upon whom this loss must fall. The rational course is to provide an ample sum for reserve and depreciation, and if, in addition, there is a profit, the prices charged may be cautiously reduced. As, however, it is difficult to raise a price after it has once been reduced, it would appear better in many cases to reduce the profit from time to time by discounts rather than to make a permanent reduction in the rates charged. No discount rates need be published, and the discounts would come as a kind of bonus, which would be greatly appreciated by the consumers, and would be varied from year to year according to the success of the undertaking.

The Motor Omnibus Crisis.

IN September last we expressed the view that the boom in motor omnibuses might lead to unfortunate results. Apparently the day of reckoning has now come, and along with it some disastrous effects. No fewer than five motor omnibus companies are now in liquidation. Engineers associated with the electrical industry have good reason to know that a new industry requires the most careful handling. Above all things, it is necessary that the company promoter should be avoided. If the development of the motor omnibus had been left to the older omnibus companies, such as the London General Omnibus Co. and the London Road Car Co., having large experience of the conditions to be met, the motor omnibus industry might have gone forward quietly, and all might have been well. There has, however, been some reckless finance. Companies concerned with motor omnibuses alone have sprung up like mushrooms, and the older omnibus companies have been forced to take up the newer form of locomotion more quickly than they would prob-

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ably have done otherwise. Doubtless the older companies will survive, but nevertheless they will certainly suffer, and undoubtedly a severe blow has been struck at the motor omnibus industry. Under present conditions, any company depending simply on the motor omnibus is not likely to exist for long, when, as in the case of the London Power Omnibus Co., the cost per car-mile amounts to 1s. 6d., as compared with earnings of 11d. Recently much has been written about the absurdly low rates at which the travelling public are carried, and there is a marked tendency for fares to be raised. The raising of fares, however, will not make up such a difference as here indicated, and we must certainly look forward to a further evolution of the motor omnibus to make the problem commercially possible.

Electric Lighting in the City of London.

THE chequered career of public electric lighting in the City of London has from time to time been commented on in these columns. It will be remembered that many years ago the Corporation permitted the City of London Electric Lighting Co. to install a type of arc lantern which, though doubtless satisfactory at the time, recently became so much out of date that some improvement became imperative. This improvement took the drastic form of substituting incandescent gas for arc lighting, the standards for the latter being removed. The City of London Company not unnaturally protested against this unfair treatment, and submitted to the Streets Committee of the Corporation a proposal for altering and improving the lighting in the City. The proposal took the form of an offer to light the streets around the Central Markets with flame arcs at a cost of £18 per lamp per annum, a reduction of £6 on the price hitherto paid. The Charing Cross & City Company were also to be given a chance of showing their ability to supply a satisfactory light.

IN connection with this scheme the Streets Committee last week submitted certain recommendations to the Court of Common Council, who have approved them. The recommendations propose that demonstrations shall be allowed in certain of the main streets as follows: The City of London Company are to light Holborn Viaduct by means of flame arc lamps on standards. Arc lamps of an enclosed type are to be erected by the same company in Farringdon-street, including Holborn Circus, and in part of the Old Bailey, while smaller lamps are to be provided in Newgate-street. The maximum charges for these lamps will be £17. 10s. per lamp per annum, against the present rate of £26; the smaller lamps will be charged at £12. 10s. and £10. 10s., according to size. The Charing Cross, West End & City Company are to light part of Cannon-street by means of centrally hung flame arc lamps at a cost of £17. 10s. per lamp per annum. The work of erection is to be put in hand as quickly as possible, and the demonstrations are to continue until next March. It is to be hoped that the results of these experiments will be such as to induce the Corporation to again light the streets of the City electrically.

Electricity in Horticulture.

A GOOD deal of work has been done at one time or another with a view to providing an artificial stimulus to vegetable growth. Several experimenters have tried electrical means. Among these is Mr. B. H. THWAITE, who a short time ago read a Paper on this subject before the Royal Botanical Society, and who is undertaking experiments in forcing fruit, vegetables and flowers in the Royal Botanical Gardens, Regent's Park, London. Actinic rays, to take the place of those from the sun, are to be supplied from arc lamps, and the stimulating effect of atmospheric electricity is to be obtained artificially by electrostatic means. Mr. THWAITE has developed a scheme for utilising as completely as possible all the energy generated. The dynamo will be driven by a gas engine, whose exhaust gases will be supplied to the plants, while the discharge water from the cooling jacket will be employed in heating the greenhouses; the dynamo supplies current to the arc lamps, and an electrostatic machine, driven from the engine crank, electrifies the atmosphere and discharges on to the plants. The successful and economical application of such a scheme on a large scale should lead farmers in days to come to view a summer like the present with equanimity.

Personal.—The Lords Commissioners of His Majesty's Treasury have appointed Sir Henry W. Primrose, K.C.B., C.S.I., to be chairman of the Pacific Cable Board, in succession to the late Sir Spencer Walpole, K.C.B.

New York-Colon Telegraph Route.—The Western Union Telegraph Co. give notice that the cable route from New York to Cuba and on to Colon (Panama) was opened for transmission of traffic yesterday (Aug. 1).

New Type of Trolley Pole.—The *Railway and Engineering Review* states that the Erie Railroad has adopted a new form of steel pole for carrying overhead wires. It is of tripod construction instead of the four or more legs usually employed. It consists of special U bars arranged at angles of 120 deg. round the axis of the pole, and bound together by malleable castings. This method is said to give an absolutely rigid fastening without any hole being drilled in the U section.

Institution of Mechanical Engineers.—At the opening meeting of this Institution's conference at Aberdeen the president (Mr. T. Hurry Riches) announced that Mr. Charles Hawksley had communicated to the council a wish to commemorate the centenary of the birth of his late father by giving the sum of £1,000 for the foundation of a scholarship or premium. This generous offer has been accepted by the Institution. The terms on which it is to be held are under consideration. It was announced that Mr. W. Sitt (Bath) had been elected a member of the council in the room of the late Sir Benjamin Baker and that Mr. A. Huson (London) had been nominated treasurer in place of Mr. F. W. Ellis, who has lately retired.

Experiments with Warning Signals.—According to the *Railway and Engineering Review*, the Prussian railway authorities have been making experiments on the line between Berlin and Stettin to find a method for insuring greater efficiency in observance of signals. In the effort to obtain a preliminary signal to give warning of a stop signal, many devices were tested. These included flashlights by the side of the track when nearing a signal and other visible signs. Electric-wave transmission to the locomotive also was tried. The method found most satisfactory consists of fastening two or three horns with a rubber bulb, similar to those used on automobiles, to the telegraph poles at intervals. These are electrically operated, and have been found trustworthy in warning engineers. The railway authorities have already decided to experiment further with these preliminary signals on a number of roads.

Cable Interruptions.	Date of Interruption.
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Brest—Dakar	July 22, 1907
Kotonou—Libreville	July 18, 1907
Gibraltar—Tangier.....	July 29, 1907

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Fifteen-cycle Single-phase Locomotive.—In connection with the extension of the Pennsylvania Railroad into New York, on which electric traction will be used, a special locomotive has been designed and is described in the *Street Railway Journal*. It will be required to fulfil special duties, as the gradient reaches 2 per cent. in places and a high speed must necessarily be maintained. The locomotive is built in two halves, each of which is capable of exerting a draw-bar pull of 24,000 lb. It will be supplied with single-phase current at 11,000 volts from an overhead wire. A striking feature is the accessibility of the parts that may require attention. The voltage regulating switches are arranged immediately above the main 11,000 volt auto-transformer, which is carried under the cab in front of the motor axles, while the blower equipment and reverse switches are placed directly over the main motors. There are four 500 H.P. motors on each locomotive with a permissible overload of 100 per cent. The maximum output per locomotive is therefore 4,000.

Submarine Cables for the Transmission of Energy at High Pressure.—The *Elettricista* describes a case of the transmission of electrical energy at high pressure through submarine cables. The cables in question form part of the line connecting Venice with Lido. This line is partly overhead, and is supported on insulators fastened on iron trellis-poles, which are fixed in cement foundations; but as it has to pass across several navigable canals, it is necessary that a part should be submarine. The longest submarine section is somewhat over half a mile, and is laid at a depth of about 3½ fathoms. Energy is transmitted by three-phase current at 6,200 volts and a frequency of 42. Three single cables are used to allow of greater flexibility. A fourth cable is laid which provides against possible damage due to blows from anchors, &c. The cables used are constructed with a new type of insulating material, having gutta-percha as a base. Over the core, which is 25 sq. mm. in section, are wound two layers of insulating material of different compositions. These are protected against damp by a lead sheath, which is covered with tarred jute and with an armouring of phosphor bronze wire. This system was chosen in order to diminish the loss of energy due to eddy currents and hysteresis.

"Sineplat."—We recently (*The Electrician*, Vol. LIX., p. 230) gave an abstract of a Paper read by Mr. C. O. Bastian before the Glasgow Section of the Institution of Electrical Engineers, which described a new method of employing copper as a leading-in wire for electric lamps. A factory for the preparation of these wires, which are known as the "Sineplat," has now been established by Platinum Substitutes (Ltd.) in East-road, Hoxton, London, and is interesting from the fact that it is claimed to be the first to employ crippled children industrially. Their employment is rendered possible by the co-operation of the Ragged School Union, whose officials have arrangedto look after the children while on duty.

The Lord Mayor, whose interest in the improvement of the lot of cripples is well known, inaugurated the factory on Friday last, and expressed the hope that the venture would stimulate the efforts of others in the same direction.

The number of children at present employed is 30 though there will soon be accommodation for about three times that number. The actual work of sealing the copper in the glass is very simple and is performed in the following way: The copper, in the form of a thin strip, is covered with a small piece of special glass tubing and the whole is placed in the blow-pipe flame. This enamels the metal with a thin coating of glass and a perfect vacuum is said to be obtained. Owing to the fact that the copper is in the form of a strip the pressure exerted by it on the glass is very evenly distributed, and by this means it is claimed that the ill-effects due to the unequal expansion of copper and glass are guarded against.

Composite Arc Lamp Electrodes.—The *Electrical World* describes some newly patented inventions relating to this subject, all of which are assigned to the General Electric Company. One patent, issued to Mr. J. Harden, relates to a lower electrode composed essentially of a titanium compound, the upper electrode being either of carbon alone or containing small quantities of titanium carbide, ammonium chloride or magnesium sulphate. The lower electrode may contain 90 parts of the titanium carbide to 10 parts of carbon; or it may consist of 75 parts of titanium chloride, 10 parts of carbon, 3 parts of ammonium chloride, 2 parts of magnesium sulphate and 2 parts of tar to act as a liquid binder. It is stated that while light-producing salts, such as lime and magnesia, are used in some forms of electrode to colour the arc, such salts are merely evaporated into the arc by the heat produced, whereas the titanium carbide in the electrode described is ionised by the current, the ionised vapour thus formed serving as the principal gaseous medium through which current between the electrodes passes. Other patents, issued to Mr. R. H. Read, relate to the admixture of various carbides with the carbon. When aluminium carbide is used it is stated that a good arc from ¼ in. to ⅜ in. length may be maintained by 1 ampere with a drop across the arc of 50 volts. Several other carbides also give good results.

A Method of Protecting Trolley Wires at Railway Crossings.—A description of a special trolley wire guard, which is used on several American tramways, at places where steam railways are crossed on the level, is given in the *Street Railway Journal*. The guard is made of woven galvanised iron, aluminium or copper wire, with extra heavy selvaged edge, and may be of any desired length all in one piece. When in position the guard assumes the form of an inverted trough. This feature of the guard, which is always alive, makes it certain that if the pole jumps the wire the supply of current will not be cut off and the car can proceed without interruption. Besides making for lightness the open mesh form of construction provides against the accumulation of ice and snow and damage from winds. In addition, the guard offers practically no resistance to the passage of exhaust gases and steam from locomotives passing under it. Still another feature insured by this lightness is the doing away with the necessity of providing special suspension for the guard. The actual weight of the guard as installed is 13 oz. per running foot of aluminum and 18 oz. per running foot of galvanised iron wire and copper wire. The hangers are made of galvanised iron, drilled to take the standard ear, and they hold the mesh to its proper shape. To clamp the ear and mesh to the under body of the hanger, eye-bolts with set nuts are furnished. Due consideration has been given to the question of strains. To provide against them substantial hangers are spaced 5 ft. apart. The wire mesh itself is Roebling No. 10 galvanised and copper wire and No. 9 aluminum with No. 6 Roebling selvage. In addition to its use at steam railroad crossings the guard also is available for service in car houses, at undergrade crossings, and, in fact, everywhere that the slipping of the pole from the wire is likely to be specially inconvenient.

ARRANGEMENTS FOR THE WEEK.

British Association—Section G.

FRIDAY, August 2nd (to-day).

Joint Meeting with Section B. Discussion on "Gaseous Explosions with Special Reference to Temperature."

Visit to a Demonstration of Boot and Shoemaking at the works of the Union Company.

SATURDAY, August 3rd.

Visit to the Leicester & Swannington Railway.

MONDAY, August 5th.

Papers on "Pupin's Compensated Cable for Telephone Transmission," by Sir W. H. Preece, K.C.B., F.R.S.; on "An Oscillograph Study of Duddell Arcs of Low Frequency," by Mr. J. T. Morris; on "Developments of Electric Incandescent Lamps,' by Mr. L. Gaster; on "Modern Machinery and its Future Development," by Mr. H. T. Brackenbury; on "A Machine for Weighing the Forces on a Cutting Tool," by Mr. J. F. Brooks; and on "The Governing of Hydraulic Turbines," by Mr. R. S. Ball.

TUESDAY, August 6th.

Papers on "Ferro-concrete and Examples of Construction," by Mr. J. S. E. de Vesian; on "Some New Uses for Reinforced Concrete," by Mr. W. N. Twelvetrees; on "The Ice Problem in Engineering Work in Canada," by Mr. H. T. Barnes; on "The Equipment of the Engineering Laboratory of the Finsbury Technical Institute," by Prof. E. G. Coker; and on "Submarine Signalling," by Mr. J. F. Millet.

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EXPERIMENTS ON OSRAM, WOLFRAM, ZIRCON AND OTHER LAMPS.

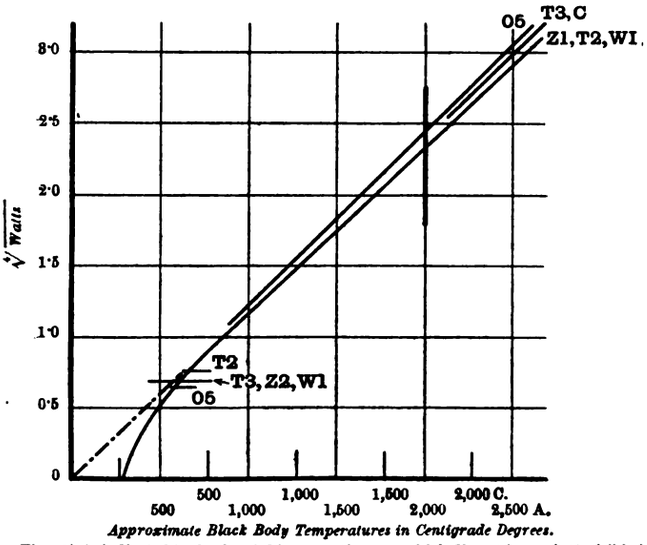
BY J. T. MORRIS, F. STROUDE AND R. MILWARD ELLIS.

(*Concluded from page 587*).

Summary.—In this Paper the authors publish the results of some researches made by them on the physical properties of Osram, Wolfram, Zircon and other lamps. The effect of voltage variation when the lamp is working on direct current is discussed. A simple relation is found connecting expansion and watts, and an estimation of the filament temperature is attempted. A new method of obtaining specific heats is described and some experimental results are given. Physical data concerning the materials of which the filaments are made are also given.

PART III.—ON OBTAINING SPECIFIC HEATS OF FILAMENTS BY A NEW METHOD.

In order to obtain specific heats it is necessary to know, besides the weight, the energy supplied and the resulting temperature rise. In Part II. of this Paper it has been shown that $\sqrt[4]{\text{watts supplied}}$ can be used to obtain approximate "black body" temperatures, and thus for a lamp filament these quantities can be obtained from an oscillogram of its starting current when supplied with constant voltage. Two such curves are shown in Figs. 10 and 11. The timing of the plates was accomplished by means of the voltage wave form of an alternator running at constant speed, which was recorded on the same oscillogram. As the lamp was switched on to constant voltage the rate of supply of energy was easily obtained from the record.*



The points indicated by horizontal bars are those at which filaments are just visible in the dark.

FIG. 9.—$\sqrt[4]{\text{WATTS}}$–TEMPERATURE CURVES.

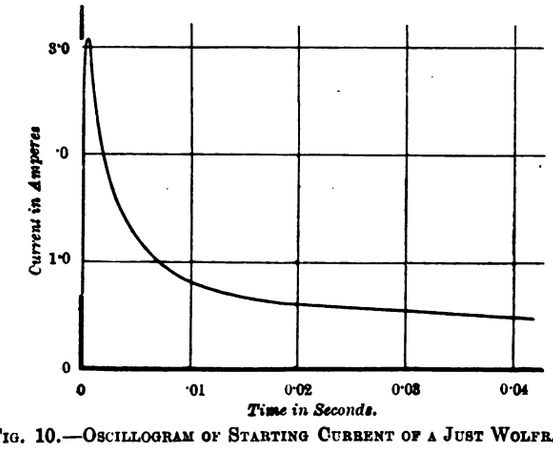


FIG. 10.—OSCILLOGRAM OF STARTING CURRENT OF A JUST WOLFRAM LAMP.

* For these oscillograms the authors have to thank Mr. A. G. Warren, who kindly took them for the purpose of this Paper.

In Fig. 12 are shown curves connecting energy supplied and approximate "black body" temperatures for metallic filament lamps, and Fig. 13 gives similar curves for a 220 volt 5 c.p. carbon filament lamp.

From these curves were deduced Figs. 14 and 15, which show the variation of specific heat with temperature. Owing to the inertia of the strips, &c., of the oscillograph and the energy stored in the magnetic field of the filament, the initial parts of the oscillograms are somewhat unreliable, as shown by the ratios given in Table III. The portions of the specific heat curves derived from these parts are therefore shown dotted.

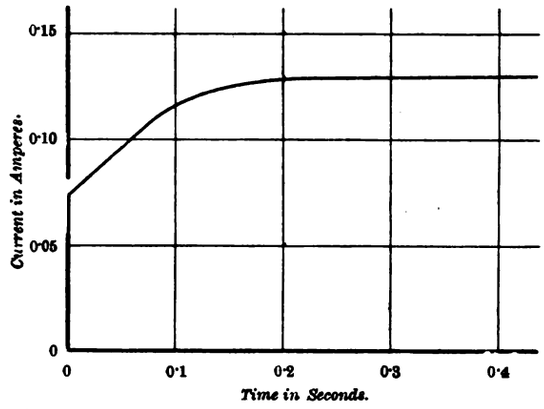


FIG. 11.—OSCILLOGRAM OF STARTING CURRENT OF A 220 VOLT CARBON LAMP.

Fig. 15 also includes the curve given by H. F. Weber for the specific heat of carbon, which, it will be noticed, is in good agreement with the curves obtained by this method. The authors are not aware, however, that it has been previously shown that the specific heat of carbon continues to rise after the flat portion of the curve obtained by Weber. The heights marked on the right of these two curves show the values for the specific heats of the metals marked thereon obtained from the well-known law of Dulong and Petit—viz.:

Specific heat × atomic weight = 6·3 (for solids).

The general tendency among the metals is for the specific heat to decrease with rise of temperature.

It must be distinctly understood that these experimental results are only intended as indications of the possibility of the method, and not as trustworthy values for the specific heats.

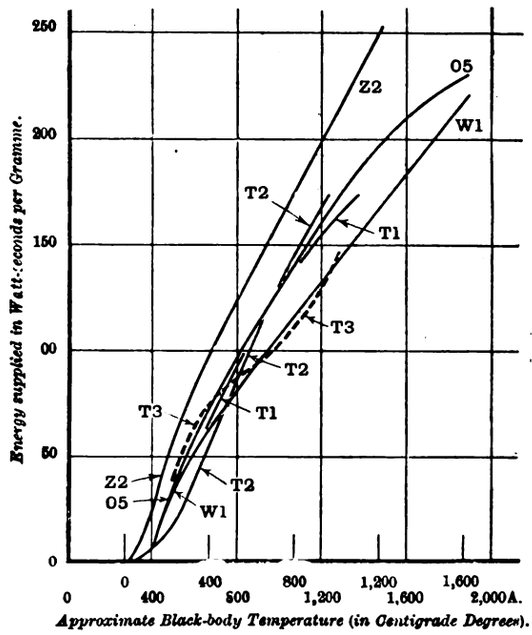


FIG. 12.—ENERGY-TEMPERATURE CURVES FOR METALLIC FILAMENTS.

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Table V.

Distinctive mark.	Name of lamp and candle-power.	L'ngth of filament, cms.	Diameter of filament, cms.	Int. brilliancy H.C.P. per sq. in. of projected area.	Int. brilliancy H.C.P. per sq. cm. of projected area.	Watts per sq. in.	Watts per sq. cm.	Watts per horizontal c.p.	Horizontal c.p. per watt.	Specific resistances. Hot. Microhms per in. cu.	Hot. Microhms per cm. cu.	Cold. Microhms per in. cu.	Cold. Microhms per cm. cu.	Density, grammes per cubic cm.	Temp. coef. (°C.) At working temp.	Temp. coef. (°C.) 0°C. to 100°C.	Approximate specific heat at 1,000°C. (C.G.S.)	Expan. coeffic't (C.G.S.) $\times 10^6$.
..	Carbon 220 volt 5	19·4	0·0054	..	..	565	87·7	..	..	780·0	1,980·0	..	..	1·7	..	..	0·46	..
C1	Carbon 100 volt 16 ..	20·5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2·94
T	Tantalum 110 volt 25..	73·8	0·0049	440	68	222	34·4	1·60	0·63	31·2	79·3	4·98	12·65	..	..	0·35	..	..
T1	Tantalum 110 volt 25..	65·2	0·0050	460	71	266	41·3	1·83	0·55	33·3	86·0	..	..	16·5	..	..	0·04	..
T2	Tantalum 110 volt 25..	65·2	0·0050	420	66	278	43·1	2·07	0·48	32·5	82·5	5·72	14·50	..	0·17	0·32	0·05	..
T3	Tantalum 110 volt 25..	65·2	0·0050	405	63	250	38·8	1·94	0·52	36·0	91·6	6·26	15·90	..	0·16	0·31	0·03	..
O1	Osram 107 volt 32 ..	55·2	0·0040	755	117	330	51·1	1·37	0·73	28·9	73·4	..	..	18·0	..	..	..	..
O2	Osram 107 volt 32 ..	55·2	0·0041	849	130	348	54·0	1·32	0·76	28·1	71·4	3·26	8·29	18·5	0·36	0·28	..	4·6
O3	Osram 105 volt 50 ..	55·2	0·0055	980	152	394	61·1	1·27	0·79	32·1	81·4	2·84	6·32	17·0	0·57	0·43	..	5·0
O4	Osram 120 volt 50 ..	55·2	0·0048	1,070	166	419	64·9	1·23	0·81	34·5	87·8	2·78	7·05	18·0	..	..	..	..
O5	Osram 120 volt 50 ..	55·2	0·0048	1,190	185	467	72·5	1·23	0·81	30·9	78·6	2·46	6·25	..	..	0·44	0·04	..
W1	Just-Wolf. 110 volt 40	49·5	Ext. 0·0058	812	126	332	51·5	1·29	0·77	36·0	91·5	2·90	7·38	..	0·55	0·42	0·03	4·0
W2	Just-Wolf. 110 volt 40	46·5	Int. 0·0034	1,050	162	376	58·4	1·13	0·89	36·0	91·5	2·80	7·10	16·0	0·59	0·41	..	5·0
Z3	Zircon 110 volt 35 ..	61·0	0·0041	735	114	315	48·9	1·35	0·74	26·9	68·4	..	..	19·0	..	..	..	..
Z1	Zirc.-Wolf. 110 volt 35	61·0	0·0042	820	127	379	58·8	1·46	0·69	22·9	58·0	..	..	23·0	..	..	..	..
Z2	Zirc.-Wolf. 110 volt 35	61·0	0·0042	870	135	394	61·1	1·42	0·71	22·0	55·9	3·54	9·00	..	0·27	0·14	0·04	..

Part IV.—Physical Constants connected with the Lamps.

With a view to determine definitely the resistance temperature coefficients of the materials of the lamp filaments at ordinary temperatures the ensuing experiment was carried out. The lamps were immersed in a paraffin oil bath containing an electric heater, and their resistances were measured at different temperatures of the bath by means of a Wheatstone bridge. The results of the experiment are given in Fig. 16,

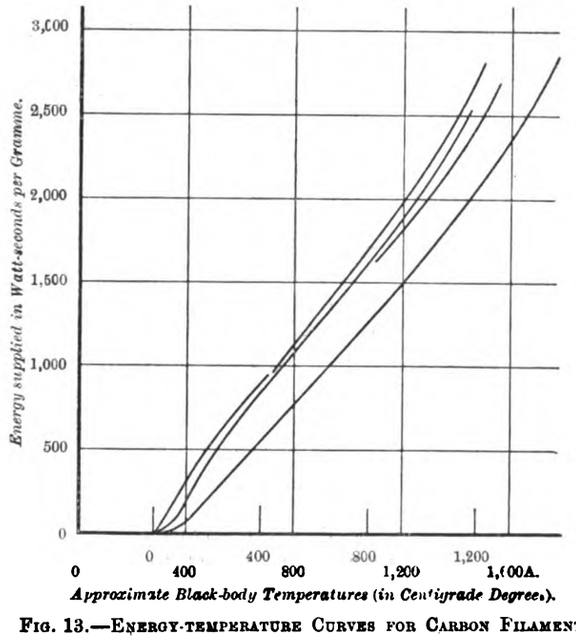

Fig. 13.—Energy-temperature Curves for Carbon Filaments.
The curves are derived from four oscillograms of a single 220 volt 5 c.p. lamp.

and the resistance temperature coefficients are included in the table of physical constants (Table V.). It will be seen that the Zircon-Wolfram lamp filament has a very low coefficient (0·14), showing clearly that it is an alloy. The same characteristic may be noticed for the low candle-power Osram lamps. The high candle-power Osram lamps, however, have temperature coefficients of 0·43 and 0·44 and the Wolfram lamps also show high values for this figure. Assuming these values to be constant up to the working temperatures, the latter become :—

Tantalum	1,600°C
Osram	2,900°C
Wolfram	2,900°C
Zircon	3,900°C

The first of these figures is obviously low and the others are certainly high; the resistance temperature coefficient must therefore decrease for the Tantalum and increase for the other three kinds of lamps. The values of this coefficient, at the working temperature, obtained on the assumption on which Fig. 9 is based, are in agreement with the above conclusion, as will be seen on reference to Table V.

Table V.—The *diameters* given were obtained by micrometer measurement and were in most cases corroborated by means of a microscope. The Just-Wolfram filament is tubular, as is shown by the diameters given.

The high *intrinsic brilliancy* of these metallic filament lamps constitutes a real objection to their use for direct illumination and counterbalances to some extent the advantage derived from their greater efficiency.

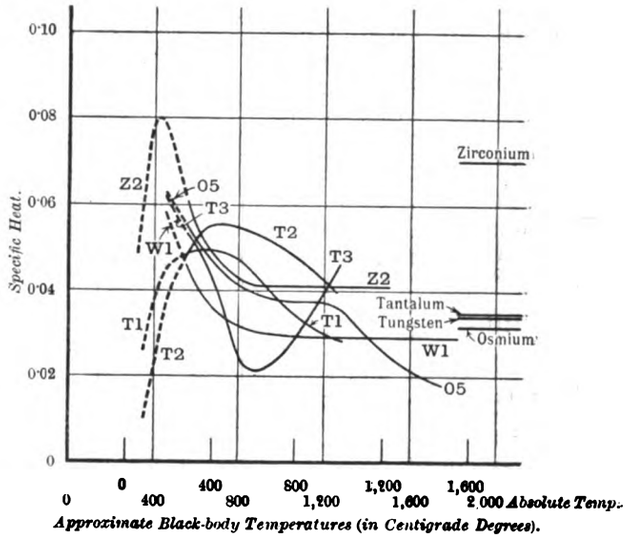

Fig. 14.—Specific Heat—Temperature Curves for Metallic Filaments.

From an inspection of the column headed *density* it will be seen that these refractory metals are exceptionally heavy (density of lead = 11·5).

The expansion coefficients are taken over the entire range, and are obtained from Fig. 8.

Table VI.—This table collects the indices of the relations given in Table II. The indices of the candle-power temperature relations are also given. This index, according to Guilleaume's law for "black bodies" (C.P. $\propto T^{12}$), is twelve. This is approximately true for Carbon lamps, but for Osmium and Tantalum lamps the index is 10·7, and for the remaining lamps (which all contain a considerable proportion of tungsten) practically 10·0. Possibly the divergence of these indices is due to the fact that carbon acts more like a black body than the metallic filaments at these high temperatures.

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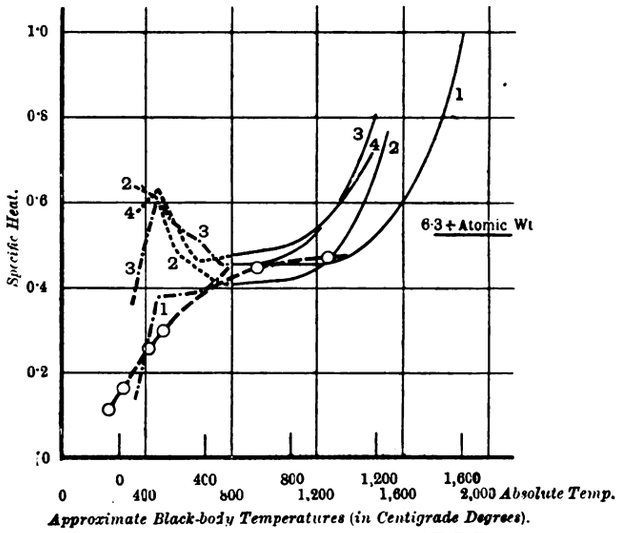
An examination of Table V. leads one to the conclusion that the low candle-power Osram lamp is more alloyed than the high candle-power lamps—the latter more nearly approximating to pure tungsten.

Conclusion.

It is now abundantly clear that in the past few years great strides have been made in improving the efficiency of electric



N.B.—The curve containing observations is that of H. F. Weber.

Fig. 15.—Specific Heat—Temperature Curves for Carbon Filaments.
The curves all refer to the same lamp.

incandescent lamps. The authors, however, from considerable experience gained in the handling and use of these lamps, have come to the conclusion that, as far as those of the lamps tested which contain tungsten are concerned, it would be better to make some sacrifice in efficiency in order to gain in mechanical strength. This has already been done in the case of the Tantalum lamp.

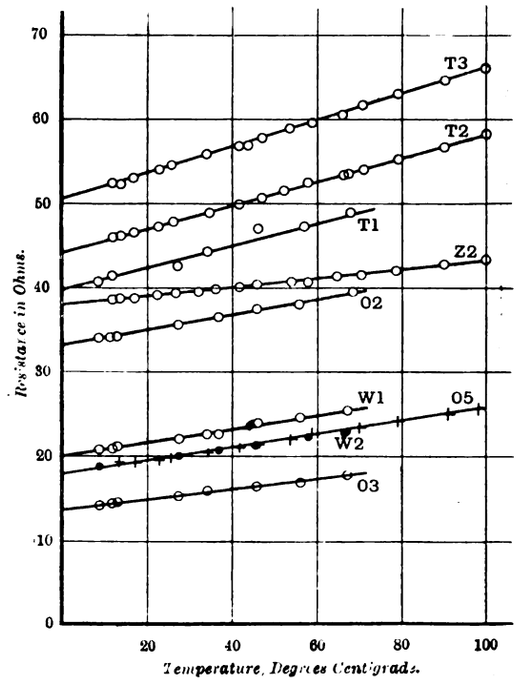


Fig. 16.—Resistance-temperature Curves from 0°C. to 100°C.

There is no doubt that the principal objects to be attained with these lamps are moderate candle-power, suitability for use on 220 volt circuits, reasonable life and capability of use in any position, while still retaining the mechanical robustness of the ordinary carbon lamp. The initial cost of the lamp

Table VI.

Name of lamp.	C.p.-volt index. Mean over whole range.	C.p.-volt index. 10% either side of normal.	C.p.-watt index. Mean over whole range.	C.p.-watt index. 10% either side of normal.	C.p.-temp. index. Mean over whole range.
*Carbon, 220 v., 5 c.p.	7·35	..	3·08	..	12·32
*Carbon, 110 v., 50 c.p.....	6·48	..	3·00	..	12·00
*Carbon, 110 v., 25 c.p.-H.E.	6·33	..	3·05	..	12·20
*Carbon, 55 v., 16 c.p.	6·32	..	3·18	..	12·72
*Carbon, 10 v., 2 c.p.....	7·88	..	3·77	..	15·08
*Osmium, 2 55 v., 25 c.p...	4·57	..	2·69	..	10·76
*Tantalum, 110 v., 25 c.p...	4·33	..	2·50	..	10·00
Tantalum, 110 v., 25 c.p...	4·59	4·37	2·67	2·50	10·68
Tantalum, 110 v., 25 c.p...	4·49	4·49	2·64	2·64	10·56
Tantalum, 110 v., 25 c.p...	4·70	4·70	2·75	2·75	11·00
Osram, 107 v., 32 c.p.	4·04	4·04	2·51	2·51	10·04
Osram, 107 v., 32 c.p.	4·03	4·03	2·50	2·50	10·00
Osram, 105 v., 50 c.p.	3·97	3·38	2·50	2·24	10·02
Osram, 120 v., 50 c.p.	3·97	3·50	2·50	2·20	10·00
Osram, 120 v., 50 c.p.	3·65	3·65	2·34	2·34	9·36
Just-Wolf., 110 v., 40 c.p...	3·91	3·36	2·49	2·17	9·96
Just-Wolf., 110 v., 40 c.p...	3·94	3·94	2·48	2·48	9·92
Zircon, 110 v., 35 c.p.	4·02	3·53	2·49	2·24	9·96
Zirc.-Wolf., 110 v., 35 c.p...	3·96	3·73	2·43	2·30	9·72
Zirc.-Wolf., 110 v., 35 c.p...	4·08	4·03	2·49	2·49	9·98

* Lamps from previous Paper.

itself is not of such serious importance as is commonly supposed. At the present time an ordinary 3·5 watt per candle carbon lamp consumes during its life some 10 to 20 times its initial cost in electric energy. In other words—say the lamp cost 10d., it would consume some 13s. worth of electric energy in its life, so that it is commercially quite sound to pay five times the price for a lamp if the current bill is cut down to one half, even though the life of the lamp may be reduced.

Finally, the authors wish to express their indebtedness to the General Electric Co., the Edison & Swan Co., Siemens Bros. and the Zircon Syndicate for the courteous assistance they have rendered.

THE VARIATION OF MANGANIN RESISTANCES WITH ATMOSPHERIC HUMIDITY.

BY W. JAEGER AND ST. LINDECK
(of Charlottenburg).

We have read with interest the article under the above title emanating from the National Bureau of Standards at Washington, which appeared recently on p. 339 of *The Electrician*, and conclude from it that the statement made by the Physikalisch-Technische Reichsanstalt for more than 10 years, that manganin is a material with a particularly constant resistance, is confirmed.

Messrs. Rosa and Babcock, it is true, have found that the value of the higher resistances (of the Reichsanstalt form) shows a yearly cycle *in the climate of Washington* corresponding to the variations of the relative humidity at different times of the year. The amplitude of these variations is about 0·01 to 0·02 per cent., an increase in humidity causing an increase in resistance. According to their own explanation this phenomenon has, however, nothing to do with the resistance material, but is traced back to the swelling of the shellac used for insulating purposes, and to the resulting elastic deformation of the resistance wire. If the humidity is artificially kept for several months at a nearly constant value, according to Messrs. Rosa and Babcock, the resistance remains "remarkably constant."

The circumstance that the manganin itself plays no part in the phenomenon under notice is very rightly commented on in the Notes (*The Electrician*, p. 329).

Allusion may next be made to the fact that the measurements of Messrs. Rosa and Babcock, in so far as the influence of the *atmospheric* humidity comes into the matter, are made only on *resistance box coils*, that is to say on such resistances in which the highest possible constancy was not to be expected.

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No information is given about the variations in *standard resistances* under natural conditions. For this reason the title of the article is somewhat too general.

Owing to the wide general application of manganin resistances made on the Reichsanstalt model it appears important to us to call attention to the fact that this very interesting discovery of a source of error which has been found in the climate of Washington need cause no anxiety to the owners of such resistances. For (1) evidently the phenomenon makes its appearance to the extent noticed only in a climate as unfavourable as that of a Washington summer. (2) It affects only high resistances, while Messrs. Rosa and Babcock are also of the opinion that resistances of 1 ohm and under remain constant. It is thus possible by calibrating the box, &c., to determine whether the phenomenon is present or not. (3) Even the variations noticed in Washington are unimportant for most practical measurements, for they are small and distributed over a long interval of time. By the use of drying materials, &c., it is further possible when required to easily remove the influence of the humidity.

Moreover, it will be presumably possible in the near future to remove the faults noticed by quite insignificant alterations in the methods of manufacture.

How unfavourable the climatic conditions of a Washington summer are for electrical precision measurements may be gathered from the authors' article. It is necessary to artificially reduce the humidity in the laboratory at this time of the year "to secure more perfect insulation than could be obtained otherwise." Without artificial drying the relative humidity in the Washington laboratory often rises to over 70 per cent. In the laboratory at the Reichsanstalt the conditions are much more favourable, as the following will show.

From the observations of Liebenthal, which lasted from the beginning of April, 1894, to the end of March, 1895, when the humidity in the optical laboratories of the Reichsanstalt was determined almost daily by an Assmann's aspirator hygrometer,* we calculated the mean relative humidity for each month as follows:

Table I.

1894 ..	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	39	47	57	50	58	52	48	41	30%

1895 ..	Jan.	Feb.	March.
	26	22	30%.

A humidity of from 65 to 70 per cent. was only noticed during a very few summer days. Accordingly the phenomenon found by the authors has not yet been noticed at the Reichsanstalt. It is, indeed, extremely improbable that variations in resistance as great as those observed in Washington would have escaped our notice.

Since the publication of Messrs. Rosa and Babcock's article we have made measurements on 10 standard resistances (2 coils each of 10 and 100 ohms and 3 coils each of 1,000 and 10,000 ohms) which were calibrated with the utmost precision, at the end of April of this year in the usual way† by comparison with the 1 ohm standards of the Reichsanstalt; the measurements were again taken at the end of June. However, the accuracy obtained was slightly less in June than in April, because the new series was not so complete as that in April, and because the temperature corrections were somewhat greater than those in the first series.

The above Table I. and Fig. 1 of Messrs. Rosa and Babcock's article show that the relative humidity increases rapidly from April to June. In the present year June has been very damp in Charlottenburg.

For two reasons the resistances of the Physikalisch-Technische Reichsanstalt ought to have shown the phenomenon at least quite as strongly as those of the National Bureau of Standards. For since April of this year the former were exposed to the air, while the latter during the whole time of observation were immersed in oil. Further, the humidity in the laboratories in Washington during the summer was reduced for six to eight hours every day. This was not done in Charlottenburg.

* *Zeit. f. Instrumentenkunde.* Vol. XV. p. 157, 1895.

† *Zeit. f. Instrumentenkunde*, Vol. XVIII., p. 97, 1898. *Wied. Ann.*, Vol. LXV., p. 572, 1898. *Zeit. f. Instrumentenkunde*, Vol. XXVI., p. 15, 1906.

Table II. gives the results found:—

Table II.—*Values in International Ohms at 18° C.*

Designation.	Measured values.		Difference June-April in 1/1000%
	End of April, 1907.	End of June, 1907.	
10 A.....	$10{\cdot}0001_9$	$10{\cdot}0001_7$	−0·2
10 B.....	$10{\cdot}0001_1$	$10{\cdot}0000_7$	−0·4
100 A.....	$99{\cdot}992_0$	$99{\cdot}991_7$	−0·3
100 B.....	$99{\cdot}990_1$	$99{\cdot}989_7$	−0·4
1,000 A.....	$1{,}000{\cdot}05_2$	$1{,}000{\cdot}06_8$	+1·6
1,000 B.....	$1{,}000{\cdot}03_1$	$1{,}000{\cdot}04_3$	+1·2
1,000 C.....	$1{,}000{\cdot}07_3$	$1{,}000{\cdot}09_2$	+1·9
10,000 A.....	$10{,}005{\cdot}1_7$	$10{,}005{\cdot}2_3$	+0·6
10,000 B.....	$10{,}005{\cdot}1_3$	$10{,}005{\cdot}1_2$	−0·1
10,000 C.....	$10{,}002{\cdot}2_4$	$10{,}002{\cdot}2_4$	±0·0

The variations in 7 out of 10 of the resistances, *including the three 10,000 ohm coils*, are, as shown above, less than 1 part in 100,000—*i.e.*, within the unavoidable errors of observations. If the variations noticed are considered as real the values in June are in general slightly smaller than those in April. These seven resistances do not show any indication of the phenomenon found by Messrs. Rosa and Babcock. With the three 1,000 ohm resistances a small increase of 1 or 2 in 100,000 is noticed. Further observations must show whether the explanation of Messrs. Rosa and Babcock is applicable here.

In any case the conclusion may be drawn from the above observations, in connection with the mass of other observations available at the Reichsanstalt, that the *variations of resistance due to the shellac, if existing at all in our climate, remain very small.*

That resistances wound on lacquered wooden spools are unsuitable for precision work in consequence of the swelling of the wood, has been known for a long time at the Reichsanstalt. For this reason resistances of this type are not given certificates as precision resistances by the Reichsanstalt.

The other phenomenon at first noticed at the Reichsanstalt, that resistances of high values sometimes increase slightly during a long period of time, has nothing whatever to do with the observations of Messrs. Rosa and Babcock. The baking of higher resistances prepared from hard-drawn wire for the purpose of ageing them causes a considerable decrease in resistance. In the course of several years in general the resistance again rises somewhat.

The proposals of the authors to overcome the faults noticed in Washington by making the resistances independent of the variations in humidity by coating them with paraffin or by enclosing them in a glass tube are considered by us undesirable. The formerly much-used paraffin insulation (*e.g.*, the older resistance boxes of Messrs. Siemens & Halske) has been abandoned by the Reichsanstalt in order to allow the coils to be placed in petroleum (in which paraffin is soluble) thus permitting a more accurate determination of their temperature and avoiding thermo-electric effects. For not only standard resistances which are also designed for measurements of current strengths and which may be heavily loaded under these circumstances but even resistance box coils and potentiometers*, are sometimes used to advantage in petroleum. If the use of petroleum is given up an essential advantage which has been striven for in the construction of the Reichsanstalt coils is lost.

According to the explanation given by Messrs. Rosa and Babcock for the variations in their resistances the shellac saturated silk ribbon which covers the metal spool is especially harmful. If this covering can be omitted the variations may be obviated very simply without any alteration in the usual construction. Researches towards this end are already being made in the Reichsanstalt.

Meters and Morals.—Under this title the *Electrical World* gives an account of the predicament in which the Citizens' Gas & Electric Co. of Waterloo, Ia., are placed through an order of the Court, obtained by the temperance party, compelling all saloons to have their cellar doors nailed up tight. Now the meter readers cannot get at the meters, and the saloon-keepers refuse to interfere with the doors.

* *Zeit. f. Instrumentkunde*, Vol. XXVI., p. 178, 1906.

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GREAT WESTERN RAILWAY.—ELECTRIC POWER AND LIGHTING AND THE ELECTRIFICATION OF THE HAMMERSMITH & CITY RAILWAY.

Rather more than a year ago we were able to give a preliminary description of the generating station which was being erected by the Great Western Railway Co. at Park Royal to supply electrical energy to the Hammersmith & City Railway and for other purposes (*The Electrician*, Vol. LVII., pp. 362 and 406). Now that the work is complete we are able to give the following more detailed description:—

This new electric supply system has been installed partly to meet the requirements of the Metropolitan Railway Act, 1902, which provided that, concurrently with the electrification of part of the Metropolitan Company's Inner Circle Railway, the Hammersmith & City line, owned jointly by the Metropolitan Company and Great Western Company and also the lines of the Great Western Company used in connection with the Hammersmith & City Railway, should be electrified. The extent of the line which has been electrified and for which power is supplied by the Great Western Company is shown in Fig. 1. It includes the Hammersmith & City line proper, with its branch line from Latimer-road to Uxbridge-road and the Great Western additional lines between Bishop's road and Westbourne Park. From Uxbridge-road to Addison-road the trains run over the West London line, a portion of which has, in consequence, had to be electrified, together with two bays at Addison-road Station. The system of supply to the trains on these lines had necessarily to be the same as that in use in the trains running over the Metropolitan Company's lines on the Inner Circle Railway between Bishop's-road and Aldgate. The new electric system also provides for the supply of power for arc and incandescent lighting and small motor work throughout the Great Western Company's system in the London district, as well as on the Hammersmith & City Railway, as shown in Fig. 2.

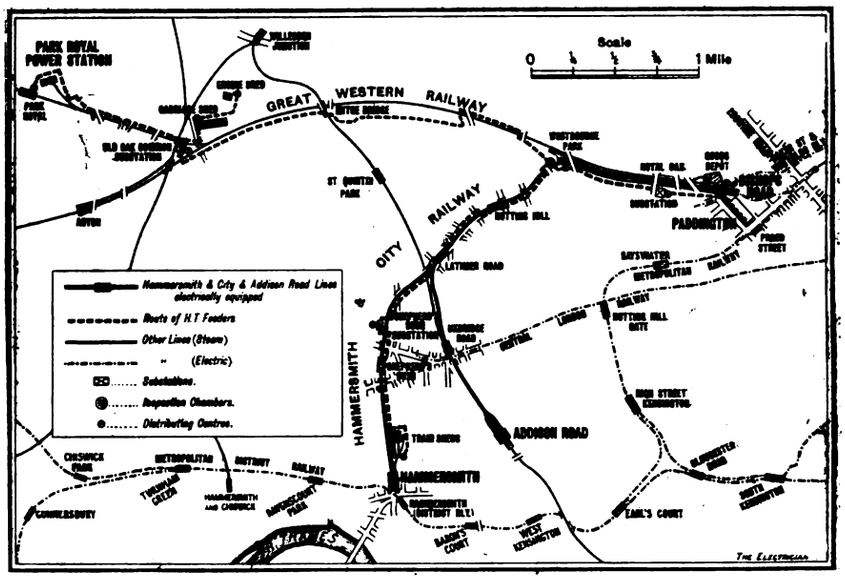

FIG. 1.—MAP SHOWING HAMMERSMITH & CITY RAILWAY.

The lighting supply for the Great Western Company's own purposes has, up to the present, been provided from a generating station near Paddington, containing plant which was laid down in 1884 by Mr. J. H. Gordon. The Great Western Company's new electric system includes a main generating station, three sub-stations, and 11 distributing centres.

The generating station is situated at Park Royal, beside the Great Western Company's new line to High Wycombe. The three sub-stations are situated as follows: At the junction between the High Wycombe line and the Great Western main line at Old Oak Common, at the south side of the Great Western main line at Royal Oak, and on the west side of the Hammersmith & City Railway at Shepherd's Bush.

The distance from Park Royal to Old Oak Common is about 1 mile, to Royal Oak about 4⅓ miles, and to Shepherd's Bush about 5 miles.

The distributing centres are situated as follows: One at each end of the Royal Oak and Shepherd's Bush sub-stations, two at Old Oak Common adjoining the new locomotive sheds and the new carriage sheds, one at Westbourne Park station, one at the new train sheds at Hammersmith, and the remaining five in the neighbourhood of Paddington station.

The electrical power is generated at Park Royal as three-phase alternating current, with a frequency of 50 periods and at a pressure of from 6,300 to 6,600 volts, and is transmitted at this pressure to the three sub-stations. In the sub-stations the greater part of the three-phase current is converted by motor converters from about 6,500 volts alternating to 600 volts direct current, and at this pressure the current is supplied to the conductor rails of the Hammersmith & City Railway, and the lines worked in connection with it, from the Royal Oak and Shepherd's Bush sub-stations. From Old Oak Common, Shepherd's Bush and Royal Oak sub-stations, direct current at 600 volts is also distributed for sundry power purposes, and also for arc lighting to the Great Western Company's locomotive sheds, carriage sheds, goods yards and offices and Paddington station. A certain part of the three-phase supply is distributed from each sub-station at the full pressure of about 6,500 volts to the distributing centres, where it is transformed down by static transformers to either 220 or 110 volts. At this pressure the alternating current is used for arc and incandescent lighting and small motor work throughout the Great Western Company's locomotive sheds, carriage sheds, stations, goods yards, offices and hotel at or near Paddington, and on the Hammersmith & City Railway.

MAIN GENERATING STATION AT PARK ROYAL.

Buildings.—Fig. 3 shows the general arrangement on the site and Fig. 4 a view of the generating station. It shoud be noted that the present station occupies only about one-sixth of the ground available, and is so designed and placed on the site as to enable five other similar stations to be built as the demand for power increases. At the extreme east end of the present station are the coal silos, built below ground level, so as to be underneath the railway siding which connects with the main line. The silos are constructed of ferro-concrete and have a total storage capacity of about 400 tons of coal. They are divided into five funnel-shaped sections, from the mouthpieces at the bottom of which the coal passes into a basement which accommodates the filling apparatus for the coal conveyers.

The main building is a steel structure filled in with brick and roofed with glass and slate, the wooden framework for the latter being lined on the inside with fireproof plaster.

The boiler house, at the east end of the main building, is arranged in three bays, and is 115 ft. 6 in. long by 95 ft. wide and 90 ft. high to the peak of the roof of the centre bay. The two side bays are for the accommodation of the boilers, leaving the centre bay clear. A set of steel coal bunkers built between the main stanchions is provided over the centre bay, with a total storage capacity of about 600 tons. Space is provided above the coal bunkers and in a basement underneath the stoking floor for the coal and ash-conveying plant. The feed pumps and accessories and the water-softening and purifying plant are placed in the space between the west wall of the boiler house and the first pair of stanchions. A main flue is built behind each block of boilers, and these are joined together outside the east end and are carried into the base of a chimney in such a way as to leave room for the connection to the same chimney of a similar main flue when the present station is doubled, the chimney being placed in line with the south wall of the present boiler house. A bye-pass flue is also provided outside the east end of the boiler house. The flues are arranged so that connection can be made to a second chimney which will be built outside the north-east corner of the building when the station is extended. The present chimney is 12 ft. square, internal dimensions, and is 250 ft. high. It is built of brick set in cement mortar up to the level at which the flue enters, and set in lime mortar above that level. The boiler house is ventilated by louvres.

To the west of the boiler house, and separated from it by a party wall, is the main engine room, which is also arranged in three bays, the two side bays taking the engine sets and the centre bay the condensing plant, which is also above floor level. The switchboards are arranged on galleries extending across the whole breadth of the

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engine room at the west end. The concrete foundation blocks for the main engines and for the condensing plant leave five passages in the basement, from end to end of the engine room. The three centre passages and the space at the east end of the foundation blocks accommodate the pipework, and are separately drained and entirely shut off from the remaining two passages and the switchboard basement at the west end, which accommodates the cables. The engine room is 121 ft. long by 108 ft. 6 in. wide and 50 ft. high from the engine-room floor level. The depth of the basement is 8 ft. The engine-room floor is paved with red tiles, and the walls are faced with white crystopal tiles. The roof is ventilated by hinged casements in the sides of the lanterns.

As an annexe to the engine room on the north side a building 121 ft. long by 25 ft. 7 in. wide and about 36 ft. high is provided, which is divided into two portions, each 60 ft. long, to serve as a workshop and as stores respectively.

The office buildings, built as an annexe to the engine room at the west end, measure 108 ft. 6 in. long by 20 ft. wide and about 23 ft. high, and include two battery rooms on the ground floor, as well as the necessary accommodation for the staff on the first floor. Under the offices, and just outside and throughout the length of the west wall of the engine room, a cable tunnel is provided, through which the feeder cables are carried after leaving the switchboard basement. The general arrangement is shown in Fig. 6.

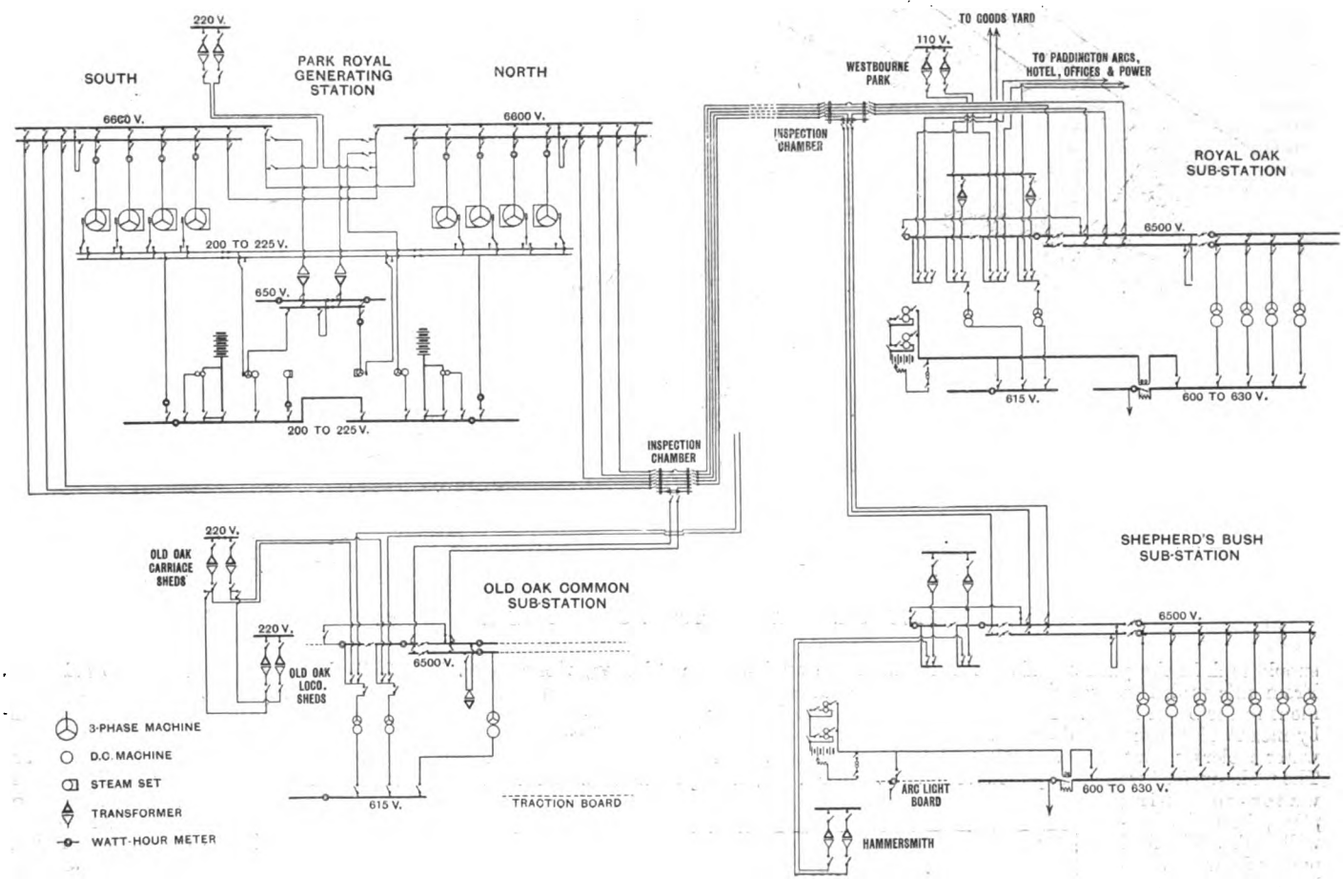

FIG. 2.—GENERAL SCHEME OF DISTRIBUTION.

Plant.—Before proceeding to describe in detail the plant in the boiler house and engine room, it will be convenient to refer to the coal-handling plant (Fig. 5) and to explain briefly the circulation of water and steam between the steam-driven feed pumps, the boilers, which are of the water-tube type, and the main engines, which are of the reciprocating high-speed triple-expansion type.

Coal Handling Plant.—Coal is brought on to the site over a railway siding in connection with the new line to High Wycombe, a special train of steel hopper waggons, each of which has a carrying capacity of 20 tons, and is provided with flap doors, through which the coal is delivered from the bottom of the waggon into the coal silos, provided for this purpose. From the mouthpieces in the bottom of the coal silos coal is delivered on to two tray conveyers, which feed it into the boots of two bucket elevators, which in turn raise the coal out of the centre of the silo to a height of 50 ft. above the boiler-house floor level, and feed it on to two bucket conveyers for transmission to the boiler house. Overflow shoots are provided, through which coal is returned to the coal silos in the event of the elevators being kept running while the bucket conveyers are stopped. The two bucket conveyers are carried by means of an overhead gantry as far as the east wall of the boiler house, and pass up the inside of this wall and over the steel coal bunkers. After discharging coal into the steel bunkers the buckets pass down into the basement at the west end of the boiler house, where ashes are fed into them by means of two travelling fillers provided with snouts which fit on to the boiler ash shoots. The bucket conveyers then pass up the inside of the east wall of the boiler house and out by the overhead gantry, and discharge the ashes into steel hoppers placed over a separate railway siding, and from which the ashes are discharged by gravity into waggons, an ash-quenching water-spray being provided at this point. The whole of the coal-conveyer and elevator plant is arranged so as to be in duplicate, and the normal carrying capacity of each set is 50 tons of coal per hour, when also dealing with ashes. The driving gear is placed in the driving house at the end of the gantry over the coal silos, and a Denison automatic integrating weigher is fitted in the run of each bucket conveyer, just on that side of the driving gear where the chain is slack. Each bucket conveyer is driven through worm gear by a 10 B.H.P motor, while the tray conveyer and bucket elevator corresponding to each bucket conveyer are driven through worm gearing by a single 12 B.H.P. motor. These motors are driven by three-phase current at 650 volts, and are of the E.C.C.'s patent type, the rotor having two windings and the starting up being normally effected by a special starting switch. Should, however, the supply of current be cut off, the starting switch can be left in the "on" position, and the motors start up on load without damage, but, of course, with increased current. It may here be stated that the same type of motor is used for driving the condenser pumps, the stokers, the drainage sump pumps and two centrifugal pumps used in connection with the water supply and drainage water. Provision is made for stopping the conveyers from various points of the buildings by means of push buttons, which close tripping circuits in connection with the motor switches. From the steel bunkers in the boiler house the coal is fed through volumetric measuring boxes, of which there is one in front of each boiler, and down shoots into the magazines above the boiler stokers. The measuring boxes, of the Ingrey revolving box type, are fitted with adjustable shutters for adjusting their capacity, which is about 4 cwt., within small limits, and are also provided with counters for registering the number of times each box is emptied.

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Circulation of Water and Steam.—The normal circulation of the water and steam is as follows, neglecting, for the present, many of the alternative and bye-pass details :—

Water is supplied from the Canal at Old Oak Common, with an alternative supply from the Metropolitan Water Board, to a water supply tank in the yard outside the west end of the engine room. From this tank it passes through a pipe to the pump room basement in the boiler house. From this point the water is pumped, by means of a centrifugal pump, through two cylindrical drain-water coolers, up into an overhead feed tank in the engine room. The make-up feed water is supplied from the overhead tank, through water-softening plant, into the hot-well tanks. The feed pumps draw from the hot-well tanks with an alternative connection to the main water-supply pipe and deliver through water meters and pump-exhaust feed heaters to the boiler-feed ranges. The steam after passing through the steam pipes and engines may be exhausted to atmosphere, but normally passes through mechanical oil separators into surface condensers, from which the condensed water is drawn by air pumps and delivered by force pumps to a height of 20 ft. at the west end of the boiler house, to the inlet of an electrical oil-separating and filtering plant, and thence to the hot well tanks. The circulating water for the condensers is drawn from lodges under the cooling towers by centrifugal pumps, and after passing through the condensers is pumped to a height of 31 ft. above the engine-room floor, and returned to the top of the cooling towers, make-up water being obtained from the water-supply tank in the yard.

Steam-raising Plant and Accessories.—The boiler house contains 10 Babcock & Wilcox double-drum water-tube boilers, the 5 boilers in each side bay being arranged in two batteries of two boilers and one battery of one boiler. Each boiler has a heating surface of 5,764 sq. ft., has a normal evaporative capacity of 19,200 lb. of water per hour at a pressure of 200 lb. per square inch and is equipped with a self-contained superheater, proportioned so that steam is delivered at a temperature of 550°F. at the boiler stop valve. The boilers are fitted with mechanical stokers of the chain-grate type. The drums which revolve the grates are driven through worm gear, and a ratchet and pawl arrangement with speed adjustment, from eccentrics on an overhead shaft running along the front of each block of boilers. Each stoker shaft can be driven from either end by a 15 B.H.P. three-phase motor, a clutch being provided at each end for connecting or disconnecting either motor. The motors are started up by means of starting switches placed on the stoking floor.

In the pump room there are four steam-driven feed pumps of the vertical type, each pump having a capacity of 6,000 gallons per hour, delivered against the working pressure of 200 lb. per square inch. Each feed pump can deliver into either of two 4 in. 'bus pipes, which are carried round three sides of the pump room. The water carried by each of these two 'bus pipes is measured by a Kennedy water meter, and passed through a feed heater in which

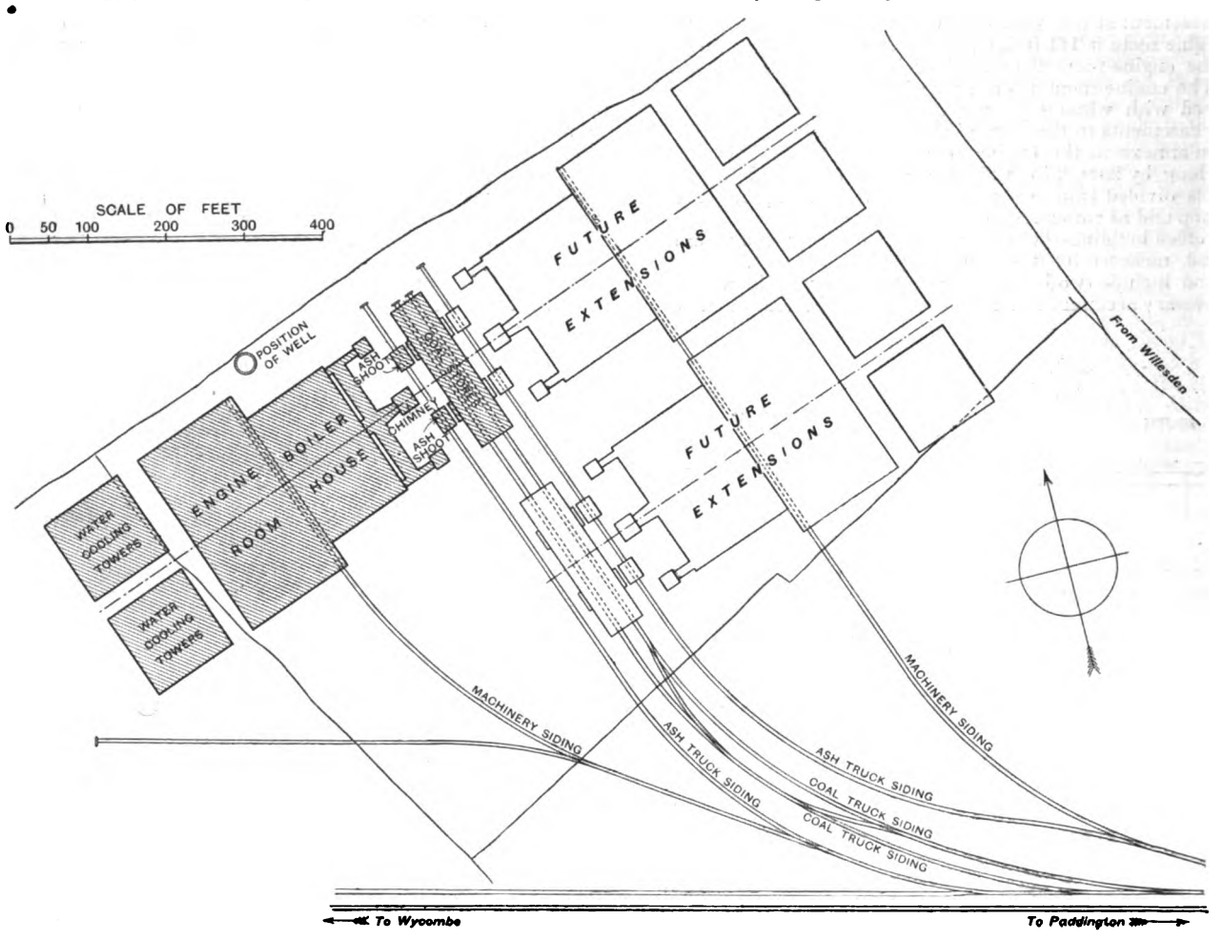

FIG. 3—GENERAL ARRANGEMENT OF GENERATING STATION ON SITE.

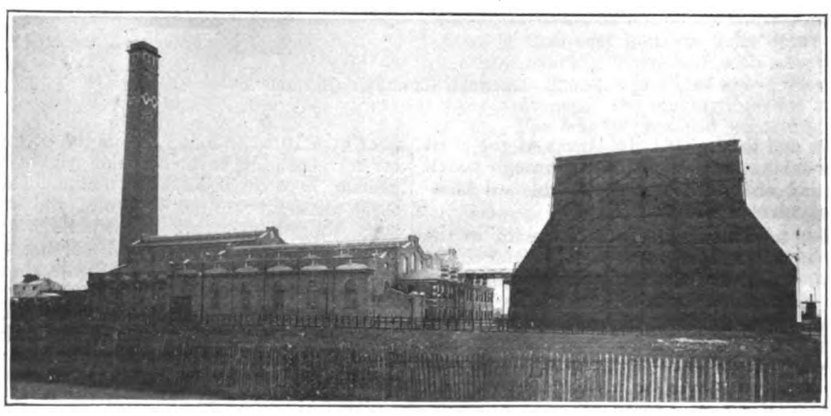

FIG. 4.—VIEW OF POWER STATION.

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the water is heated by the exhaust steam from the feed pumps. To the main 'bus pipes are connected two duplicate 4 in. feed pipes, which are carried along the front of each block of boilers, the corresponding pipes on each side being connected at the east end of

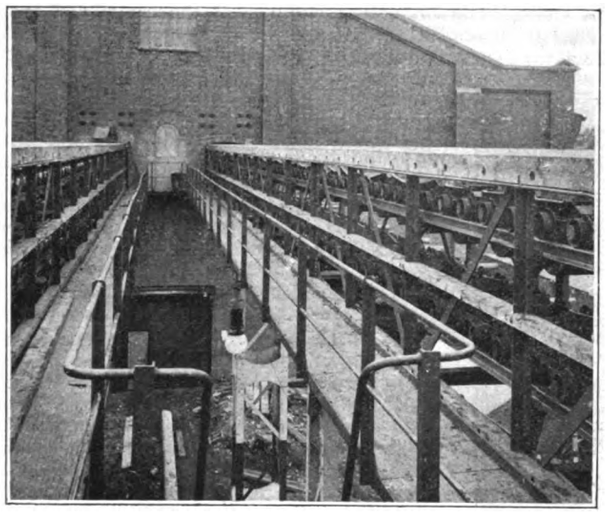

FIG. 5.—COAL CONVEYING PLANT.

the boiler house through valves. Each feed pump is also provided with duplicate suction pipes; one suction pipe is connected to the hot-well tank beneath it, there being two cast-iron hot-well tanks in the boiler house basement 25 ft. by 18 ft. by 7 ft. deep. The other suction pipe is connected to the 5 in. water supply main, through which water can be drawn either from the water supply tank in the yard or from one of the main condenser circulating water pipes.

The make-up water can be supplied direct to the hot well tanks from the supply main, but is normally pumped up into an overhead feed tank, 18 ft. by 16 ft. by 6 ft. deep, placed overhead in the engine room, by means of a three-phase motor-driven centrifugal pump with a capacity of 150 gallons per minute. On its way to the feed tank or to the hot-well tank the make-up water can be passed through two cylindical drain-water coolers, which deal with the hot boiler blow off and drainage water. From the feed tank the make-up feed-water passes through the Paterson water softening plant, which is arranged in duplicate on either side of the pump room, each plant being capable of treating and filtering 2,500 gallons of water per hour. The make-up water inlet to the softening plant is controlled by a valve worked by a ball in the hot-well tank below, so that the right quantity of make-up water is regulated automatically. The make up water, on its way to the mixing-chamber, passes through a tank, the outlet of which is in the form of a weir. The height of the water in this tank, depending on the amount of water passing, is made to raise or lower a float which is geared to a way-shaft, from the ends of which needle valves are operated which control the proportions of the lime and soda which pass into the mixing chamber with the make-up water. After passing through the mixing-chamber, the water is filtered first through wood fibre and afterwards through sand, and finally passes down into the hot well, through a tumbling bay and settling tank and over a weir, to enable the quantity of make-up water to be measured if required.

The oil-separating and filtering plant for the treatment of the condensed steam from the condensers on its way back to the hot well tank is also in duplicate, and is placed on each side of the pump-room outside of the water softening plant. Each plant is capable of separating oil from and filtering 8,000 gallons of water per hour. The air-pump discharge is delivered into a small settling tank with a tumbling bay outlet and with float and measuring gear, in which some of the free oil is separated by gravitation. The tumbling bay discharges into a distributing trough from which the sets of oil-separating batteries are supplied through a number of valves, arranged so that any unit of the battery may be entirely shut off if required, without interfering with the efficient working of the plant. The batteries consist of long wooden troughs supported on insulators and in which are suspended iron plates alternately connected to either pole of the 225 volt direct-current supply, and controlled by a change-over switch so that the polarity can be reversed as required in order to keep the plates clear of the grease which accumulates as a scum on the surface of the water. The batteries discharge into a collecting tank, from which the water is led to a sand filter, which is also divided into sections. The fil-

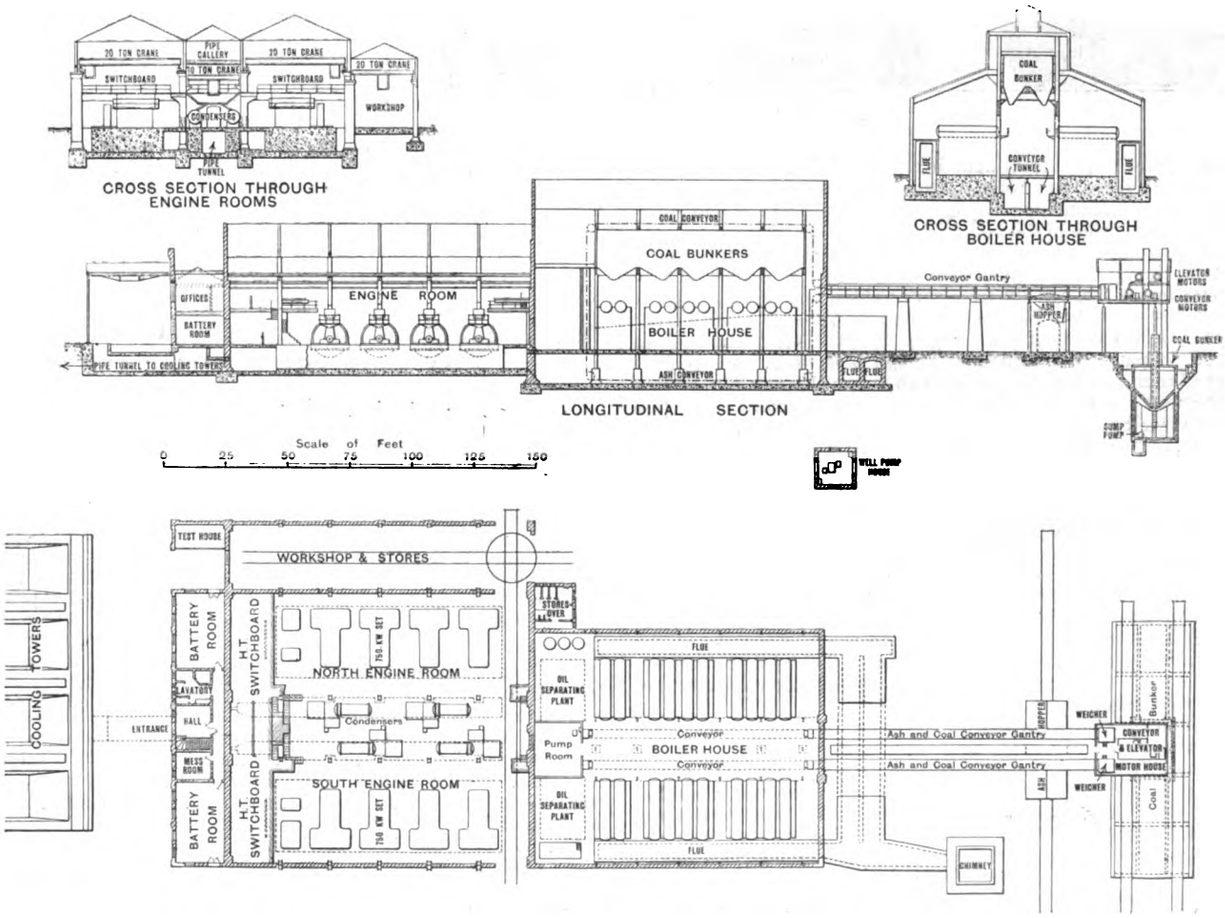

FIG. 6.—SECTION AND PLAN OF GENERATING STATION.

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tered water then passes into the hot-well tank below. When the water rises to a certain level above the sand filter, owing to the latter becoming clogged, the filter is automatically cleaned by flushing it with water which passes through the sand in the opposite direction to the normal.

Steam Distribution, Condensing Plant, Cooling Towers, &c.—The main steam pipes between the boilers and the engine sets are arranged on the duplicate system in the boiler house, and on the ring system in the engine room. Each boiler is connected, through a non-return valve and stop valve, to two 8 in. main steam pipes carried down the side of the boiler house, over the main flues, and connected across the end of the boiler house above the pump room. The 10 in. ring in the engine room is teed off the double line in the boiler house through the necessary valves, and is itself divided into sections by valves between the branch pipes to the different engines. It will be seen from Fig. 6 that the main engines are arranged in pairs with reference to the pipe-work, the separate engines of each pair being supplied with steam through 8 in branch pipes connected to the separators on the engine bedplates, a bye-pass pipe and valve being provided between the separators on each pair of engines, for use in case a section of the main ring has to be shut off. Each of the main steam pipes in the boiler house is provided with a steam separator on each side of the branch to the engine room ring, and these separators are drained by "Sentinel" steam traps, which can be bye-passed when required. In other respects, the usual auxiliary, drain and other pipes which are provided do not call for special mention. The whole of the steam pipes are made from solid-drawn steel tubes, with steel flanges riveted on to the tubes which are expanded into them. The main steam pipes are supported by clips and hangers from brackets, the nuts of the hangers being provided with spherical seats and spring cushions. Where the main pipes pass through the engine room wall they are supported by rollers.

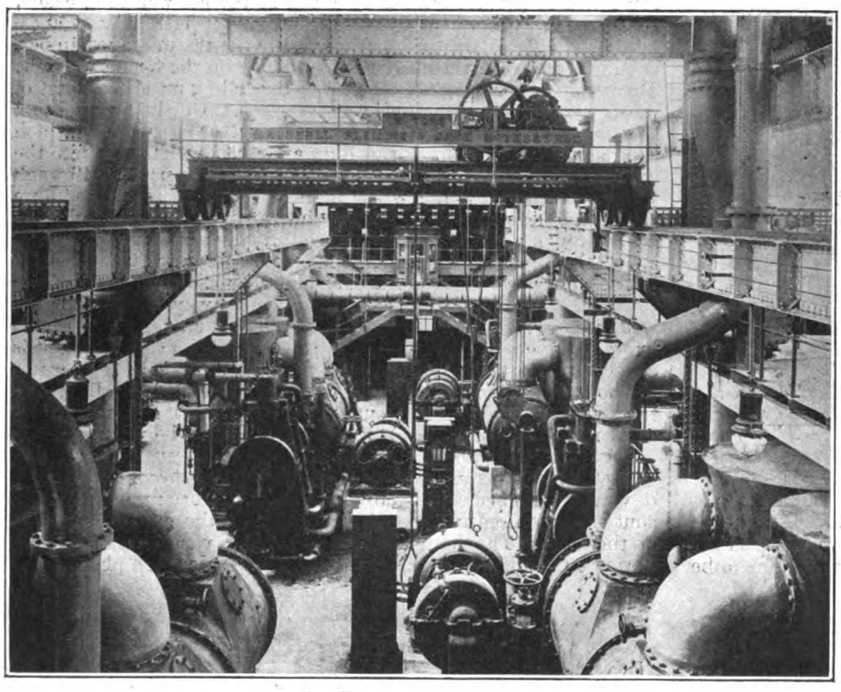

FIG. 7.—CONDENSING PLANT.

The exhaust steam from the low-pressure cylinder of each main engine is carried by a 20 in. pipe with a Y-piece, one branch of which leads, through an automatic valve, to a vertical atmospheric exhaust pipe passing up through the engine-room roof, the other branch leading through a valve to a mechanical oil separator and thence into a condenser. The mechanical oil separator is of the Reavell type, containing expanded metal baffles, and is provided to extract as much oil as possible from the exhaust steam before it reaches the condenser, leaving the remainder to be dealt with in the oil separating and filtering plant already described before the condensed water is returned to the boilers. From the bottom of the mechanical separator the oil falls by gravity to a small steam-driven force pump, by which it is pumped to settling tanks in the basement.

The condensing plant is placed above floor level in the centre bay of the engine room and is divided into four sections, one for each pair of engines, each section consisting of a surface condenser, combined air and force pump and circulating pump. Each surface condenser is designed to deal with 42,000 lb. of exhaust steam per hour. The air pumps are driven direct by a two-crank compound steam engine, and are of the Edwards' type. A small force pump is also driven by each air pump engine, for raising the condensed water to the inlet of the oil separating and filtering plant in the boiler house. The circulating pump is of the centrifugal type, designed to deal with 178,000 gallons of water per hour, and is driven by a three-phase 650 volt motor. The circulating water is brought to the pump suction of the condensing plant by four separate 20 in. pipes, run in the engine room basement under the centre bay, and after passing through the condensers, rises vertically to a gallery over the centre bay, 80 ft. above the floor level, and through non-return valves to two main pipes, which take it along the gallery and out at the west end of the engine room to the cooling towers. Fig. 7 shows the arrangement of this plant.

The cooling towers, which are of the Klein natural draught wood type, are arranged in four towers, each of which can be divided into two sections. The galvanised steel main distributing trough is carried along the east end of the towers, and takes the water discharge from the two main pipes from the engine room, and distributes it to the four towers, a separate distributing valve being provided for each section of each tower. The main distributing trough is provided with a tumbling bay and measuring weir. Each cooling tower is 104 ft. long and 21 ft. wide at the base, the height from the base to the water inlet being 24 ft., and to the top of the tower 74 ft. Each tower is designed to cool 145,000 gallons of water 35°F. from 115°F., under ordinary conditions of temperature. The water cooled by each tower falls into a separate concrete lodge, which is connected through a sluice valve to a main suction trench, in which are placed the roses at the ends of the four suction pipes, through which the water is drawn by the circulating pumps, the sluice valves for these suction pipes being placed in a separate valve pit outside the suction trench.

(To be continued.)

THE PRODUCTION OF HIGH-FREQUENCY OSCILLATIONS FROM THE ELECTRIC ARC.*

BY L. W. AUSTIN.

Summary.—The author gives a short historical account of the work that has been done in the production of high frequency oscillations and then describes the apparatus used by him in his experiments on this subject. Researches are made into the effect of a change in frequency and of an alteration in the shunt resistances. The author confirms Poulsen's statement that the oscillations become more powerful when the arc is formed in hydrogen. Experiments are described on the arc in steam and compressed air, on the efficiency of the oscillations, and on the effect of air pressure and on the continuity of the wave trains produced from the direct-current arc.

The first experiments for the production of electrical oscillations from direct currents appear to have been made by Prof. Elihu Thomson,† who in 1892 proposed the following method for transforming continuous currents into continuous trains of high-frequency oscillations. A source of direct current at 500 volts was connected through high inductive resistances to a spark-gap, which was shunted by a condenser and inductance. An air blast or magnet was used to blow out the continuous-current arc.

Mr. W. Duddell‡ in 1900 described experiments showing that when a suitable inductance and capacity are placed in shunt around an ordinary direct-current arc a musical tone is given out. According to Duddell the following conditions must be fulfilled in order that the oscillations may be satisfactorily produced. The carbons must be solid, not cored; the arc must be of suitable length (1 mm. to 2 mm.), and the current must be of suitable strength (3 to 5 amperes). In addition, a high resistance must be placed in the main arc circuit and the ohmic resistance of the shunt circuit around

* Abstracted from the *Bulletin* of the Bureau of Standards.
† U.S. Patent No. 500,630, July 4, 1892.
‡ W. Duddell, *Journ.* Inst. Elec. Eng., Vol. XXX., p. 232; 1900.

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the arc should be in general less than 2 ohms. About 5 millihenrys and from 1 mfd. to 5 mfd. form a suitable shunt circuit.

The cause of this phenomenon has not been made entirely clear; but, according to Duddell's theory, the production of oscillations requires that the VI curve of the arc should have a falling characteristic—that is, that dV/dI should have a negative value and be greater numerically than r; V represents the P.D. across the arc, I the direct current, and r the resistance in the shunt circuit around the arc. The simple explanation of the formation of the oscillations according to this theory is as follows: When the shunt is closed on such a circuit as has been described, a part of the current flows into the condenser, thus robbing the arc of a part of its current; but since V increases as the current in the arc decreases, this really increases the P.D., and the condenser continues to charge. When in turn it discharges through the arc it increases the arc current and thus decreases the P.D. until entirely discharged. The process then repeats itself.

According to Duddell, the frequency of the oscillations in the singing arc depends only on the inductance and capacity in the shunt circuit except as it is modified by the damping, and the frequency is limited by the fact that dV/dI ceases to be negative at a moderately high frequency. Good results may, however, be obtained between 500 and 10,000 per second by a proper adjustment of inductance and capacity.

This theory has been treated mathematically by P. Janet*, who has arrived at conclusions agreeing with those of Duddell. A second theory of the phenomenon has been advanced by Maisel†, who claims that the sign of dV/dI in the arc is of no importance, but that the occurrence of oscillations depends only on the temperature of the negative electrode. He holds that as the current is withdrawn from the arc by the charging of the condenser the temperature of the electrode falls until the arc is extinguished, being re-lighted again by the backward surge of the charge from the condenser the next instant, provided the temperature has not fallen too low. He contends that, according to his own observations and those of Corbino,‡ the current in the shunt circuit is not sinusoidal, and that the frequency cannot be determined simply by the formula $1/n = 2\pi\sqrt{CL}$, and also that it has been shown by Salomonson§ that a frequency as high as 400,000 may be produced.

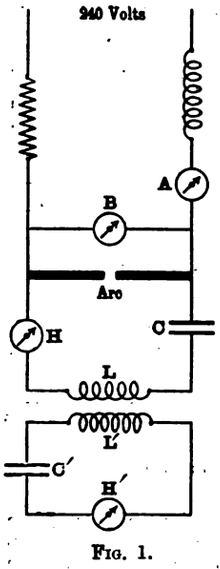

FIG. 1.

In 1902 Prof. R. A. Fessenden|| proposed a spark-gap or arc fed by continuous current as a source of radiation for wireless telegraphy and afterwards developed the idea, calling attention to the advantages of using high potential and forming the arc under pressure.

H. Th. Simon, and Simon and Reich¶ have also experimented extensively on this subject, using metal electrodes as well as carbon; and more recently Simon** has published a theory of the phenomenon based on his own theory of the arc. In this he agrees with Duddell and Janet as to the necessity of a falling characteristic for the arc curve, and concludes that high frequency oscillations can probably best be obtained by using high voltage and low current and electrodes, which are good conductors of heat like the metals.

Since the present work was begun, V. Poulsen†† has announced the successful production of oscillations ranging as high as one million per second and of considerable power, which have been used successfully in wireless telegraphy. In the Poulsen arc the anode is copper and the cathode carbon, while the arc is formed in an atmosphere of hydrogen which appears considerably to increase the intensity of the oscillations.

Arrangement of Apparatus.—During the first portion of the work the source of current was for the most part a 240 volt constant potential circuit, though at times 120 volts were substituted for this. The current was cut down by a variable resistance and the primary of a small transformer was introduced into the main circuit as a choking coil. A diagram of the connections is shown in Fig. 1. Here A is a direct-current ammeter, B a direct-current voltmeter across the arc, H a hot wire ammeter reading to 10 amperes, with a resistance of about 0·3 ohm. The capacity C consisted of one or two small mica condensers of 0·04 mfd. capacity each. The inductance L, generally used in the oscillatory circuit, consisted of three turns of No. 16 wire wound on a battery jar. The inductance of this coil and the connecting wires amounted to 0·009 millihenry approximately. The frequency of the oscillations was always measured by the resonance method in a secondary circuit so loosely coupled to the primary that the reaction between the circuits was negligible, as shown by special experiments. This secondary circuit consisted of a variable air condenser, C', a hot wire ammeter, H', reading to 0·23 ampere and having a resistance of 7 ohms, a coupling inductance, L', of 25 turns of No. 16 wire wound on a jar, and sometimes a variable roller inductance in addition.

Experiments with the Graphite Arc.—Preliminary experiments were made, using as the electrodes of the arc solid carbon, cored carbon, copper, graphite, and copper anode with carbon cathode. It was found that with all of them oscillations with a frequency of over 100,000 could be produced. The first three gave in general only transitory high-frequency oscillations, at least when the arc was formed in air, and it was only in the case of graphite electrodes that it was found possible to get steady enough conditions so that any quantitative observations could be made.

Below are given the data of a typical experiment:—

Primary Circuit.

Electrodes	graphite, ends flat.	Arc length	about 0·3 mm.
Diameter.....	12 mm.	Inductance in shunt circuit .	0·009 millihenry.
Resistance in series with arc	about 50 ohms.	Capacity	0·4 ohm.
Arc current....	4 amperes.	Alternating current in shunt..	4 amperes.
P.D. across arc	26 volts		
P.D. open circuit	242 volts.		

Secondary Circuit.

Inductance	0·168 millihenry.	Resistance	7 ohms.
Capacity	Variable.	Current	0·1—0·2 ampere.

It was found that under the above conditions the high-frequency oscillations were readily obtained and were very constant, sometimes running for half an hour without attention before the oscillations disappeared. When the frequency was measured by the secondary resonance circuit it was discovered that there were well-marked maxima corresponding to frequencies of 295,000, 580,000 and 910,000 per second. The lowest frequency appears to carry the largest part of the energy, while the highest was the weakest. The frequency calculated from the inductance and capacity of the primary circuit was 260,000. It seems possible that there may be other frequencies present of even shorter period and less intensity, but I was unable to detect them.

Change of Frequency.—According to Simon's results with low-frequency arcs the frequency should increase with increasing current and with decreasing arc length. These points were investigated, and the results are shown in Tables I. and II. and in the curves of Figs. 2 and 3. Table I. and the curves *a*, *b*, *c*, Fig. 2, show the effect on the three maxima due to changing the resistance in the main circuit. It is to be noted that the lower frequency changes less than the other two, and that the three frequencies roughly approximate to the ratios 1 : 2 : 3. It was not considered possible to measure the change in arc length with any accuracy, as the total range of length over which the oscillations could be obtained was only a few tenths of a millimetre. Table II. and curve *g*, Fig. 3, therefore show only the relation between the change in frequency of the second maximum and the current change produced by changing the arc length. Curve *g* shows that the frequency increases with decreasing arc length much more rapidly than would be the case if the change were entirely due to the resulting change in current, showing that the shorte ing of the arc produces by itself an increase in frequency.

Experiments were also made on the effect of using the 120 volt circuit instead of the 240 volt, and also on the effect of putting two arcs in series. The capacity in the primary circuit in these experiments and in the one shown in Table II. was 0·08 mfd. The results are shown in Tables III., IV. and V. and in the curves of Fig. 3. It is seen that the curves for one arc at 120 volts and 240 volts lie near together. The observed difference may be due to a slight difference in the adjustment of the arc length. The introduction of a second arc in series with the first produced a marked lowering in the frequency, while the alternating current rose from 5 to 7 amperes.

Resistance in the Shunt Circuit.—Under the conditions given above, adding an ohm to the resistance of the shunt circuit destroyed the oscillations entirely, while ½ ohm reduced them about one-half. No change in frequency, as far as could be observed, attended the changes in resistance and alternating current in the shunt oscillatory circuit.

In connection with the graphite arc some experiments were made in wireless telephony. A wire was connected to the secondary oscillatory circuit and run up outside the window of the laboratory

* P. Janet, *Comptes Rendus*, 134, p. 821; 1902.
† S. Maisel, *Physikal. Zeits.*, Vol. V., p. 550; 1904.
‡ M. Corbino, Atti dell' Assoc. Elettr. Ital., 7., p. 369, also p. 597; 1903.
§ Wertheim Salomonson, Konink. Akad. Wetensch. Amsterdam, Versl., p. 381; 1902-3.
|| U.S. Patents No. 706,742, Aug. 12, 1902; No. 730,753, June 9, 1903; No. 793,649, July 4, 1905.
¶ Simon and Reich, *Physikal. Zeits.*, Vol. III., p. 278, 1902; Vol. IV., p. 364, 1903.
** H. Th. Simon, *Physikal. Zeits.*, Vol. VII., p. 433, 1906.
†† V. Poulsen, *Electrotech. Zeits.*, Vol. XXVII., p. 1040, 1906.

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while the other side of the secondary was earthed. The current in the antenna was about 0·1 ampere. A microphone was inserted in the antenna, and when this was spoken into the words could be understood in a telephone connected to an electrolytic wireless receiver attached to a similar antenna wire on a neighbouring building about 50 metres distant. The articulation was loud and fairly distinct; but the hissing noises from the arc were disturbing. This arrangement was of course merely experimental. By making better use of the energy and using proper aerials and microphone a much greater distance could have been covered, probably several miles.

The Arc in Hydrogen.—According to Poulsen, much more powerful oscillations can be produced with the arc in hydrogen than can be obtained in air. This point was tested in a simple but effective way, suggested by Poulsen, by forming the arc in the interior of a gas flame. It was found at once that the high-frequency oscillations formed much more readily with the carbon and carbon-copper electrodes than in air. The best results were obtained using a copper anode with a carbon cathode, or with both electrodes of graphite.

While the pressure of the hydrogen enabled the oscillations to be produced more easily and to be maintained with greater arc length (up to about 0·8 mm. in the case of graphite at 240 volts), the most remarkable effect was the increase in the energy which could be drawn from the oscillatory circuit. As has been before mentioned, no resistance of more than 1 or 2 ohms could be inserted directly in the oscillatory circuit without destroying the oscillations. Large resistances can, however, be placed in the secondary coupled circuit and in this way power can be derived from the primary circuit.

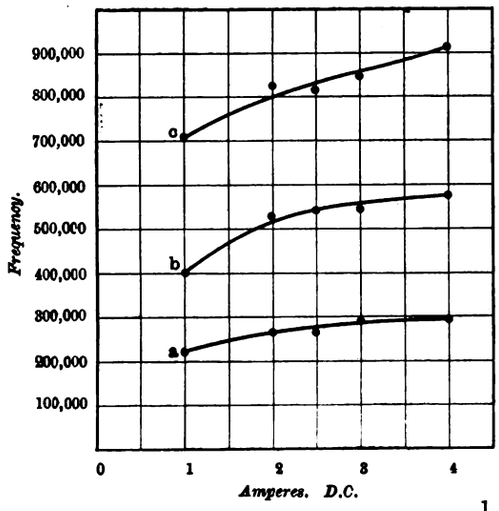

FIG. 2.—GRAPHITE ARC 240 VOLTS CALCULATED $n=\frac{1}{2\pi\sqrt{LC}}=260{,}000$.

(See Table I.)

With the graphite arc in air at 240 volts only about 6 or 8 watts can be absorbed in this way. With the arc in hydrogen supplied in sufficient quantities this power may amount to more than 100 watts, in one experiment bringing a 110 volt 32 c.p. lamp to full brightness.

Below are given the data of an experiment with the arc in hydrogen which may be compared with the data given above when the arc was in air.

Primary Circuit.

Direct current without oscillations	5 amperes.
Direct current with oscillations	2·5 amperes.
P.D. without oscillations	40 volts.
P.D. with oscillations	90-100 volts.
P.D., open circuit	240 volts.
Alternating current in primary	9 amperes.
Capacity	0·08 mfd.

Secondary Circuit.

Inductance	0·168 millihenry.
Capacity	0·00011 mfd.
Resistance	110 volt 32 c.p. lamp.
Alternating current	1 ampere.

The most noticeable thing in the above experiment, after the marked increase in power developed, is the marked decrease in direct current and increase in fall of potential across the arc. This depends on the amount of load in the secondary, and with the secondary removed the differences would have been less. The same changes can be noted in the graphite arc in air, but then the current drops only about 0·1 ampere and voltage increases but a few volts.

The presence of the hydrogen, at least when poured in a stream directly into the arc, as in the present case, has a very detrimental effect on the sharpness of tuning. The maxima frequently become so unsteady that it is almost impossible to determine the frequency. This may be due to the blowing about of the arc by the gas stream. Very peculiar pressure conditions certainly exist in the arc, as is shown by the remarkable way in which the gas flame in which the arc is formed is blown outward when the oscillations are taking place.

The cause of the beneficial effect of hydrogen in the arc is not entirely clear. It seems certain that it is partly due to the high heat conductivity of the gas which helps to cool the electrodes between the surges of the current. According to Poulsen, in addition to the cooling effect, there is a marked influence on the electrical conductivity of the arc which he considers of great importance; but this is a question which will require further investigation before conclusions can be reached.

The Arc in Steam.—Experiments were also made in which the arc was formed in steam. The graphite electrodes were used in some cases and in others the copper anode and carbon cathode. It was found possible to duplicate all of the effects observed with the arc in hydrogen. Oscillations were obtained as readily and with approximately the same power. Oscillations of great power were also observed when the arc was formed under water, where the steam was produced by the heat of the discharge. In this case frequently cooling became too rapid, so that the arc blew itself out.

The High Potential Arc in Compressed Air.—In the following experiments I have made use of the ideas of Fessenden and Simon in putting the arc under pressure, using a high potential circuit, small current, and metallic electrodes. The source of current was a set of 10 500 volt direct-current dynamos in series, driven by a 2 H.P. motor A fixed resistance of about 30,000 ohms was in series with the machines, and on short-circuit the direct current was 0·15 ampere. The voltage on open circuit, as measured on a Braun electrostatic voltmeter, was 4,500 volts.

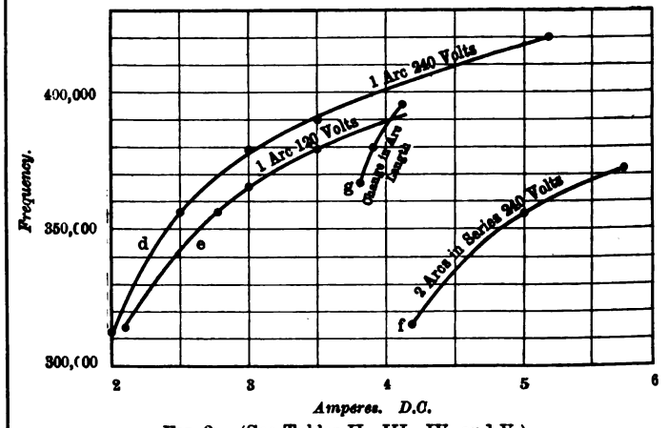

FIG. 3.—(See Tables II., III., IV. and V.)

In Fig. 4 the general arrangement of the circuits is shown. Here T is the compressed air arc, A a direct-current ammeter, V a Braun electrostatic voltmeter, C a Fessenden compressed air condenser having a capacity of 0·0044 mfd., L the three turn jar inductance of 0·009 millihenry and R the 30,000 ohm series resistance.

The leads WW run to the terminals of the set of small dynamos. The air chamber P is of massive iron with removable ends and with small windows of heavy glass at the front and back for observing the arc. The electrodes proper E were thin caps of metal, shaped as shown in Fig. 5, and screwed down by nuts and rubber washers to the ends of the electrode tubes T. These were hollow and arranged for water circulation. The electrode tubes were introduced into the pressure chamber through tightly fitting brass sleeves, the space between the two being filled with mutton tallow to make an air-tight joint. The sleeves were insulated from the pressure chamber by hard rubber rings. Air pressures up to about 7 atmospheres were obtained by means of a double cylinder automobile pump.

The observations below give the complete data of a typical experiment:—

Air pressure in arc	6·8 atmospheres.
Electrodes	silver, 0·8 mm. thickness.
Direct current without oscillations	0·15 ampere.
Direct current with oscillations	0·11 ampere.
P.D. of arc without oscillations	90 volts.
P.D. of arc with oscillations	2,000 volts.
P.D., open circuit	4,500 volts.
Arc length	about 0·4 mm.
Inductance in shunt circuit	about 0·009 millihenry.
Capacity	0·0044 mfd.
Alternating current	11·5 amperes.
Frequency	850,000.

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Table I. (Fig. 2.)—*Current Changed by Changing Resistance.*
240 volt circuit. P.D. across arc about 34 volts.

Currents.		Frequency.	Currents.		Frequency.
D.C.	A.C.	*n*.	D.C.	A.C.	*n*.
1·0 amp.	2·2 amp.	217,000 400,000 705,000	3·0 amp.	3·5 amp.	289,000 550,000 860,000
2·0 ,,	3·2 ,,	263,000 520,000 820,000	4·0 ,,	4·0 ,,	295,000 580,000 910,000
2·5 ,,	3·5 ,,	274,000 540,000 820,000			

Table II. (Fig. 8, curve g.)—*Direct Current changed by changing Arc Lengths.*
120 volt circuit.

Direct current.	P.D. across arc.	Alternating current.	Frequency.
			n.
3·8 amperes.	40 volts.	1·5 amperes.	368,000
3·9 ,,	34 ,,	2·3 ,,	380,000
4·1 ,,	26 ,,	4·8 ,,	394,000

Table III. (Fig. 3, curve e.)
1 arc, 120 volt circuit. P.D. across arc about 30 volts.

Currents.		Frequency.
Direct current.	Alternating current.	*n*.
2·1 amperes.	1·0 amperes.	315,000
2·8 ,,	1·5 ,,	356,000
3·0 ,,	1·5 ,,	365,000
3·5 ,,	2·0 ,,	379,000

Table IV. (Fig. 3, curve d.)
1 arc, 240 volt circuit. P.D. across arc about 34 volts.

2·0 amperes.	2·2 amperes.	312,000
2·5 ,,	2·5 ,,	356,000
3·0 ,,	3·2 ,,	378,000
3·5 ,,	4·1 ,,	390,000
5·2 ,,	4·9 ,,	420,000

Table V. (Fig. 3, curve f.)
2 arcs in series, 240 volt circuit. P.D. across arc about 54 volts.

4·2 amperes.	5·8 amperes.	316,000
5·0 ,,	6·7 ,,	355,000
5·8 ,,	6·2 ,,	371,000

The most noticeable thing in these observations is the remarkable rise in arc P.D. when the oscillations occur. It is evidently a more marked example of the phenomenon described above with the arc in hydrogen. It is also seen that the oscillations cause the direct current to drop in the same way that was observed in the low potential arc. It has always been found to be one of the characteristics of the singing arc and also of the low potential, high frequency arc, that no resistance of more than an ohm or two can be introduced into the shunt oscillatory circuit without causing the oscillations to cease. In the high potential arc this is not the case. Resistances amounting to several hundred ohms may be introduced without any detrimental effect.

The question of the presence of other frequencies than the fundamental was investigated by means of the secondary resonance circuit, but none was found. Unlike the low potential arc this arc showed no change of frequency when the direct current was reduced by more than half by increasing resistance. There was also no change in frequency when the arc length was varied.

Efficiency of the Oscillations.—A 110 volt 100 c.p. lamp was placed in the shunt oscillatory circuit, and at a frequency of 650,000 an alternating current of 2·1 amperes was observed. By means of direct-current observations this was determined to represent a consumption of about 200 watts. As the available power, after subtracting that absorbed in the series resistance, amounted to but a little over 300 watts, the efficiency was more than 60 per cent.

Experiments were also made at higher frequencies by the same method, 180 watts being obtained at 1,500,000 and 140 watts at 3,500,000. At about 4,500,000 the oscillations became irregular and the observations were not pushed further.

Effect of Air Pressure.—Fig. 6 shows the remarkable increase in the oscillations produced by the increased air pressure. Starting with the apparatus and data indicated in the typical experiment, already cited, the air pressure was gradually decreased with the result shown in the figure. Above 5 atmospheres little change takes place, but below this the oscillations fall off rapidly and become much less steady. Below 2 atmospheres this unsteadiness becomes so great that no accurate readings can be taken.

During the work several different metals were tried as electrodes. Of these copper gave results nearly as good as silver, while zinc, aluminium and platin-iridium (10 per cent. Ir.) were all much poorer. This seems to indicate that metals with the higher heat conductivities are best suited for the purpose.

Continuity of Wave Trains.—It has been generally assumed that oscillations formed from the direct current arc are undamped, *i.e.*,

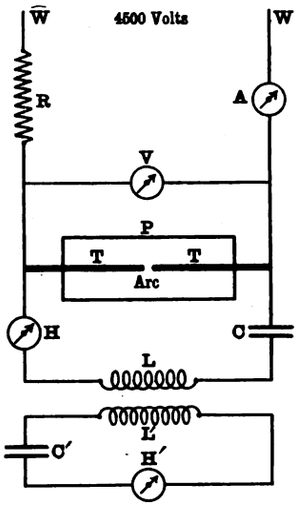

Fig. 4.

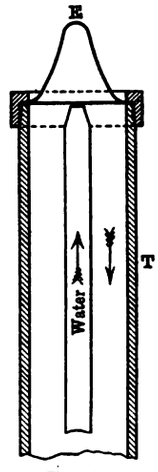

Fig. 5.

that the wave trains are continuous. While this is undoubtedly the case at low frequencies (singing arc) there is a point above which the arc breaks up into successive sparks, probably depending on the magnitude of the direct current. The high potential arc in compressed air is certainly not continuous. Using one of the circuits for which data have been given, the damping coefficient γ, measured by Drude's method, amounted to about 0·1 per period. We have in this case simply a spark discharge with the sparks following each other very rapidly. Attempts were made to determine whether the waves were undamped in the case of the low potential graphite arc at frequencies of 300,000 and 100,000. The observations indicated that damping existed; but the constant slight shifting back and forth of the frequency due to changes in the arc might very well have stimulated this effect. Therefore, the indications cannot be considered conclusive.

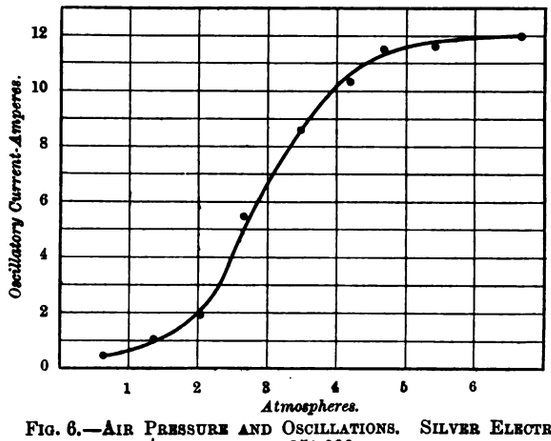

Fig. 6.—Air Pressure and Oscillations. Silver Electrodes. $n = 850{,}000$.

Summary of Results.

1. The experiments show in agreement with Salomonson *that the ordinary singing arc with carbon or, better, graphite* electrodes is capable of producing oscillations of several hundred thousand per second.

With the Graphite Arc.

2. The oscillations as investigated in a secondary resonance circuit show three frequencies of decreasing intensity corresponding approximately to the first three harmonics. This shows that the wave is not only not sinusoidal, but not even symmetrical.

3. The frequency increases with increasing direct current. Figs. 2 and 3.

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4. The frequency increases with diminishing arc length. Fig. 8.

5. Putting arcs in series reduces the frequency. Fig. 8 (equivalent to increasing arc length).

6. The frequency does not, as far as has been observed, vary with the intensity of the oscillations.

7. No considerable resistance can be placed in the shunt oscillatory circuit without destroying the oscillations. Resistance may, however, be introduced into the secondary coupled circuit, thus giving means of obtaining power.

8. The power is much increased when the arc is formed in hydrogen or steam.

With High-Voltage Arc in Compressed Air.

9. When an arc is formed in air at a pressure of 6 atmospheres between silver or copper electrodes, the direct current being less than 0·2 ampere and the voltage of the circuit 4,500 volts, the arc takes on all the characteristics of a very rapid spark discharge. (*a*) The frequency is independent of the direct current and of arc length and depends only on the inductance and capacity of the oscillatory circuit. (*b*) No other frequency than the fundamental has been observed. The wave is probably sinusodial.

10. Unlike the low potential arc, resistances of several hundred ohms may be inserted in the shunt oscillatory circuit, and thus power amounting to more than 60 per cent. of that calculated to be available can be derived from the oscillations.

11. The high-voltage arc is nearly free from the hissing noises always heard at low voltages. It is therefore particularly well suited for use in wireless telephone experiments.

SIR DAVID GILL'S ADDRESS TO THE BRITISH ASSOCIATION.*

To-night, for the first time in its history, the British Association meets in the ancient city of Leicester: and it now becomes my privilege to convey to you, Mr. Mayor, and to the citizens generally, an expression of our thanks for your kind invitation and for the hospitable reception which you have accorded to us.

Here in Leicester, and last year in York, the Association has followed its usual custom of holding its annual meeting somewhere in the United Kingdom; but in 1905 the meeting was, as you know, held in South Africa. Now, having myself only recently come from the Cape, I wish to take this opportunity of saying that this southern visit of the Association has, in my opinion, been productive of much good; wider interest in science has been created amongst colonists, juster estimates of the country and its problems have been formed on the part of the visitors, and personal friendships and interchange of ideas between thinking men in South Africa and at home have arisen which cannot fail to have a beneficial influence on the social, political and scientific relations between these colonies and the mother country. We may confidently look for like results from the proposed visit of the Association to Canada in 1909.

One is tempted to take advantage of the wide publicity given to words from this chair to speak at large in the cause of science, to insist upon the necessity for its wider inclusion in the education of our youth and the devotion of a larger measure of the public funds in aid of scientific research; to point to the supreme value of science as a means for the culture of those faculties which in man promote that knowledge which is power, and to show how dependent is the progress of a nation upon its scientific attainment.

But in recent years these truths have been prominently brought before the Association from this chair; they have been exhaustively demonstrated by Sir William Huggins from the chair of the Royal Society, and now a special guild† exists for their enforcement upon the mind of the nation.

These considerations appear to warrant me in following the healthy custom of so many previous presidents—viz., of confining their remarks mainly to those departments of science with which the labours of their lives have been chiefly associated.

The Science of Measurement.—Lord Kelvin in 1871 made a statement from the presidential chair of the Association at Edinburgh as follows: "Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than the looking for something new. But nearly all the grandest discoveries of science have been the reward of acurate measurement and patient, long-continued labour in the minute sifting of numerical results."

Besides the instances quoted by Lord Kelvin in support of that statement, we have perhaps as remarkable and typical an exemplification as any in Lord Rayleigh's long-continued work on the density of nitrogen which led him to the discovery of argon We shall see presently that, true as Lord Kelvin's words are in regard to most fields of science, they are specially applicable as a guide in astronomy.

One of Clerk Maxwell's lectures in the natural philosophy class at Marischall College, Aberdeen, when I was a student under him there, in the year 1859, ran somewhat as follows:—

A standard, as it is at present understood in England, is not a real standard at all; it is a rod of metal with lines ruled upon it to mark the yard, and it is kept somewhere in the House of Commons. If the House of Commons catches fire there may be an end of your standard. A copy of a standard can never be a real standard, because all the work of human hands is liable to error. Besides, will your so-called standard remain of a constant length? It certainly will change by temperature, it probably will change by age (that is, by the rearrangement or settling down of its component molecules), and I am not sure if it does not change according to the azimuth in which it is used. At all events, you must see that it is a very impractical standard—impractical because if, for example, any one of you went to Mars or Jupiter, and the people there asked you what was your standard of measure, you could not tell them, you could not reproduce it, and you would feel very foolish. Whereas, if you told any capable physicist in Mars or Jupiter that you used some natural invariable standard, such as the wave-length of the D line of sodium vapour, he would be able to reproduce your yard or your inch, provided that you could tell him how many of such wave-lengths there were in your yard or your inch, and your standard would be available anywhere in the universe where sodium is found.

That was the whimsical way in which Clerk Maxwell used to impress great principles upon us. We all laughed before we understood; then some of us understood and remembered.

Now the scientific world has practically adopted Maxwell's form of natural standard. It is true that it names that standard the metre; but that standard is not one-millionth of the earth's quadrant in length, as it was intended to be: it is merely a certain piece of metal approximately of that length.

It is true that the length of that piece of metal has been reproduced with more precision, and is known with higher accuracy in terms of many secondary standards, than is the length of any other standard in the world; but it is, after all, liable to destruction and to possible secular change of length. For these reasons it cannot be scientifically described otherwise than as a piece of metal whose length at 0°C. at the epoch A.D. 1906 is = 1,553,164 times the wave-length of the red line of the spectrum of cadmium when the latter is observed in dry air at the temperature of 15°C. of the normal hydrogen scale at a pressure of 760 mm. of mercury at 0°C.

This determination, recently made by methods based on the interference of light waves and carried out by MM. Perot and Fabry at the International Bureau of Weights and Measures, constitutes a real advance in scientific metrology. The result appears to be reliable within one ten-millionth part of the metre.

The length of the metre, in terms of the wave-length of the red line in the spectrum of cadmium, had been determined in 1892 by Michelson's method, with a mean result in almost exact accordance with that just quoted for the comparisons of 1906; but this agreement (within one part in ten millions) is due in some degree to chance, as the uncertainty of the earlier determination was probably 10 times greater than the difference between the two independent results of 1892 and 1906.

We owe to M. Guillaume, of the same International Bureau, the discovery of the remarkable properties of the alloys of nickel and steel, and from the point of view of exact measurement the specially valuable discovery of the properties of that alloy which we now call "invar." He has developed methods for treatment of wires made from this alloy which render more permanent the arrangement of their constituent molecules. Thus these wires, with their attached scales, may, for considerable periods of time and under circumstances of careful treatment, be regarded as nearly invariable standards. With proper precautions, we have found at the Cape of Good Hope that these wires can be used for the measurement of base lines of the highest geodetic precision with all the accuracy attainable by the older and most costly forms of apparatus; whilst with the new apparatus a base of 20 km. can be measured in less time and for less cost than one of a single kilometre with the older forms of measurement.

After referring at length to the numerous problems with which the astronomer of to-day is concerned, the author concludes as follows:—

The ancient philosophers were confident in the adequacy of their intellectual powers alone to determine the laws of human thought and regulate the actions of their fellow-men, and they did not hesitate to employ the same unsupported means for the solution of the riddle of the universe. Every school of philosophy was agreed that some object which they could see was a fixed centre of the universe, and the battle was fought as to what that centre was. The absence of facts, their entire ignorance of methods of exact measurement, did not daunt them, and the question furnished them a subject of dispute and fruitless occupation for 25 centuries.

But astronomers now recognise that Bradley's meridian observations at Greenwich, made only 150 years ago, have contributed more to the advancement of sidereal astronomy than all these speculations of preceding centuries. They have learned the lesson that human knowledge in the slowly developing phenomena of sidereal astronomy must be content to progress by the accumulating labours of successive generations of men; that progress will be measured

* Extracts from the Presidential Address delivered by Sir David Gill, K.C.B., D.Sc., F.R.S., at Leicester on Wednesday last.

† The British Science Guild.

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for generations yet to come more by the amount of honest, well-directed and systematically discussed observation than by the most brilliant speculation; and that, in observation, concentrated systematic effort on a special thoughtfully selected problem will be of more avail than the most brilliant but disconnected work.

By these means we shall learn more and more of the wonders that surround us, and recognise our limitations when measurement and facts fail us.

Huggins's spectroscope has shown that many nebulæ are not stars at all; that many well-condensed nebulæ, as well as vast patches of nebulous light in the sky, are but inchoate masses of luminous gas. Evidence upon evidence has accumulated to show that such nebulæ consist of the matter out of which stars (*i.e.*, suns) have been and are being evolved. The different types of star spectra form such a complete and gradual sequence (from simple spectra resembling those of nebulæ onwards through types of gradually increasing complexity) as to suggest that we have before us, written in the cryptograms of these spectra, the complete story of the evolution of suns from the inchoate nebula onwards to the most active sun (like our own), and then downward to the almost heatless and invisible ball. The period during which human life has existed on our globe is probably too short—even if our first parents had begun the work—to afford observational proof of such a cycle of change in any particular star; but the fact of such evolution, with the evidence before us, can hardly be doubted. I most fully believe that, when the modifications of terrestrial spectra under sufficiently varied conditions of temperature, pressure and environment have been further studied, this conclusion will be greatly strengthened. But in this study we must have regard also to the spectra of the stars themselves. The stars are the crucibles of the Creator. There we see matter under conditions of temperature and pressure and environment, the variety of which we cannot hope to emulate in our laboratories, and on a scale of magnitude beside which the proportion of our greatest experiment is less than that of the drop to the ocean. The spectroscopic astronomer has to thank the physicist and the chemist for the foundation of his science, but the time is coming—we almost see it now—when the astronomer will repay the debt by wide-reaching contributions to the very fundamenta of chemical science.

By patient, long-continued labour in the minute sifting of numerical results the grand discovery has been made that a great part of space, so far as we have visible knowledge of it, is occupied by two majestic streams of stars travelling in opposite directions. Accurate and minute measurement has given us some certain knowledge as to the distances of the stars within a certain limited portion of space, and in the cryptograms of their spectra has been deciphered the amazing truth that the stars of both streams are alike in design, alike in chemical constitution and alike in process of development.

But whence have come the two vast streams of matter out of which have been evolved these stars that now move through space in such majestic procession?

The hundreds of millions of stars that comprise these streams, are they the sole ponderable occupants of space? However vast may be the system to which they belong, that system itself is but a speck in illimitable space; may it not be but one of millions of such systems that pervade the infinite?

We do not know.

"Canst thou by searching find out God? canst thou find out the Almighty unto perfection?"

PROF. SILVANUS P. THOMPSON'S ADDRESS TO SECTION G OF THE BRITISH ASSOCIATION.*

After considering the severe loss sustained by the engineering profession by the death of Sir Benjamin Baker, the author discusses the extraordinary development of engineering during recent years. We must not delude ourselves with imagining that the happiness and welfare of mankind depend only on its material advancement; or that moral, intellectual and spiritual forces are not in the ultimate resort of greater moment. But if the inquiry be propounded what is it that has made possible this amazing material progress, there is but one answer that can be given—science. Chemistry, physics, mechanics, mathematics, it is these that have given to man the possibility of organising this tremendous development. And the great profession which has been most potent in applying these branches of science to wield the energies of Nature and direct them to the service of man has been that of the engineer. Without the engineer how little of all this activity could there have been; and without mathematics, mechanics, physics and chemistry where was the engineer?

If, looking over this England of Edward the Seventh, we try to put ourselves back into the England of Edward the Sixth—or, for that matter, of any pre-Victorian monarch—we must admit that the differences to be found in the social and industrial conditions around us are due not in any appreciable degree to any changes in politics, philosophy, religion or law, but to science and its applications.

Interaction of Abstract Science and its Applications.

In engineering, above all other branches of human effort, we are able to trace the close interaction between abstract science and its practical applications. Often as the connection between pure science and its applications has been emphasised in addresses upon engineering, the emphasis has almost always been laid upon the influence of the abstract upon the concrete. We are all familiar with the doctrine that the progress of science ought to be an end in itself, that scientific research ought to be pursued without regard to its immediate applications, that the importance of a discovery must not be measured by its apparent utility at the moment. We are assured that research in pure science is bound to work itself out in due time into technical applications of utility, and that the pioneer ought not to pause in his quest to work out potential industrial developments. We are invited to consider the example of the immortal Faraday, who deliberately abstained from busying himself with marketable inventions arising out of his discoveries, excusing himself on the ground that he had no time to spare for money-making. It is equally true, and equally to the point, that Faraday, when he had established a new fact or a new physical relation, ceased from busying himself with it, and pronounced that it was now ready to be handed over to the mathematicians. But, admitting all these commonplaces as to the value of abstract science in itself and for its own sake, admitting also the proposition that sooner or later the practical applications are bound to follow on upon the discovery, it yet remains true that in this thing the temperament of the discoverer counts for something. There are scientific investigators who cannot pursue their work if troubled by the question of ulterior applications; there are others no less truly scientific who simply cannot work without the definiteness of aim that is given by a practical problem awaiting solution. There are Willanses as well as Regnaults; there are Whitworths as well as Poissons. The world needs both types of investigator; and it needs, too, yet another type of pioneer—namely, the man who, making no claim to original discovery, by patient application and intelligent skill turns to industrial fruitfulness the results already attained in abstract discovery.

There is, however, another aspect of the relation between pure and applied science, the significance of which has not been hitherto so much emphasised, but yet is none the less real—the reaction upon science and upon scientific discovery of the industrial applications. For while pure science breeds useful inventions, it is none the less true that the industrial development of useful inventions fosters the progress of pure science. No one who is conversant with the history, for example, of optics can doubt that the invention of the telescope and the desire to perfect it were the principal factors in the outburst of optical science which we associate with the names of Newton, Huygens and Euler. The practical application, which we know was in the minds of each of these men, must surely have been the impelling motive that caused them to concentrate on abstract optics their great and exceptional powers of thought. It was in the quest—the hopeless quest—of the philosopher's stone and the elixir of life that the foundations of the science of chemistry were laid. The invention of the art of photography has given immense assistance to sciences as widely apart as meteorology, ethnology, astronomy, zoology and spectroscopy. Of the laws of heat men were profoundly ignorant until the invention of the steam engine compelled scientific investigation; and the new science of thermodynamics was born. Had there been no industrial development of the steam engine, is it at all likely that the world would ever have been enriched with the scientific researches of Rankine, Joule, Regnault, Hirn or James Thomson? The magnet had been known for centuries, yet the study of it was utterly neglected until the application of it in the mariner's compass gave the incentive for research.

The history of electric telegraphy furnishes a very striking example of this reflex influence of industrial applications. The discovery of the electric current by Volta and the investigation of its properties appear to have been stimulated by the medical properties attributed in the preceding 50 years to electric discharges. But, once the current had been discovered, a new incentive arose in the dim possibility it suggested of transmitting signals to a distance. This was certainly a possibility, even when only the chemical effects of the current had yet been found out. Not, however, until the magnetic effects of the current had been discovered and investigated did telegraphy assume commercial shape at the hands of Cooke and Wheatstone in England and of Morse and Vail in America. Let us admit freely that these men were inventors rather than discoverers: exploiters of research rather than pioneers. They built upon the foundations laid by Volta, Oersted, Sturgeon, Henry, and a host of less famous workers. But no sooner had the telegraph become of industrial importance, with telegraph lines erected on land and submarine cables laid in the sea, than fresh investigations were found necessary; new and delicate instruments must be devised; means of accurate measurement heretofore undreamed of must be found; standards for

* Abstract of the presidental address delivered yesterday by Prof. S. P. Thompson, D.Sc., F.R.S., at Leicester.

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the comparison of electrical quantities must be created; and the laws governing the operations of electrical systems and apparatus must be investigated and formulated in appropriate mathematical expressions. And so, perforce, as the inevitable consequence of the growth of the telegraph industry, and mainly at the hands of those interested in submarine telegraphy, there came about the system of electrical and electromagnetic units, based on the early magnetic work of Gauss and Weber, developed further by Lord Kelvin, by Bright and Clark, and last, but not least, by Clerk Maxwell. Had there been no telegraph industry to force electrical measurement and electrical theory to the front, where would Clerk Maxwell's work have been? He would probably have given his unique powers to the study of optics or geometry; his electromagnetic theory of light would never have leapt into his brain; he would never have propounded the existence of electric waves in the ether. And then we should never have had the far-reaching investigations of Heinrich Hertz; nor would the British Association at Oxford in 1894 have witnessed the demonstration of wireless telegraphy by Sir Oliver Lodge. A remark of Lord Rayleigh's may here be recalled, that the invention of the telephone had probably done more than anything else to make electricians understand the principle of self-induction.

In considering this reflex influence of the industrial applications upon the progress of pure science it is of some significance to note that, for the most part, this influence is entirely helpful. There may be sporadic cases where industrial conditions tend temporarily to check progress by imposing persistence of a particular type of machine or appliance; but the general trend is always to help to new developments. The reaction aids the action; the law that is true enough in inorganic conservative systems, that reaction opposes the action, ceases here to be applicable, as indeed it ceases to be applicable in a vast number of organic phenomena. It is the very instability thereby introduced which is the essential of progress. The growing organism acts on its environment, and the change in the environment reacts on the organism—not in such a way as to oppose the growth, but so as to promote it. So it is with the development of pure science and its practical applications.

In further illustration of this principle one might refer to the immense effect which the engineering use of steel has had upon the study of the chemistry of the alloys. And the study of the alloys has in turn led to the recent development of metallography. It would even seem that through the study of the intimate structure of metals, prompted by the needs of engineers, we are within measurable distance of arriving at a knowledge of the secret of crystallogenesis. Everything points to the probability of a very great and rapid advance in that fascinating branch of pure science at no distant date.

History of the Development of Electric Motive Power.

The author deals historically with the evolution of electrotechnical science from the days of Faraday, who, in 1821, after studying the phenomena of electromagnetic deflection of a needle by an electric current, first succeeded in producing continuous rotations by electromagnetic means. His pieces of apparatus were merely toys, but they demonstrated the essential principle. Two years later we find Barlow's wheel, followed by the devices of Sturgeon, to whom is due the momentous invention of the soft iron electromagnet. How slowly the importance of this discovery was recognised is now a matter for astonishment. To state that Sturgeon died in poverty 26 years later is sufficient to indicate his place among the unrequited pioneers of whom the world is not worthy. Six years elapsed, and then there came a flood of suggestions of electric motors in which was applied the principle of intermittent attraction by an electromagnet. The names of Henry, Dal Negro, Ritchie and Jacobi are closely connected with this part of the subject. In 1831 Faraday made the cardinal discovery of the mechanical generation of electric currents by electromagnetic induction, the fundamental principal of the dynamo, thus rendering it possible to pass from the pile of Volta and other forms of primary battery to generators capable of giving comparatively unlimited power.

In 1857 Mr. Robert Hunt, F.R.S., read a Paper before the Institution of Civil Engineers on "Electromagnetism as a Motive Power," in which the future of electric power was discussed. Judging by the discussion, the future did not appear to be rosy. The rapid falling off of the pull of the electromagnet as the keeper recedes from the pole, and the generation of a back E.M.F. by the electric motor, were looked upon as serious defects.

The most eminent engineers in 1857 one and all condemned the idea of electric motive power as unpractical and commercially impossible. Even Faraday, in his lecture on "Mental Education" in 1854 had set down the magneto-electric engine along with mesmerism, homœopathy, odylism, the caloric engine, the electric light, the sympathetic compass, and perpetual motion as coming in different degrees amongst "subjects uniting more or less of the most sure and valuable investigations of science with the most imaginary and unprofitable speculation, that are continually passing through their various phases of intellectual, experimental, or commercial development, some to be established, some to disappear, and some to recur again and again, like ill weeds that cannot be extirpated, yet can be cultivated to no result as wholesome food for the mind."

Since that time, however, 50 years have passed and Lord Kelvin remains the sole and honoured survivor of those who discussed Mr. Hunt's Paper, but now the electric motor is a gigantic practical success, and hundreds of factories have discarded their steam engines to adopt electric driving. One may well ask: What has wrought this astonishing revolution in the face of the unanimous verdict of the engineers of 1857?

The answer may be given in terms of the action and reaction of pure and applied science. Pure science furnished a discovery; industrial applications forced its development; that development demanded further abstract investigation, which in turn brought about new applications. It was beyond all question the development of the dynamo for the purposes of electrotyping and electric light which brought about the commercial advent of the electric motor. For about that very time Holmes and Siemens and Wilde and Wheatstone were at work developing Faraday's magneto-electric apparatus into an apparatus of more practical shape; and the electric lighthouse lamp was becoming a reality which Faraday lived to see before his death in 1867. This eventful year witnessed the introduction of the more powerful type of generator which excited its own magnets. And even before that date a young Italian had made a pronouncement which, though it was lost sight of for a time, was none the less of importance. Antonio Pacinotti in 1864 described a machine of his own devising, having a specially wound revolving ring magnet placed between the poles of a stationary magnet, which, while it would serve as an admirable generator of electric currents if mechanically driven, would also serve as an excellent electric motor if supplied with electric currents from a battery. He thereupon laid down the principle of reversibility of action, a principle more or less dimly foreseen by others, but never before so clearly enunciated as by him. And so it turned out in the years from 1860 to 1880, when the commercial dynamo was being perfected by Gramme, Wilde, Siemens, Crompton and others, that the machines designed specially to be good and economical generators of currents proved themselves to be far better and more efficient motors than any of the earlier machines which had been devised specially to work as electromagnetic engines. Moreover, with the perfection of the dynamo came that cheap source of electric currents which was destined to supersede the battery.

At that time there was a notion abroad, which persisted into the eighties, that no electric motor could possibly have an efficiency higher than 50 per cent. This idea certainly delayed the progress of events, yet the matter was clearly understood by such men as Lord Kelvin, Joule, Mascart, Ayrton and others. Pure science stepped in to confirm the possibility of a high efficiency in the electric motor, and also to set right the misleading idea that the best way of arranging a battery was so to group its component cells that its internal resistance should be equal to the resistance of the rest of the circuit. Later, Hopkinson and Kapp showed how the dynamo could be designed from electromagnetic principles. Ewing followed with magnetic studies of the materials involved, and Brown, Mordey, Crompton and Kapp perfected the structural developments. Later on alternating currents claimed the attention of engineers, and again pure science stepped in, in the suggestion by Galileo Ferraris of the extremely beautiful theory of the rotatory magnetic field. Ever since the Frankfort Exhibition in 1891 the commercial possibility of electric transmission has been assured and it is now possible to supplant the isolated steam engine by an electric motor on account of the higher efficiency of very large generating plant.

Education and Training of Engineers.

Interplay of action and reaction make for progress not only in the evolution of the scientific industries, but also in the development of the individual engineer. In him, if his training is on right lines, pure theory becomes an aid to sound practice; and practical applications are continually calling him to resort to those abstractions of thought, the underlying principles, which, when known and formulated, are called theories. Recent years have brought about a so much better understanding of education, in its bearing upon the professions and constructive industries, that we now seldom hear the practical man denouncing theory, or the theorist poohpoohing practice. It is recognised that each is useful, and that the best uses of both are in conjunction, not in isolation. As a result of this better understanding distinct progress is being made in the training of engineers. Of this the growth of the engineering departments of the universities, and of the technical colleges and schools, affords striking evidence. The technical schools, moreover, are recognising that their students must have a sound preliminary education, and are advancing in the requirements they expect of candidates for admission. They are also finding out how their work may best supplement the practical training in the shops, and are improving their curricula accordingly. In the engineering industry, too, Great Britain is slowly following the lead taken in America, Germany, and Switzerland, in the recognition afforded to the value of a systematic college training for the

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young engineer, though there is still much apathy and even distrust shown in certain quarters. Yet there is no doubt that the stress of competition, particularly of competition against the industry and the enterprise of the trained men of other nations, is gradually forcing to the front the sentiment in favour of a rational and scientific training for the manufacturer and for the engineer. As William Watson, in his "Ode on the Coronation," wrote in a yet wider sense of England:—

> For now the day is unto them that know,
> And not henceforth sh› stumbles on the prize;
> And yonder march the nations full of eyes.
> Already is doom a-spinning. . . .

Truly the day is "unto them that know." Knowledge, perfected by study and training, must be infused into the experience gained by practice: else we compete at very unequal odds with the systematically trained workers of other nations. Nor must we make the mistake here in the organisation of our technical institutions of divorcing the theory from its useful applications. In no department is this more vital than in the teaching of mathematics to engineering students. For while no sane person would deny that the study of mathematics, for the sole sake of mathematics, even though it leads to nothing but abstract mathematics, is a high and ennobling pursuit, yet that is not the object of mathematical studies in an engineering school. The young engineer must learn mathematics not as an end in itself, but as a tool that is to be useful to him. And if it is afterwards to be of use to him, he must learn it by using it. Hence the teacher of mathematics in an engineering school ought himself to be an engineer. However clever he be as a mathematical person, his teaching is unreal if he is not incessantly showing his learners how to apply it to the problems that arise in practice; and this he is incapable of doing if these problems do not lie within his own range of experience and knowledge. Were he a heaven-born senior wrangler, he is the wrong man to teach mathematics if he either despises or is ignorant of the ways in which mathematics enter into engineering. The fact is that for the great majority of engineering students, the mental training they most need is that which will enable them to think in physics, in mechanics, in geometric space, not in abstract symbols. The abstract symbols, and the processes of dealing with their relations and combinations, are truly necessary to them, but they are wanted not for themselves, but to form convenient modes of expressing the physical facts and laws, and the inter-dependence of those physical facts and laws. When the student loses grip of the physical meaning of his equations, and regards them only as abstractions or groupings of symbols, woe betide him. His mathematics amount to a mere symbol-juggling. That is how paper engineers are made. The high and dry mathematical master who thinks it beneath him to show a student how to plot the equations $y = A \sin x$, or $r = b \sin \theta$, or who never culls an example or sets a problem from thermodynamics or electricity, must be left severely on one side as a fossil. Better a living Whitworth scholar than a dry-as-dust Cambridge wrangler. He at least knows that elasticity is something more real than the group of symbols $E = p \div \frac{\Delta x}{x}$, which any mathematician may "know," even though he be blissfully ignorant whether the force required to elongate a square inch bar of steel by one one-millionth of its length is 10 ounces or 10 tons.

One evidence of the wholesome change of opinion that is springing up concerning the training of engineers is the abandonment of the system of taking premium pupils into works with no other test of qualification than that of the money-bag. Already many leading firms of engineers have been finding that the practice of taking sons of wealthy parents for a premium does not answer well, and is neither to their own advantage nor in many cases to that of the "pupil," whom it is nobody's particular business in the shops to train. Premium pupilage is absolutely unknown in the engineering firms of the United States or on the Continent of Europe. The firms who have abandoned it are finding themselves better served by taking the ablest young men from the technical schools and paying them small wages from the first, while they gain experience and prove themselves capable of good service. Messrs. Yarrow & Co. have led the way with a plan of their own, having three grades of apprenticeship, admission to which depends upon the educational abilities of the youths themselves. Messrs. Siemens have adopted a plan of requiring a high preliminary training. The Daimler Motor Co. has likewise renounced all premiums, preferring to select young men of the highest intelligence and merit. Messrs. Clayton & Shuttleworth have quite recently reconstructed their system of pupil-apprenticeship on similar lines. The British Westinghouse Company and the British Thomson-Houston Co. have each followed an excellent scheme for the admission of capable young men. Even the conservatism of the railway engineers shows signs of giving way, for already the Great Eastern Railway has modernised its regulations for the admission of apprentices. What the engineering staffs of the railway companies have lost by taking in pupils because of their fathers' purses rather than for the sake of their own brains it is impossible to gauge. But the community loses too and has a right to expect reform.

To this question, affecting the whole future outlook of engineering generally, a most important contribution was made in 1906 by the publication by the Institution of Civil Engineers of the report of a committee (appointed in November, 1908) to consider and report to the Council upon the subject of the best methods of education and training for all classes of engineers. This committee, a most influential and representative body made certain recommendations, including one so vital that it must be quoted in full:—

> "A leaving examination for secondary schools, similar in character to those already existing in Scotland and Wales, is desirable throughout the United Kingdom. It is desirable to have a standard such that it could be accepted by the Institution [of Civil Engineers] as equivalent to the studentship examination and by the universities and colleges as equivalent to a matriculation examination."

One may well wonder why such a reasonable recommendation has not long ago been carried out by the Board of Education. Perhaps it has been too busy over the religious squabble to attend to the pressing needs of the nation.

The second set of recommendations relates to engineering training. It begins with the announcement that "long experience has led to general agreement among engineers as to the general lines on which practical training should proceed"; but goes into no recommendations on this head beyond favouring four years in workshops, on works, in mines or in offices, expressing the pious desire that part of this practical training should be obtained in drawing offices, and suggesting that during workshop training the boys should keep regular hours, be subject to discipline, and be paid wages. It then lays down a dozen recommendations as to the "academic" training suitable for the average boy. He should leave school about 17; he should have a preliminary year, or introductory workshop course of a year, either between leaving school and entering college, or after the first year of college training. If the workshop course follows straight on leaving school there must be maintenance of studies either by private tuition or in evening classes, so that systematic study be not suspended. For the average student, if well prepared before entering college, the course should last three academic years (three sessions); in some cases this might be extended to four or shortened to two. A sound and extensive knowledge of mathematics is necessary in all branches of engineering, and those departments of mathematics which have no bearing upon engineering should not claim unnecessary time or attention. The committee strongly recommends efficient instruction in engineering drawing. The college course should include instruction (necessarily given in the laboratory) in testing materials and structures, and in the principles underlying metallurgical processes. In the granting of degrees, diplomas and certificates importance should be attached to laboratory and experimental work performed by individual students, and such awards should not depend on the results of terminal or final examinations alone.

All this is most excellent. It will be seen that it is entirely incompatible with the premium-pupil system, which may, therefore, be regarded as having been weighed and found wanting. For two things clearly stand out—that the young engineer must be college-trained, and that when he goes to works he should be regularly paid. It would have been well if the committee could have been more explicit as to the proper course of workshop training; for instance, as to the systematic drafting of the young engineer through the shops—forge, foundry, pattern shop, fitting shop, &c., and as to the proper recognition of the duty of the shop foreman to allocate work to the novice in suitable routine. These are, doubtless, among the matters in which "long experience has led engineers to general agreement." But this being so, it would have been well to state them authoritatively. A notable feature of this report is its healthy appreciation of the advantages of training, and an equally healthy distrust of the practice of cramming for examinations. So soon as any subject is crammed, it ceases to afford a real training. "Nature provides a very convenient safety-valve for knowledge too rapidly acquired." It is even whispered that a new species of crammer has arisen to "prepare" candidates in engineering for the graduate examinations of the Institution of Civil Engineers. The distinguished framers of this epoch-making report on the education and training of engineers at least give no countenance to any such parasitical development. For the scheme of education and training at which the committee has aimed is genuinely scientific, a happy federation of the theoretical with the practical. It seeks to place the training on a broad basis, and to secure to every future engineer worthy of the name the advantage of learning his professional work in both its aspects. It seeks, in short, to take advantage of that reflex action between science and its applications in which lies the greatest stimulus to progress. Its adoption will utilise for the young engineer, and therefore for the engineering industry as a whole, the facilities for training now so widely afforded throughout the country. If the institutions, schools and colleges where engineering training is offered are but rightly developed and co-ordinated, the engineers of Great Britain need have no fear as to holding their own against the trained engineers of other countries. It is for the employers to make use of these institutions, and to show that sympathetic interest in their efficiency which is essential to their full success.

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With the number of THE ELECTRICIAN for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with THE ELECTRICIAN. The twelfth monthly issue of the Supplement was published (Gratis) with THE ELECTRICIAN for July 26.

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THE POSITION OF THE ELECTRICAL INDUSTRY.

Although we have no desire to discuss the broad question of Protection, which ought to be considered solely by those who have made a special study of such matters instead of being introduced into the arena of party politics, we nevertheless think the evidence given by Mr. W. L. MADGEN before the Tariff Commission, which we reproduce elsewhere, worthy of attention by those interested in the electrical industry. The early history of the industry is now well known, and it is acknowledged how fatal were the results of early legislation when Parliament passed the Electric Lighting Act of 1882 and did not modify the Tramway Act of 1870, the latter of which gave no encouragement to electric traction. Possibly Parliament had in view the benefit of municipal ownership, which has so much increased since those early days, and if that is so the subsequent history should surely be a lesson to those who endeavour as far as possible to stifle private enterprise, so as to enable municipal enterprise at some time or another to step in when the situation appears to be sufficiently favourable.

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Undoubtedly the restrictive effect of this early legislation enabled foreign countries to obtain an invaluable start in the development of a new industry. If circumstances had been otherwise, there is no reason why we should not now be holding the same position in the manufacture of electrical machinery as we do in the manufacture of electric cables. As it is, our manufacturers have been very seriously handicapped. It may be urged that after so many years the manufacturers of this country should have obtained the necessary experience and be able to compete effectively. They have had to contend, however, against two or three important factors. First of all it has been a case of our smaller concerns competing with the older and larger concerns of other countries. Given otherwise identical conditions the larger concerns must always stand at an advantage, as there is more experience to go upon, and the establishment charges are smaller, so that lower prices can be quoted. The second factor in the case is that the purchaser is always predisposed to those manufacturers who have had the necessary experience and whose plant has given satisfaction, in preference to those whose plant has not been tried to the same extent, even if the newer manufactures may be somewhat cheaper. Consequently, as Mr. MADGEN puts it, if the American "Jones" type of truck has given satisfaction, a British corporation is likely to require the American truck, even though a British manufacturer may make practically the same "Jones" type of truck at a lower price.

Lastly, of course, there is the factor that our foreign competitors have a free market in this country, which market our manufacturers find very difficult to defend, and its defence requires all their energies without turning their thoughts very seriously to the capture of foreign markets. It is on account of early legislative blunders that Mr. MADGEN pleads, not necessarily for permanent protection, but for temporary protection to make some reparation for the injustice done to the industry in the early days. To some people it will, no doubt, appear too late for such reparation to be made, but Mr. MADGEN'S view of the matter is certainly worthy of consideration in view of the depressed state of the industry at the present time. As to whether such protection is desirable from every point of view we do not profess to express an opinion, but it does appear that from the point of view simply of the electrical industry something material might be gained.

Another point touched upon by Mr. MADGEN is the very large number of foreign firms trading under British names. One undertaking alone is reported to have imported goods to the value of £1,200,000 into Great Britain during the past year, and it is said that a leading German firm trading under an English title advertises that among its customers are numbered over 50 British municipalities. It is only natural to expect that articles should be purchased in the cheapest market, but it is a little odd that so many municipalities which, nominally at least, have the welfare of the working classes of this country at heart, should purchase so largely from foreign sources. To some extent this may be due to the British sounding names adopted by branches of foreign firms, making it difficult for the purchaser to discriminate between home products and imported articles if he desires to do so.

THE BRITISH ASSOCIATION AT LEICESTER.

(FROM OUR OWN CORRESPONDENT.)

Wednesday, July 31st.

Those visitors who delayed becoming members or associates until to-day will assuredly not leave matters until the last moment at future meetings. By 11 o'clock this morning all seats for the Presidential Address, with the exception of those in the gallery of the Royal Opera House, had been allotted. This is particularly unfortunate for late comers, especially in view of the fact that holders of tickets for to-night's function can claim the same seats on Friday evening, when Mr. W. Duddell, F.R.S., will deliver a discourse on "The Arc and Spark in Radio Telegraphy."

The Presidential Address contains little that is of interest to readers of *The Electrician*, for, as it may be imagined, Sir David Gill devoted himself almost entirely to his own subject of astronomy. For this reason we have given only two short extracts from his address. He did, however, make a strong appeal for the adoption of some natural standard of length in place of the arbitrary "yard," and defined the metre as "a piece of metal whose length at 0°C. at the epoch A.D. 1906 is 1,553,164 times the wave-length of the red line of the spectrum of cadmium when the latter is observed in dry air at the temperature of 15°C. of the normal hydrogen scale at a pressure of 760 mm. of mercury at 0°C." Now, this result is correct to within one ten-millionth part of a metre, and is undoubtedly a much more scientifically accurate definition than that which describes the metre as a fraction of the earth's quadrant and is known to be hopelessly wrong. It is to be hoped therefore that the wave-length definition will be adopted universally, and we shall then hear the last of the rod of metal, with lines ruled on it, which is kept in a Government office.

During the day a Council meeting of the Association was held. This was followed by a meeting of the Sectional committees and then of the General committee, at which the report of the Council for the year 1906-1907 was received and adopted.

Thursday, August 1st.

So far as the general public is concerned, the interest attaching to the British Association reached its maximum for the last 12 months yesterday, with the delivery of the Presidential Address, and another maximum will not occur until the next Presidential Address is delivered. This is evidenced by the fact that the daily press gives a great deal of space to the president and almost ignores the authors of Papers. For those, however, who take more than a passing interest in the affairs of the great British Association, Wednesday's proceedings partook of the nature of a preliminary canter, and the really serious work began to-day. In Section G (Engineering) Prof. S. P. Thompson, F.R.S., delivered his presidential address, which was not a whit less brilliant than the former literary and scientific efforts which have characterised Dr. Thompson's career. He commenced with a sympathetic reference to the death of Sir Benjamin Baker, and then proceeded to consider the interaction of abstract science and its applications. As will be seen in another column, he maintained, first of all, that the pursuit of scientific research for its own sake, or as an adjunct to industrial advancement, depended entirely on the person concerned. Some people could not carry out an investigation unless they had the application of the results as a goal, while with other people the commercial application of a discovery was a matter of small importance, and they could not take it into account during the progress of their work. He then instanced cases of industrial applications which actually compelled further scientific research. His comparison of the condition of the electric motor in 1857 and in 1907 was extremely interesting. In 1857 a Paper was read before the Institution of Civil Engineers by Mr. Robert Hunt, F.R.S., the title being "On Electromagnetism as a Motive Power." This Paper was followed by a debate in which Grove, Smee, Tyndall, Cowper, Joule, Bidder and Stephenson all condemned the idea of electric motive power as impractical and commercially impossible! Prof. Thompson next dealt with the education and training of engineers, and strongly advocated the study of mathematics

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by engineering students, under the direction of an engineer teacher. Discussing the teacher of Mathematics Prof. Thompson said: "Were he a heaven-born senior wrangler, he is the wrong man to teach mathematics if he either dispises or is ignorant of the ways in which mathematics enter into engineering."

The Presidential Address of Sir Philip Magnus to Section L (Educational Science) dealt principally with elementary education, and only at the conclusion was secondary or university education referred to. Most people will agree with Sir Philip that university education in this country has suffered much at the hands of the unscientific reformer. Our conception of the functions of a university has undergone many violent changes. Between the ideal of the University of London, prior to its reorganisation, and that of a mediæval university, in which students were never plucked, obtaining their degrees whether they did their work well or badly, there have been many variations, but he thought it might be said that, recently at any rate, we had come to realise the fact that our universities, to fulfil their great purpose, must be schools for the preparation of students for the discharge of the higher duties of citizenship and professional life, and institutions for the prosecution of research, with a view to the promotion of learning in all its branches. Examinations for degrees, necessary as they were as tests of the extent of a student's acquired knowledge, must be regarded as subordinate to these two great functions.

Of all the presidential addresses perhaps none was more interesting than that of Prof. A. Smithells, F.R.S., to Section B (Chemistry), which commenced with a consideration of ignition temperatures of gases. It is proposed, by the way, that there shall be a joint meeting of the engineering and chemical sections to discuss this question. Prof. Smithells then proceeded to add a few more remarks on the question of the atom and, of course, his view is that of the chemist as distinct from that of the pure physicist. He refused to admit that the chemist should also be a mathematician, but urged that he should rather be a skilled craftsman and an exact experimenter. The presidential address of Prof. A. E. H. Love, F.R.S., to Section A (Mathematics and Physics) consisted entirely of a dynamical theory to account for the shape of the earth, and was therefore of no direct interest to electrical engineers.

ON THE DISCHARGE OF CONDENSERS CHARGED BY TRANSFORMERS, AND ON THE REGULATION OF RESONANCE TRANSFORMERS.*

BY A. BLONDEL.

Summary.—The author considers the working of transformers used for the production of oscillations, and investigates the conditions determining the nature of the secondary discharges.

For several years past the oscillatory discharges of condensers required in connection with wireless telegraphy have in some cases been obtained by the use of alternating current transformers, the condenser being connected across the secondary of the transformer. Soon after the introduction of this method, it was found advantageous to use a condenser of definite capacity, as a greater or smaller capacity did not give as good results. The value of this capacity was found to lie in the neighbourhood of that required to produce resonance.

Such an arrangement of transformers with condensers in the secondary circuit adjusted for resonance is in use at the large wireless telegraph station at Nauen, near Berlin, the transformers being of the open magnetic circuit type.

The theory of this method of obtaining oscillations does not appear to be quite clearly understood, as it seems to be tacitly assumed that the best results can only be obtained by adjustments in the secondary circuit. It may, on the other hand, be shown that equally good results are obtainable by adjustments of the primary self-inductance, and by the use of transformers of the closed magnetic circuit type having reactance coils in their primary and secondary circuits. The general arrangement of a resonance transformer is shown in Fig. 1, in which T is the transformer, 1 and 2 being its primary and secondary windings respectively, S_1 and S_2 the additional self-inductances in the two circuits, A and B the supply mains, and C the condenser; L_3 being the primary of the oscillation transformer.

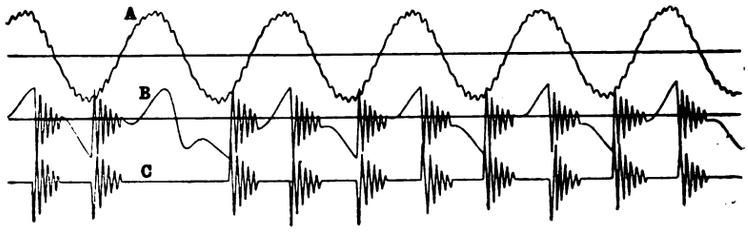

FIG. 2.—OSCILLOGRAM OF ARC.

Too much stress has been laid on the desirability of obtaining exact resonance, as if the object were in all cases an increase in the secondary voltage; whereas the main interest of such an arrangement—so far as wireless telegraphy is concerned—lies in the variable state of oscillation which occurs when the natural period of vibration of the system more or less closely approaches the period of the supply circuit, without necessarily being exactly equal to it.

The problem has been investigated by the author in two ways. First, by an analytical method; and secondly, by means of oscillograms. The latter fully bear out the conclusions arrived at by the first method.

The nature of some of the various discharges obtainable is illustrated in the following series of oscillograms.

In Fig. 2 are shown three curves, the first of which, A, represents the wave of primary P.D. The second, B, represents the P.D. across the condenser terminals; and the third, C, the discharge current. The discharge or oscillation circuit contains an additional self-inductance. We have in this case a single discharge during each alternation of the primary P.D. Such discharges are obtained when the natural period of vibration of the secondary circuit is considerable and when the disruptive P.D. across the discharge electrodes is in the neighbourhood of the maximum of the P.D. wave which would be produced across the condenser terminals if the discharges were suppressed.

Several discharges per alternation may be obtained if the disruptive P.D. is considerably below the maximum of the secondary P.D. wave, and if the natural period of oscillation of the secondary circuit is short in comparison with the period of the supply circuit.

The interval between two consecutive discharges may be controlled by adjusting the natural frequency of oscillation so that it is in the neighbourhood of the frequency of the supply circuit, and the effect desired may be obtained either by resonance or by the production of beats. An analytical investigation of this case shows that the resultant waves of P.D. and current are obtained by superposing on the normal steady waves which occur when the discharges are suppressed (by sufficiently separating the discharge electrodes), two damped disturbances, one of which is of a periodic character, and is of great importance, while the other is non-periodic and is generally negligible. The result of this superposition is a wave of condenser P.D. of varying amplitude. In Fig. 3 are shown waves exhibiting such beats. A is the wave of primary

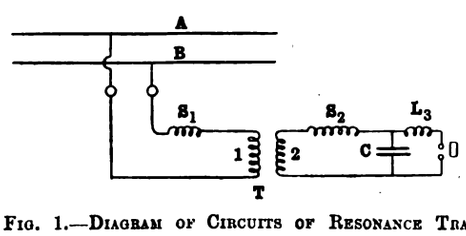

FIG. 1.—DIAGRAM OF CIRCUITS OF RESONANCE TRANSFORMER IN THE GENERAL CASE, ASSUMING THE PRIMARY CURRENT TO BE SUPPLIED BY MAINS A AND B.

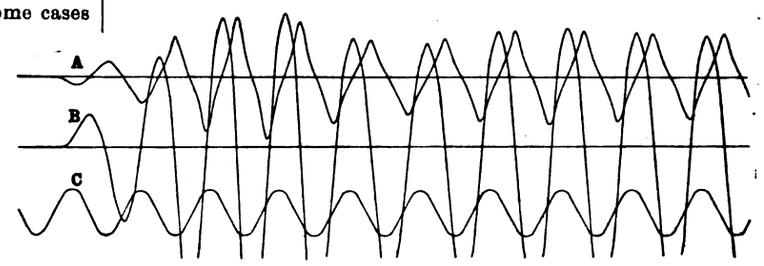

FIG. 3.—OSCILLOGRAMS. A is secondary pressure, B the pressure at condenser terminals, and C the pressure of the mains.

* Abstracted from *L'Éclairage Électrique*.

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current during the variable period immediately after the switch has been closed and before a steady state has been reached, B is the corresponding wave of condenser P.D., while C is the primary P.D. wave. The curves refer to the case of an additional self-inductance in the secondary only, this self-inductance being less than that required to produce complete resonance. The discharge electrodes were separated so far that no disruptive discharges of the condenser could take place. The beats, or alternate increase and decrease of amplitude in the waves A and B, are here well marked. If now the discharge electrodes be brought nearer each other until disruptive discharges begin to take place, we obtain the curves shown in Fig. 4. It will be seen that after each disruptive discharge the amplitude of the P.D. wave across the condenser progressively increases until the instantaneous P.D. becomes high enough to bring about a disruptive discharge. In this way the disruptive discharge may be adjusted to take place once in every few periods instead of taking place twice during each period, as in Fig. 2, where the conditions are far removed from resonance. Effects similar to those shown in Fig. 4 may be obtained by introducing self-inductance into the primary alone.

It will now be seen how, by working in the neighbourhood of resonance, and by choosing a suitable value for the disruptive P.D., it is possible to prevent a disruptive discharge from taking place during each half-wave, the excessive heating of the discharge electrodes, which gives rise to a singing arc, being thereby avoided.

The design of a suitable resonance transformer for producing the effects considered is a matter of great complexity, which requires

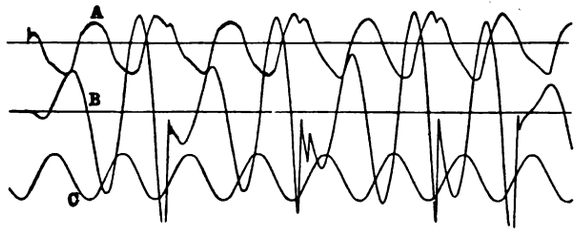

FIG. 4.—OSCILLOGRAMS. A is the primary current, B pressure at the condenser, and C pressure of mains.

due consideration of the damping effects produced by the resistances and by the iron losses. The superiority of the open magnetic circuit transformer for this purpose has by no means been established; but in any case the additional choking coils should have an open magnetic circuit. A good combination is obtained by employing an ordinary transformer having choking coils of the open magnetic circuit type in its secondary.

TARIFF COMMISSION.

In what follows we give the evidence of Mr. W. L. Madgen, managing director of the Brush Electrical Engineering Co. (Ltd.), before the Tariff Commission. Hitherto the electrical industry has not received much attention at the hands of the Commission:—

The Brush Company employs about 2,000 hands and is primarily concerned with the manufacture of electrical machinery, but it has established auxiliary departments for stationary and locomotive steam engines, and railway and tramway rolling stock. By establishing these subsidiary departments we can turn out a complete electrical tramcar, or supply an electrical tramway or railway, laid down and equipped complete.

I wish to draw attention to certain aspects of the electrical manufacturing industry in this country of which political controversialists, the Press, and the general public appear to be ignorant. The points which I should like to make prominent are, firstly, the very serious effect of past and mistaken legislation in retarding the establishment and development of electrical manufactures in England; and, secondly, the extraordinary proportion of the electrical machinery and apparatus in this country which has been manufactured abroad, but which bears the names of companies registered in England, and is, therefore, necessarily supposed to be the product of British labour.

It is now admitted that early electrical legislation in this country was misguided. Parliament itself admitted as much when, in 1888, it repealed the purchase clauses of the Electric Lighting Act of 1882, which, by its harsh restrictions upon private enterprise, had made electric supply business commercially impossible in the intervening period. The Tramway Act of 1870, which, of course, did not contemplate electric traction, was crudely applied to the new conditions, and operated in the same way to discourage the conversion of horse tramways. The demand for electrical machinery in these early years was, therefore, restricted, so that British firms had small encouragement to establish works for its manufacture. When some years later the demand did arise, it was impossible for the experience and the trade to be suddenly created, and consequently foreign makers easily secured a firm footing in the British market and in the unprotected markets abroad. Great factories had been established in the United States, Germany and elsewhere before the British firms began to overcome the preliminary legislative difficulties. The consequence is that to this day the British manufacturer is engaged in an uphill struggle with the competition of these older and more powerful foreign firms, which, when it suits the exigencies of the moment, can dump their goods into England at prices unapproachable by British firms. A British manufacturer rarely tenders for any important contract without expecting to find that American and German companies have offered a lower price, apparently based on the cost of labour and material with a contribution towards reducing the incidence of their administration and general charges upon the cost of production for their protected home market. It was the opinion of such an eminent authority as the late Sir Frederick Bramwell that this unfortunate error of the Legislature, which so effectually discouraged electrical manufacture during that vitally important initiatory period, had for ever lost to England any hope of establishing effective competition with foreign countries. That this blunder of Parliament was a main cause of England's backwardness in the manufacture of electrical machinery is further evidenced by the flourishing condition of British makers of electric cables, who are certainly second to no American or Continental rivals. In their case the business was founded for the purpose of submarine telegraphy in the first place, and the manufacturers had the good fortune not to cross the path of a Legislature overzealous for the cause of public ownership of undeveloped industries. I claim on behalf of the British electrical manufacturer that Parliament owes a debt to the trade, and that it should make reparation for the injustice of which it was guilty in the critical decade when rival commercial nations were eagerly catering for the immediate and future electrical requirements of the world. Parliament should now provide that the British electrical manufacturer should have at least a few years' breathing space during which he may make up for the loss of those invaluable early years. Ever since, foreign competition has been hitting him while he is down, and unless he is granted an opportunity of gaining a foothold by the temporary restriction of free importation, it is difficult to foresee much improvement in the present position. It is useful to recall that the political economists upon whose theories the free trade policy was based acknowledged the expediency in certain cases, as, for example, in newly-developed Colonies, of temporary protection, recognising that otherwise the establishment of manufactures was scarcely possible. Great Britain is practically in this position in regard to the electrical industry, and the past action of the Government, which prevented it from starting level with foreign competition, entitles it now to some consideration.

The other peculiar feature of the electrical manufacturing trades which is calculated to mislead the public as to the comparative strength of Great Britain in this department of industry, is the extent to which business is carried on from branch offices of foreign firms, which are given titles apparently describing them as British undertakings. American and German manufacturers have opened branch offices under titles which appear to rank them amongst home industries. In its report for the last complete year of working one of these undertakings disclosed that goods to the value of £1,200,000 had been imported from its foreign works and sold in Great Britain during the twelve months. The leading German firm trading under an English title advertises that amongst its customers are numbered over 50 British municipalities.

Not only in electrical machinery itself, but in other requirements of electric traction and supply undertakings, the home trade has necessarily been labouring under serious difficulties. When, for example, electric tramways began to be constructed on a large scale in this country, some years after they had become the common means of urban transport abroad, British firms were naturally at a great disadvantage, having had no experience in manufacturing. The cars themselves, owing to their unwieldiness, could not so conveniently be imported, but the trucks, motors, controllers, trolley wire standards, and other necessaries, were supplied from the Continent and America, and as their early experience was associated with foreign goods, British users have been slow to overcome their prejudice against home products in these lines. When the company decided to form a department for the manufacture of trucks, the staff met with the greatest difficulty in persuading tramway managers to order these articles in preference to the American makes to which they had become accustomed, and which had gained their confidence. The Brighton Corporation were to order trucks for their tramcars (that is, the underframe part), and they had specified a type of American-made trucks. We make trucks of that type; we will call it the "Jones" type. We are not Jones & Co., but we make the "Jones" type of truck. The American price was somewhat higher than ours in this case. We went to the Town Council and represented that our trucks were British throughout and were of that type, but they said, in effect, "No, we want the foreign make." So we got together a meeting of the workmen in our truck department and asked them to elect their own chairman and to consider the facts. They drew up a letter (a very good letter it was) which they sent to the town clerk of Brighton, remonstrating against the order going abroad. But the order did go abroad. That was the first case that I know of where an employer got his workmen together in a common cause of this kind, and they certainly came to the scratch very well. It is, of course, in ignorance of such facts that the daily newspapers pose as mentors of the British manufacturer when the news is published of important contracts going abroad. It would be better for the Press to recognise, with a good grace, that under the present free import conditions the British manufacturer cannot possibly compete successfully on every occasion with foreign firms whose home market is preserved. The normal posture of the British manufacturer is one of desperate defence of the home trade; that of the foreign manufacturer, free from any anxiety so far as

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his own territory is concerned, is one of vigorous attack upon the British and other neutral markets. The foreign manufacturer has nothing to lose in such a contest. It will pay him to export goods on the well-known costs formula for a dumping market, but for a British manufacturer any policy of the kind would spell early ruin. It is not any want of intelligence, enterprise, or industry that handicaps him; it is the crushing economic force behind his competitors, who, with a large home market absolutely secured to them, can direct all their energies to the invasion of Great Britain and the unprotected areas abroad. If there is any validity in the military analogy so frequently used by the Press in referring to "commercial warfare," how can it be pretended that one of the combatants—whose territory is always open to the occupation of a multitude of enemies, and who has no opportunity whatever of counter attack—is lacking in skill and resourcefulness because he is occasionally defeated by the superior forces of his numerous opponents. A fierce critical note appeared in a London paper recently touching the order of £100,000 worth of steel cars from America for one of the tube railways. It was made out to be a pitiable instance of the sluggishness of the British manufacturers that there was no factory in the country capable of securing this contract. Considering that there had been no previous demand in England for such articles, it is difficult to understand what theory of business method could have justified any English firm in equipping a factory on the chance that some day or other such a contract would be obtainable. The manufacturer who has two markets open to him should always be able to overcome the manufacturer who has only one, and that one quite unprotected.

I have frequent business relations with American and Continental merchants and manufacturers and their officials, and I have hitherto fail to perceive their alleged superiority so much advertised by the British Press. On the contrary, I consider that the highest standard of commercial ability is to be found in the British manufacturing centres, London, Glasgow, Belfast, Lancashire, Yorkshire, Tyneside, and the Midlands. The British manufacturer has a grasp of his work, is strenuous in dealing with it, and is usually a more robust type than his rivals. In general he is more of a sportsman than a money-grubber in his business, and submits in silence to much unmerited abuse from University professors on the one hand and the halfpenny Press on the other. The mere fact that without the great economic advantages possessed by foreign protected manufactures British industry has maintained a position of such eminence is sufficient disproof of the absurd denunciations of the popular Press. Foreign countries have only such advantages in respect of processes of manufacture as have accrued through greater experience and larger markets.

The rents are probably about the same in this country as abroad; the salaries are higher in America and lower on the Continent. As compared with London our rates are lighter at Loughborough. If we went to a thoroughly rural place we would not be so hard hit by rates for a long time to come, but we should then have that other difficulty, the housing for the workmen.

Any reasonable preferential arrangement with the colonies would be very beneficial indeed. We export to the colonies, and have recently secured our first order for Canada, owing to the preferential tariff. They discriminate in our favour to the extent of 10 per cent., and by reason of that 10 per cent. we were just able to secure the contract for the rolling-stock for an inter-urban line.

If we had a moderate duty, capital would be attracted into the electrical business. It should be a very great British industry.

Our firm alone employs some 2,000 men, and that means a living for some 5,000 people. With a reasonable protection we could easily double that. In fairness to ourselves and to the rest of the community a duty of somewhere between 5 and 10 per cent. would be reasonable. It has been a terribly uphill task, and many other firms have gone down by the way. The failures have been numerous, but not for the want of hard endeavour. The duties would not raise prices appreciably. Internal competition would be against that. I have heard often that the result of protected trades is combinations, but these combinations never seem to last. The duties would unmask those houses that adopt British names. There is a certain sentiment, which is not always shared by corporate bodies, I am sorry to say, that actuates our fellow countrymen towards home-made stuff, and it must be in order to get round that that these firms pose under British names.

CORRESPONDENCE.

ILLUMINATION OF SIDE STREETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with your leading article on the above subject, the figures given below may possibly be of interest. The electric light tests were made in College-place, N.W., a typical "side street," in which the St. Pancras Electricity Department have erected a number of different lamps with a view to comparing their relative merits under working conditions. The incandescent gas lamps were tested in a neighbouring street (Camden-street, N.W.).

The measurements were made along the curb with a Trotter "Universal" photometer, the screen being kept horizontal throughout. In an article which I recently contributed to one of your contemporaries I gave my reasons for considering that the average illumination in candle-feet per yard length of street afforded a true criterion of the value of street lighting. Whether, however, my contention be justifiable or not, the above figures are strictly comparable, being taken under precisely similar conditions. The height of post was in each case 10 ft. 4 in. and the lamps were placed along the curb.

Type of lamp.	Watts per post.	Cubic ft. per hour per post.	Mean candle-ft. to 20 yds.	Relative cost of gas and current (at 1½d. per unit, or 2/2 per 1,000 cub. ft.).
Tantalum lamp in Reason-Harrison fitting	81·5	..	0·085	1·0
Osram lamp in Reason fitting	105 0	..	0·098	1·2
Bastian mercury vapour lamp	132·9	..	0·083	1·55
Tantalum in Loftus lantern	81·5	..	0·05	1·8
Low-pressure gas burner	..	4·25	0·04	2·1
Nernst lamp in Holophane globe	110·0	..	0·05	2·5

One point which these figures bring out is the importance of reflectors, and in this respect gas is specially handicapped owing to the impossibility of keeping reflectors of any description clean and untarnished.

If only station engineers could be persuaded to make a few simple illumination tests in their own districts, so as to have authentic figures to lay before the lighting authorities, instead of mere estimated candle-power, their task would be a very much easier one. So long as it is simply a question of juggling with candle powers the gas "expert" is *facile princeps*.—I am, &c.,

KENELM EDGCUMBE.

87, Victoria-street, S.W., July 30.

DOUBLE-CIRCUIT SINGLE-PHASE MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorry to see that "Abstractor of the Article" thinks it necessary to abuse me because I happen to differ from Mr. Osnos; I think that "Abstractor" will find it more profitable to consider his technical remarks more carefully instead.

If Mr. Osnos does not wish to be misunderstood, he ought to define the meaning of all his symbols. I made an honest attempt to understand his article, but evidently failed, and am, therefore, very much obliged to the "Abstractor" for explaining to me that v_1N_1 is *not* the flux of mutual induction, as I took it to be, but is a *hypothetical* flux. This explanation throws a vivid light on Mr. Osnos' theory; since the resultant torque T of his motor depends on v_1N_1 (*see* formula (1) p. 515), and since that flux is *hypothetical*, it follows that his resultant torque is also *hypothetical!* I trust it is better than that. Perhaps "Abstractor" will consider this point. If he does, I hope he will take the opportunity of saying what N_2 stands for.—I am, &c.,

VAL. A. FYNN.

Basel, July 27.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps you will kindly allow me to offer the following remarks on Mr. Fynn's letter.

Any actually existing physical quantity T may, for purposes of mathematical treatment, be regarded as made up of any number of hypothetical components T_1, T_2, T_3, &c., so that we may always write $T = T_1 + T_2 + T_3$. The components T_1, T_2, T_3 may have any values whatsoever, and are only subject to the condition that their sum be equal to the actually existing quantity T. In a special case the decomposition of T into its hypothetical components may happen to be effected in such a manner as to make $T_2 = -T_3$, and hence $T = T_1$. Thus the provisionally hypothetical quantity T_1 may obviously turn out to be, on closer investigation, equal to the real or actually existing quantity T. All this is very elementary and obvious, but it does not appear to be so to Mr. Fynn, who, with a note of triumph, exclaims that if T_1 be hypothetical, it cannot possibly be equal to the real torque T!

The symbol N_2 stands for the hypothetical flux due to the short-circuit current which passes between the brushes *a*—*i.e.*,

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N_2 denotes the flux which would be produced by i_2z_2 if the stator ampere-turns i_1z_1, were suppressed,

The method of *hypothetical fluxes* employed by Mr. Osnos in his investigation needs no defence at my hands; it has been so largely used by many well-known writers that I can only express surprise at Mr. Fynn's apparent ignorance of it.

Lastly, I fail to see that my comments on Mr. Fynn's first letter contain anything which might be described as "abuse."

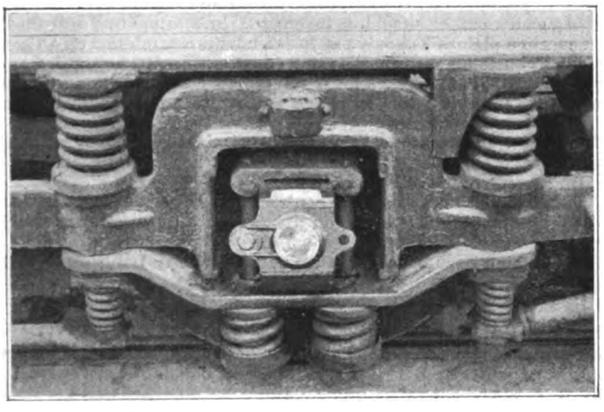
—I am, &c., ABSTRACTOR OF THE ARTICLE.

[This correspondence is now closed.—ED. *E.*]

NEW STEERING CONTROL FOR TRAMCARS.

A system of steering control, which embodies a new principle in the connection of wheels and axles to bi rail trucks or vehicles, has been invented by Mr. J. S. Warner, who claims to have demonstrated that in order to avoid excessive flange friction and excessive wear of wheel and rail treads, the planes of the wheels must be slightly changed continuously, or, in other words, any two axles should never be parallel to each other except for an instant occasionally.

The radial action of a car equipped with this steering control is stated to be more perfect than with any other known device, although the actual set of the wheels on curves is dependent, not only on the curvature, but on the weight, speed, wheel-base, length and height of the car. So delicate is the suspension of a car that when standing still the whole vehicle may be swayed horizontally with an amplitude of 3 in. or 4 in. with one hand. The Warner



GEAR CONNECTING AXLE BOXES TO MAIN FRAME.

Engineering Co. claim that the car-body runs with a minimum of shock and vibration in an almost mathematically straight line. It is said to be impossible for the wheels, which are continually steered round the inequalities in the track (thus giving a maximum of rolling with a minimum of skidding), to communicate the slight track deviations to the car-body.

A rigid four-wheel truck, with the gauge clearance necessary in practice, however equal the wheels or dead parallel the axles may be, will generally set on the track so that in a few yards it has run hard against the flanges to one side, and when the flange pressure has reached a certain maximum, or when a slight kink in the track is encountered, the front wheels of the car are skidded right over to the other side, and in a very short distance the reverse sway occurs. This action of parallel axles or rigid trucks can be easily observed by glancing along the side of most single truck tram cars, and gives rise to corrugation.

The figure shows the gear for connecting the axle boxes to the main frame of the car. The links shown on either side of the axle boxes swing at an angle to the main frame, passing through radial slots in the yoke bridge, which is the bar passing under the axle boxes, and connect to knuckle joints concealed inside the journal box springs. The pins passing through the lower ends of these links are set radially to the king pin in the centre of the car. In order to produce a movement which is the mechanical equivalent of this at the upper end of the links, where the space does not permit of the pins being set radially to the king pin, pins parallel to the axle are employed, passing through a bridge piece which rocks transversely on the axle box, while at the same time the axle box itself tilts or rotates to and fro upon its journal. We are informed that a number of cars are being converted to this system, including some for the Metropolitan Electric Tramways (Ltd.).

DUST-PROOF TWIN CARBON ARC LAMPS.

The British Thomson-Houston Co. of Rugby have lately designed and placed on the market a twin carbon arc lamp, which is said to be especially suitable for outdoor use, or in foundries and such places where there are corrosive fumes. Fig. 1 shows an external and Fig. 2 an internal view of the lamp. The line resistance is of the external pattern and suitable for mounting in a pole base or on the wall. With this arrangement the lamp runs much cooler and allows the casing to fit closely and completely cover the working parts. The lamp is said to be suitable for single operation on high-voltage circuits, and in many cases is claimed to have an advantage over the two-in-series type, especially for shop and office lighting. It has two arcs in series within the enclosing globe and consumes about the same energy as the 5 ampere series multiple lamp. It gives a steady white light. The carbons are placed close together, and to the observer the effect is the same as if the light emanated from a single arc. The negative carbon holder is so arranged that no shadows are cast. 10 mm. carbons are used, and with 12 in. upper and 5 in. lower the lamp will burn approximately 100 hours. The series coil is wound with a patent enamelled copper wire, which is said not to be affected by heat or moisture.

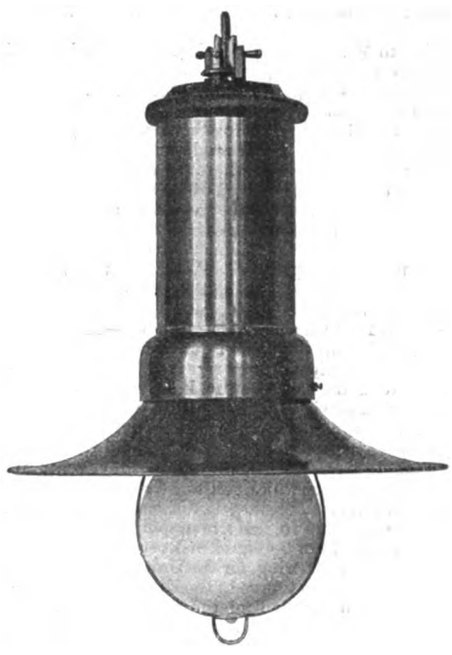


FIG. 1.

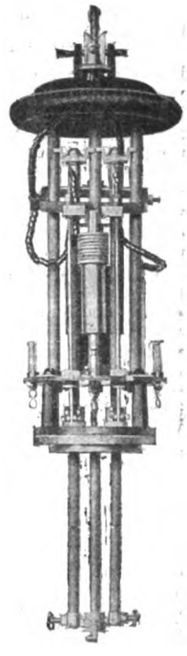


FIG. 2.

The lamp is designed to operate singly on from 200 to 250 volt direct-current circuits, and can be adjusted to take from 2·75 to 3·5 amperes. All the working parts are very accessible, and they can be easily removed for repair or replacement. The overall length is 24½ in , and the weight, including casing and reflector, 17 lb.

PARLIAMENTARY INTELLIGENCE.

RADIO-TELEGRAPHIC CONVENTION.

In the House of Commons on Tuesday, Sir E. SASSOON moved the adjournment of the House to call attention to the declared intention of His Majesty's Government to ratify the Radio-Telegraphic Convention of Berlin, 1906, without affording the House an opportunity of discussing the subject. He said the evidence given before the Select Committee revealed points of doubt which had hitherto been unsuspected. The Convention was bound to affect the commercial needs and strategic interests of this country, and the evidence left it doubtful whether the leap in the dark did not involve a risk offering no compensating advantage. If the Government were actually committed to ratification then the reference to the Committee was perfectly superfluous. It was said that if we adhered to the Convention, and it was desired that modifications should be made, Great Britain would have no more voice in the matter than Persia or Uruguay, countries which had no sort of connection with wireless telegraphy. It would be time enough to say that wireless telegraphy was comparable to telephones and cables when wireless services were in an acknowledged financial position, and when they had uniform rules of working, with due means of calculating charges. They were told that, if things went wrong, all they had to do was to retire from the Convention; but would it be pos-

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sible to revert to the present state of things when such a delicately-poised mechanism as the wireless installation was involved? So far as he had been able to gather, the members of the Committee of Defence had not had their minds collectively drawn to the bearing of the Convention.

Mr. S. GWYNN seconded the motion. He had regularly attended the sittings of the Committee and carefully considered the bearing of the Convention, and he was strongly opposed to ratification. He believed the one purpose of the Convention was to break up the Marconi Co. and to destroy the regulations with which the company had surrounded their organisation. It was suggested that the Convention would give freedom in that matter to the Navy, but it was evident that the same result could be got by the issue of licences to use wave-lengths other than those used by the Admiralty (viz., from 600 to 1,600). They were told that the object of the Convention was to avoid the interference which occurred at present. He maintained that the only true way of avoiding interference was to leave the matter to be dealt with by every receiving station and transmitting station. The Convention proposed a mechanical and inconvenient code of regulations which would stereotype interference. He protested against the unfair use made of the term "monopoly" in connection with the Marconi Co.'s endeavour to safeguard their interests. That company were the only people who could sell a particular article. In that sense only were they monopolists. But a monopoly like that was a most creditable one; it rested not on privilege, but upon efficiency. They were first in the field, and they had created their position with no help from the Government and no resources that were not equally open to everyone. To his mind the strongest objection to the Convention was the stereotyping of the wave-lengths.

Mr. HALDANE, replying to Mr. Gwynn, pointed out that Mr. Marconi, like other inventors, sold his rights to a powerful company, and it was with a company that controversy was at present maintained. That being so, he thought questions of sentiment were a trifle out of place. The real question was whether the Government, following out the policy of the previous Government and carrying it to completion, had done right in entering into an international Convention whereby each nation should put into its licences a clause compelling those who obtained those licences to accept messages from other systems. Surely it was more in the interests of humanity that there should be the utmost freedom of intercommunication than that there should be the restrictive system which existed at present. It was not a question of bureaucratic pressure. What was the situation in regard to those who made use of wireless telegraphy? Under the law of this, and he should think of every civilised, country the matter was regulated by the State. In 1903 various subjects in connection with wireless telegraphy were discussed at the Berlin Conference, and, among others, the subject of intercommunication was reserved for a future conference. The Post Office took the course of making provision for the possibility of this Convention being signed. They were then passing the Wireless Telegraph Act of 1904, which gave them control over the licences and at the same time they were negotiating with the Marconi Co. for the terms upon which they should carry on the business, and they eventually, in August, 1904, came to an agreement which contained a clause to which he invited the attention of the House, because it disposed once and for ever of the contention that the Marconi Co. had a monopoly which was now being unjustly taken away. Clause 10 of that agreement stated that, in the event of His Majesty's Government adhering, for the United Kingdom, to a convention, the company undertook to observe in the United Kingdom and on British ships the provisions of article 6 of the Convention and any detailed regulations made thereunder, and among the regulations was one by which the company undertook to accept the obligation of interchange and communication without assistance or reservation, but without prejudice to their patent rights. Those patent rights were not affected, the broad ground of the agreement being that, notwithstanding the Marconi Co. had made stipulations with other people, they bound themselves to give up their rights if the Post Office entered into such a Convention as was now entered into. That removed any contention as to hardship on the Marconi Co., and the Government were justified in making the agreement in the public advantage. The Convention was confined to communication between shore and ship, not between ship and ship, or between land station and land station. That class of communication was untouched. The Admiralty were kept outside, for they did not wish their instruments to be hampered by the obligation to receive other messages. The true purpose of the Convention was to make sure that any ship, whatever the system, should be able to communicate with the shore she was approaching. The Admiralty, the Army, the Post Office, the Committee of Imperial Defence and Lloyds all approved the Convention. They had all the men of science on their side, with the exception of the distinguished gentleman (Dr. Fleming), who was the adviser of the Marconi Co., and Mr. Marconi himself. So far as he knew, with the exceptions he had mentioned, the whole body of science was with the Government.

Mr. GWYNN said there was no witness on the abstract question of science. The evidence of the scientific witnesses, except in the one case of Mr. Charles Bright, was for some company interested.

Mr. HALDANE said then he would not put it higher than that there was a considerable body of scientific opinion in favour of ratifying the Convention. The Canadian standard form of licence was exactly that for which the Government were contending. The Colonial Premiers also took, so far as he knew, exactly the view of the Imperial Government. The Government thought it expedient, in the interests not only of public convenience, not only of international amenities, but of business —and, for that matter, of humanity—that there should be the freest possible interchange of messages between ships and the stations they came near. The Convention left the control in their hands. All they were aiming at was to get other nations to agree on a system they might all adopt. The Admiralty were satisfied that that plan would be useful in case of war. The War Office was satisfied that there were great advantages in the system from a military point of view. The Post Office were satisfied, as was also the commercial world. The contrary view was only held by those who claimed for themselves some sort of monopoly right; but there was no question of monopoly right here; for he contended that the Marconi Company contracted themselves out of any such monopoly right. The Government had thought the matter out thoroughly, and had entered into the Convention because they believed it to be a good one. Unless, therefore, the House carried the motion now submitted, they proposed to proceed forthwith to ratify it.

The motion was, by leave, withdrawn.

ROYAL ASSENT.

The following Acts of Parliament received the Royal assent on July 26:—

Electric Lighting Orders Confirmation (Nos. 1, 2, 4 and 5), Portobello and Musselburgh Tramway (Levenhall Extension) Order Confirmation, Brighouse Corporation, London United Tramways, Great Northern and City Railway, Devonport Corporation, Central London Railway, King's Norton and Northfield U.D. Council, L. and N.W. Railway, Electric Supply Corpn.

LEGAL INTELLIGENCE.

De la Valette v. Riches & Co.

Before Mr. Justice Walton and a common jury the hearing was concluded on Tuesday of this case, in which plaintiffs claimed for balance of goods sold and delivered. This claim was admitted, and the case was heard on a counterclaim, on which damages were claimed for alleged breach of contract.

It was alleged that in March, 1905, it was orally agreed between plaintiff and Mr. G. T. Riches on behalf of defendants, that the latter should be the sole representatives of plaintiff in Great Britain and Ireland for the sale of plaintiff's patent magneto igniters and the parts of the same until plaintiff's patent should be taken over by a company; and that in the meantime plaintiffs should pay to defendants commission on all goods sold to any customers within the radius mentioned. It was urged that on Sept. 22, 1906, by a letter, plaintiff refused to continue the agency and to supply defendants with the patent igniters, although the patent had not been taken over by any company.

The defence in the counterclaim was that plaintiff did not make the agreement alleged, and that no period in which defendants should act as plaintiff's agents was mentioned.

Evidence as to the terms of the contract having been heard,

The jury found for defendants on the counterclaim and awarded £750 damages.

After hearing arguments on a point of law, his Lordship reserved judgment.

Electrical Ageing of Flour.—J. N. Alsop's Patent 14,006, 1903.

Mr. Justice Parker has concluded the hearing of the petition for the revocation of this patent. The facts were set out in our last issue.

Mr. A. J. WALTER, for petitioners, said it was admitted that the process did not increase the nutritive properties of flour, and contended that if a patent did not do one or more of the things claimed it was bad. Respondents had sought to amend by striking out the whole body of the specification dealing with the effect of the process in increasing the proteids, but the patent would never have been granted if it had been explained that it was for two inventions which could be separated, one for bleaching the flour with oxides of nitrogen and the other for increasing the proteids. The patentee did not say how the effect of bleaching was produced. There was no detail and there was nothing as to the voltage or the amperage of the current. The patentee stated as the fundamental basis of his process that he produced a gas which he did not know the composition of. The whole foundation of the letters patent that he obtained was that he had discovered a new means of producing proteids and diminishing the starchy compounds. It was to do that and incidentally to bleach that the letters patent were taken out. The patentee now desired to say that the process would be the same as that which he designed although it did not alter the chemical composition of the flour.

Mr. Justice PARKER, in giving judgment, said that if a patent was taken out for a result which could not be produced, the consideration failed, and if it was for a process producing two results, and only one was in fact produced, the consideration partially failed. On that ground the patent in this case was invalid. The gases produced by a disruptive discharge of electricity were, according to the evidence, NO, a trace of ammonia, and, if copper electrodes were used, a slight trace of ozone. The NO on contact with air was partially oxydised making NO_2, N_2O_4, N_2O_3, and if the air contained vapour a little nitric acid. If copper electrodes had been used there might be yet another oxide, NO_3. The trace of ammonia was so slight that it might be ignored, and the specification did not insist on copper electrodes. The gaseous medium, therefore, consisted, for practical purposes, of four oxides of nitrogen with a little nitric acid, the whole diluted in air. NO if used alone did not bleach flour. NO_2, N_2O_4 and N_2O_3 did, and nitric acid did, if not directly, at any rate by reason of the production of nitrogen peroxides when it came in contact with atmospheric air. They had this curious result, that the patentee claimed a process of bleaching by the use of five constituents diluted in air, four of which would bleach flour

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and were disclaimed, while the other had no bleaching effect. The gaseous medium was practically the same as that produced under Andrews' specification, and there was no subject matter for a patent in producing it electrically instead of chemically. It had been suggested that he should give leave to further amend the specification, but he thought no amendment which could be made would obviate the defects in the patent.

The petition was, therefore, granted, with costs.

R. N. Cunningham v. Marylebone Borough Council.

At Marylebone (London) County Court on Friday last plaintiff claimed £86 odd for work done and goods supplied. Two amounts had been paid into Court.

Mr. DRURY, for plaintiff, said that in 1905 the Council decided to change their voltage from 100 to 240, and one of the conditions of the change was that they had to make good to consumers all lamps, fittings, &c., rendered useless by the change. Plaintiff sought to recover £45 for a motor-generator which had become necessary by reason of the change of voltage and which he had purchased on defendants' order. The second item (one of £20) was in respect of new arc lamps which plaintiff, as a contractor to the Council, had supplied to an Edgware-road dealer on a Borough Council official's order, and the remainder of the claim was for balance of different accounts for work done for defendants.

PLAINTIFF said he did a large business in charging accumulators, and when the supply was changed to 240 volts his position would naturally be made worse, and it was for that reason that the generator was suggested and finally ordered by defendants. One of defendants' engineers gave plaintiff permission to order new arc lamps for the job he was doing for the Council at Edgware-road.

For the defence it was submitted that the generator was ordered to compensate plaintiff as consumer at Seymour-place for any inconvenience suffered in the change of system. As there was no current previously supplied to one of his addresses the Council would not have agreed to supply the generator there, inasmuch as it would have been plaintiff's place in starting the installation to have put in all fittings, &c., necessary for such installation. The Council's engineer denied having given plaintiff permission to order four arc lamps, but said that a payment had been made for the loan of lamps at the address in question.

His HONOUR awarded plaintiff £25 odd—£18 for the arc lamps, £2. 19s. 11d. in respect of balance from accounts and £5 for loss sustained at Seymour-place. He said he did not think plaintiff could recover for the generator, inasmuch as place seemed the essence of the contract between the parties. This verdict was irrespective of the sum paid into Court.

Hay v. Northern Counties Electricity Supply Co. (Ltd.)

At the West Hartlepool County Court on Friday, his Honour Judge O'Connor was engaged for seven hours in hearing this action for damages in respect of noise and vibration at plaintiff's house, alleged to have been caused by the machinery at defendants' power station situate behind plaintiff's premises.

Mr. MEYNELL, for plaintiff, said his client bought the house about 10 years ago for £180, and expended £192 on alterations and repairs. Plaintiff and his family occupied the house, and his wife carried on business as a general dealer in the shop on the ground floor. When the company erected their power house three years ago, they only put down one light engine, and though the noise was certainly a nuisance, it was not then so serious that plaintiff thought it necessary to take steps in the matter, but as the company's business extended they put down additional and heavier engines, and now the noise was simply intolerable, whilst plaintiff's premises were considerably damaged. As a consequence plaintiff had spent £28. 10s. in further repairs.

PLAINTIFF and a number of expert witnesses gave evidence as to the damage and also as to the noise and vibration.

Mr. TAYLOR, for the defence, pointed out that plaintiff lived within 30 or 40 yds of the railway on which trains were continually passing and close to a roadway in continual use for heavy traffic. The noise, therefore, that would be a discomfort to people living in a peaceful village, he submitted, would be no discomfort to people living under the conditions surrounding plaintiff and other residents in the street where plaintiff dwelt. He suggested that any damage to plaintiff's premises was due to natural causes, such as weather, &c., and the alterations effected by plaintiff.

His HONOUR found that the damage to plaintiff's property was the result of the alterations which he himself had made in converting the premises into a shop. He, however, awarded plaintiff £10 for the annoyance which he had undoubtedly suffered from the noise and vibration.

A similar claim by another property owner in the vicinity was adjourned.

Re Sun Electrical Co. (Ltd.)—On Wednesday Mr. Justice Neville sanctioned a petition by the company for the reduction of the amount of its issued capital from £23,764 to £19,164. Henceforth the capital of the company will be £45,400.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Canada's Century: Progress and Resources of the Great Dominion." By R. J. Barrett, F.R.G.S. (London: "Financier & Bullionist.") 6s. nett.

"The Law of Trade Unions," by T. Seton Jevons, B.A. (London: Effingham Wilson), 2s. net.

ASSESSMENT OF ELECTRICITY WORKS.

The Hon. A. Lyttelton, K.C., M.P., commenced on the 18th ult. (as arbitrator) the hearing of an appeal of the Metropolitan Electric Supply Co. against their assessment in Paddington at £29,960 gross and £20,976 ratable, the former rate having been £9,000.

Mr. C. A. Cripps, K.C., and Mr. Walter Ryde (instructed by Messrs. Barlow, Barlow & Lyde) represented the company, and Mr. Horace Avory, K.C., and Mr. H. Fletcher Moulton (instructed by Mr. J. H. Hortix) appeared for the Assessment committee.

Mr. CRIPPS put in a valuation upon the 1906 accounts, showing a ratable value of £7,013, whereon Mr. Avory objected to the 1906 accounts being looked at as being subsequent to the Assessment committee's decision, and it was agreed on both sides to base the valuations on the 1905 accounts. In 1904 the company's Marylebone powers of supply were sold to Marylebone Council, but the company continued the supply under a working agreement until Aug. 6, 1905, when the Council began to gradually take over the consumers, and it was not until March 31, 1906, that the last Marylebone consumers passed over from the company's to the Council's supply. The committee valued the company's entire undertaking (including Marylebone) upon the 1905 accounts, but the company contend that in 1905, when the assessment was made, it was known that the hypothetical tenant would not be in enjoyment of the Marylebone receipts (which represented in 1905 more than one-third of the company's total receipts), and that the working expenses would, in consequence, bear a higher ratio to gross receipts in the future.

The general manager of the company (Mr. J. CONACHER) said of the company's total receipts (£266,950 in 1905) the amount received from Marylebone was £95,145, leaving £171,805 for the company's existing undertaking, and he estimated that the working expenses would be reduced from £77,051 to £61,296. He made the ratable value in Paddington upon the 1905 accounts thus adjusted £6,515.

Mr. ROBERT HAMMOND gave evidence and his repair and renewal funds worked out upon the 3 per cent. tables as follows: Tenants £8,334, landlords £42,006.

Mr. D. WATNEY gave his valuation of the buildings throughout the entire system at £407,364, and said that a proper allowance for repairs and renewals was ¾ per cent. thereon (£3,054), including sinking fund on expiring leases.

Mr. D. DINWIDDY put in a valuation for the entire undertaking of £33,000 ratable value. He adopted Mr. Conacher's estimates of receipts and expenses applicable to the reduced area of supply, allowing the engineers' estimates for repairs and renewals and a tenant's share at 10 per cent. upon gross receipts. His allocation to the borough of Paddington was: Electric services £3,934, trunk mains £1,922, Amberley-road works £1,192—ratable value, £7,048.

Mr. A. H. HOWARD (for respondents) said his valuation of the 10,000 volt mains in Paddington was £51,175, the cost having been £34,926, and of the 1,000 volt mains in Paddington at £18,717.

Mr. R. J. BEALE put the valuation of the buildings over the whole system at £222,211.

Mr. W. G. COOKE, who had advised the Assessment committee, put the ratable value at about £25,000. Messrs. William Eve & Sons' valuation amounted to £27,873 ratable. Messrs. R. J. Beale and J. G. W. Aldridge, C.E. (Messrs. Aldridge & Ranken), also gave evidence.

The case was concluded, and the Arbitrator reserved his award.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Applications are invited by Stepney (London) Council for the post of engineering draughtsman to assist the borough electrical engineer in the preparation of plans, specifications, &c., in connection with the erection of a riverside electricity station. Applications to the engineer and manager (Mr. W. C. P. Tapper), 27, Osborn-street, Whitechapel, E., by Aug. 10. See also an advertisement.

There are vacancies for two premium pupils at Bedford Corporation electricity works. Particulars from the borough electrical engineer (Mr. R. W. L. Philips, A.M.I.E.E.), Cauldwell-road, Bedford. See also an advertisement.

An electrical engineer, with experience in the design of d.c. generators, is wanted for a position in the engineering department of a large American manufacturing company. See an advertisement.

An electrical mechanician is required by the Uganda Protectorate Government. Two years' engagement, with possible extension. Salary £200 per year, with free quarters. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by Aug. 12. See advertisement.

Mr. W. E. Curnock, M.Sc. (Victoria), B.Eng. (Liverpool), has been appointed head of the department of mechanical engineering and building trades at the Battersea (London) Polytechnic. Mr. Curnock served his apprenticeship with the Liverpool Engineering Co., and has also had practical experience with Messrs. Siemens Bros. & Co. and other firms. He was formerly chief assistant in the engineering department of the Northampton Institute and for

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the past three years has held the position of head of the engineering department in the Technical College, Huddersfield.

Mr C. E. D. Greenhalgh, assistant station superintendent at Wakefield, has been appointed working assistant at the electricity works of the Malvern District Council.

Bexley Council have appointed Mr. Geo. Kent, of the Potteries Electric Traction Co., engineer's assistant at the electricity works.

Mr. W. F. G. Swann, B.Sc., has been appointed assistant lecturer and demonstrator in physics at Sheffield University.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

University of Birmingham.—The engineering courses in this university extend over four years, and students who enter after matriculation and who pass successfully the examinations at the end of each year will be entitled to the degree of B.Sc. in that branch of engineering to which they devote themselves. The technical engineering classes include lectures on the strength of materials, theory of steam, gas and other heat engines, hydraulics, machine design, strength of structures, distribution of power, drawing (including the design of tools), prime motors, dynamos and other forms of machinery. The courses in civil engineering include constructional work in masonry and steel, railway work, &c., with practical surveying in the field throughout the summer term. In the engineering laboratory the work will include the determination of the strength of materials, including compressive, bending, tensile and tortion tests, experimental study of the steam engine and boiler, frictional efficiency tests, the flow of water over wires and through orifices, &c. There will be lectures and demonstrations on all branches of electrical engineering, and the work in the electrical laboratory will include testing of continuous and alternating-current machinery, electrical instruments, meters, lamps, batteries, &c. The session 1907-8 commences on Oct. 1. Full particulars can be obtained from the Secretary.

University of Glasgow.—The new session commences on Oct. 17 and ends on March 16, 1908. The students usually spend the summer months in practical work, thus receiving their training on the "sandwich" system. Prospectuses of the courses for the degrees of B.Sc. and D.Sc. in engineering, mining and architecture and syllabuses of all classes, &c., can be obtained from the Assistant Clerk, matriculation offices, the University, Glasgow.

University of Manchester.—Copies of a prospectus containing particulars of the lecture, laboratory and drawing courses in engineering and the course in physics (including electrical engineering), mathematics and chemistry, qualifying for the degrees in engineering and the engineering certificates, can be obtained from the Registrar.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars as to fees, &c., can be obtained at the Institute, St. John's street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Aberdeen.—The city electrical engineer (Mr. J. Alex. Bell) recommends the Council to remove the copper strip and to lay new cables on the solid system on both sides of Union-street, at an estimated cost of about £9,000.

Amersham.—The Missenden & District Electric Light & Power Co. propose to apply for a provisional order for Great and Little Missenden, Lee, Chartridge, Chesham Bois and Coleshill.

Aston.—At the meeting of the Council on Wednesday the Electricity committee reported that they had received applications for electric current from a number of firms, including the Wolseley Sheep-Shearing Machine Co. and the Armorduct Co., who are building new works at Witton. They have also made arrangements with the Birmingham Tame and Rea District Drainage Board to supply the board with alternating current to work additional machinery. In order to give a supply in Witton and to meet the anticipated demands of the Drainage Board, two larger-sized h.t. cables are to be laid from the electricity works to Salford Bridge (in place of the existing ones) at a cost of £1,650.

Asylum Lighting.—Hull Asylum committee have referred to a sub-committee the proposal to put down an electric light and power installation at Willerby Asylum, at an estimated cost of £8,530.

Billingham.—The Council are considering a scheme for the electric lighting of Haverton Hill and Port Clarence, which are present lighted by oil lamps.

Brighton.—Last week the Tramways committee reported that, in view of the heavy charges which will have to be borne in respect of renewals in the near future, increased revenue must be provided in order to meet such charges.

The committee conclude that the requirements of the case necessitate a revision of the fares applicable throughout the undertaking, and submitted a scheme based upon a system of ½d. stages, with a minimum fare of 1d. The committee were advised by the manager that the revision of fares now proposed would result in an increase of revenue of about £2,500 per annum, and recommend that the scheme proposed should be put in force as soon as the necessary arrangements can be made.

This was agreed to, but a long discussion took place on the proposed new fares, and ultimately the matter was adjourned after an amendment by Ald. Carden had been carried.

Broadstairs.—There is a demand here for an extension of the electric street lighting. It is asserted that "visitors will not come below the electrically lighted area (in Albion-street), as they think that, being so badly lighted in the lower parts, they are the slums of Broadstairs." The Lighting committee is dealing with the matter.

Ceylon.—A technical college, established by the Government in 1893 and reorganised and largely extended in 1897, is the regular channel of admission of the Ceylonese into the service of the Government in the departments of civil engineering, electrical engineering, telegraphy, &c. In 1906 there were 104 students. New buildings, including extensive laboratories, have recently been erected.

The only public telephone exchanges in Ceylon are at Colombo, where there are two exchanges with a total of 188 subscribers. A new exchange has recently been erected at Fort, Colombo, at a cost of Rs.75,000.

City of London.—Last week the Corporation approved the following experiments being made in connection with the improved electric lighting of the streets:—

1. City of London Electric Lighting Co. to light Holborn Viaduct by flame arc lamps on standards; Farringdon-street, including Holborn Circus and the Old Bailey (part), by enclosed arc lamps; and Newgate-street by smaller lamps; the charges to be £17. 10s. each per annum for the flame arcs (instead of the existing charge of £26 per lamp), and for the smaller lamps £12. 10s. and £10. 10s. per annum each respectively.

2. The Charing Cross, West End and City Electricity Supply Co. to light Cannon-street (between Budge-row and St. Paul's-churchyard) by centrally-hung flame arc lamps at £17 10s. per lamp per annum.

All costs of installations, including standards, lamps and maintenance, are to be at the expense of the companies, the necessary works to be proceeded with as expeditiously as possible and the demonstrations to be continued until March next.

Croydon.—On the recommendation of the Lighting and Electricity committee an agreement has been entered into with the County of London Electric Supply Co. for the supply of electrical energy in bulk to the company on the terms follows: 3d. per unit for energy supplied for first two years, and 2½d. per unit for energy supplied after, subject to discounts.

Dublin.—The Corporation have decided to apply for a provisional order to extend the area of electricity supply to Cabra, Ashtown, &c.

Dundee.—The Tramways committee have authorised the immediate construction of the Downfield tramway extension, and tenders are to be invited for the construction of the permanent way and overhead equipment. The total estimated cost is £10,000.

Electric Lifts in Workhouses.—Edmonton Guardians have decided to provide electric lifts for the laundry at Edmonton House at a cost of £372.

Grimsby.—An unopposed inquiry was held on Thursday last into the Council's application for sanction to a further loan of £3,825 for electricity supply.

Hackney (London).—£2,009 is to be credited to the refuse destructor account, as the value of the heat supplied to the electricity works for the year ended March 31.

Ilford.—The electrical engineer (Mr. A. H. Shaw) has been authorised to substitute electric lamps for the existing 63 oil lamps in Grove-road, Chadwell Heath. Current is to be supplied by overhead wires, and the Board of Trade has been asked to sanction the scheme.

Inquest.—At Acton on Wednesday an inquest was held into the death of a switchboard attendant, named Lewis, who was engaged at the G.W. Railway generating station at Park Royal.

Evidence was given by witnesses who saw deceased going into a room at the rear of the building; shortly after a loud report was heard, and it was discovered that he had come into contact with some live wires.

The Coroner said it was a mystery, but it appeared that Lewis had fallen against the wires.

A verdict of accidental death was returned.

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Islington.—A special meeting of the Council was held on Tuesday to consider the interim report of the Special committee on the financial and technical position of the electricity undertaking.

The report sets out the scheme of street lighting extensions, &c., adopted by the late Council, which involved the substitution of 714 incandescent gas lamps by 245 arc lamps. The total estimated cost of the extensions was £21,011, of which £3,812 was stated to have already been sanctioned by L.C.C. as part of a similar scheme authorised by the late Vestry, but subsequently held over by the first Borough Council. The total amount to be borrowed was therefore, £17,200. The Lighting committee proposed to make no addition to the present charge of £15,734 for street arc lighting in respect of current to be supplied to the additional arc lamps to be erected, thus reducing the cost per unit for street lighting from 3½d. to 2½d., and of the cost per arc lamp per annum (inclusive of carbons and trimming) from £37. 14s. 11d. to £25. 19s. 5d. The cost of the 245 arc lamps and columns was estimated at £5,023, the interest and redemption charges on which (estimated at 7 per cent.) would amount to £351 per annum. These charges would be payable out of the general rate. The cost chargeable against the undertaking both for public and private lighting would therefore be £15,988, of which interest and redemption charges were estimated (on the basis of 4½ per cent.) to amount to £730. Having regard to the present rate of interest and the fact that the period of repayment of loans is no longer 42 years, the rate for interest and redemption would more probably be 6 per cent., so that the latter item would be increased to £960 per annum. 604,200 units of electricity would be required to supply the 245 additional arc lamps, the cost of which was estimated by the late borough treasurer (at ¾d. per unit) to amount to £1,888 per annum. Having regard to various economies which have recently been effected in the generation of electricity, the electrical engineer (Mr. A. Gay) was of opinion that this amount would be reduced to £1,660. The cost of carbons and maintenance chargeable to the general rate was estimated by Mr. Gay at £1,520. The total cost per annum would, therefore, be £4,491. The annual cost of the 714 gas lamps (proposed to be displaced) was £3,376 per annum.

The contracts entered into by the authority of the late Council in respect of the scheme amount to £14,574, and the value of the material actually received to May 11 was £7,443, leaving material yet to be delivered of the value of £7,131. The amount of wages already expended was £1,109. The amount, therefore, to which the Council was not yet committed was £5,328.

The committee state that they have arrived at the following conclusions:—

(*a*) That the scheme was ill-conceived, and, if carried out, would be detrimental to the interests of the borough;

(*b*) That the streets affected by the scheme are already well lit by incandescent gas;

(*c*) That the probable demand for current by private consumers in the thoroughfares in question is so small that the large outlay represented by the apportionment for private lighting is not justified; and

(*d*) That the adoption of the scheme would prevent the possibility in the future of any appreciable reduction in the lighting rate, which it is admitted has been excessive.

The committee are, therefore, of opinion that the scheme should not be further proceeded with. Although an immediate loss of £331 per annum and a further yearly charge would be incurred, the interests of the ratepayers would be better served by recognising such loss than by completing a scheme which would (they think) entail a permanent charge upon the undertaking without a corresponding relief to the general rate. They accordingly recommended:—

(*a*) That the scheme be abandoned so far as regards certain roads and that the resolution of the Council of March 2, 1906, authorising the committee to proceed with the scheme be altered or amended accordingly;

(*b*) That it be an instruction to the committee to remove the arc lamp column in certain named roads and to take into stock the unused material ordered or supplied; and

(*c*) That the Finance committee be instructed to make provision for the payment of the expenses resulting from the taking of the unused material purchased or contracted for into stock out of the general cash balance and to make no charge for the loss of bank interest against the electric light undertaking.

The recommendations caused a good deal of discussion, and though most of the members with experience in electrical matters, including Messrs. S. Lambert and H. B. Vorley (an ex-chairman and chairman respectively of the Lighting committee, and Ald. Mills), spoke strongly against the retrogade proposals of the committee, the report was ultimately adopted.

Italy.—The "Bulletin" of the French Chamber of Commerce at Milan notifies that a request for a concession for an electric railway from Brescia to Caffaro to cost £200,000 will shortly be submitted to the Council of Public Works.

Japan.—The construction of an electric tramway between Chofu and Shimonoseki, about 5 miles in length, is under consideration, as well as an electric tramway between Moji and Kokura in the same district.

In 1906 underground telegraph cables to the value of £2,834 were imported into Shimonoseki from the United Kingdom and Germany, and electric light apparatus from the United Kingdom and the United States to the value of £2,394.

Keady (Ireland).—The Council have consulted Mr. Meenan, of Dublin, in regard to a proposed electricity supply scheme.

Light Railways.—An inquiry was held on Friday into the application of the London United Tramways (1901) Ltd., for an extension of time for constructing the light railways from Twickenham Green to Sunbury, from Hounslow to Hanworth, Cranford, and to the Staines boundary. Evidence was given by the managing director (Sir J. Clifton Robinson) and others, and the Commissioners decided to reduce the time asked for from three to two years.

"Light in the Country."—Messrs. R. J. Nicholson, of Manchester, write:—

We should be glad if you would allow us to slightly amplify the notice you kindly gave us last week, and so remove an ambiguity which we fear might be conveyed to your readers. Although "Light in the Country" is written with the object of interesting the private householder, the booklet is distributed only through the medium of the electrical trade, to whom we supply copies gratis, printed in such a way that the benefit of all resulting business is secured to those contractors who avail themselves of our offer. In this direction we are doing no more than following the admirable example set by manufacturers of acetylene and other self-contained gas plants, whose enterprise in the distribution of high-class localised printed matter offers serious competition to the efforts of electrical contractors.

Llanelly.—On Monday the Council decided to purchase 50,000 units of electrical energy per annum from the Llanelly & District Electric Light & Traction Co. at a price named in an agreement between the Council and the South Wales Electrical Power Distribution Co, but without prejudice to certain rights of the Council.

London County Council.—On Tuesday loans of £14,000 to Hackney, £11,145 to Hammersmith and £5,000 to Poplar were granted for electric lighting purposes.

Proposed Tramway Extensions.—The Highways committee submitted proposals for new tramways for which it was suggested that application be made for Parliamentary sanction in 1908. Two of the lines proposed—viz, from West Norwood to the Crystal Palace and from Forest Hill to the Crystal Palace—are proposed to be constructed on the overhead system, The total capital cost involved is estimated approximately at £351,000. of which £229,000 represents cost of constructing and equipping the proposed tramways and £122,000 the gross cost of street widenings.—Adjourned.

L.C.C. Tramways.—The new electric tramway routes from Moorgate-street to Highbury and to King's Cross were opened for traffic on Monday.

Luton—The Council have sealed the agreement for leasing the tramways to J. G. White & Co.

Maidstone.—The Council have agreed to give a supply of electricity to the Tilbury Dredging Co. at their quarry in Postley Fields.

The light railway order to authorise the extension of the tramways to Loose & Tovil has been confirmed.

Mexico.—Mr. L. J. Jerome, H.M. Consul at Mexico City, draws attention to the demand in Mexico for electrical appliances such as electric lamps, incandescent or arc lights, high and low-tension cables, dynamos and motors, either steam or water driven, &c. Mr. Jerome says factories are largely using motors with direct connection, instead of overhead pulleys and belting for power transmission to machine tools, and adds that nearly all electrical appliances used in the Mexican Republic are American.

Mr. Jerome further states that the American-built passenger cars used on the street railways and electric tramways of Mexico City, although nearly all new, present a most dilapidated appearance; the flimsy material of which they are constructed, built to deceive the eye when new, rapidly takes on a shoddy and worn appearance when subjected to the extremes of damp and dryness, which alternate according to the season at the Mexican capital. The cars are hardly worth repairing after they have been run a few months. They suffer, moreover, from having nearly all the movable brass parts stolen at night when in the company's yards.

Middlesex Light Railways.—The chairman of the Middlesex Light Railways committee (Sir Francis Cory-Wright) on Wednesday opened the new tramway from Palmer's Green to Winchmore Hill.

Peterborough.—Some of the side streets are to be lighted electrically at the same cost as that of the present gas lighting. The electrical engineer (Capt. Gill) has been authorised to carry out the work.

Post Office Servants.—The Select Committee appointed last year to inquire into the wages and conditions of service, &c., of Post Office servants, has issued its report. Various recommendations are made, including the following:—

Male telegraphists in London should have a minimum wage of 22s. at 19 years of age and 26s. at 21. The maximum is 65s., and female telegraphists get more favourable terms with regard to earlier wages, on the ground that a considerable number leave comparatively early in their career to be married, and that, therefore, the minimum is more important to them than the maximum.

There are about 600 P.O. telephone operators in London, all females, and they begin at 17s. per week, at the end of nine years getting 26s. The Committee recommends that the minimum should remain as at present, but that the maximum should be 28s. per week.

In regard to male sorting clerks and telegraphists in the provinces, the Committee think there should be five classes of towns and districts, arranged according to cost of living, and that the minimum should range from 16s. to 18s. and the maximum from 40s. to 56s. A similar recommendation as regards classification is made in the case of the female

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sorting clerks and telegraphists, and in their case the minimum is 14s. or 15s. and the maximum from 28s. to 36s.

Portugal.—The "Diario do Governo" of July 19 contains a copy of a contract entered into by the Municipal Council of Povoação with M. P. Vieira for the lighting by electricity of that town and of the valley das Furnas. The "Diario" may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

Presentations.—Last week Mr. H. W. Ashton, switchboard attendant, of Harrogate, was presented with a marble clock on his marriage.

Mr. Walter Kidner, who has resigned his post as chief assistant to the Leatherhead and district electricity Co., to take up a similar appointment under the Horsham Council has been presented with a pair of framed photographs, tobacco pouch and pocket book by his late colleagues.

Provisional Order Revocation.—The Sevenoaks Electric Lighting Order of 1903 has been revoked by the Board of Trade.

Stretford.—An inquiry was held here on Tuesday into the application of the Council for sanction to borrow £53,460 for extensions of the electricity undertaking.

The clerk (Mr. G. Abrahams) said the undertaking had been successfully managed without incurring any charge on the rates. The opening of the Chorlton and Altrincham tramway routes had increased the demand for electricity, and the generating station had now practically reached its maximum capacity. The present application would meet their requirements for five or seven years, and the Council wished for permission to repay in a period of 25 years.

The Inspector (Mr. H. R. Hooper) said he would have to adjourn the inquiry to see the accounts, as £1,955 expenditure had been incurred above the amount sanctioned. The application should have been divided into two parts—one as to excess expenditure and the other to new works. It might also be necessary to separate tramway expenditure under the powers given by the Board of Trade from the suggested general expenditure. He asked that amended estimates and particulars should be supplied showing how the excess expenditure was to be dealt with.

Telephone Statistics.—During June the National Telephone Co. opened 31 new exchanges and added over 4,000 new telephone stations to its system. The entire system now contains 1,351 exchanges and 428,933 stations. The new Telephone Directory issued by the National Company is now published.

Turkey.—In the Salonica district public works which are about to be taken in hand include the construction of an electric power station near the quay, and it is anticipated that the local tramways will be converted from horse to electric traction and take energy from this station.

At Uskub, in the same district, the formation of a local company for the construction of a narrow gauge railway between Uskub, Kalkandelen and Gostivar is talked about and is urgently required, but nothing has yet been settled. If the railway is constructed it is to be worked electrically if the water power along the route is found to be adequate for the purpose.

Uruguay.—There are 272 km. of tramlines in Montevideo, of which 134 are owned by the Sociedad Comercial (the local appellation of a London company, the United Electric Tramways of Montevideo, Ltd.). This company completed last year the conversion of 85 km. of its route to electric traction and the remainder of the lines are under process of conversion. The remaining lines are owned by the German Transatlantica Co., who are also electrifying their lines as the finances of the company will allow. The remaining lines are owned by the Norte Co., who employ horses for haulage, and are said to not even contemplate the conversion of the line to electric traction.

At Fray Bentos, capital of the department of Rio Negro, some progress has been made in installing the electric light for public and private uses, the contract having been placed with a British firm.

Walthamstow.—Two gas lamps in Fleeming-road are to be converted to electric, and three new tantalum lamps are to be erected. Electric lamps are to be erected in six other roads.

Westminster Bridge.—The Thames Conservancy have approved the proposal of the L.C.C. to improve the lighting of Westminster Bridge by the substitution of electric lights for the present gas lamps, dispensing with gas lighting altogether. The lights are to be shaded on the river side with darkened glass.

Wolverhampton.—The Corporation are recommended to construct an extension of the tramways on the Lorain surface-contact system.

Woolwich.—At the meeting of the Council last week, the Electricity committee reported that the time was not yet opportune for adopting either of the alternative policies for the electricity undertaking suggested by the consulting engineer, Sir Alex. Kennedy.

The committee consider that ultimate progress would be on much safer lines by the exercise of caution and by awaiting the results of the present year's working under the more economical conditions they hope to secure. It is absolutely necessary, however, to increase the capacity of the steam plant at Woolwich to meet next winter's load, and they therefore propose to instal three new boilers and one induced-draught fan, and in order to avoid unnecessary delay they obtained quotations from Messrs. Davey, Paxman & Co. and the Sturtevant Engineering Co. for supply of the plant, and recommended that the tenders of these firms be accepted. The recommendations were adopted.

The acting electrical engineer submitted a report showing the alterations necessary to place the charge for street lighting on the maximum demand system, so that the works department is not charged at a higher rate than any other consumer. The revised charge is as follows: (*a*) When taking each circuit of lamps separately the cost for current only on the maximum demand system is £2,073, 5s. 11d., (*b*) when taken collectively the cost is £1,904. 15s. 1d., (*c*) when taken collectively on the flat system the cost is £3,583. 3s. 3d. The loss to the Electricity committee in revenue if the alteration is carried out under (*b*), which is the proper arrangement, in the electrical engineer's opinion, would be £1,678. 8s. 2d., reducing the average price from 3d. to 1·6d. per unit. He considers the works department should reimburse the actual ascertained cost of repairs and maintenance, which during the year amounted to £1,208. 9s. 11d., equivalent to approximately 1d. per unit, whereas it has always been estimated and charged at 0·5d. per unit. He also suggests the works committee should pay the cost of converting the side street posts already converted, and the interest and loan repayments on the cost of the Eltham and Plumstead arc mains and lamp services, instead of the estimated figure of 0·37d. per unit. The Council adopted these suggestions, and decided to apply for sanction to borrow £3,000 to cover anticipated expenditure as follows: £500 for meters, £1,750 for mains and £750 for house services.

Yardley.—The time for transferring the Yardley Provisional Order (1906) has been extended by two months.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Bristol.—The accounts of the Electricity department for the year ended March 25 were submitted to and adopted by the Corporation on Tuesday.

The total capital expended is £718,967. 14s. 7d., an increase of £47,351. 4s. on the year. The nett receipts from sale of current by meter for lighting were £45,045. 1s. 8d., and for power and heating £11,970. 18s.; sale of current by contract produced £18. 10s., rental of meters (£2,680) and motors (£576), making total receipts from private lighting and power £60,244. 19s. 11d. Public lighting, &c., made total of £72,439. 19s. 5d. Expenses were £31,353. 15s. 11d., leaving gross profit £41,086. 3s. 6d. Interest and dividend on stock absorbed £20,988. 4s. 8d., and instalment of principal and redemption and sinking fund accounts came to £15,908. 2s. 1d. £2,500 was placed to reserve for renewals (being difference between provision for renewal of assets on the basis recommended by Prof. Dicksee and amount of statutory repayment of loans), and after some small payments £8,657. 12s. 6d. was carried forward. 8,600,277 units of electric current were generated; 831,737 units were supplied to public lamps, 2,884 (estimated) were sold by contract, 5,367,151 were metered to private consumers for light and power and 216,374 were used by day-load consumers through controlling clocks and unregistered. The total maximum supply demanded was 5,378 kw. There are 3,000 consumers (against 2,827 in 1906), representing the equivalent of 365,552 30-watt lamps connected (against 302,846), including motors and heating apparatus of the equivalent of 5,805 H.P. connected. The load factor was 13·62 per cent., against 13·70. Works cost was 0·729d. per unit (including 0·321d. for coal), against 0·796d. in 1906, and the total cost was 1·093d., against 1·188d. The total revenue represented 2·629d. per unit, against 2·835d. in 1906.

In the report of the city electrical engineer (Mr. H. Faraday Proctor) it is stated that the third instalment of the Avonbank electricity works has been practically completed as regards building operations. The present extension, including foundations, building and plant equipment, will be completed at under one-fourth the cost of the earlier portion of the works. The mileage of mains laid has increased from 284 to 301. The number of lamps installed by private consumers increased by 16,993, or double the increase of the previous year; and there was a similar increase in the demand for power. Tests which have been made at the Temple Back works (continues Mr. Proctor) with "Osram" lamps show that (taking the current prices for electricity in Bristol) an Osram lamp giving 32 c.p. costs about 15 per cent. less per hour than an average 16 c.p. carbon filament lamp, including lamp renewals in either case. At present, Osram lamps must be suspended vertically, and are not manufactured of a lower candle-power than 32 for the ordinary pressure of supply, and the demand being much greater than the supply they are difficult to procure. Subject to these qualifications, the lamps have been found most satisfactory and their life on alternating-current supply systems is very good.

In moving the annual report and accounts the chariman of the Electrical committee (Ald. Pearson) referred to the great increase in the demand for current for light and power. 1906 was a bad year, but the increase during the past year was a good average one. It was very gratifying that while the output increased the cost had gradually decreased, and the possibilities of economies were by no means ended yet. Street lighting would be the next matter dealt with by them. They had recently decided upon starting a business branch for pushing the concern and establishing an office in a fairly central situation. They would have fine showrooms where various appliances could be seen both for lighting and power. The balance in hand was liable to a charge of £3,765. 1s. 2d. in the event of the failure of an appeal in respect of the wages of workmen. That amount represented money spent in labour in works absolutely

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proper to form the subject of a capital charge, but owing to the fact that the workmen, instead of being casual labourers, were men in the committee's permanent employ, the inspector (Mr. Ross Hooper) struck out the amount from the loan. There were several other points raised by Mr. Hooper to which the committee took exception, and in respect to these various questions, with one exception, the L.G. Board had granted the appeal of the committee. That meant that the wages of workmen in permanent employ were allowed up to March, 1906 (£2,079), and he had no doubt the balance to March, 1907, would, in due course, be allowed also. The point upon which the Board had not given way was in respect of an engine which had been put out of use, and in respect of which £1,400 was struck off their loan, as being estimated loss, by Mr. Hooper. But in regard to that machine the Board were prepared to reconsider the matter in the event of the committee deciding to re-erect the engine.

The report and accounts were adopted, and Ald. PEARSON moved that a supply of electrical energy be given at Avonmouth. He said that during the last 2½ years the committee had been in negotiation with the Docks committee with reference to the supply of electricity for lighting and power in connection with the new and existing dock, and they had now come to an arrangement to supply at a price which would not admit of a present profit to the Electrical committee, and might possibly involve them in a small loss until—as it was confidently anticipated—other customers were obtained at Avonmouth. The committee were advised that the best method of supply would be by means of extra high pressure three-phase current delivered from Bristol, and that the scheme could be carried out, including mains, plant and all other equipment (but not providing for purchase of land) for £3,800. The committee recommended that application be made to borrow this sum, and that they be authorised to enter into such contracts as might be necessary for carrying out the scheme. The Docks committee were prepared to take 500,000 units at 2d. a unit, which worked out at £4,100.

The resolution was carried unanimously.

Coventry.—The annual report and accounts of the electric light department were approved by the Council on Tuesday.

The chairman of the Electric Light committee (Ald. WEST) said that it was proposed to appropriate the profit as follows: £2,451 to capital account, £1,000 in relief of rates, and £1,663 placed to reserve. The works were producing generating current at 0·66d. per unit, and selling at an average price of 1½d., the production price being the lowest of all but three towns in the kingdom.

Manchester.—The report of the Tramways committee for the year ended March states that during the year the equivalent of over 10 miles of single track was opened for traffic, and through running arrangements were made with Oldham and Ashton-under-Lyne Corporations.

The aggregate length of single track open for traffic at the end of the year was over 169 miles. The traffic revenue amounted to £712,975 11s. 3d. (compared with £661,806 in 1905-6), and the total revenue was £719,672. 4s. 10d.; working expenses were £454,692. 13s. 7d. (against £433,560. 17s.) After adding £1,910. 12s. 7d. for bank interest, the total sum available was £266,891. 3s. 10d., against £232,097. 13s. 1d. After paying interest (£50,140. 12s. 8d.), sinking fund (£39,594. 8s. 7d)., tramway rental (£24,038. 14s. 5d.), &c., the balance £147,038. 19s. 7d.) has been appropriated as follows: £87,827. 3s. 5d. has been placed to reserve for renewals and depreciation, £55,000 was voted in aid of rates, and £4,211. 16s. 2d. for street improvements, &c. 143,264,501 passengers were carried (against 133,923,932), 15,523,459 car-miles were run (against 14,655,908), 25,072,791 units of electrical energy were used (against 22,164,445) or 1·61 units per car-mile (against 1·53d.), the average traffic revenue was 11·02d. per car-mile (against 10·84d.), and the average working expenses per car-mile (including power) were 7·03d. (against 7·10d.). The capital outlay during the year was £50,033. 3s. 10d., making a total of £1,725,844. 19s.

Marylebone (London).—The Electric Supply committee issued their report for the first complete year of municipal working on Tuesday.

The total capital expended to March 31 was £1,965,605, an increase of £134,005 on the year. The gross revenue for sale of current was £155,594, and the total revenue £158,459. Working expenses, management, &c., absorbed £49,818, and other expenses brought the total to £52,727. The cost per unit sold averaged 1·45d. (against 1·622d. estimated), made up as follows: Generation 0·77d., distribution 0·22d., management 0·30d., rent, rates, &c., 0·16d. The committee believe that during the current 12 months there will be a reduction in management expenses. The average price charged for current was 4·7d. per unit. The total sales showed a substantial advance, and steps are being taken to secure an increased power load. There was a net balance of £22,061 after payment of interest and providing £10,578 for redemption of loans and reduction of capital indebtedness. The committee recommend that the nett balance be placed to reserve.

The committee are to frame a tariff of charges so that the accounts will show a surplus at the end of the year as nearly as possible approximating the sum (£12,250) named by the Council's accountants (Messrs. Price, Waterhouse & Co.) as a proper provision for reserve.

Nelson.—The total net income of the electricity department for the year ended March 25 was £8,561. 3s., including £8,371. 15s. 3d. from the sale of current.

After paying expenses the gross profit was £4,834. 3s. 3d. Interest absorbed £1,964. 16s. 6d., and sinking fund £2,317, leaving a net profit of £552. 6s. 3d., compared with a loss of £332. 10s. 8d. on the previous year. 969,430 units were generated; 835,544 units were sold, including 236,778 for private lighting and 33,919 for power. 293,243 units were supplied to the tramways and 252,546 to light railways, while 19,058 were sold by contract. The equivalent of 26,695 8 c.p. lamps is connected, and there are motors of 188½ H.P. Capital expenditure is £72,153. 3s. 10d., an increase of £1,284. 11s. 11d. on the year.

The total revenue of the light railways was £7,342. 1s. 7d. Total expenses were £5,581. 1s. 10d. (6·60d. per car-mile), leaving a gross profit of £1,775. 10s. 2d., to meet interest (£1,071. 19s. 10d.) and sinking fund (£764. 15s. 7d.), so that there was a net deficit of £61. 5s. 2d. 2,035,300 passengers were carried and 203,203 car-miles run. 252,546 units of electricity were consumed (1·24 per car-mile). The total capital expended is £35,662. 5s. 7d., an increase of £1,570. 15s. 11d.

Swansea.—The accounts of the electricity department for the year ended March 31 show capital expenditure £136,994, an increase of £11,895.

Revenue for the year was £18,583 (against £16,097), including £18,095 (£15,796) from supply of current and £489 (£301) motor rent, &c. Total costs were £9,550 (£7,912), and gross profit was £9,033 (£8,185). Interest absorbed £4,950 (£4,865) and sinking fund £3,239 (£2,693), leaving a net profit of £741 (£339). 1,909,856 (1,715,372) units were sold, of which 703,992 (630,286) were for private lighting, 510,474 (405,016) for power and heating, 190,568 (187,928) for public lighting and 504,832 (492,142) for tramways. Works costs were 0·86d (0·83d.) per unit sold, and total costs 1·17d. (1·09). The maximum load was, for ordinary supply, 915 kw. (787 kw.), and for tramways 300 kw. (as in previous year), and the load factor was 17·9 (17·8) per cent. The connection to the mains are equivalent to 86,274 (75,946) 8 c.p. lamps.

Wallasey.—The accounts of the tramways department for the year ended March 31 show capital expenditure £138,917, increase of £1,331.

Income was £43,608. Gross profit was £16,293 (against £14,351). Interest required £5,157 (£5,276), sinking fund £2,337 (£2,325) and instalment of loan £297 (£286), and £3,000 (£4,000) has been placed to depreciation and reserve. After meeting capital charges, £3,340 (£2,100) has been devoted to the relief of rates and £1,952 (£413) carried forward. The total expenses were 8·67d. (8·90d.) per car-mile, and gross profit was 3·47d. (2·98d.). 7,995,451 (7,528,337) passengers were carried and 862,124 (819,216) car-miles run. The average receipts per car-mile were 11·76d. (11·66d.). The current consumed was 1,316,215 (1,272,206) or 1·52 (1·55) units per car-mile.

Wimbledon.—The accounts of the electricity supply department for the year ended March 31 show total nett capital expenditure of £168,317. 18s. 2d., an increase of £17,143. 11s. on the year.

The receipts from sale of current by meter was £18,230. 12s. 6d. The revenue from public lighting was £5,730. 1s. 6d., and after taking into account meter rental, &c., and allowing for bad debts, the total revenue was £24,230. 2s. 10d. Generation expenses were £6,860, cost of distribution £67. 19s., public lamp maintenance £730. 19s. 4d., rents, rates and taxes £726. 11s. 4d., management expenses £2,071, law and Parliamentary and special charges making up a total expenditure of £10,626. 17s. 7d., leaving a gross profit of £13,603. 5s. 3d. After deducting interest and sinking fund (£10,149. 15s. 1d.) and amount applied to general district rate (£1,330), the balance (£2,123. 10s. 2d.) was placed to suspense account. 2,084,434 units were generated, 1,152,696 were sold to private consumers, and 611,208 were supplied to public lamps. There are 2,289 consumers in Wimbledon and 262 in Merton, representing a total of 124,879 8 c.p. lamps connected. There are 62 arcs and 1,081 incandescent posts (equivalent to 5,588 8 c.p. lamps) for public lighting. The total maximum supply demanded was 1,311 kw.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Portsmouth Council invite tenders for supply, delivery and erection of one h.t. switchboard, and of steam, exhaust, circulating water and sundry other pipework. Tenders to the town clerk (Mr. Alexander Hellard), Town Hall, Portsmouth, by noon Aug. 14. See advertisement.

Portsmouth Tramways committee invite alternative tenders for periods of 6 or 12 months for the supply of best large smokeless Welsh steam coal for their power station. Tenders to the Town Clerk, Town Hall, Portsmouth, by noon Aug. 5.

Grimsby Corporation invite tenders for supply, delivery and erection of one 500 kw. continuous-current dynamo direct-coupled to a triple-expansion three-crank high-speed double-acting engine. Tenders to the borough electrical engineer, Mr. W. A. Vignoles, Corporation electricity works, Grimsby, by first post Monday, Aug. 19.

Barnes District Council invite tenders for two sets of mechanical stokers (for Babcock boilers) and feeder and distributor cables. Tenders to the clerk, Council House, High-street, Mortlake, by noon Monday, Aug. 12.

Dublin Lighting committee invite proposals for the supply of motors to their consumers on the hire-purchase system. Conditions, &c., from the Secretary of the Lighting committee, 3, Cork-hill, Dublin.

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Paddington (London) Guardians want tenders by 10 a.m. Aug. 12 for installation of electric fire alarms at the workhouse. Forms from the Clerk, 313-319, Harrow-road, London, W.

Kettering Council want tenders by August 28 for engine and dynamo (315 kw.), with pipe-work connections, and for extension switchboard panel.

Stockport Corporation want tenders by noon Aug. 9 for supply and fixing of 10 tramcar top-covers. Particulars from the Borough Surveyor.

Acton Council want tenders by noon Aug. 20 for wiring and fitting, under assisted wiring scheme. Specification, &c., from Mr. J. Martin Blair, 130, Churchfield-road, Acton.

Tenders will be received by the Deputy Postmaster-General, *Adelaide*, until noon Sept. 25, for supply of 700 yds. 104 pair-light lead-covered silk and cotton-insulated telephone cable, as per specification 146, and the following quantities of paper-insulated lead-covered 12½lb. conductors, as per specification 14: 7½ miles 208 pair, 3½ miles 156 pair, 4 miles 104 pair, 2½ miles 78 pair, 7 miles 52 pair, 2½ miles 26 pair. Tenderers must state the country in which the articles have been made or produced, and where the material has been made or produced, and tenders must be accompanied by a deposit or receipt for deposit of 5 per cent. Specifications can be seen, and forms of tender obtained, at the General Post Offices, Adelaide, Melbourne, Sydney, and Brisbane, and at the Commonwealth Office in London, 72, Victoria-street, S.W.

Tenders are invited for the lighting by gas, oil, electricity or other illuminant of the street, thoroughfares, &c., of the city of *Calcutta*. The city comprises approximately an area of 20 square miles, containing about 170 miles of main thoroughfares and 130 miles of smaller streets, besides several squares, markets, latrines, slaughter houses, &c., which are now lighted by gas and oil lamps. The new contract is timed to commence on May 1, 1911, and the successful tenderer will be required to have all arrangements completed and ready to begin and continue the lighting with effect from that date. Tenders should be for 10, 15 or 20 years. Further particulars are given in an advertisement, and tenders will be received by the Vice-Chairman of the Corporation up to 3 p.m. Jan. 2, 1908.

The "Madrid Gazette" of July 18 notifies an application by the Compañia Anonima de Tranvias de *Barcelona* for a concession for an electric tramway to connect with the tramway from Barcelona to San Andrés. One month from July 18 is allowed for the presentation at the Directorate-General of Public Works, Madrid, of other applications on terms more favourable to the Government.

The "Madrid Gazette" of July 25 contains a notice inviting tenders for the lighting by electricity alone or by electricity and gas of the city of *Alcoy*. Tenders by Aug. 18 to the Secretaría de la Alcaldía constitucional, Alcoy. Local representation is necessary. A deposit of 600 pesetas (about £21) is required to qualify tender.

The "Madrid Gazette" may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Walthamstow Council have accepted the following tenders for electric and tramway stores for the year ending March 31, 1909:—

W. T. Henley's Co., single, two and three-core cables, paper insulated, also Chatterton's compound, pure rubber tape, Blackley tape, fine solder, luting; Connolly Bros., three-core cables, rubber insulated, and P. & B. tape; Liverpool Electric Cable Co., single and two-core cables, rubber insulated, and indiarubber-covered wires (subject to cables being of Cable Makers' Association standard); Siemens Bros. & Co., white tape, waterproof tape, jointing and plumber's metal, resin; Johnson & Phillips, gum tape, P. & B. paint, soldering fluid, petroleum jelly, putty, lead sleeves, lead sealing ends; H. Tuchman, carbons for open arc lamps; A. G. Pestalozzi & Co., carbons for enclosed and flame arc lamps (subject to electrical engineer being satisfied with samples); Cryselco Ltd., Maxim Electric Co. and Sunbeam Lamp Co., incandescent lamps; British Thomson-Houston Co., incandescent traction lamps; Berry, Skinner & Co., tantalum lamps; H. G. Mayer & Co., Nernst lamps; General Electric Co., d.p. main switches and fuses, coupled tumbler switches, tumbler switches, distribution boards, back plate holders, dust shot, opal shades, casing and capping, enamel iron shades, steel conduit, saddles and staples, glass jars, trolley globes; Krupka & Jacoby, coupled tumbler switches, tumbler switches, distribution boards, lamp holders; British Westinghouse Co., tumbler switches, lamp-holder adapters, wall plugs, cutouts, single-pole and double-pole, and gear wheels, armature coils, commutators and lubricating oils, &c.; Armorduct Mfg. Co., china bridge fuses; Falk, Stadelmann & Co., ceiling roses, counterweight sets, wood blocks (recessed), 2½ in. casing and capping, 12 in. enamel iron shades, No. 1, glass jars, trembling bells, barrel pushes, salammoniac, phosphor bronze, twin bell wire, single bell wire, Sinclair insulators, shackle rings, chimney brackets; Edison & Swan Co., wall plugs, d.p. cutouts, rectangular wood blocks for 1, 2, 3 and 4 switches; Universal Electric Mfg. Co., house service fuse boxes; Sunbeam Lamp Co., opal shades, wood blocks (six switches), enamel iron shades, tin fuse wire, tinned copper ditto; Electrical Co., casing and capping; Ecco Battery & Electrical Co., zinc rods, porous pots; J. W. Rowlands & Co., pinion wheels, trolley heads; Estler Bros., brass terminals; Brecknell, Munro & Rogers, rubber cap, trolley booms, trolley cord; W. A. Tomkins, controller fingers; Consolidated Supply Co., upholsterer's twine; W. S. Fuller, castings; C. C. Wakefield & Co. and Silvertown Oil Co., lubricating oils, grease, &c.

On Tuesday London County Council adopted the adjourned recommendation of the Highways committee to accept the tender of Willans & Robinson (at £43,195) for manufacture and delivery of two sets of turbo-generators.

For wiring, fittings, &c., for the Central School of Arts and Crafts, Holborn, the London County Council received the following tenders:—

W. Barton & Sons (*accepted*)	£2,120	J. O. Grant & Taylor	£2,821
Barlow Bros. & Co.	3,466	F. Suter & Co.	2,767
D. Hulett & Co.	3,294	H. J. Galliers	2,714
W. G. Cannon & Sons	3,200	Beaven & Sons	2,700
F. A. Glover & Co.	3,150	Vaughan & Cook	2,525
S. G. Cozens	3,128	Pinching & Walton	2,497
Aberdeen Elec. Eng. Co.	2,918	C. C. Pudney	2,480
Cox-Walkers (Ltd.)	2,854	Mercer, Rance & Co.	2,025

Messrs. Mercer, Rance & Co. had asked to amend their tender.

The tender of Spencer & Co. has been accepted by the London County Council for coal and ash conveyors for the Greenwich generating station at £2,314 The New Conveyor Co. tendered at £2,548 and R. Dempster & Sons at £3,554.

Two tenders were received for oil tanks, filters, &c., for the Greenwich generating station, and that of Shelby & Co. at £423. 10s. 6d. was accepted by the London County Council on Tuesday. S. Russell & Sons also tendered at £654. 13s. Tenders from selected firms were obtained by the L.C.C. for the supply of heavy machine tools for the central car repair depot and the following four firms submitted tenders for all or some of the items required: Buck & Hickman, C. W. Burton, Griffiths & Co., Hobdell, Way & Co. and Ludwig Loewe & Co. In each case the lowest tender was that of Buck & Hickman and their tenders for (1) two motor-driven tyre-turning lathes and (2) two high-speed 8½ in. s.s. and s.c. lathes (at £2,288) were accepted. The offers made for the remaining items (two high-speed vertical type boring mills and one high-speed vertical milling machine) were not considered satisfactory, and the Highways committee were authorised to make special arrangements for obtaining them during the recess.

The tender of the General Electric Co. (at £375. 1s. 2d.) for wiring material for tramway sub-stations has also been accepted by the London County Council. The Edison & Swan Co tendered at £379. 7s. 1d.

Leyton Council have placed their annual contract for electricity meters with Venner & Co. The Council have also accepted the following tenders for tramway stores:—

General Electric Co., electrical accessories (including switches, bells, gongs), cable, mica, vulcanite fibre, &c.; H. G. Mayer & Co., incandescent lamps; Consolidated Accessories Co., trolley poles, P. and B. tape, asbestos sheet; Estler Bros., steel balls, race rings; Mountain & Gibson, horn blocks, axle boxes, sand hopper and life-guard castings, trolley standards and bases, rocking arms and caps, springs, radial truck controlling gear castings and springs, adjusting axle collars, axle box bearings, truck springs, brake brackets, axle box springs, &c.; Thornton & Crebbin, brake shoes; Malleable Steel Castings Co., motor and armature bearings, &c.; British Westinghouse Co., controller fingers, contacts, drum rings, handles, motor cutouts, automatic circuit-breakers, canopy switches, resistance boxes, carbon brush holders, pinion and gear wheels, mica cores, &c.; W. T. Henley's Telegraph Works Co., pure para strip; Wm. Wood & Co., bearing metal.

Leyton Council have also accepted the following tenders on schedules of prices:—

Consolidated Accessories Co. and Mountain & Gibson, glass; Consolidated Accessories Co., tinware, brushes, &c.; George Tyrie and Lamb & Pontifex, brushes; Lamb & Pontifex, Illingworth & Co., Wm. Wood & Co., Household Specialities Co. and A. B. Gross & Co., car-cleaning materials; Geo. Hatch, bolts, nuts and washers, screws, &c.; Pinchin, Johnson & Co., paints, varnishes, &c.; Theo. Phillips, Son & Co. and Palmer & Co., oils; Alex. Duckham & Co. and Palmer & Co., lubricating oils; Cornes & Co, transfers; Henry Matthews, timber.

Stepney (London) Council have received the following tenders for testing equipment:—

A. W. Penrose & Co. (*accepted*) £357 and	£362	Edison & Swan Co.	£455
General Electric Co	575	Electric Construction Co.	446
British Thomson-Houston Co.	542	Switchgear Co.	427
Kelvin & James White	539	W. White & Co.	423
Pooley & Austin	468	Johnson & Phillips	415
		Union Electric Co.	393

Stepney Council have accepted the tender of W. Badger for the annual supply of meter cases at £99. 5s. (There were four tenders, varying in amount from that of the accepted to £132. 5s. by Buck & Hickman.) The Council have also accepted the tender of the Reason Mfg. Co., for the annual supply of time switches at £183. Venner & Co. tendered at £294, Johnson & Phillips at £371.

Woolwich Council have accepted the tender of Davey, Paxman & Co. for three boilers for the electricity works at £1,855, and that of the Sturtevant Engineering Co. for an induced draught fan at £260.

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Woolwich (London) Council have placed an order with Callender's Co. for l.t. twin rubber-insulated lead-covered cable, with Siemens Bros. & Co. for three-core paper-insulated lead-sheathed cable, and with Doulton & Co. for stoneware ducts.

Wednesbury Council have accepted the following tenders: Phœnix Dynamo Co., balancer boosters and switch gear; Tudor Accumulator Co., storage battery; and H. Gough & Son, generating station buildings.

Southwark (London) Council have accepted the tender of the Haste Pump Co. for an electrically-driven boiler-feed pump at £245. There were 18 tenders (from 14 firms); the lowest was £195 and the highest £325.

Rochester Corporation have accepted the tender of Dick, Kerr & Co for constructing the permanent way of an extension of tramways at £33,568. 17s. 5d., and for the overhead equipment at £3,417. 18s.

Walthamstow Council have accepted the tender of the Westminster Electrical Engineering Co. at £74 for stripping and re-insulating one of the large armatures.

The Empire Roller Bearings Co. have received a further order for 380 axleboxes and spare parts for the Rio de Janeiro tramways, making over 600 axleboxes supplied to the Rio Janeiro company.

Fulham Electricity committee have accepted the tender of Wm. Edgar & Co., for the supply of 135 Nernst lamps and fittings at 35s. 6d. each.

Bath Council have accepted the tender of the National Telephone Co. for electric fire alarms and bells at £131 per annum for seven years.

Kensington (London) Guardians has placed an order with Rawlings Bros. for installing the electric light in the board-room at £48. 15s.

Bruce Peebles & Co, have received a repeat order from Paisley Corporation for a 750 kw. h.t. alternator.

Luton Council have accepted the tender of John Wilson & Co. for pipework, &c., at £647. 5s. 1d.

Blackpool Council have accepted the tender of Foster & Co. for a boiler at £447.

Dartford Council have placed an order with W. Lucy & Co. for cut-outs at £14. 2s

Colchester Education committee have accepted the tender of F. Peacock for wiring the East Ward schools at £108. 6s.

Bolton Tramways committee have accepted the tender of Hadfield's Steel Foundry Co. for tramway crossings.

Rugby Council have placed an order with W. T. Henley's Co. for service cable.

Storage Battery Contracts.—During the past fortnight the D.P. Battery Co. has secured contracts for the erection of storage batteries (over 1,300 cells of 1,270,000 watt-hours) at Fleetwood, Tadcaster, Ilford, Brechin, Montrose, and Alderly Edge, amongst other places. During the past month the company has, we are informed, completed power installations at Southampton Docks for electric cranes at Portsdown, Gosport and Pontefract, for electric tramways at Letchworth (Garden City), Stratford-on-Avon, Mansfield, and several smaller contracts for the Admiralty and War Office.

Water Purifiers.—The Paterson Engineering Co. have received the following orders:—

From Birmingham Corporation, for "Paterson" condensation water purifier with quartz sand filters (for Summer-lane station), capable of removing all trace of oil from 350,000 lb. of condensed steam per hour; from Ayr Corporation, for "Paterson" combined exhaust heater, softener and grease eliminator of 4,000 gallons hourly capacity, fitted with quartz sand filter; and from Barnsley Corporation, for a combined grease eliminator and make-up softener of 3,500 gallons capacity.

BUSINESS NOTICES.

The Deutsche Gasglühlicht Aktiengesellschaft (of Berlin) notify that, pending the erection of a factory for the manufacture of metallic filament lamps in England in conjunction with the General Electric Co. (Ltd.) (71, Queen Victoria-street, London, E.C.), they have placed the sole agency for their "Osram" (tungsten) lamp for Great Britain with that company.

Mr. Maurice Graham informs us that he has, as from July 15 last, resigned all his interest in the firm of Graham, Morton & Co., engineers and contractors, Leeds, as he has decided to devote the whole of his time to his consulting work in the special study of the transmission and handling of materials by labour-saving machinery. On Oct. 19 Mr. Graham leaves England for a twelve months' tour round the world (visiting Egypt, India, China, Japan, Australia, United States, Canada, &c.).

Messrs. Crompton & Co. notify that their works at Chelmsford will be closed from noon Aug. 3 to 9 a.m. Aug. 12. All communications should be sent to head office (Salisbury House, London Wall, E.C.), and orders requiring immediate attention should be forwarded by Aug. 1.

The Tempered Spring Co. have removed to more commodious premises, and in future their address will be Burton Weir Works, Sheffield. The company are duplicating most of their machinery and are also putting down the most modern appliances for making springs of the highest quality.

The works and offices of the Langdon-Davies Motor Co. (Ltd.) will be closed from August 5 to August 10 inclusive. A small staff will deal with urgent orders.

Personal.—Mr. H. E. Brain, whose resignation of the post of electrical engineer to the Buenos Ayres & Pacific Railway we announced recently, is now in London in connection with his business in Buenos Ayres. He will be glad to hear from English manufacturers of electrical and other machinery desirous of being represented in Argentina. Letters may be sent to Mr. Brain at 44, Bernard-street, Russell-square, W.C.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the London Bankruptcy Court on Tuesday the public examination took place of Carl von Buch, 4, Sun-court, Cornhill, whose accounts show liabilities £22,850, assets £247. Debtor stated that he began business in 1892 as a financial agent, and promoted various companies, including the New Century Engine and the Ekstromer Accumulator Companies. Examination concluded.

The trustee (Mr. H. L. Howell, 132, York-road, Westminster Bridge, London, S.E.) in the bankruptcy of Alfd. Parker Jones and Cecil Hellyar (trading as A. Parker & Co.), electrical engineers and contractors, 130, Upper Richmond-road, East Sheen, has been released.

Claims against the Hudson Economiser Co. (Ltd.) (in liquidation) are to be sent by Aug. 17 to Mr. D. F. Basden, 33, St. Swithin's-lane, London, E.C.

Conduit & Fittings (Ltd.) is being wound up voluntarily. Mr. H. D. Brown, 4, Monument-street, London, E.C., is liquidator.

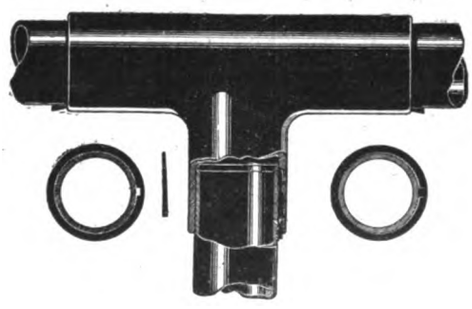
A meeting will be held on Aug. 30 at the offices of Gaff, Harper & Co., 54, New Broad-street, London, E.C., to receive an account of the winding up of the London Electrical Synd. (Ltd.).

Winding-up Petition.—A petition in the High Court by Gent & Co. for the winding up of the Brockie Poll Arc Lamp (Ltd), or for the continuation of the voluntary winding up under the supervision of the Court, will be heard on Aug. 7.

CATALOGUES, &c.

Ceiling Fans.—The latest list issued by Crompton & Co. (D 29) deals with their well-known ceiling fans. A fully-illustrated description is given in the list of the construction of these fans, and among the illustrations is a sectional view of the method of ceiling suspension. This is clearness itself.

Pin contact Conduits.—The mechanical and electrical continuity of all-steel conduits is now practically a necessity, owing to the



"Simplex" Pin-contact Device.

higher voltages in use. Simplex Conduits (Ltd.) are in a position to supply a pin-contact device which makes conduits electrically and mechanically continuous at practically no increase in cost over an ordinary socket-joint installation. Existing installations can be made continuous at a very slight cost. The pin contact is shown in the illustration. A small slot is left in the lip of all socket fittings, and when the enamelled tubing is socketed home in the ordinary way a small hardened metal pin or dowel is inserted and hammered sharply home. The pin cuts its way into the fitting and into the skin of the tube, and, being under great pressure, makes efficient and lasting contact without the necessity of scraping or injuring the enamel in any way; the projecting part of the pin may subsequently be filed off flush. The device dispenses with much labour in conduit erection and requires no skill in fitting.

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"*Kohinoor*" *Arcs.*—This well-known enclosed arc lamp of the Union Electric Co. is now fitted with a new cover and inverted reflector, making it suitable for all kinds of interior lighting. List No. 1,344, just published, gives prices and particulars.

Slyp-not.—This is the trade name given to a new belt dressing supplied by Watts, Fincham & Co., Billiter-buildings, London, E.C. A neat booklet just off the press gives particulars and instructions for use.

Pocket Lamps.—A handy form of pocket-lamp, fitted with a secondary cell, is described in a list just published by L. E. Wilson & Co., 20, Cross-street, Manchester. It is known as the "Thomson" pocket-lamp, and comprises a 2-volt accumulator in a special case, which is fitted with a bull's eye lamp and thumb switch. The lamp will give light for six hours from one charge. Special fittings are provided for cycle and motor-car use.

Water Softeners.—A speciality of water-softening plant and purifiers is made by the old-established Stanhope Water Engineering Co., of 20, Bucklersbury, London, E.C., who are issuing a useful booklet describing their Collett-Stanhope apparatus.

Springs.—The Tempered Spring Co. send us lists of their latest productions in the way of springs for various purposes.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from July 24 to 30, with the ports of destination:—

Africa—Alexandria, £445 (including £233 telegraph material); Cape Town, £69; Beira, £121; Bolama, £290; Delagoa Bay, £21; Durban, £332; East London, £1,026; Kilindini, £13,450 (telegraph cable); Sekondi, £8. *Argentina*—Buenos Ayres, £7,028 (including £5,831 telegraph material). *Australasia*—Adelaide, £102; Auckland, £1,430 (telegraph material); Melbourne, £2,720; Perth, £50; Sydney, £1,204; Wellington, £92. *Belgium*—Ghent, £50; Ostend, £74. *Brazil*—Maceio, £9; Pars, £74; Rio Janeiro, £10. *Burma*—Rangoon, £70. *Canada*—Toronto, £1,278. *China*—Shanghai, £185; Tientsin, £976 (telegraph material). *Denmark*—Copenhagen, £113. *France*—Paris, £27. *Germany*—Bremen, £10; Bremerhaven, £200; Cologne, £35; Hamburg, £50, *Holland*—Amsterdam, £458; Rotterdam, £67. *Hong Kong*, £382. *India*—Bombay, £461; Calcutta, £1,254; Karachi, £25; Madras, £81. *Italy*—Leghorn, £26. *Japan*—Kobe, £95; Nagasaki £1,876; Tokyo, £1,109 (including £252 telegraph material); Yokohama, £182. *Malta*, £55. *Persia*—Balek Pappan, £811; Moulmein, £6. *Russia*—St. Petersburg, £1,063 (including £765 telegraph material). *Siam*—Bangkok, £31. *Spain*—Santander, £12. *Straits Settlements*—Penang £58. *Singapore*, £176. *Sweden*—Stockholm, £507. *Uruguay*—Monte Video, £160. *U.S.A.*—Boston, £187. *West Indies*—Port Swettenham, £11. Total £40,642, against £61,178 in the corresponding week last year) July 25 to 31).

PATENT RECORD.

SPECIFICATIONS PUBLISHED.

1906 Specifications.

3,172 Montgomery. Ship's telegraphic apparatus.
6,838 Johnson. Dynamo-electric generators.
8,238 Beaver & Claremont. Electric cables.
9,112 B. T.-H. Co. (G.E. Co., U.S.) Motor control systems.
10,552 Spence. Conversion of alternating to continuous current.
10,554 Lake. (Stromberg-Carlson Telephone Mfg. Co.) Telephone switchboards.
10,558 Lake. (Stromberg-Carlson Telephone Mfg. Co.) Telephone wall boxes.
10,580, 10,598, 10,599 & 10,600. Lake. (Stromberg-Carlson Telephone Mfg. Co.) Telephone exchange systems.
10,585 Punga. Alternating-current electric motors. (Date applied for, 5/5/05.)
10,601 Lake. (Stromberg-Carlson Telephone Mfg. Co.) Telephone apparatus.
11,028 Jackson. Tail lamps for motor cars.
11,058 Stout. Electric circuit-breakers.
11,462 Zani. Electromagnetic power transmission apparatus.
11,652 Buhot. Electric batteries. (Date applied for, 23/5/05.)
11,657 Oppenden & Pollak. Electrical switches and fusible cut-outs.
11,676 Berry & Harrison. Connecting the conductors of circuits, especially in wiring buildings.
11,858 Warwick Machinery Co. (G.E. Co., U.S.) Mechanism for fluid turbines.
11,944 Just, Hanamann & Vereinigte Electricitäts A.-G. Incandescing bodies for incandescent lamps.
11,974 Hadfield. Magnetic material.
12,295 Chadburn's (Ship) Telegraph Co. & Grant. Ships' mechanical telegraphic apparatus for communicating between one part of same to another.
12,325 Justice. (Deutsche Gasglühlicht Akt.-Ges., Auer-ges.) Electric glow lamps.
12,497 B.T.-H. Co. (G.E. Co., U.S.) Control of dynamo-electric machines.
12,500 Brown. Electric telegraph apparatus.
12,686 Spence. Electro-magnetic friction clutch reversing gear.
12,730 B.T.-H. Co. (G.E. Co., U.S.) Machines for use in the manufacture of incandescent lamps.
12,821 B.T.-H. Co. (A.E.G.) Suspending the conducting wire of electric railways.
13,050 Kingsbury. (Western Electric Co.) Telephone switchboard cord reel.
13,415 B.T.-H. Co. (G.E. Co., U.S.) Electric switches and operating mechanism therefor.
13,585 Auvert & Ferrand. Apparatus for transformation of single-phase alternating current into continuous current. (Date applied for 3/7/05.)
13,589 Mier y Miura. Electrolytic meters for electricity.
13,601 B.T.-H. Co. (G.E. Co., U.S.) Switches.
13,928 Wetter. (May.) Electric meters of the motor type.
13,978 Morgan Crucible Co. & Grant. Applying pressure to commutator brushes.
14,342 Allan. Prepayment mechanism for electric and other meters.
14,359 B.T.-H. Co. (G.E. Co., U.S.) Electromagnets.
14,592 Harris. Electric measuring apparatus.
14,911 Bould. Joint boxes, fuse boxes and switch boxes.
14,945 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H.) Electric starting machines having flywheels that can be uncoupled when working light loads.
15,060 Schattner. Electric meters of the electrolytic type.
15,223 B.T.-H. Co. (G.E. Co., U.S.) Systems of electric motor control.
15,283 Turner. Controlling and operating the points of electric railways and tramways.
15,483 Kirwan & Quaney. Switching devices for use with stopping place indicators.
16,314 Westwood & Jones. Terminals of electrical machinery or apparatus.
16,360 Warwick Machinery Co. (G.E. Co., U.S.) Governing mechanism for turbines.
16,668 Proctor. Arc lamps.
16,690 Berglund, Hjorth & Ljungman. Electric apparatus for ignition of mines.
16,729 Ketchum. Dynamo-electric generators.
16,819 Allan. Electric starting switches and regulators.
16,870 Greenfield. Anodes for electrolytic purposes.
16,895 B.T.-H. Co. (G.E. Co., U.S.) Electric transformers.
16,984 B.T.-H. Co. (G.E. Co., U.S.) Air-brake systems.
17,071 Parusel. Signalling apparatus for electric railways.
17,130 Delany. Telegraphy.
17,343 Felten & Guilleaume-Lahmeyerwerke Akt.-Ges. Electrical current interrupters. (Date applied for, 18/8/05.)
17,561 B.T.-H. Co. (G.E. Co., U.S.) Systems of electric distribution.
17,768 Bridge. Electrically treating air and other gases.
18,083 Horch. Commutator switch for two igniting sources of electricity.
18,086 Herberts & Herberts. Fuse boxes.
18,135 Ross. Instruments indicating flow of electricity through conductors.
18,376 Grant. Ship and analogous telegraphic apparatus.
18,408 Lake. (Semenza.) Electric insulators for high-tension conductors.
18,445 Waterhouse. Electric glow-lamp holders.
18,478 Newton & Brush Electrical Engineering Co. Packing for movable joints in turbines.
18,829 Reithoffer & Moraweitz. Operating electric clocks by electrical waves.
18,957 Euker. Electric motor control apparatus. (Date applied for, 31/8/05.)
19,009 Warwick Machinery Co. (G.E. Co.). Buckets for elastic fluid turbines.
19,150 Edwards. Controllers for the trolley poles of electric cars.
19,219 Watkinson & Payne. Regulating or controlling the pressure of the current in an electric circuit.
19,299 Olver & Crawford. Switch mountings.
19,462 Hunter. Destination indicators for tramway cars.
19,620 Forster. Incandescent lamps.
19,762 Mathes. Tramway point and operating mechanism.
20,210 Lederer. Supports for metallic filaments.
20,463 B.T.-H. Co. (A.E.G.) Arc lamps.
20,703 Davy. Electrical resistances.
20,719 Felten & Guilleaume-Lahmeyerwerke Akt.-Ges. Alternating-current electromagnets. (Date applied for, 30/9/05.)
21,063 Seyboth & Baumann. Elastic fluid turbines.
21,146 Odman. Controllers for electric elevators. (Date applied for, 1/3/06.)
21,348 Pörscke. Galvanic cells.
21,349 Cowper-Coles. Electrolytic production of copper wire strip or the like.
21,767 Hewitt. Apparatus for producing oscillatory electric currents. (Date applied for, 9/10/05.)
21,952 Howorth. (Maschinenfabrik Oerlikon.) Power plants for the production of alternating electric current by steam engines.
22,465 Etchells. Controlling mechanism.
22,498 Davis & MacGahan. Electrical measuring or indicating instruments. (Date applied for, 21/10/05.)
22,519 Frick. Electric transformer furnaces. (Date applied for, 18/12/05.)
22,658 Weichert. Apparatus for the electrolysis of fluids.
22,715 Dearlove & Brown. Electric condensers or the like.
22,752 Connor & Stubbs. Electrodes.
22,779 Thompson. (Ges. für. Drahtlose Telegraphie.) Aerial conductor arrangements for wireless telegraphy.

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COMPANIES' MEETINGS AND REPORTS.

Direct United States Cable Co. (Ltd.)

The sixtieth ordinary general meeting was held on Friday last under the presidency of Mr. E. M. UNDERDOWN, K.C.

The GENERAL MANAGER AND SECRETARY (Mr. T. Finnis) read the notice convening the meeting and the auditors' report.

The CHAIRMAN then said: I am glad to say we have no exciting topics to deal with, our traffic is going on well up to the present time, we have suffered from no misfortune, and I trust that that indicates a condition of things which will be considered by you as satisfactory. The revenue for the six months to June 30 last, after deducting outpayments, amounted in round figures to £57,056, while the working and other expenses, including provision for pension fund and income tax, but exclusive of cost of maintenance of cables, absorbed £24,699, leaving a balance of £32,357 as net profit. With £17,032 brought forward, this makes a total of £49,389, which has been appropriated as follows: An interim dividend of 4s. per share was paid to March 31, requiring £12,142, and the proposed final dividend of 4s. per share and a bonus of 2s. 6d. per share to June 30 will require £19,731. We transfer to reserve account £15,000, and carry forward £2,516, making together the before-mentioned total of £49,389. The revenue has shown a slight improvement during the past half-year as compared with the corresponding period of 1906, although that was a period of great activity in the Atlantic cable business. The working expenses in London and at the stations show some small natural increases in consequence of the greater activity, the remaining expenses appearing in the revenue account being of a more or less fixed character. There is an appreciable reduction in the item of income tax, as was foreshadowed in the remarks made to the shareholders last year. The reserve fund account having been credited with £8,790 from interest on the investments and £2,367 from profit on sale of securities, and with the £15,000 mentioned transferred from revenue, and, on the other hand, having been debited with £4,184 for cost of maintenance of the cables, and with the amount of £40,000 which you will observe from the report we have decided to put aside as provision on account of market depreciation of securities, the balance of the account now amounts to £491,968. The investments have been increased during the half-year by £36,319. Their total cost amounts to £533,435, but with the before-mentioned provision of £40,000, the value they actually show is about the amount they would realise if sold to-day. I firmly believe that the depreciation shown in the quotations is only a temporary matter, and I trust that we shall return to a more normal state of things. Meanwhile, I think you may congratulate yourselves that this period of depression has had so small an effect upon your securities—not more than about 7 per cent. I observed quotations in a paper which showed that recently there has been an augmentation in the value of securities amounting to something like £50,000,000. Let us hope that that improvement will go on. A summary of the results of working during the whole financial year shows as follows: Receipts on revenue account were £117,435, less expenses and other ordinary payments £50,080, leaving £67,355. We have paid in dividends £56,156 and placed to reserve £15,000, making together £71,156, less the decreased balance in hand as compared with June, 1906, of £3,801, making the amount before mentioned of £67,355. The reserve fund account, apart from the provision of £40,000 for depreciation in the market value of securities, has been increased on balance during the year by £27,784, as follows: By transferring from revenue £15,000, interest on investments, &c., £17,117, and profit on the sale of securities £2,656, making the total credits £34,773; deduct cost of maintaining the cables, £6,989, leaving the increased balance of £27,784. I now move the adoption of the report and accounts and the declaration of the final dividend and bonus as set out therein.

Sir JAMES PENDER, Bart., seconded the motion, which was carried unanimously.

Resolutions were then approved re-electing the retiring directors (the Hon. H. A. E. Cochrane, M.P., and Mr. John Varley) and the auditors (Messrs. Deloitte, Plender, Griffiths & Co., and J. J. Sawyer & Co.), and a hearty vote of thanks to the directors and staff brought the proceedings to a close.

Anglo-American Telegraph Co. (Ltd.)

The half-yearly general meeting was held on Friday last, Mr. FRANCIS A. BEVAN presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the auditors' report.

The CHAIRMAN said: This is our half-yearly meeting, and we do not deal fully with the accounts on this occasion. I think we may congratulate ourselves on the progress of the company's business during the past half-year. The traffic receipts have increased by about £2,200, but there was a falling off in the earnings of the "Minia" of over £4,000. As I always remind you, the earnings of the "Minia" are a precarious sort of income, and can never be counted upon. Therefore, deducting the increase in traffic receipts from the reduced amount from the "Minia," there is a nett decrease of £1,812. 16s. 5d. On the other hand, working expenses have decreased by £698 and law expenses by £283; but our chief decrease is in the cost of repairs of cable, in which item there is a nett decrease of £5,461. 4s., so that the gain in revenue for the six months is £4,100, which accounts for the increased balance carried forward. For the forthcoming half-year I hardly think we can expect the very large receipts we had for the corresponding half-year of 1906, when there was great activity on the Stock Exchange. I now come to the question of the renewal fund. You will have noted that the Directors considered it right to give you notice the other day, when communicating the amount of dividend to be paid and the amount of the balance to be brought forward, to allude to the fact that there had been considerable depreciation in the value of securities held on account of our renewal fund. This depreciation has now reached a large sum (no less than £83,000). You will remember that we entered into a sort of agreement that our renewal fund should stand at £1,000,000, but if you deduct this £83,000 it is manifest that the renewal fund stands at considerably less than £1,000,000. The question arises therefore: What shall we do? We are engaged in renewing the shore ends of two of our cables, and this will absorb about £40,000, which will have to come out of the renewal fund. Towards this sum there is the nominal surplus on the renewal fund of £26,000, and we have credited the fund with the half-year's interest on securities (about £13,000) making £39,000 towards £40,000, so that the real value of the renewal fund, taking the depreciation account, is not quite £920,000. Under these circumstances the directors consider it is right to resume the operation that we carried out for some years, namely, setting aside £20,000 out of our annual receipts towards making up the amount to the nominal £1,000,000. If we have any good fortune the year's interest of £30,000 and the £20,000 set aside will soon bring up the fund to the nominal amount. We do not, however, propose to be examining year by year the amount of the renewal fund—we propose not to revalue for something like three years. What the position may be then I cannot say, but at present it does not look as if securities were likely to rise in the immediate future, more especially British securities in which the greater part of your renewal fund is invested. There is one other matter to which I will allude. I have referred to the renewal of our shore ends and have mentioned that these shore ends are exposed to damage by trawlers, and this liability to damage seems to increase. We have been in communication with the Government authorities upon the point, and I am glad to be able to say that they are taking the matter into serious consideration. You know also that we have had a lawsuit with the Newfoundland Government on the subject of their taxation of our cables. We contested the Newfoundland Government's power of taxing us in this way, but the decision of the local courts has gone against us. We have now under consideration whether we shall appeal to the Higher Court in England. The only other matter to which I may allude is that the directors have elected on the board Mr. Maitland Kersey, and his name will come up in due course for confirmation by the shareholders. I now move the adoption of the report and accounts.

Sir GERALD FITZGERALD, K.C.M.G., seconded the resolution.

Mr. EDMONDS asked what had become of the French lawsuit?

Sir JOHN SWINBURNE asked whether anything had been received on that account?

The CHAIRMAN: The action is dead, and I am informed that we have received about £1,100.

Mr. HARDCASTLE: Do I understand that if the renewal fund should increase in value within the year, say by £90,000, which would bring it up to the normal £1,000,000—and some people think there will be considerable appreciation in securities—you would still continue for two years to add £20,000 to the fund out of revenue.

The CHAIRMAN: That is a natural question to ask. I trust the anticipations of an improvement may be realised, in which case we shall not require this money, but I think all will agree that it is not a wise thing to be constantly revaluing our renewal fund. If there is a surplus so much the better. If the situation were to change considerably, either for the better or the worse, I suppose the directors would have to reconsider their policy.

After some further general discussion, the resolution was put to the meeting and carried unanimously.

A cordial vote of thanks was tendered to the chairman, the directors and staff, and the proceedings terminated.

City & South London Railway Co.

The forty-sixth ordinary general meeting was held on Wednesday, the Right Hon. C. B. STUART-WORTLEY, K.C., M.P., presiding.

The SECRETARY (Mr. W. F. Knight) read the notice calling the meeting.

The CHAIRMAN said: We meet you this time at the close of the most eventful half-year in our history, since and excepting, of course, that in which our original line from the Monument to Stockwell was opened for public traffic by the illustrious prince who is now King of these realms. A good many things might be said of the great change during the past six months, but, to put it in a concrete form, I may say that at the close of the half-year we had for 49 days been actively working an added length of 1 mile 17 chains of new line, the completion and opening of which had put us in the relation of feeding and being fed by the three oldest of the four great systems connecting London with the Midlands and the North, as well as in a like relation with the tube railway which passes through King's Cross on its way from Finsbury Park to Hammersmith. And since June 22 we have been in like contact at Euston with what is popularly called "the Hampstead Tube," but which, it ought to be remembered, is a Highgate tube as well. We have thus in the half-year become partakers in the advantages of no less than five great new possibilities. The result so far is such as to give us encouragement in every case. Of the Hampstead and Highgate connection it is too soon to say anything beyond reminding you that over and above our share in the interest on the small sum expended in making an underground subway at Euston from our tube to theirs, practically every shilling of new traffic

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that that connection may bring in will be clear profit to us. The broad results, however, of the half-year, which includes the seven weeks during which the four other new connections have been open, are as follows: We have a 10 per cent. increase (10,148,780 against 9,045,120) in the number of passengers carried. We have run 90,980 trains against 90,376 in the corresponding period of last year. We have carried 110 passengers per train against 100. Our receipts per train have been 17s. 1·73d. against 16s. 1·67d. Our receipts per train-mile have also improved, being 31·83d. against 31·62d. On the other hand, our expenses per train-mile have fallen from 15·08d. to 14·94d. The receipts per passenger are again lower, being 1·75d., against 1·80d., a fact which follows from the same movement which results in the slightly smaller takings from season tickets. But the most satisfactory feature of all is the fact that in the face of the manifest all-round increase in the volume of our business, and notwithstanding the increased price of coal and other supplies, our working expenses stand in the improved proportion of 44·38 per cent. of gross receipts against 44·94 in the corresponding period. The pecuniary result to you is that there is £6,120 more available for distribution in dividends than there was a year ago. Against this there has to be set an increase of £1,784 interest on 1901 preference stock, which had not become payable in June, 1906, also £2,500 for interest for four months on the new 1903 preference stock which a year ago was still unissued. Setting off the £4,284, the aggregate of these new preference charges, against the £6,120 of increased dividend money, we get for the ordinary stockholder an amount which comfortably enables us to pay him at the rate of 2½ per cent. per annum, against 2¼ this time last year, and to carry forward practically the same sum as we did then. I think I may go so far as to say that the results of the seven weeks for which we have been working to Euston and King's Cross certainly look as if, without much difficulty, we are going to maintain our existing dividends, and, perhaps, make a bit more beside. We have the solid fact that in 11 weeks from May 11 to July 28 we have an average increase in receipts of £640 a week. You will be interested to hear that we have arranged and put into operation through bookings with the Midland and Great Northern Railways; also with the Hampstead and Highgate, and Piccadilly and Brompton Tubes; likewise to Earl's Court on the District Railway (including admission to the Exhibition).

So much for our present position. Our more remote prospects have been improved during the half-year by the fact that the new scheme of the London & North Western Railway for an electric railway from Watford to Euston, bringing passengers to a new underground station at Euston, with subway communication with our station there, has passed through Parliament. You have doubtless read of efforts that have been made and measures taken to bring about such increases in underground railway and tube and omnibus fares as will put an end to useless and internecine competition. No one now denies that these cheap transit industries, whether they are to be financed from municipal or from private resources, must be run upon a more remunerative basis than heretofore. Well, we have attended some of these conferences which you have read about, but of course, our chief competitor is not in the room when we go there. In these discussions our part has so far been to some extent the part of spectators, for the competition we have to face is not so much that of omnibuses or of other railways, but has to be looked for elsewhere. In this matter our attitude has never been aggressive, and at present our efforts are directed towards deprecating further aggressions by our great competitor, and persuading him that in some of his past measures there has been some injustice to us that ought to be remedied and some financial policy that might well be reconsidered. We claim, and we hope the public are beginning to agree, that after all the efforts you have made, the risks you have taken, and the patience you have shown, you deserve not to be raided, but to be rewarded. I now move the adoption of the report and accounts.

Mr. CHARLES SEYMOUR GRENFELL seconded the motion, which was carried unanimously.

The declaration of the dividends on the preference and ordinary stocks was then approved, and a hearty vote of thanks to the Chairman, Directors and staff was accorded unanimously. The Chairman having briefly replied, the proceedings terminated.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—At an extraordinary meeting on Friday, the provisional agreement entered into with the Cie. Générale de Tramways de Buenos Ayres for the acquisition of the Buenos Ayres & Belgrano Electric Tramways Co.'s undertaking was approved.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—The report for the half-year ended June 30 shows that the balance available for dividend is £4,463, and it has been decided to pay 4 per cent. for the half-year.

CENTRAL LONDON RAILWAY CO.—The capital expended during the half-year ended June 30 was £6,351. 12s. 5d. Compared with the corresponding period in 1906 there has been a decrease of £15,599. 3s. 2d. in receipts, and of £4,371. 19s. 5d. in working expenses; but rates and taxes have required £355. 0s. 2d. more. The balance on the half-year is £74,950. 8s. 9d., or £11, 227. 3s. 9d. less than in 1906. The number of passengers carried was 20,260,871, against 20,721,508 and 22,336,489 respectively in the two preceding half-years. After providing for debenture interest, &c., there remains £70,891. 1s. 2d. The directors recommend the declaration of dividends for the half-year at the rate of 3 per cent. on the undivided ordinary and at the rate of 4 per cent. on the preferred ordinary stock. Dividend on the deferred ordinary stock is not payable until the result of the year's working has been ascertained and the balance (£31,423. 0s. 2d.) is carried forward. After careful observation and inquiry, the directors decided, though with much regret, to abandon the system of charging a uniform fare of 2d. and to adopt an increased charge to 3d. for passengers travelling beyond seven or eight stations. This alteration came into effect on July 1. It is proposed that a conference, or committee, of representatives of the Metropolitan, the Metropolitan District and the North London railways, the various tube and tramway undertakings, and the omnibus and motor-bus companies, should be established to deal with questions affecting their common interests, and of adjusting differences that may from time to time arise.

CHILIAN ELECTRIC TRAMWAY & LIGHT CO. (LTD.)—The report for 1906 states that there is a balance to debit of profit and loss of £2,448. The renewal fund, which was created in 1905 and amounted to £8,867, has been charged with the cost of the modifications and the restoration of the property damaged by the rioters in Santiago. Owing to frequent traffic disturbances, caused by several serious breakdowns of the machinery at the power station, and also owing to the occurrence of an earthquake in Santiago on Aug. 16 last, which stopped the service during 11 days, the total passengers carried was less than during 1905 by 9,098,550, the tramway receipts being less by $329,365.80. The power station is now in thoroughly efficient condition, and during the year the following additions have been made to the machinery therein: Two new accumulator batteries, one turbine and two boilers, increasing the power capacity to 5,700 kw. The rolling stock has also been added to by 10 new cars, and 20 new cars on order will be delivered in the course of this year. After prolonged negotiations with the municipality of Santiago, the company has succeeded in obtaining a prolongation of the concession for a further 25 years to 1953. The Nuñoa line has been reconstructed from horse to electric traction, and was opened for almost its whole length on Dec. 31. Owing to the fall in the rate of exchange and in accordance with the clause in the concession, the fares on the system in Santiago were doubled on Dec. 17, 1906, and resulted in a great improvement in the gross returns. On Dec. 20, 1906, a contract was entered into between this company and the Deutsch-Ueberseeische Elektricitäts-Gesellschaft, of Berlin, for that company to supply the system in Santiago with current produced from water power at a rate much below the present cost of power, and when this installation is complete the directors look for a substantial decrease in operating expenses. The managers have so far failed to succeed in obtaining adequate compensation from the Government of the Chilian Republic for the damage sustained by the company in consequence of the riot in Santiago in October, 1905; but the damage arising from that cause had been met by funds locally set aside in Santiago for that purpose. The business of the electric lighting department also suffered owing to the disturbances and breakdowns in the power station and the earthquake. However, the department showed the following increases compared with 1905:—In private lighting, 32 per cent.; in public lighting, 1 per cent.; whilst the tramway service required 7 per cent. less current, so that, including the amount required for the company's own consumption, the consumption in 1906 was 7,668,752 against 7,688,277 units. The number of consumers increased from 849 in 1905 to 1,360 at the end of 1906.

CROMPTON & CO. (LTD.)—At the meeting last week the chairman (Mr. John Trotter) congratulated the shareholders upon the fact that the estimate made at the last meeting of a greatly improved state of affairs had been realised. The works had been very fully occupied; they had found it necessary to carry out a further extension of the shops, but before those were completed a still further increase became necessary and would take place during the current year. The nett profit was £38,291, against £20,000, so that they had beaten the record by about £7,000, their previous highest profit being £31,226 in 1901. They had also deducted £6,572 from nett profit in order to write off stock. They could pay double the amount of dividend which they paid last year—namely, 5 per cent., and he regarded a good honest 5 per cent. as the minimum rate that any trading concern ought to pay. They were not proud of the dividend, but in view of the present condition of the electrical industry it was matter of thankfulness that they had got back to 5 per cent. and that they were able to place a good sum to reserve. He next dealt with the company's holding in the Electric Supply Corpn., and the progress made by the latter company. £1,500 was set aside for contingencies and doubtful debts, and £10,712 was placed to reserve, increasing that fund to £20,000. During the year £4,500 worth of new tools had been added, but, notwithstanding this, the value of plant and tools had been written down to £79,687. The handsome balance of £5,840 remained to carry forward. The growth of the business was so great that the directors asked the shareholders to agree to an increase in the borrowing powers from the present limit of £150,000 (in which was included the debenture issue of £100,000) to £200,000. After dealing very fully with the accounts, Mr. Trotter said the outlook for the current year was satisfactory, good orders and contracts having already been received, and they regarded the further capital as a precautionary measure.

Col. R. E. CROMPTON seconded the resolution, and said the improved results were due to the gradual effect on their business of their engineering knowledge. Their officials had had many years of hard times, with a gradual decline in prices, and their one study in the last few years had been how to make both ends meet. They had done so in their contract department before, but last year they had made a profit in every department. Prices had not risen, so that the profits had been made by rigid economy and care in designing. Their work had been done so well that in some cases they had obtained higher prices than the market figure purely on account of excellence of work.

The motion for the adoption of the report and accounts was agreed to, as was a further motion sanctioning the increase of the borrowing powers by £50,000.

DUBLIN & LUCAN ELECTRIC RAILWAY CO.—After providing for debenture interest, the available balance is £1,035. 8s. 5d., out of which the directors recommend payment of the usual half-yearly dividend on the 5 per cent. preference shares (absorbing £475); that £250 be paid to the contractors on account of the amount remaining due to them for electrical equipment; that £92. 19s. 6d. be written off electric signal installation

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account (that amount having been paid for a new system of signalling during the past half-year, and that the balance (£217. 8s. 11d.) be carried forward.

DUBLIN UNITED TRAMWAYS CO.—At the meeting on Tuesday the chairman (Mr. W. M. Murphy) said the receipts (which included £2,114 from the Howth traffic) constituted a record for the first half of the year. They attributed this satisfactory result to the International Exhibition. During the last half-year the cars were run 144,153 miles more than in the corresponding period of the previous year, and of course an increased supply of current was required for working the additional mileage. The average consumption of electricity per car-mile had also increased in a marked degree owing to the heavier cars in use and the higher rates of speed permitted. These conditions accounted for an additional consumption of 911,848 units, an increase of 20 per cent., although the car mile age increased by only 4 per cent. But, though coal cost them an average of 5d. per ton more than in the corresponding half-year, the total cost of generation per unit was actually less, being 0·357d. against 0·375d. last year. The increase in traffic expenses (£1,560) was all accounted for by the increased mileage, while the increase in the general charges (£1,287) was caused by the additional accident insurance agreed to be paid in respect of the exceptional risk during the Exhibition year, and by increases in rates, taxes and rents. They had expended £7,157 on the reconstruction of the Dalkey line, but this was charged against revenue. They had also charged against revenue £998 for substituting side poles for centre poles in three thoroughfares. They had a considerable grievance with regard to those centre poles. Though protesting against placing them in the centre of the roadway in the first instance, they were obliged to do so in obedience to the requirements of the Corporation, and it was under pressure from the same body that they were called upon to move them at their own expense and place them in the position which they originally proposed. That was the kind of thing that happened when public bodies embarked on their own account in undertakings which would be much better left to private enterprise. Since the tramways were completely converted to electric working in 1901 the yearly receipts had risen from £187,279 to £274,831, or about 37 per cent., and there was every prospect of a steady continuance of that increase, to meet which additional rolling stock was necessary. They had also had to consider the power available at the Ringsend generating station, for though the plant originally installed had been able to meet all demands up to the present, on some recent occasions the reserve margin was below a safe limit. They, therefore, determined to run no risks, and recently they installed a 1,000 kw. turbine generating set. They had also had to continually increase their car accommodation.

EDMUNDSONS' ELECTRICITY CORPN. (LTD.)—At the meeting on Friday the chairman (Mr. F. E. Gripper) said the result of the past year's working had been most disappointing and had caused the board much anxiety. The revenue was derived from two sources (profit from trading and income from investments). The net trading profit, after deducting all expenses and charges, was only £4,056, against £27,709 a year ago. It had always been foreseen that when the works of their subsidiary companies were fairly established the amount of contracting work done and the income from that source would be reduced. The policy of the board during the year, especially in view of the difficulty of raising capital for electrical undertakings, had been to restrict as much as possible all capital expenditure which could possibly be avoided or delayed, and that policy had necessarily had the effect of reducing the trading profit, and also to a certain extent had affected the development of some of their undertakings. The reduction in trading profits would have been of a less serious nature if there had been anything like a substantial increase in income from their investments. Unfortunately there had been no such increase, the results actually showing a small decrease, £31,136 against £32,182 in 1905. Profits had in many cases increased substantially, but the increased income had to a large extent been required for meeting charges on capital which in 1905 did not rank for dividend, and the increase in earnings had therefore not benefited the company. In consideration of the serious situation arising from the passing of the preference dividend, the directors asked the large shareholders whom they called together to appoint a committee to act in advising and assisting the board in taking steps to improve the position of the company. The committee had been formed, and consisted of seven of the largest shareholders in the company. The business of electric supply for some years past had been carried on under increasingly severe competition. The effect of gas competition had been felt by every electric lighting undertaking in the country, and especially in country towns. He expressed his belief in the ultimate success of the great majority of the company's undertakings.

ELECTRIC SUPPLY CORPN. (LTD.)—At the annual meeting on Wednesday the chairman (Mr. C. F. Tufnell), in moving the adoption of the report, said that one of the most satisfactory features of the accounts was the fact that in the case of six towns which showed a loss in 1905 (Dalkeith, Dollar, Jedburgh, Melrose, St. Andrews and Exmouth), every one of them with the exception of Exmouth had turned the corner, and the revenue from the sale of current for lighting and power, meter rental, &c., exceeded the working costs. The same remark applied to Totnes station, which was now working at a profit. At Exmouth the gross revenue had increased from £241 to £671, and it was confidently anticipated that during the present year this would also show a profit. As to the three stations opened during the past year (Hitchin, Dumbarton and Falmouth) they had no comparative figures to go upon. At Hitchin a good start had been made; the Falmouth works had been in operation barely a month; and the prospects at Dumbarton seemed very good. By their bill, which had received the Royal Assent, the Chelmsford and Totnes Companies would cease to exist as separate concerns, and their business would be transferred to and form part of the general business of the company.

GENERAL ELECTRIC CO. (LTD.)—At the meeting on Friday the chairman (Mr. G. Byng) moved the adoption of the report and said that the accounts did not differ very materially from those of last year, and under the prevailing conditions must be considered satisfactory. They had added to their properties to the extent of £19,200, which had gone entirely into extensions of their works, buildings and machinery. They had so far avoided any further issue of shares, except ordinary shares, which mostly represented the reinvestment by directors of the dividends declared upon those shares from year to year. The sum written off for depreciation was about the same as last year, and was based upon the scale agreed upon with the auditors. Their stocks again showed an increase, which was largely due to dearer raw materials—copper, iron, lead, timber, cotton, rubber and other materials,. They had valued their stocks on a most conservative basis. The rises in materials were, he said, largely due to the manipulations of foreign trusts and speculators. There seemed to be some idea in the minds of many that the present trade system enabled them to obtain cheap raw materials. All facts experienced in the course of their business during the last few years had proved just the contrary. English manufacturers possessed no means whatever—they seemed even to have lost those means they had in the past—of influencing the prices of their raw material. The past year had been marked by the introduction of an important invention affecting the electric lighting industry. The aim at which they had worked for a great many years—namely, that of improving the efficiency of the incandescent lamp, had been attained by the introduction of a lamp having the wolfram (tungsten) metallic filament as a basis. He was of opinion that the advent of that lamp would have a most beneficial effect upon their industry, and they had from the beginning done everything to assist the development of the new lamp. They had been fortunate enough to come to a sound business arrangement with the holders of the first and what they were convinced were the master patents of the lamp, and, in connection with their Robertson lamp factory they had made an arrangement for its manufacture in England. He was sure they would be glad to learn that thus the English workman was assured of his share in the results of that invention. In the meanwhile they had secured for immediate sale in this country a considerable proportion of the output of the German works.

Their works had been kept busy throughout the year. Their directors (Mr. Railing at Witton and Mr. Bevis at Peel Works) had travelled abroad to keep themselves constantly informed of any progress made, and thus both those important works had been kept up to date by adopting every improvement necessary for efficient and scientific production. The carbon works had done fairly well, and they had again to acknowledge the great help which the home and colonial governments had given to them in that undertaking; but he could not help complaining of the action of many municipalities. For the sake of, sometimes, a small percentage many orders had gone abroad. Prices for heavy work had been kept low, mainly through internal competition. They had found foreign competition less active during last year; but there were indications that business on the Continent was getting slacker, and dumping would soon begin here again. For instance, last year they carried out a large contract in the West of England to the entire satisfaction of their customer. An extension of that contract was advertised, and within three days seven continental travellers were on the spot, and three offered to do the work at considerably lower prices than the lowest English tender, "whatever that might be." The uncertainty as to foreign competition was worse for the English manufacturer than the actual competition itself. Their profits were less than last year by about £2,000. To that extent they had been obliged to reduce the amount placed to reserve, which now stood at £118,000. England's industries used to be assisted by abundant capital. Very little of such capital was available at present, but their foreign competitors enjoyed that advantage now, to their detriment. Another great evil was the abuse of their limited company law. The tendency of every little man to turn himself into a limited company, with £7 share capital and £5,000 debentures, was becoming daily more accentuated. It made the giving of credit most precarious, it interfered with legitimate trading, it led to positive dishonesty and swindling, and constituted a huge public scandal.

The directors' report on the accounts was adopted unanimously without discussion, and the dividend of 5 per cent. on the ordinary shares was approved.

GREAT NORTHERN & CITY RAILWAY CO.—The total revenue for the six months ended June 30 was £49,838. 4s. 3d., and cost of working £24,615. 12s. 2d. (49·39 per cent.). After providing for debenture interest and other charges, and setting aside £500 to form the nucleus of a renewal fund, the directors recommend that the balance (£1,035. 9s. 1d.) be carried forward. The number of passengers carried (including season ticket holders) was 8,269,435, against 8,087,740 for the corresponding period last year; the number of local season tickets issued during the half-year was 3,995, against 3,131; and the number of three-route season-ticket holders using the company's line during the past half-year was 2,735.

LONDON, BRIGHTON & SOUTH COAST RAILWAY CO.—At the meeting on Wednesday, the chairman (Lord Cottesloe) referred to the effects of tramway competition on their traffic, and said the electrification of the South London Railway was proceeding as rapidly as possible. It was hoped that this line would be completed in the course of next year, but, in the meantime, they were arranging to accelerate the present steam train service by running past certain stations where it was considered hopeless to attempt to compete at present with the tramways.

NORTH METROPOLITAN ELECTRIC POWER SUPPLY CO.—An extraordinary meeting was held on Tuesday, and on the motion of the chairman (Mr. C. G. Tegetmeier) a resolution was passed authorising the board

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to borrow a sum not exceeding £133,000, by the issue of 4 per cent. debentures.

SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.—At the meeting on Friday the chairman (Mr. R. Forrest) referred to the unfortunate circumstances in which the company was placed. It had exhausted its capital, and financiers deeply interested in the undertaking declined to find more capital unless power was obtained for the issue of prior lien debenture stock. The larger consumers of power had formulated a scheme for keeping the undertaking going, and the principal creditors had agreed to accept preference share of the nominal value of £160 in respect of each £100 of indebtedness. The directors confidently believed that the undertaking would be a most successful one, and they were encouraged in their belief by the opinions of experts who had investigated the affairs of the company. The position largely arose from the delays of the consumers connecting up with the company. If that could have been got over, the financial difficulties would not have arisen and the undertaking might have quickly reached a profit-earning basis.

The report and balance-sheet having been adopted without comment, the election of the following new directors was unanimous:—Messrs. W. F. Brown, J. W. Hutchinson, W. Cope, W. G. Dalziel, T. Griffiths, W. L. Madgen, A. G. T. Hutchinson, and T. O. Callender.

At a subsequent extraordinary meeting, an arrangement between the company, the debenture holders and the Treforest Electrical Consumers Co. (Ltd.) was approved. The present indebtedness of the company is £82,000, with certain contingent liabilities that may bring the amount up to £99,000. Under the agreement the Treforest Co. will find £30,000 to modernise and increase the plant at Treforest. The chairman (Mr. W. G. Dalziel) prophesied a successful issue from the present difficulties by harmonious working between the new company and the old, and by economy in administration.

TOPSHAM ELECTRICITY SUPPLY CO. (LTD.)—Capt. J. J. Holman presided at the meeting last week. The report stated that there had been an unlooked for increase in the demand for electric current, and the number of consumers had more than doubled. The income was £243, and the profit £98. A dividend of 3 per cent. was declared.

NEW COMPANIES, STATUTORY RETURNS MORTGAGES AND CHARGES.

NEW COMPANIES.

ELECTRICAL MFG. CO. (LTD.) (94,300.)—Reg. July 23, capital £13,000 in £1 shares, to acquire business and undertaking of P. Walters & Co., to adopt an agreement with W. Powles and to carry on the business of electricians, electrical and telegraph engineers, makers of electric tramcars, motor cars and cycles, manufacturers of and dealers in dynamos, motors, telephones, bells, electroliers, arc and other lamps, electric-light fittings, heating and cooking apparatus, &c. First directors are W. Powles (permanent managing director), A. Hilton and E. E. Moore. Reg. office: 249 and 251, Kensal-road, London, N.W.

H. JONES, WILSON & CO. (LTD.)—(94,289.)—Reg. July 23, capital £1,500 in £1 shares, to take over and carry on the business of engineers and electrical suppliers carried on at Liverpool, as H. R. Jones, Wilson & Co. Reg. office: 28, Chapel-street, Liverpool.

MARTEN & JELLICOE (LTD.) (94,313.)—Reg. July 24, capital £10,500 in 10,000 ordinary shares of £1 each and 10,000 deferred ordinary shares of 1s. each, to carry on the business of mechanical, electrical and general engineers, manufacturers of and dealers in motor and other vehicles and magnetic, telegraphic, telephonic and other apparatus, &c. Reg. office, 75-7, Shaftesbury-avenue, London, W.C.

TREFOREST ELECTRICAL CONSUMERS CO. (LTD.) (94,335.)—Reg. July 25, capital £100,000 in £1 shares, to produce, sell and distribute electrical energy, to manufacture, purchase, sell, let on hire or otherwise deal in or with plant, machinery, fittings, cables, wires, tubes, meters, &c., to adopt an agreement with the South Wales Electrical Power Distribution Co. and Stanley Boulter, to promote or concur with the last-named company or the Cwmbran Electrical Consumers Co. (Ltd), or any other company or person, in promoting Parliamentary bills or provisional orders. First directors: H. Bramwell (chairman), Sir Wm. T. Lewis, Bart., R. B. Thomas, W. H. D. Newton, W. N. Lewis, W. H. Mathias, G. T. Hutchinson and W. L. Madgen.

WIRELESS TELEPHONY (ENTERTAINMENTS) CO. (LTD.) (94,195.)—Reg. July 15, capital £1,500 in £1 shares, to adopt an agreement with F. E. Brown and H. F. Rogers, and to carry on the business indicated by the title. Reg. office: 4, International Exchange, Edmund-street, Birmingham.

STATUTORY RETURNS.

BRIDGWATER AND DISTRICT SUPPLY AND TRACTION CO, (LTD.)—Return to July 11 gives capital as £15,000 in £1 shares, of which, 12,749 have been taken up, in addition to 100 which have been forfeited. £3,877 has been received, including £10 paid on forfeited shares, and £8,882 is considered as paid. Mortgages and charges, £12,000.

BRITISH ALUMINIUM CO. (LTD.)—In the return to June 18, capital is £1,300,000 in 60,000 6 per cent. preference, 40,000 7 per cent. preference and 40,000 ordinary shares of £5 each, and 20,000 conversion and 40,000 1908 conversion shares of £10 each, of which 20,000 6 per cent. preference, 40,000 7 per cent. preference, 40,000 ordinary and 20,000 conversion have been taken up. £5 per share has been called up on 20,000 6 per cent. preference 33,540 7 per cent. preference and 38,001⅝ ordinary, and £4 per share on 20,000 conversion, and £537,708 has been received. £12,292 is considered as paid on 6,460 7 per cent. preference and 1,998⅜ ordinary. Mortgages and charges: £300,000 5½ per cent. Lock Leven debentures, £241,420 5 per cent. debenture stock.

BUENOS AYRES & BELGRANO ELECTRIC TRAMWAYS CO. (LTD.)—In return to May 21 capital is £850,000, in shares of £5 each, of which 100,000 ordinary, 40,000 A preference and 27,500 B preference have been taken up. £5 per share has been called up on 40,000 A preference and £200,000 has been received. £637,500 is considered as paid on 100,000 ordinary and 27,500 B preference. Mortgages and charges, £500,000.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO (LTD.)—Return to May 29 gives capital as £3,000,000 in £10 shares, all of which have been taken up and paid for in full. Mortgages and charges, £752,400.

HARRINGTON ELECTRIC LIGHT CO. (LONG EATON) (LTD.)—In return to May 23 capital is £5,000 in £1 shares, of which 3,900 have been taken up and paid for in full. Mortgages and charges, nil.

HARWICH ELECTRIC LIGHTING & TRAMWAYS CO. (LTD.)—Return to Dec. 31, 1906, gives capital as £50,000 in £1 shares, of which seven have been taken up. No calls have been made. Mortgages and charges, nil.

LOWDEN ELECTRIC LAMP CO. (LTD.)—A return of allotments filed June 11 shows that 70 ordinary and 400 5 per cent. preferred ordinary shares have recently been allotted for cash. In December, 1906, 2,830 shares were taken up (1,030 for cash and 1,800 credited as fully paid) out of a nominal capital of £3,000 in £1 shares. In March, 1907, the capital was increased by the creation of 1,000 new shares of £1 each.

J. C. LYELL & CO. (LTD.)—The capital return to June 13 is £2,000 in 500 ordinary and 1,500 preference shares of £1 each, of which 500 ordinary and 619 preference have been taken up. £1 per share has been called up on the preference and £619 has been received. £500 is considered as paid on the ordinary. Mortgages and charges, nil.

SIEMENS' ELECTRIC APPLIANCES (LTD.)—Return to July 8 gives capital as £25,000 in 250 shares of £100 each, all of which have been taken up. £100 per share has been called up on 7, and £30 per share on 243, and £7,990 has been received. Mortgages and charges, nil.

TELEPHONE CO. OF EGYPT (LTD.)—Return to April 24 gives capital as £200,000 in 36,000 preferred and 4,000 deferred shares of £5 each, of which 28,000 preferred and 4,000 deferred have been taken up. £5 per share has been called up on 16,000 preferred, and £90,000 has been received. £80,000 is considered as paid on 12,000 preferred and 4,000 deferred. Mortgages and charges, £100,000.

THOMSON-DAVIES TELEPHONE SYSTEM (LTD.)—According to return to Jan. 28 (filed May 31), capital is £6,000 in £1 shares, of which 5,695 have been taken up. £1 per share has been called up on 842 and 12s. 6d. per share on 360 shares, and £997 has been received, leaving £90 in arrears. £4,493 is considered as paid on 4,493 shares. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

BRITISH EVER-READY ELECTRICAL CO. (LTD.)—Issue on July 23 of £500 5 per cent. debentures, part of series created March 30, 1904, to secure £10,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £6,000.

ENGINEERING INSTRUMENTS (LTD.)—Issue on July 15 of £590 5 per cent. debentures, part of series created November 30, 1906, to secure £5,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £2,410.

HOLLOWAY ELECTRIC SUPPLY CO. (LTD.)—Issue on June 29 of £3,200 5 per cent. debentures, part of series created Dec. 28, 1900, to secure £20,000, charged on the company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £15,000.

D. SANTONI & CO. (1906) (LTD.)—Issue on July 20 of £220 6 per cent. debentures, part of series created May 31, 1907, to secure £2,750, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £2,420.

CITY NOTES.

MEMORANDA (Aug. 1).—Bank rate 4 per cent. (since April 25, 1907), Price of silver 32d.—32 1/16d. per oz. Consols 82 1/16—82 1/16 for money, 82⅜—82⅞ for account; 2½ per cent. annuities 81—81¼. Consols Pay Day, Sept. 2; Stocks and Shares Continuation Days, Aug. 13 and 27; Ticket Days, Aug. 14 and 28; Pay Days, Aug. 15 and 29; Mining Share Carry-over Day, Aug. 12.

BRITISH ELECTRIC TRACTION CO.—The directors have declared the half-yearly dividend on the 6 per cent. preference shares.

METROPOLITAN DISTRICT RAILWAY CO.—The directors recommend a dividend for the past half-year at the rate of 1½ per cent. on the 4 per cent. guaranteed stock, compared with 1½ per cent. for the corresponding half of last year.

OXFORD ELECTRIC CO. (LTD.)—The directors have declared an interim dividend at the rate of 5 per cent. per annum for the half-year June 30, tax free.

WESTMINSTER ELECTRIC SUPPLY CORPN. (LTD.)—The directors have declared an interim dividend for the half-year ended June 30 at the rate o 10 per cent. per annum, less tax.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 21	1,751	- 107	8	12,200	- 25
Airdrie	,, 19	214	+ 27	28	6,319	+ 16
Anglo-Argentine	...	...	...	...	...	...
Ashton-under-Lyne Corp	,, 27	432	+ 104	18	7,097	+ 737
Ayr Corporation	,, 27	524	+ 12	11	4,215	- 158
Baker St. & Waterloo Ry.	,, 27	2,445	+ 1,194	4	10,145	+ 4,656
Barnsley	,, 19	169	+ 10	28	4,606	- 6
Barrow	,, 19	342	- 34	28	6,891	- 69
Bath Electric Trams, Ltd.	,, 21	890	- 69	30	22,664	- 491
Birkenhead Corporation	,, 28	1,065	- 23	4	4,451	+ 39
Birmingham Corporation	,, 27	5,221	...	17	101,612	...
Birmingham & Mid.	,, 12	849	...	27	21,477	...
Blackburn Corporation	,, 24	1,217	+ 118	§17	19,333	+ 764
Blackpool Corporation	,, 25	2,121	+ 92	16	17,990	- 1,568
Blackpool and Fleetwood	,, 27	1,385	+ 78	4	4,483	- 24
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 28	2,387	+ 136	17	38,834	+ 1,455
Bournemouth Corporation	,, 24	1,883	+ 131	¶16	27,764	+ 173
Bradford Corporation	,, 27	4,977	+ 51	17	79,763	+ 358
Brighton Corporation	,, 28	997	- 148	17	15,466	- 1,595
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 26	5,134	- 304	3	11,166	- 474
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 27	1,308	+ 150	17	19,666	+ 125
Burton Corporation	,, 28	307	- 16	17	5,003	- 252
Bury Corporation	,, 21	1,301	...	16	17,624	...
Calcutta Tramways Co.	,, 27	R47,098	+ R1,129	3	R142,581	+ R12,016
Camborne-Redruth	,, 27	122	- 5	30	3,525	+ 36
Cardiff Corporation	,, 27	2,245	- 42	17	38,091	+ 2,970
Cavehill	,, 19	209	+ 57	28	2,362	+ 107
Central London Railway	,, 27	5,164	- 132	4	21,791	- 1,379
Charing C., Euston & H'stead	,, 27	2,515	...	4	10,445	...
Chatham & Dist. Lt. Rys.	,, 25	863	+ 105	‡30	20,807	+ 1,764
City & South London Rly.	,, 28	2,123	+ 414	4	12,747	+ 2,610
City of Birmingham	,, 19	3,003	...	28	78,503	...
Colchester Corporation	...	...	...	...	...	...
Cork Electric Trams Co.	,, 25	573	- 19	30	13,607	- 450
Croydon Corporation	,, 26	1,509	- 63	17	24,452	- 1,537
Devonport & Dist. Trams	,, 19	533	- 11	28	12,744	+ 6
Dover Corporation	,, 27	261	- 79	17	3,940	- 555
Dublin & Lucan Railway	,, 26	157	+ 11	4	549	+ 13
Dublin United	,, 26	7,167	+ 1,488	‡4	27,428	+ 6,731
Dudley Stourbridge	,, 19	906	- 2	28	23,462	- 505
Dundee Corporation	,, 24	1,319	- 12	10	11,592	- 394
East Ham Council	,, 27	952	- 7	17	15,673	- 402
Exeter Corporation	,, 26	357	+ 25	17	5,466	+ 491
Falkirk and District	...	...	...	...	...	...
Gateshead & Dist. Trams	,, 19	1,046	+ 50	28	28,175	+ 695
Glasgow Corporation	,, 27	15,666	+ 817	8	140,909	+ 1,484
Glossop	,, 27	147	+ 4	30	4,067	+ 62
Gravesend—Northfleet	,, 19	286	+ 12	28	6,647	+ 2
Great Northern & City Rly.	,, 27	1,651	+ 42	4	6,761	+ 127
Gt. Northern, Piccadilly, &c.	,, 27	4,130	...	4	17,090	...
Greenock & Port Glasgow	,, 19	878	+ 225	28	18,629	- 19
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 19	378	+ 24	28	7,776	- 438
Hastings Elec. Trams Co.	,, 25	1,280	+ 410	4	3,841	+ 1,561
Hong Kong	,, 27	...	+ $968	17	...	+ $34,509
Huddersfield	,, 27	1,635	+ 99	17	27,077	+ 1,010
Hull Corporation	,, 27	2,329	- 26	17	49,461	+ 1,947
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 24	147	+ 5	17	2,121	+ 163
Ipswich Corporation	,, 27	498	- 44	17	6,960	- 567
Isle of Thanet Co.	,, 27	1,208	- 135	43	18,067	- 413
Jarrow	,, 19	140	...	28	3,363	...
Keighley Corporation	,, 25	188	+ 24	4	609	+ 39
Kidderminster & District	,, 19	172	+ 5	28	3,124	- 160
Kilmarnock Corporation	,, 27	255	- 15	10	1,815	- 5
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 25	1,178	+ 384	30	31,064	+ 8,145
Lancashire United	,, 21	1,526	+ 423	30	36,313	+ 9,580
Leamington	,, 19	195	- 4	28	4,280	- 680
Leeds Corporation	,, 27	6,763	+ 15	17	111,463	+ 4,257
Leicester Corporation	,, 27	2,389	- 70	4	9,146	- 278
Leith Corporation	,, 27	567	- 26	‡11	5,932	+ 48
Lincoln Corporation	...	...	...	...	...	...
Liverpool Overhead Rly.	,, 28	1,633	+ 79	4	6,825	+ 552
Liverpool Corporation	,, 20	11,881	+ 778	29	310,590	+ 4,148
*London County Council	,, 20	32,855	+ 6 692	16	498,623	+ 76,379
London United	,, 26	7,688	+ 387	‡30	185,612	+ 4,310
Lowestoft	,, 27	292	- 13	43	7,296	+ 915
Maidstone Corporation	,, 27	151	+ 11	17	1,873	- 95
Manchester Corporation	,, 27	15 495	+ 1,544	17	251,066	+ 20,189
Mersey Railway	,, 27	1,752	+ 103	4	7,349	+ 706
Merthyr	,, 19	228	+ 35	28	5,813	+ 315
Metropolitan Dist. Railway	,, 28	7,626	+ 19	4	31,598	+ 9
Metropolitan Elec. Trams	,, 19	5,584	+ 1,833	28	124,290	+ 29,037
Middleton	,, 19	411	+ 14	28	9,731	- 200
Nelson Corporation	,, 27	164	+ 11	18	2,625	+ 18
Newcastle-on-Tyne Corp.	,, 27	4,015	- 238	17	71,169	+ 299
Newport (Mon.)	,, 27	693	+ 28	17	12,371	+ 1,539
Northampton Corporation	,, 26	454	- 45	§17	7,384	- 357
Oldham, Ashton & Hyde	,, 19	640	+ 313	28	16,797	+ 766
Oldham Corporation	,, 28	2,099	+ 96	18	34,907	+ 2,348
Perth (N.B.) Corporation	,, 24	212	- 1	10	1,727	+ 32
Perth (W.A.) Elec. Trams	,, 26	1,375	+ 16	30	42,936	- 1,470
Peterborough	,, 19	141	- 5	28	3,401	- 124
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 27	2,221	- 307	17	33,924	- 1,623
Potteries	,, 19	1,827	+ 75	28	52,663	+ 1,342
Preston Corporation	,, 24	934	+ 41	17	12,975	+ 185
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 25	587	+ 72	‡17	9,850	+ 1,459
Rothesay	,, 19	1,218	+ 219	28	5,081	- 254
Salford Corporation	,, 29	4,741	+ 61	17	80,797	+ 1,627
Sheerness	,, 17	68	- 1	28	1,537	- 39
Sheffield Corporation	,, 28	5,682	+ 257	18	99,006	+ 4,320
Singapore Trams	,, 27	$9,302	+ $1,682	17	$162,793	+ $30,774

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	July 21	528	...	17	6,354	- 354
South Metropolitan	,, 19	944	+ 436	28	21,221	+ 2,541
Southport Tramways	,, 19	389	- 29	28	7,879	- 517
South Staffs	,, 19	919	+ 75	28	24,995	+ 1,778
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 27	1,576	- 19	17	24,484	- 140
Sunderland and District	,, 21	528	+ 29	30	13,101	+ 1,628
Swansea Trams	,, 19	1,010	+ 93	28	23,869	+ 783
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 19	50	- 1	28	1,170	- 86
Tynemouth and District	,, 19	508	+ 135	28	6,118	- 674
Tyneside Trams Co.	,, 24	511	+ 34	30	13,710	+ 663
Victoria, Elec. Supply Co. of	June 23	689	+ 22	13	11,229	+ 979
Wallasey District Council	July 27	950	+ 2	17	14,426	+ 279
Walsall Corporation	,, 20	572	+ 55	30	14,777	- 460
	,, 27	536	- 23			
Warrington Corporation	,, 25	383	- 5	17	6,391	+ 228
West Ham Corporation	,, 25	2,422	+ 65	17	40,535	+ 1,125
Weston-super-Mare	,, 17	355	+ 38	28	2,677	- 360
Wolverhampton Co.	,, 19	490	+ 67	23	12,544	+ 661
Wolverhampton Corpn.	,, 24	853	+ 12	1	853	+ 12
*Worcester	,, 19	339	+ 3	28	7,566	- 217
Wrexham	,, 19	115	+ 3	28	2,806	- 37
Yorkshire W.R. Trams	,, 28	1,169	+ 285	30	33,617	...
Yorkshire Woollen District.	,, 19	1,044	+ 111	28	26,725	+ 1,307

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., July 31.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to July 31. Highest.	Business Week to July 31. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	Anglo-Argentine Ord. Shares	8⅛—8⅛	4 13 0	Ap, Oct	8⅛	8⅛
5	2/9	Do. 5½ per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	6⅛	6⅛
St.	6¾	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5¾	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3 —3¼	3 4 0	May ..	3⅛	3⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	4¾—5	5 0 0	My, Nv	4⅞	4⅞
St.	4¼%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	..	..
St.	7¾	British Columbia El. Ry. Df. Ord.	127 —132	4 8 6	Mr, Spt	131	..
St.	6¾	Do. Pref. Ord. Stock	113 —114	4 7 6	My, Nv	113¾	..
St.	5¾	Do. 5% Cum. Perp. Pref. Stock	103 —106	4 14 6	Ju, Jul	..	..
40	4¼%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 —102	4 8 0	Ja, Jul	100	..
5	3/0	Buenos Ayres & Belgrano Ord.	4⅛ -4⅜	3 11 9	Ap, Oct	4⅛	4⅛
5	3/0	Do. 6 per Cent. "A" Cum. Pref	4¾—5¼	5 11 0	Ap, Oct	4⅝	4⅝
5	3/0	Do. "B"	4¾—5¼	5 14 0	April ..	..	..
St.	5¾	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5¾	Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	100	..
St.	5¾	Buenos Ayres Elec. Trams. (1901) Ltd.	92 —97	5 3 0	Ja, Jul	96	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs	99 —103	5 7 0	Ja, Jul	..	..
100	6¾	Do. 6 per Cent. 1st Deb. Bonds	101 —105	5 14 0	Ap, Oct	103¾	..
5	4/6	Calcutta Tramways (1 to 137,610)	7⅛—7¼	5 3 0	Mr, Spt	7⅜	7⅛
100	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —106	4 5 0	Ja, Jul	104½	..
St.	..	Cape Electric Tram Shares	5/16 -7/16	.. .. ..	..	..	..
..	5¾	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —98	5 2 0	My, Nv	..	..
1	5¾	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	83 —88	5 14 0	Fb, Aug	..	..
100	5¾	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
		Do. 6 per Cent. "B" Ditto	78 - 82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅜	3 15 0	July .	1⅜	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 10 0	Ja, Jul	..	..
St.	5¾	Do. 5 per Cent. Reg. Mort. Deb.	95 - 98	5 2 0	Ja, Jul	..	..
St.	5¾	Madras Elec. Trams. 5% Deb. Stk.	96 —99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	103 —105	4 5 6	Fb, Aug	..	..
St.	t%	Perth E. Trams. 1st Mt. Db. Stock	100 —104	4 13 0	Ja, Jul	..	..
..	$%	Sao Paulo Tramway, Light & Power Co. $100 Stock	113 - 122	6 7 0	..	..	..
..	5¾	Do. 5 per Cent. 1st Mt. $500 fdb	13⅜—15⅜	5 5 0	Ju, Dec	94½	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½ - 5½	5 14 0	Mr, Spt	..	..
10	3/1½	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8⅜	5 15 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 —97	4 12 9	Ja, Jul	96½	..
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,090)	6¾ 7¾	5 3 3	Ap, Oct	..	..
5	2/3	Do. (80,001 to 100,000)	6½—7½	.. ..	..	7⅛	6⅝
50	5¾	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 —53	4 11 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼—2¾	..	Fb, Aug	..	..
St.	5¾	Do. 5 per Cent. Deb Stock	89½—92½	5 11 6	Ja, Jul	..	..
St.	5¾	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ 96½	5 3 6	Ja, Jul	..	..
St.	6¾	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —1 6	5 13 0	Ja, Jul	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5¾	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	⅜-½	3 6 9	April ..	⅜	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	⅛—¼	6 0 0	May ..	⅛	..
St.	5¾	Do. 5 per Cent. Deb. Stock	95 —98	5 2 0	Ja, Jul	96	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	..	..
..	5¾	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101¾	4 19 0	Ja, Jul	100	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., July 31.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 31. Highest.	Lowest.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 – 11	6 6 0	Mar, Sept,	..	..
10	4/8	Do. 4½ per Cent. Cum. Pref.	9⅞ – 10⅛	4 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1 ½ – 10⅜	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4% per Cent. Deb. Stock (red.) ...	99 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 –100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅜ – 8⅜	5 14 6	March....	..	..
5	3/6	Do. 7 per Cent. Pref.	7½ – ⅝	4 6 0	Mar, Sept	7⅜	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	19 - 1 2	3 18 0	June, Dec	..	..
5	2/6	Charing Cross(W.End & City)El.Sup.Co.	3½ – 4	6 5 0	Feb, Aug	2⅞	..
5	2/3	Do 4½ per Cent. Pref.	3⅜ – 4½	5 3 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 – 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3½ – 4⅜	6 0 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3½ – 4⅜	5 6 0	March ..	4⅛	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 104	4 6 6	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 – 9½	6 6 0	Feb, Aug	9⅛	9⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼ – 12½	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	123 –125	4 1 3	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 – 99	4 11 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	3⅜ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 4⅝	5 4 11	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	7⅛	..
10	6 0	† Do. 6 per Cent. Cum. Pref.	10½ – 11⅛	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)....	106 –109	4 2 9	Jun, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	94 - 97	4 12 6	May, Nov	15½	14⅜
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜ – 5⅜	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅜	4 11 0	Mar, Sept	..	..
St.	4½%	† Do. 4½ 1st Deb. Stock (red).....	96 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ – 7⅛	6 4 0	April, Oct	..	..
5	5/0	†Kensington & Knightsbridge Ord.....	8½ – 9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½ – 7	4 5 9	Jan, July	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 1 0	..	..	..
St.	4%	Kensington. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	100 - 103	3 17 9	April, Oct	..	..
3	2/4⅓	London Electric Supply Ord.	1⅜ 2⅛	5 12 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅝ – 6⅛	5 14 0	Mar, Sept	5⅞	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	98 – 99	4 4 8	Jan, July	..	..
5	4/0	†Metropolitan Electric Sup. Ord.	5⅜ – 6½	6 8 0	April. Oct	6⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4½ – 5⅜	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 –107	4 4 0	June, Dec	107	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	98 - 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –18⅞	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord.(£9 paid)	9⅞ – 9⅝	4 15 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	93 - 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅜ – 7	5 16 4	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛ – 5⅛	4 16 0	Feb, Aug	..	..
100	4%	† Do. 4 per Cent. Mort. Deb. red. 1907.	97 – 18	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 –19	4 11 10	Jan, July	..	..
10	6/0	Notting Hill Electric Ord.....	11½ – 12⅝	6 0 0	March ..	11⅝	..
5	4/6	Oxford Electric Ord.	6⅜ – 6½	5 12 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 - 97	4 2 6	Jan, July	..	..
5	5.0	†St. James' & Pall Mall Elec. Ord.....	7⅜ – 8⅛	6 1 0	Feb, Aug	..	..
5	3/6	† Do. 7 per Cent. Pref.	6 – 7	5 0 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86 –91	3 17 0	Jan, July	88⅜	..
5	..	Smithfield Markets Electric Sup. Ord...	⅜ – 1⅝	..	Feb	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	1⅞ – 2⅜	6 3 0	April	2⅛	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜ – ⅝	3 6 9	..	..	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.....	1⅛ – 1⅜	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 –103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1½ – 2½	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 - 97	4 12 9	April, Oct	..	..
5	6/6	Westminster Elec. Sup. Ord.	9⅜ 10	6 3 0	Mar, Sept	9⅝	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅜	4 2 0	Jan, July	5⅜	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	88 – 93	4 6 0	Jan, July	83	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ – ⅝	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅜ – 1⅛	4 17 6	Jan, July	⅝	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	92 – 97	4 13 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db Stk.	94 - 97	4 13 0	Jan, July	..	..
10	9⅜	Bristol Tramways & Carriage Ord.	14⅛ – 14⅜	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8⅛ – 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 - 99	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅜ – 3	..	June, Dec	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.....	7⅛ – 7⅜	7 1 6	Feb, Aug	7⅛	7⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	99 – 102	4 18 0	April, Oct	101	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 – 81	5 11 0	May, Nov	..	..
St.	4%	Central London Ordinary Stock..	73 – 75	5 6 9	Feb, Aug	74⅛	74⅛
St.	4%	Do. 4 per Cent. Pref. Stock	92 – 94	4 5 0	Feb, Aug	94	..
St.	4%	Do. Deferred Stock	53 – 56	7 2 5	Feb	54⅛	..
100	4%	Do. 4 per Cent. Debs.	101 – 105	3 16 0	Jan, July	104	102½
St.	4%	Charing X. Euston & Hmpstd Per. Db. Stk.	51 – 54	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	18 – 111	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	45 – 47	4 5 0	Feb, Aug	48⅛	46⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 – 121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1899)	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½ – 14½	4 4 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	12⅞ – 13⅝	4 7 0	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	1⅞ – 2⅛	..	Feb, Aug	..	..
10	4/0	†G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 1	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ % b.St	98 –101	4 9 0	April, Oct	99⅛	..
10	9%	Imperial Tramways Ord.....	11½ – 12½	7 4 0	Mar, Sept	..	..
10	6%	Do. 6 per Cent. Pref.	6⅛ –11	5 9 1	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Debs.	97 - 19	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1⅛	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Deb. St.	94 –97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅛ – 1⅜	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6⅝ – 7⅛	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 – 86	4 13 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜ – 8⅜	5 14 8	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 88	4 11 0	Jan, July	87⅛	..
St.	..	Mersey Con. Ord. Stock	2 –4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	..	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅜ – ⅝	..	April..	⅝	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ – ⅝	5 7 0	Feb, Aug	⅝	⅝
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	..	..
5	..	New Gen. Trac. 6 per Cent. Cum. Pref.	⅜ – 1⅜	..	May	..	..
1	0/03	Potteries Electric Traction Ord.	⅝ – ⅞	7 3 0	April, Oct	..	..
1	5%	Do. 5 per Cent. Cum. Pref.	⅝ – ⅞	6 3 0	Feb, Aug	⅝	..
St.	4½%	Do. 4½ per Cent. Deb Stock	93 – 18	4 11 9	May, Nov	..	..
1	0/7½	St. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅞ – 1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	14 – 18	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London...	64 – 67	7 9 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	⅞ – 1⅛	..	..	3⅛	3⅛
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – 90	5 0 0	Jan, July	..	..

SHRE.	LAST DIVIDEND	NAME.	Price Wed., July 31.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO JULY 31. Highest.	Lowest.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅝ – ¾	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅝ – 1⅛	8 16 0	April, Oct	1⅛	..
1	9/4⅜	Babcock & Wilcox Ord.....	8⅞ – 9⅛	6 1 6	April, Oct	8⅞	8⅝
1	0/7½	Do. Pref.....	1⅜ – 1⅝	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅝ – 7⅛	6 18 0	July, Feb	..	..
5	3/0	† Do. 6 per Cent. Pref.	5⅝ 6⅛	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 –104	4 6 6	Jan, July	..	..
St.	4½%	St. British Thome'n-Houst'n 4½% 1st Mt.Db.	87 – 91	4 19 0	Mar, Sept	..	..
f	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	Feb, Aug	1⅛	..
£1.	4%	Do. 4 per Cent. Mort. Deb. Stock	19 – 64	6 5 0	Jan, July	..	..
½	..	Brush Electrical Engineering	⅜ – ⅝	..	March ..	⅝	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅞ 1⅜	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 –74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9½ – 10⅛	7 2 6	Jan, July	10⅛	10
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜ – 5⅝	4 9 0	Jan, July	..	..
St	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	105 –107	4 4 0	Nov, May	105½	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅝ – 1⅝	5 12 6	May, Nov	1⅝	1⅝
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb. (red.)	95 –100	4 10 0	Feb, Aug	..	..
1	0/2½	Chadburn's (Ship) Telegraph Ord.	1⅛ – 1⅜	8 0 0	March ..	1⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	5 7 0	April, Oct	..	..
3	2/0	*Crompton & Co. (Nos. 1 to 54,000)	1⅞ – 2⅛	7 1 0	Jan, July	2⅛	2
5	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	93⅛ – 96⅛	5 3 6	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝ – 1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£8 pd.)	1⅛ – 1⅜	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛ – 2⅜	4 11 6	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	82⅛	83⅛
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅜ – 1	10 0 0	Jan, July	⅜	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1 – 2	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜ – ⅞	..	Jan, July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	8 11 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 85/	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11½ – 12⅜	6 0 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5½	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½ –107½	4 3 6	Mar, Sept	107	105½
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	15 – 16	6 5 0	Feb, Aug	15⅛	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April, Oct	..	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	2⅜ – 2⅝	7 6 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛ – 1	6 0 0	May, Nov	..	..
St.	4½%	† Do. 4½ per Cent. Perp. Deb. Stock ...	93 – 96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	12/0	†Telegraph Construction & Maintenance	31½ – 32⅛	5 10 9	Mar, July	31⅛	31⅛
100	4%	Do. 4 per Cent. Deb. Bonds (1900) ...	19 – 102	3 18 3	Jan, July	..	..
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.	2⅛ – 2⅞	5 16 0	..	2⅛	2⅛
1	0/6	† Do. 5 per Cent. non-Cum. Preference	1⅛ – 1⅜	4 4 6	..	1⅜	1⅜
St.	5%	† Do. 5 per Cent. non-Cum. Preferred	1⅛ – 112	4 9 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 –104	3 17 0	June, Dec	102⅜	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105⅜ – 107⅜	4 4 0	June, Dec	107⅜	106
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf. xd and bonus	9¼ – 9⅝	6 3 0	Jan, July	..	..
£	..	Willans & Robinson Ord.....	1¼ – 1⅜	..	Apr, Oct	1⅜	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	2⅜ – 4⅛	..	Apr, Oct	4⅛	4
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	—	June, Dec	..	—
100	5%	Do. 5 per Cent. Debs. (red.)	85 – 88	5 2 0	June, Dec	..	..
St.	15/0	†Anglo-American	61 – 64	6 1 0	F,My,Ag,N	63⅜	62½
St.	30/0	† Do. Preferred	107 –109	5 10 0	F,My,Ag,N	110	107½
St.	12½	Do. Deferred	1⅞ – 1⅝	9 18 3	F,My,Ag,N	1⅞	1⅝
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 – 94	4 4 6	Jn,Ap,Jy,O	93	..
10	5/0	Cuba Submarine Ord.....	7⅛ – 8⅛	6 1 9	Feb, Aug	7⅜	—
10	10/0	Do. Preference 10 per Cent.....	15⅞ – 16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	2⅝ – 3⅜	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 – 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝-103⅝	4 7 8	Jan, July	..	..
20	6/6	†Direct United States Cable xd & rights	17⅜ – 17⅝	5 19 0	Ja,Ap,Jy,O	17⅝	15⅛
100	4½%	Direct West India Cable 4½% Bg. Db. (rd.)	99 – 101	4 9 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	124 –127	5 2 0	Ja,Ap,Jy,O	130⅜	124
St.	17/6	Do. 3½ per Cent. Pref. Stock	88 – 90	3 17 9	Ja,Ap,Jy,O	89⅜	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 –105	3 16 6	May, Nov	104⅛	103
10	2/6	Eastern Extension	13⅞ – 13⅞	5 4 0	Ja,Ap,Jy,O	14⅛	13⅜
†	Do. 4 per Cent. Deb. Stock	102 –104	3 17 0	Feb, Aug	105⅜	102⅜	
St.	4%	Eastern & S. African 4% Mort. Deb. 1909	99 –102	3 18 6	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	99⅛ -100⅜	4 1 0	May, Nov	98⅜	..
10	5/0	G.N. (of Copenhagen), with Coupon 71...	84 –86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermudas 4½% 1st Mt. Db. (red.	99 –101	4 9 0	June, Dec	..	..
25	£2/6	Indo-European	£6 – £8	5 12 0	May, Nov	..	..
100	$1	Mackay Companies Common	63 – 68	5 18 6	Jan, July	..	..
100	$1	Do. Preference	67 – 69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜ – ¾	..	April	..	..
100	4%	Pacific & European Tel. 4% Guar. Debs.(red.)	19⅜ – 20⅛	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10½	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛ – 1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	..	..
10	..	West India & Panama	1/16 – 1/8	..	May, Nov	1/8	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅝	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref	6⅞ – 7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 –101	4 18 0	Jan, July	99	—
10	3/0	Western Telegraph	13⅜ – 13⅝	5 1 9	Mr,Jn,O,D	13⅜	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 –92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 –104	4 16 0	Mar, Sept	..	..
5	5 0	†Chili Telephone	6½ –7	6 2 0	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1⅛ – 1⅜	4 14 0	Nov	1⅛	..
1	0/6	Do. 5 per Cent. Pref.	¾ – 1	5 0 0	May, Nov	..	..
St.	6%	†National Co. Pref. Stock	10 –109	5 10 0	Feb, Aug	110	108½
St.	6%	† Do. Def. Stock.....	105 –107	5 12 0	Feb, Aug	106⅜	106⅜
10	6/0	† Do. 6 per Cent. Cum. 1st Pref.	11 –13	4 12 0	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Cum. 2nd Pref.	5⅛ – 11½	5 4 0	Feb, Aug	10⅜	..
5	2/6	† Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅜ – 5⅝	4 11 0	Feb, Aug	5⅝	5⅛
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	95 – 97	3 12 0	June, Dec	96	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 102	3 18 6	Jan, July	..	..
1	0/9⅜	Oriental	1⅛ – 1⅜	5 2 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜ – 1⅝	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 – 94	4 5 0	Jan, July	90	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	98 –101	4 9 0	Jan, July	..	..
5	5/0	†United River Plate.....	6⅛ – 7⅛	6 18 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	5⅞ – 6⅜	6 6 8	Jan, July	..	..
10	6 2	Globe Telegraph & Trust.....	10⅝ –11	5 0 0	Ja,Ap,Jy,O	11	10⅜
10	4/0	Do. 6 per Cent. Pref.....	13⅜ – 13⅝	4 8 0	Ja,Ap,Jy,O	13⅜	—
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

The London Companies' Electric Supply Bill.

YET another Bill promoted with the object of improving the condition of electricity supply in the metropolis has met its fate in the House of Commons. The measure in question was the offspring of the great London electric supply companies, who desired to come to an arrangement whereby they could enjoy the benefits of a mutual supply system. At present no electricity supply undertaker is allowed to assist a neighbour in times of emergency by providing a supply of electrical energy, and each is surrounded by a solid barrier of regulations absolutely forbidding any attempt at linking up which might be calculated to reduce the cost of production, and consequently also the price to the consumer. This barrier the companies tried to break down, but they have failed. Their Bill was down for second reading, but the order was discharged on Wednesday evening, and the Bill is therefore dead. Even if it had passed its second reading, it is extremely improbable that it would ever have become law, as the end of the Parliamentary Session is near.

The Capacity Effect in Cables.

THE engineer who has charge of a high-tension alternating-current distribution system is not the only person who experiences trouble in respect of the capacity of cables. For years there has raged a fierce discussion on the utility of cable-charging devices, and numerous abstruse mathematical treatises have been written showing which harmonics are present and which absent, given certain conditions. Still, there appears to be little, if any, unanimity of opinion as to whether any practical device is necessary to protect the insulation. A similar problem presents itself in the case of underground or submarine cables for telegraphic or telephonic transmission of signals, although the object in view is somewhat different. In this case any oscillations which may be set up have no disruptive effect on the insulation, but they interfere in a serious manner with the efficient working of the cable. In a submarine telegraph cable the rate of signalling is reduced, while in a telephone cable there is the additional defect that the wave-form is mutilated beyond all recognition.

SIR WILLIAM PREECE, in his Paper before Section G of the British Association, described PUPIN'S device for overcoming this defect so far as telephone cables are concerned, but it is to be regretted that nearly every speaker in the discussion confined his remarks to telegraph cables. The principle of Prof. PUPIN'S method is, of course, quite familiar, but Sir WILLIAM made public a few practical details which are of considerable interest. He explained, for instance, that if the coils were spaced a mile apart then speech was perfectly clear, but that if groups of four coils were spaced at intervals of four miles then transmission was impossible. This statement simply bore out Prof. S. P. THOMPSON'S argument that, since the capacity is equally distributed along the cable, so also must be the self-induction, which constitutes the remedy. A large amount of self-induction situated at a point behaves, indeed, with respect to an electrical impulse exactly as a mirror does with respect to light. The ideal arrangement is to have the self-induction spread evenly over the entire length of the cable, and this does not appear to be impossible of accomplishment.

MR. B. S. COHEN, in our Correspondence columns, takes exception to some of Sir WM. PREECE'S remarks, and specifically refers to the bunching together of induction coils. It is, of course, quite clear that every case must be taken on its merits, and that it is, for economic reasons, desirable to employ large inductances, for it is probably cheaper to put in a few large coils than a large number of small ones. If the cable works sufficiently well with large coils, there seems to be no need to alter the arrangement, but the point that

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Mr. COHEN does not make clear is whether the same cable would work still better with more evenly distributed inductances.

Gas and Petrol Engines.

ELSEWHERE in this issue we publish a Paper by Mr. DUGALD CLERK dealing with gas and petrol engines. Undoubtedly the difficulty of temperature difference in the cylinder is one of very great magnitude. In the discussion which took place on this Paper Col. CROMPTON suggested that fused quartz might possibly be employed instead of iron, but it is obvious that this is too poor a conductor of heat. Yet it is some such material, with a very small coefficient of expansion, that is required, for the stress set up must be enormous if the coefficient of expansion is appreciable. The difficulty, of course, is to find a material of this nature which is also a good conductor of heat and at the same time possessed of considerable strength. Whether any serious work will ever be attempted in the direction of providing a new substance for use in the construction of gas engines remains to be seen, but at present the attention of designers and others seems to be directed more towards improvement in design.

Railways and Electric Tramway Competition.

THE half-yearly meetings of shareholders of the chief railway companies are usually of considerable interest, and those held recently were more particularly so owing to the statements made with regard to the effects of electric tramway competition, which is causing a very considerable reduction in short-distance railway passenger traffic. The story told by the chairman of the Great Northern Railway Co. proved no exception, and he, moreover, did not consider that tramway competition had yet reached its limits. Faced with the same difficulties, the London, Brighton and South Coast Railway have recently decided not to stop certain of their present steam trains at those stations where competition is keenest, and thus to accelerate the service to other stations. Electrification, with its consequent improved service, will, however, doubtless lead to the recovery of a certain amount of the lost traffic, as has been the case on other railways where it has been adopted.

Wireless Telegraphy and Hospital Ships.

AN interesting Paper on this subject was presented to a meeting of the British Medical Association at Exeter last week by Staff Surgeon H. L. NORRIS, R.N. It was very properly pointed out that, to be of the greatest possible use, a hospital ship should be available immediately at the termination of a battle. This, however, might not be easy of accomplishment because the enemy has power, under the Hague Conference, to order such a ship out of sight of her own fleet. The obvious remedy is to carry wireless telegraph apparatus, but, as the author pointed out, this might be declared as contraband of war, and hence a hospital ship carrying it would be liable to arrest. Certainly the point is not an easy one to settle, but it seems of such vital importance as to warrant the immediate and careful attention of the Hague Conference now sitting. The purpose is one for which wireless telegraphy is most admirably suited, and it would be a thousand pities if it were barred from such service.

Electric Traction on German State Railways.—According to the *Kölnische Zeitung* the German Government have decided to send a commission to the United States to report on the subject of electric traction on railways. Dr. Reichel and Messrs. Wittig, Frischmuth, Pforr and Lahmeyer are the members of the commission. Dr. Reichel is well known in connection with the Marienfelde-Zossen experiments which he carried out, on behalf of Messrs. Siemens & Halske, in the autumn of 1903.

The Board of Trade and London Traffic.—It is stated that the Board of Trade have decided to form a special temporary branch to deal with matters relating to London traffic. The branch will be under the direction of Col. Sir Herbert Jekyll, K.C.M.G., at present assistant secretary in the railway department. Mr. George Ranken Askwith has been appointed assistant secretary in the railway department, in succession to Col. Sir Herbert Jekyll, and Mr. J. G. Willis a junior assistant secretary in the same department.

Copper Production in the United States.—According to the *Electrical World*, the copper production in the United States reached 906,591,947 lb. in the year 1906, an increase of 18,000,000 lb. over 1905. The stock on hand at the refineries on January 1st last amounted to 92,470,792 lb., 25,773,236 lb. less than on January 1, 1906. The consumption of refined copper for the year, including 215,000,000 lb. of copper imported, was 680,000,000 lb., exceeding that of 1905 by 80,000,000 lb. The exports for the year aggregated nearly 450,000,000 lb.

Cement-insulated Trolley Hangers.—The *Canadian Electrical News* says that Mr. S. H. Anderson, of the Pacific Electric Railway, has been experimenting with a new type of insulated hanger for trolley wire construction. The variation from the present type of hanger consists in the use of Portland cement as an insulating compound. The outside or shell of the new type of hanger will not differ from the design now generally adopted. The interior stud, however, which supports the ear will be made in a die in the form of a spool, with the threaded portion as an extension from the face of one end. This spool-shaped piece will be centred in the shell and the interior of the shell then be filled with Portland cement. Insulation will be provided by covering the stud with two or three coats of enamel baked on so that it will be unaffected by water. The cement which will replace the usual insulating material will, therefore, not be called upon to act as a dielectric, but only to perform the mechanical duty of retaining the hanger bolt in position in the centre of the shell. It is expected that this method of construction will effect a saving in first cost.

Wireless Telegraphy Notes.—According to the *Western Electrician* wireless telegraph stations have been erected on Spitzbergen and at Hammerfest and Trömso, in order that "wireless" communication may be kept up with the Wellmann North Pole expedition.

In a report on the trade of Pará (Brazil) Mr. Southgate, the acting-consul, states that several concessions were given some time ago by the States of Pará and Amazonas for the working of the Schumacher system of wireless telegraphy within each individual State. A company was formed in New York to work the concessions and a good deal of material was sent out and stations established at Pará, Breves and Santarem, all in the State of Pará. The Federal Government, however, appear to have refused the necessary licence to operate between the two States, so that progress for the moment is suspended.

According to the *Evening Standard* a wireless telegraph message has been transmitted by the Poulsen system from the liner "Hellig Olav" to a distance of 3,300 kilometres. It is said that this is the first time that a message has been successfully despatched over so great a distance from a ship.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Brest—Dakar	July 22, 1907 ..	—
Kotonou—Libreville	July 18, 1907 ..	—
Gibraltar—Tangier.....	July 29, 1907 ..	Aug. 5, 1907

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Electric Lighting in Spain.—The U.S. Consul, in his report on the district of Bilbao, states that the extension of electric lighting in Spain is very noticeable. Even the villages in the interior are supplied with cheap lighting and power, being favourably situated in the vicinity of the many waterfalls which abound in the north of Spain. The Bilbao Co-operative Society increased their power last year and now utilise four turbines of 1,200 H.P., producing 800 kw. Their machinery was obtained from Swiss and German firms. La Compania Electra, in order to compete with the society, have reduced their price to 4d. per unit and have also extended their cables to the villages and towns on both sides of the river Nervion—a distance of about 9 miles—thus competing with small local companies. A Franco-Spanish company has been formed at Irun, on the frontier, for the purpose of putting up a water-driven electric plant to supply cheap power to the south of France.

Electrical Equipment of the St. Clair Tunnel.—The *Street Railway Journal* states that the tunnel under the St. Clair River, owned by the Grand Trunk Railroad, will soon receive its electrical equipment, which will consist of six single-phase Westinghouse locomotives. The overhead system will be used, the transmission and service wires to be carried on bridge work supported by towers with concrete foundations, braced by steel rods embedded in concrete. The tunnel, which has been used for steam traction for many years, will be cleaned, the interior painted white and well lighted by electricity. A power house is being built on the St. Clair River, which will contain two turbo-generators of 2,000 H.P. capacity. The tunnel consists of an approach on the American side some 2,500 ft. long, the tunnel proper about 6,000 ft., and the approach on the Canadian side, which is 3,100 ft. long. Five steam locomotives of special design are now employed to handle freight and passenger trains in the tunnel, and they haul daily from 800 to 1,600 cars.

Telephone Topics.—Lengthy and circumstantial accounts have appeared in many of the public journals regarding what is described as an "important agreement" between the Post Office authorities and the National Telephone Co., which is to put an end, as it is naively stated, "to all unnecessary competition and duplication of telephone services." On inquiry of the National Company, whose officers would, presumably, be acquainted with such a particular and instructive document, we learn that there has been no new agreement arrived at between the company and the Post Office. Mr. Geo. Franklin (president and general manager of the National Company) informs us that the statements which have recently appeared in the papers relating to this alleged agreement probably refer to *pourparlers* which have taken place between the parties on the question of the division of London into spheres of influence, on the lines fully contemplated by the original agreement, which is in full operation, and of which particulars have appeared in our columns. (The agreement was fully abstracted in "The Electrician" Electrical Trades' Directory and Handbook, 1905, pp. 463-464. Particulars of four schedules attached to the agreement, and of a new clause relating to the terms of purchase, which was agreed to in March, 1906, appeared in the 1907 issue of "The Electrician" Directory and Handbook, pp. 578-581).

Electric Oil Supply Indicator.—In the course of a description of a generating station at Laconia, which is worked by Diesel engines, the *Street Railway Journal* gives an account of a special arrangement of lamps and contacts which has been fitted up to show the condition of the oil supply in the small tanks, and also the temperatures of the circulating water discharged from the jackets. The height of the oil in the small tank is shown by an adjustable float, which is nearly balanced by a small weight connected with the float by a cord running over two pulleys. When the float sinks in the tank the weight is pulled up and a contact made in a lamp circuit which lights a 110 volt green-coloured incandescent lamp located in a conspicuous place on the engine room ceiling. This indication is given when about 4 gallons are left in the tank, leaving sufficient time for the engineer on duty to pump in more oil. The jacket water is discharged from each cylinder in a separate pipe. On each of the three pipes is a brass and steel thermostat, with double contacts. When the temperature of the discharge water reaches about 125°F. a 110 volt circuit is closed through a red lamp on the ceiling, one lamp being fitted for each pipe. Below this temperature the thermostatic indication is given by white lamps. The supply of cooling water can be increased or diminished by valves, according to the lamp indications.

Single-phase Railway in California.—According to the *Street Railway Journal*, the first single-phase railway in California to be worked at a frequency of 15 will shortly be opened between Visalia and Lemon Cove, a distance of 23 miles. The main sub-station from which the road will receive its power is being built near the centre of the line. Here three-phase 60 cycle current at 17,500 volts will be received from the Mt. Whitney Power Co. and converted by means of two 450 kw. motor-generator sets to 11,000 volt 15 cycle single-phase current for transmission to the transformer sub-stations. Each transformer sub-station will contain two 300 kw. 15 cycle transformers for stepping the transmission voltage from 11,000 down to the trolley voltage of 3,300 volts. The pole line will be of the single-pole bracket type, and will carry the No. 000 trolley wire by means of a catenary suspension, a $\frac{7}{16}$ in. steel messenger cable being used. The 11,000 volt transmission line will be carried on the same poles. The initial rolling-stock equipment will comprise four passenger cars. There will also be two trailers and a 50 ton electric locomotive. The current collector will be of the pantagraph sliding-contact type. The passenger cars will be provided with a quadruple equipment of 75 H.P. motors, with multiple-unit control connections and automatic air brakes. A quadruple equipment of 125 H.P. motors will be installed on the electric locomotive, with the new automatic Westinghouse air-brake equipment.

Pittsburg and Butler Electric Railway.—A description of this railway given in the *Electric Railway Review* shows that several new features have been employed in its construction. The generating units consist of two 750 kw. turbo-generators, designed to operate at 1,500 revs. per min., with steam at 160 lb. pressure and 100 deg. superheat. The turbines are connected to a 750 kw. three-phase generator with a 35 kw. exciter mounted on the same shaft. The generators are wound so that either single or three-phase current, at 3,300 or 6,600 volts, can be generated. The revolving fields are of the two-pole type, and the field winding is laid in slots and retained by non-magnetic wedges. The generators are entirely enclosed and are ventilated by ducts suspended under the turbine room floor. The intakes to the air ducts are provided with screens to prevent foreign material from entering the generators. Except in the cities operation will be by single-phase alternating current, with a line pressure of either 3,300 or 6,600 volts. Within the corporate limits of Pittsburg and Butler direct current will be used. Each car is fitted with four motors, and is controlled electro-pneumatically. When using direct current the four motors are operated in series. When operating on alternating current the motors are operated two in series, forming a unit, and the two units are operated in parallel, motors 2 and 4 having earth connections. The auto-transformer has three taps brought out to the unit switches. When starting, the lowest voltage tap is put in circuit by the unit switch, and each successive point in the master controller increases the voltage. Before passing from one tap to the other an inductive resistance is put in series with the circuit, the resistance being a part of the grid resistance used in the direct-current control. The number of steps on the master controller is the same for both types of current, the fifth point being the maximum speed position. It may be noted that in these motors the reversing is done in the field winding instead of in the armature, as is usual in direct-current practice.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, August 10th.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

3 p.m. Visit to the General Post Office Central Telephone Exchange, Carter-lane, E.C.

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ELECTRIC TRACTION ON RAILWAYS.*

III.—REMARKS ON THE CHOICE OF ACCELERATION AND MOTORS.

BY PHILIP DAWSON.

(*Continued from page 374.*)

Acceleration is the measure of the increase of speed relative to time, and is usually expressed in feet or metres per second per second or in miles per hour per second.

An acceleration of 1 ft. per second per second means that in one second the speed is increased by 1 ft. per second.

It is the chief characteristic, and one of the most valuable points, of electric traction that by its use greater rates of acceleration can be obtained than is possible with steam traction. This was clearly shown in the diagram giving accelerations on various railways on p. 45 of *The Electrician* for April 26, 1907.

The choice of what acceleration is to be used for any given condition of service requires most careful consideration, and is governed by many circumstances, which may vary in the case of each and every railway. For a given road, the number of people to be handled, the distance between stations, the gradients and curves, the maximum permitted speeds at junctions and suchlike, as well as the maximum stopping time at stations, are known and fixed quantities.

The first point to be settled is the size of train unit. In the case of multiple unit motor-car trains, the "unit" is the one considered when settling accelerations in contrast to the case of locomotive-hauled trains, where it is the maximum weight to be hauled which has to be considered.

With the first method, the train unit once settled, trains of any size can be operated by joining several train units together, provided the brake and multiple unit control has been designed for such purposes.

The acceleration chosen dictates the sizes and number of the motors, and influences the generating and distributing system as well as the load factor, and its importance is therefore at once apparent. The decision as to the proper acceleration depends on several factors, two of which enter into the preliminary investigation—viz., the length of average run and the average speed required. The final choice of acceleration can only be arrived at after the preliminary investigation already referred to, and after the results obtained by it are applied station by station to the whole system under consideration.

In this connection it may be interesting to consider what is the theoretical limitation to acceleration. It is the frictional resistance between rail and wheel (which under the most divergent conditions, good and bad, may be taken to vary between 1/3 and 1/13 of the total weight on the driving axles) that limits the acceleration (and also retardation, unless magnetic brakes are used) between 10·7 ft. and 2·5 ft. per second per second, according to the value of the coefficient of friction.

Results obtained by Mr. W. P. Potter, of the General Electric Co. of America, confirm within limits the above statement. He finds that the tractive coefficient, or $\frac{\text{Weight on driving wheels}}{\text{Total tractive effort}}$, depends on the general conditions of the rails as shown below :—

	Tractive coefficient.
Dry rail	28 per cent. ... 28 per cent. with sand.
Thoroughly wet rail	20 ,, ... 25 ,, ,,
Greasy rail	15 ,, ... 25 ,, ,,

Ice and snow may make the coefficient even lower, and increase rolling friction.

In practice the maximum acceleration is limited firstly by the comfort of the passengers, and secondly by the motor and power plant which would have to be installed; and, so far, except experimentally, an acceleration of 5 ft. per second per second has never been exceeded.

In order to convert acceleration expressed in feet per second per second into miles per hour per second multiply the acceleration by 0·682.

Before proceeding further in the consideration of the question of acceleration it may be as well briefly to recall the equations which connect speed, distance, time and acceleration :—

Velocity is the rate of change of position with respect to time, and is measured by the distance passed over in a given time. Or, using the differential notation, $v=\frac{ds}{dt}$.

Acceleration is rate of change of speed with respect to time, and is expressed as $\frac{dv}{dt}$.

If the velocity varies uniformly with respect to time, then $v=kt$, where k is a constant, so that the acceleration

$$a=\frac{dv}{dt}=\frac{d(kt)}{dt}=k=\frac{v}{t}.$$

In other words, if v is the change of velocity in time t, the acceleration is expressed as v/t. Hence, if the velocity varies uniformly from v_1 to v_2 in time t the acceleration would be

$$a=\frac{v_2-v_1}{t}. \quad \ldots\ldots \quad \text{(I.)}$$

The average speed during time t is

$$V_{aver.}=\frac{v_2+v_1}{2}. \quad \ldots\ldots \quad \text{(II.)}$$

And since speed varies uniformly the distance travelled will be

$$s=\frac{v_2+v_1}{2}\,.\,t,$$

$$=\frac{v_2+v_1}{2}\,.\,\frac{v_2-v_1}{a}$$

$$=\frac{v_2^2-v_1^2}{2a}. \quad \ldots\ldots \quad \text{(III.)}$$

Substituting $v_2=at+v_1$ from equation (I.), in equation (III.) we have

$$S=\frac{(at+v_1)+v_1\,.\,t}{2}$$

$$=v_1t+\frac{1}{2}at^2. \quad \ldots\ldots \quad \text{(IV.)}$$

If the body starts from rest v_1=zero and $s=\frac{1}{2}at^2$.

The acceleration due to gravity, usually denoted by g varies slightly with the latitude. The following are a few values :—

England	32·20 ft. per second per second.
Philadelphia	32·16 ft. ,, ,,
Paris	32·18 ft. ,, ,,

When the only force acting upon a body is its weight, *i.e.*, when it is falling freely, the acceleration is g.

Hence if a body is dropped and falls s feet in t seconds, then the relation between s and t is given by the equation

$$s=\frac{1}{2}gt^2,$$

and the speed attained will be $v=gt$.

Force and Work.—There are many definitions of work, but the following is generally accepted as being the most accurate. A force is said to do work when it moves its point of application through any distance in its own direction, and the work done is measured by the product of the force into the distance through which it moves.

When a force does work on a body it gives it an amount of energy equal to the work done. Hence, if there is a

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Table I.—*Conversion Table for Miles per Hour, Feet per Second, &c.*

—	Miles per hour to feet per min.	Miles per hour to feet per sec.	Miles per hr. to metres per sec.	Metres per sec. to miles per hour.	Metres per sec. to feet per min.	Metres per sec. to feet per sec.	Ft. per min. to miles per hour.	Ft. per min. to metres per sec.	Feet per sec. to miles per hour.	Feet per sec. to metres per sec.
1	88	1·47	0·4469	2·237	196·86	3·281	0·01136	0·00508	0·6818	0·3048
2	176	2·93	0·8938	4·474	393·72	6·562	0·02273	0·01016	1·3636	0·6096
3	264	4·40	1·3407	6·711	590·58	9·843	0·03409	0·01524	2·0454	0·9144
4	352	5·87	1·7876	8·948	787 44	13·120	0·04545	0·02032	2·7272	1·2192
5	440	7·33	2 2345	11·185	984·30	16·400	0·05682	0·02540	3·4091	1·5240
6	528	8·80	2·6814	13·422	1,181·16	19·680	0·06818	0·03048	4·0909	1·8288
7	616	10·27	3·1283	15·659	1,378·02	22·96	0·07954	0·03556	4·7727	2·1336
8	704	11·73	3·5752	17·896	1,574·88	26·24	0·09091	0·04064	5·4545	2·4384
9	792	13·20	4·0221	20·133	1,771·74	29·52	0·10227	0·04572	6·1363	2·7432
10	880	14·67	4·4690	22·370	1,968·60	32·81	0·11364	0·05080	6·8181	3·0480
11	968	16·13	4·9159	24·607	2,165·46	36·09	0·12500	0·05588	7·4999	3·3528
12	1,056	17·60	5·3628	26·844	2,362·32	39·37	0·13636	0·06096	8·1817	3·6576
13	1,144	19·07	5·8097	29·081	2,559·18	42·65	0·14773	0·06604	8·8635	3·9624
14	1,232	20·53	6·2566	31·319	2,756·04	45·93	0·15909	0·07112	9·5453	4·2672
15	1,320	22·00	6·7035	33·556	2,952·90	49·21	0·17045	0·07620	10·2271	4·5720
20	1,760	29·33	8·9380	44·741	3,937·20	65·62	0·22727	0·10160	13·6362	6·0960
25	2,200	36·67	11·1725	55·926	4,921 50	82·02	0·28409	0·12700	17·0452	7·6200
30	2,640	44·00	13·4070	67·111	5,905·80	98·43	0·34091	0·15240	20·4543	9·1440
35	3,080	51·33	15·6415	78·296	6,890 10	114·80	0·39773	0 17780	23·9633	10·6680
40	3,520	58·67	17·8760	89·482	7,874·40	131·20	0·45454	0·20320	27·2724	12·1920
45	3,960	66·00	20·1105	100·667	8,858·70	147·60	0·51136	0·22860	30·7814	13·7160
50	4,400	73·33	22·3450	111·852	9,843·00	164·00	0·56818	0·25400	34·0905	15·2400
55	4,840	80·67	24·5795	123·037	10,827·30	180·40	0·62500	0 27940	37·5995	16·7640
60	5,280	88·00	26·8140	134·222	11,811·60	196·80	0·68182	0·30480	40·9086	18·2880

	In./sec.² to miles/hr./sec.	In./sec.² to metres/sec.²	Miles/hr./sec. to in. per sec.²	Metres/sec.² to in. per sec.²	Miles p'r hr. per sec. to klmt. per hr. per sec.	Klmt. per hr. per sec. to metres per sec.²	Klmt. per hr. per sec. to miles per hr. per sec.	Klmt. per hr. per sec. to ft./sec.²	Klmt. per hr. per sec. to in./sec.²	Met. per sec.² to Klmt./hr./sec.	Ft. per sec.² to Klmt./hr./sec.	In. per sec.² to Klmt. per hr./sec.
1	0·0568	0·0254	17·6	39·37	1·609	0·278	0·6214	0·91	10·92	3·6	1·097	0·0914
2	0·1136	0·0508	35·2	78·74	3·218	0·556	1·2428	1·82	21·84	7·2	2·194	0·1828
3	0·1704	0·0762	52·8	118 11	4·827	0·833	1·8642	2·73	32·76	10·8	3·291	0·2742
4	0·2272	0·1016	70·4	157·48	6·436	1·111	2·4856	3·64	43·68	14·4	4·388	0·3656
5	0·2840	0·1270	88·0	196·85	8·045	1·389	3·1070	4·55	54·60	18·0	5·485	0·4570
6	0·3408	0·1524	105·6	236·22	9·654	1·667	3·7284	5·46	65·52	21·6	6·582	0·5484
7	0·3976	0·1778	123·2	275·59	11·263	1·944	4·3498	6·37	76 44	25·2	7·679	0·6398
8	0·4544	0·2032	140·8	314·96	12·872	2·222	4·9712	7·28	87·36	28·8	8·776	0·7312
9	0·5112	0·2286	158·4	354·33	14·481	2·500	5·5926	8·19	98·28	32·4	9 873	0·8226
10	0·5680	0·2540	176·0	393·70	16·090	2·778	6·2140	9·10	109·20	36·0	10·970	0·9140
11	0·6248	0·2794	193·6	433·07	17·699	3·056	6·8354	10·01	120·12	39·6	12·067	1·0054
12	0·6816	0·3048	211·2	472·44	19·308	3 333	7·4568	10·92	131·04	43·2	13·164	1·0968
13	0 7884	0·3302	228·8	511·81	20·917	3·611	8·0782	11·83	141·96	46·8	14·261	1·1882
14	0·7952	0·3556	246·4	551·18	22·526	3·889	8·6996	12·74	152·88	50·4	15·358	1·2796
15	0·8520	0·3810	264·0	590·55	24·135	4·167	9·3210	13·65	163·80	54·0	16·455	1·3710
20	1·1360	0·5080	352·0	787·40	32·180	5·556	12·4280	18·20	218·40	72·0	21·940	1·8280
25	1·4200	0·6350	440·0	984·25	40·225	6·944	15·5350	22·75	273·00	90·0	27·425	2·2850
30	1·7040	0·7620	528·0	1181·10	48·270	8·333	18·6420	27·30	327·60	108 0	32·910	2·7420
35	1·9880	0·8890	616·0	1377·95	56·315	9 722	21·7490	31·85	382·20	126·0	38·395	3·1990
40	2·2720	1 0160	704·0	1574·80	64 360	11·111	24·8560	36·40	436·80	144·0	43·880	3·6560
45	2·5560	1·1430	792·0	1771·65	72·405	12·500	27·9630	40·95	491·40	162·0	49·365	4·1130
50	2·8400	1·2700	880·0	1968·50	80·450	13·889	31·0700	45·50	546·00	180·0	54·850	4·5700
55	3·1240	1·3970	968 0	2165·35	88·495	15·278	34·1770	50·05	600·60	198·0	60·335	5·0270
60	3·4080	1·5240	1056·0	2362·20	96·540	16·667	37·2840	54·60	655·20	216·0	65·820	5·4840

constant force F acting through a distance s, the energy E developed will be given by the equation

$$E=Fs.$$

If F is not constant, then for a short distance ds we have

$$dE=F\,ds,$$

or for the whole distance $E=\int_0^s F\,ds$.

Also we know that $v=\frac{ds}{dt}$ or $ds=v\,dt$.

Hence $$dE=Fv\,dt,$$

or $$\frac{dE}{dt}=Fv,$$

or at any instant the rate of change of energy with respect to time is the product of force into velocity.

The kinetic energy of a body, or energy due to its velocity v, is expressed by

$$E=\frac{Mv^2}{2},$$

where M=the mass of the body.

Differentiating with respect to v, we have

$$\frac{dE}{dv}=Mv, \text{ or } dE=Mv\,dv.$$

Hence $$\frac{dE}{dt}=Mv\frac{dv}{dt}.$$

But $$\frac{dE}{dt}=Fv=Mv\frac{dv}{dt}.$$

Hence $$F=M\frac{dv}{dt}$$

$$=Ma, \text{ where } a=\text{acceleration}.$$

In practical use, M is expressed in terms of the weight and a in increments of velocity (either miles per hour or feet or metres per second).

We have seen that

$$F=M\times a, \text{ or } a=\frac{F}{M}.$$

Hence, since the weight (W) of any mass (M) is the force with which gravity acts upon it, and which will, if unop-

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posed, produce in it an acceleration g, we may write for this special case of the formula $F = Ma$,

$$W = Mg \text{ or } M = \frac{W}{g}.$$

Thus, if a force of F lb. acts upon a mass weighing W lb. the acceleration produced is obtained from formula $F = \frac{Wa}{g}$

and $a = \frac{F \times g}{W}$ ft. per second per second $= \frac{0{\cdot}682 \times F \times g}{W.}$ miles per hour per second.

Hence, if W_1 be the weight of the body in tons of 2,240 lb. each, then the weight in pounds $W = 2{,}240\ W_1$. Then, if F be the applied force in pounds, the relation between it and acceleration is

$$F = \frac{2{,}240 W_1 a}{g},$$

or

$$a = \frac{F \times g}{2{,}240 W_1} \text{ ft. per second per second}$$

$$a_1 = \frac{F \times g \times 0{\cdot}682}{2{,}240 \times W_1} \text{ miles per hour per second}$$

$$a_1 = 0{\cdot}00979 \frac{F}{W_1} \text{ miles per hour per second.}$$

Transforming this expression in terms of F we have

$$F = 102{\cdot}1\ W_1\ a_1,$$

Which means that

To produce an acceleration of 1 *mile per hour per second in any train a force of* 102·1 *lbs. must be applied for every ton weight of the train.*

It may be noticed that no allowance is made in these considerations for rotating masses, as this is a refinement which may be dispensed with until the more exact calculations, applicable to any specific case, are taken up.

To obtain an acceleration of 1 metre per second per second the pull per ton = 45·63 lb.

In the case of any train in motion there are a series of forces acting upon it. Each force considered separately will tend to produce a certain acceleration, the magnitude of which will depend upon the weight of the train and the magnitude of the force. The acceleration will be positive or negative according to the direction of the force tending to produce it. The algebraical sum (*i.e.*, taking positive and negative signs into account) of these accelerations will be the resultant acceleration.

Thus, if we have a series of forces acting, F′, F″, F‴, &c., they will tend to produce on a mass M accelerations which we may call a', a'', a''' respectively—*i.e.*,

$$F' = Ma'$$
$$F'' = Ma''$$
$$F''' = Ma'''$$

Hence $\Sigma F = M\Sigma a$, or resultant forces = mass X resultant acceleration.

Hence the acceleration of any train depends on the resultant of all forces acting upon it.

The forces normally acting on an electric train are—

The tractive effort exerted by the motors.

The frictional resistances between wheels and rails and at bearings, &c.

The air resistance and windage.

The inertia of rotating masses in the trains, which can be represented by a fixed condition to the mass, and will be discussed fully later.

With these brief remarks on the general aspect of acceleration we may now approach the study of any given case.

In order to enable us to consider that important point, the choice of acceleration, it is first necessary to predetermine the average travelling speed, including stoppages, for any given line and service; for it is on this that the choice of the most favourable acceleration depends.

The above table is given to assist comparison between acceleration expressed in different units and to expedite transformation from one set of units to another.

The first thing which has to be decided upon is the average speed at which trains are to run. For preliminary investigations it suffices to base calculations upon the average distance between stations. Before the type, size and number of motors are definitely decided upon, calculations for every run on the line in question have to be gone into in order to definitely ascertain that the proposed equipments are suitable for the work, and that the average speed at which it is proposed to run will not be too costly, either from the capital or from the operating point of view, and that local restrictions of speed at junctions, curves and possible signal stops do not necessitate an unduly high maximum speed.

(To be continued.)

BURTON-ON-TRENT CORPORATION TRAMWAYS.

The results of the working of the Burton-on-Trent Tramways, as shown in the general manager's report for the year ending March 31, 1907, cannot be considered satisfactory. The expenditure has increased, and in spite of the fact that the income is greater than last year, the deficit has also gone up. The reduction in receipts is attributed to the opening of the Burton & Ashby Light Railway. This system, which is the property of the Midland Railway Co., is a competitor on one of the routes and has running powers over part of the Corporation's system. The usual order of things is here reversed, as the more general complaint is that the tramways relieve the railways of their short-distance traffic.

The total income this year amounts to £16,335. 6s. 1d. (including £759. 11s. 1d. received on account of the Light Railway Co.) This is an increase of £224. 11s. 9d. on last year's income. The current consumption per car-mile is 1·187 units. This includes the working of the light railway cars. The estimated units per car-mile used by the Corporation's cars alone is 1·16, as against 1·27 last year. The total number of units purchased was 551,758, as against 553,512; of these the estimated number consumed on the Corporation's cars was 489,427. The total revenue per car-mile has fallen from 8·88d. to 8·87d., while the operating expenses have been reduced from 6·24d. to 6·14d., notwithstanding the reduced mileage. The passengers carried have decreased from 3,505,520 to 3,383,527. This reduction is also attributed to the opening of the Burton & Ashby Light Railway, as its route extends further into the country. The parcel traffic shows an increase on last year's working, the actual numbers being 43,955 and 41,163. An endeavour has been made to popularise the parcels delivery system and the number delivered has increased from 2,518 to 3,609; as the expenditure on this account is small, there is a resultant useful revenue. It is satisfactory to learn that the system has been particularly free from accidents this year and the general manager remarks that when the annual mileage in the somewhat narrow streets, together with the level crossings, is considered, every credit should be given to the inspectors, drivers and conductors for having assisted in this result. Twenty cars are at present in use, and three of these have been equipped during the year with top-deck covers at a cost of £288. 15s., which amount has been charged to the capital account. The power for working the tramways system is purchased from the electricity department who charge 2d. per unit for the first 100,000 units and 1½d. per unit afterwards. The number of articles left in the cars during the year was 260 as against 380 last year.

A comparison of the various items of expenditure with those

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of last year, together with the cost per car-mile in both cases, is given below :—

	1905-06.	1906-07.	Cost per car-mile. 1905-06.	1906-07.
Balance brought forward	—	£229 11 6	—	0·13d.
Traffic Expenses.				
Salaries, wages, &c.	£4,163 3 3	3,927 2 3	2·30d.	2·24d.
Oil, grease, waste, &c.	59 1 1	69 14 11	0·03d.	0·04d.
Uniforms	164 1 10	105 14 10	0·09d.	0·06d.
Bags, punches, tickets &c.	53 5 4	109 16 6	0·03d.	0·06d.
Fuel, light and water at depot	53 12 0	86 4 11	0·03d.	0·02d.
Cleaning, salting and sanding track	118 14 8	134 0 3	0·07d.	0·08d.
Licences	15 0 0	15 0 0	0·01d.	0·01d.
Cleaning cars	334 4 3	316 16 7	0·18d.	0·18d.
Miscellaneous	19 18 4	18 4 3	0·01d.	0·01d.
Total traffic expenses	£4,981 0 9	£4,732 14 6	2·75d.	2·70d.
Repairs and Maintenance.				
Cars	£946 9 0	£1,021 18 9	0·52d.	0·58d.
Overhead work, &c.	223 9 2	308 11 10	0·12d.	0·18d.
Permanent way	170 9 1	347 4 8	0·10d.	0·20d.
Cables, &c.	33 11 10	31 7 0	0·02d.	0·02d.
Machinery and tools	11 11 9	9 12 9	—	0·01d.
Depot and buildings	46 18 7	1 6 6	0·03d.	—
Fuel, light and water at depot	36 16 3	41 11 0	0·02d.	0·02d.
Miscellaneous	—	9 0 9	—	—
Total repairs & maintenance expenses	£1,469 5 8	£1,770 13 3	0·81d.	1·01d.
Management Expenses.				
Salaries and wages	£325 11 2	£326 1 10	0·18d.	0·19d.
Printing & stationery	58 7 1	53 6 1	0·03d.	0·03d.
Loan & stock expenses	150 13 7	180 10 0	0·08d.	0·10d.
Fuel, light & cleaning offices	51 6 3	45 1 3	0·03d.	0·03d.
Miscellaneous	52 18 4	107 12 9	0·03d.	0·06d.
Rent, rates, taxes and insurance	658 1 3	658 10 2	0·36d.	0·37d.
Third party insurance	373 2 8	262 10 0	0·21d.	0·15d.
Total management expenses	£1,670 0 4	£1,633 12 1	0·92d.	0·93d.
Power Expenses.				
Power	£3,195 7 5	£2,844 15 2	1·76d.	1·62d.
Power to M.R. cars	—	341 9 7	—	0·20d.
Total power expenses	£3,195 7 5	£3,186 4 9	1·76d.	1·82d.
TOTAL OPERATING EXPENDITURE	£11,315 14 2	£11,323 4 7	6·24d.	6·46d.
Interest on 3% stock	£1,597 5 2	£1,559 18 8	0·88d.	0·89d.
Discount on bills	835 8 4	906 15 5	0·46d.	0·52d.
Contribution to redemption fund	1,237 18 9	1,253 11 8	0·68d.	0·71d.
Contribution to sinking fund	525 9 8	525 9 8	0·29d.	0·30d.
Interest on loans	306 15 0	444 3 10	0·17d.	0·25d.
Sinking fund on loans	—	199 1 2	—	0·11d.
Bank interest	21 14 9	—	0·01d.	—
Renewal fund account	500 0 0	1,000 0 0	0·28d.	0·57d.
	£5,024 11 8	£5,889 0 5	2·77d.	3·35d.
TOTAL EXPENDITURE	£16,340 5 10	£17,441 16 6	9·01d.	9·94d.

The receipts obtained during this year and last were :—

	1905-06.	1906-07.	Per car-mile. 1905-06.	1906-07.
Traffic receipts	£15,653 17 8	£15,102 4 11	8·64d.	8·60d.
Sale of time-tables	25 11 4	8 14 2	0·01d.	—
Lost property fees	2 0 10	3 0 3	—	0·01d.
Advertising	420 4 0	445 12 0	0·23d.	0·25d.
Bank interest	—	8 5 11	—	0·01d.
Ashby Light Rly. mileage	—	759 11 1	—	0·43d.
Deficiency	229 11 6	1,106 10 5	0·13d.	0·64d.
Damage to cars	9 0 6	7 17 9	—	—
TOTAL	£16,340 5 10	£17,441 16 6	9·01d.	9·94d.

Deficiency, March 31, 1906	£229 11 6
" " 1907	876 18 11
Total deficiency	£1,106 10 5

The gross revenue account for the 12 months shows a surplus of income over expenditure of £5,012. 1s. 6d., compared with £4,773. 5s. 5d. last year, and represents 5·4 per cent. on the capital expenditure. The repayment of debt and interest charges amount to £4,889. 0s. 5d., compared with £4,502. 16s. 11d. last year. Previous to the year's results being known it was decided that instead of contributing £500, the sum of £1,000 should be set aside, raising the reserve fund to £2,945. 3s. 11d. This sum is invested in outside securities and the interest thus earned will be added to the reserve fund. Apart from this contribution the trading account shows a surplus of £123. 1s. 1d., and as the contribution of £500 in 1905-06 resulted in a deficiency of £229. 11s. 6d. and in addition there is the contribution of £1,000 made in 1906-07, the accounts show a deficiency of £1,106. 10s. 5d., to be provided out of the rates. The undertaking paid £517. 14s. 8d. in local rates and £3,237. 5s. 5d. to the electricity department for power. The capital expenditure to date is £105,150.

GREAT WESTERN RAILWAY.—ELECTRIC POWER AND LIGHTING AND THE ELECTRIFICATION OF THE HAMMERSMITH & CITY RAILWAY.

(*Continued from page 632.*)

Main Generating Plant.—There are eight main generating sets, four in each side bay of the engine room, each set consisting of a Belliss engine driving direct an E.C.C. alternator generating three-phase current with a frequency of 50 cycles per second, at a voltage of 6,300 to 6,600 volts, the normal output being 750 kw. with an overload capacity of 25 per cent. Each main engine is of the three-crank triple-expansion high-speed type, with forced lubrication, running at 250 revs. per min. The dimensions of the cylinders are 18½ in., 27 in. and 40 in., with an 18 in. stroke. The bearings, cross-head guides, &c., are oiled by forced lubrication, provided by a small pump in the crank chamber, driven off the high-pressure eccentric strap, and each line of cylinders and valves is lubricated by a separate sight-feed lubricator. The governor is controlled by an electric motor, from the main switchboard gallery, for adjusting the speed of the engine during synchronising, and for adjusting the load between the sets running in parallel. An emergency valve, electrically controlled from the switchboard, is also fitted to each engine, so that steam may be entirely cut off in an emergency

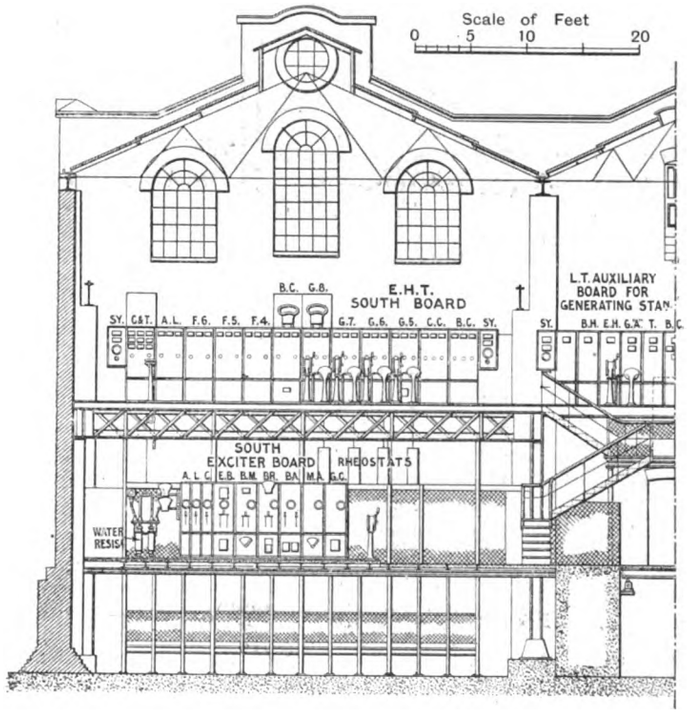

FIG. 8.—ELEVATION SHOWING ARRANGEMENT OF SOUTH PORTION OF SWITCHBOARD.

References to Panels.—F 4, F 5, F 6 = Feeder. G C, G A, G 5, G 6, G 7, G 8 = Generator. B C = Bar-Coupling. E B = Excitation Bars. B M = Booster Motor. B R = Booster. B A = Battery. T = Transformer. A L = Artificial Load. S Y = Synchronising. A = Arc Lighting. L = Lighting. C = Cranes. M A = Motor. C C = Cross Connector. C & T = Charge and Test. B H = Boiler House. E H = Engine House.

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The main three-phase generators are of the ordinary rotating field magnet type, the total weight of the magnet wheel and flywheel being about 11 tons. The stationary armature is wound in open slots, and is star connected, but the centre point is not permanently earthed. Screws are provided for sliding the armature sideways for inspection when required.

Auxiliary Plant.—The auxiliary plant is divided into eight sections each of 150 kw. capacity, four of which are normally used for supplying direct current at about 225 volts for excitation purposes and arc and incandescent lighting and for the overhead crane motors, the remaining four sets being normally used for supplying three-phase current at about 650 volts for driving the various three-phase motors throughout the generating station, including those for the stokers, the coal conveyers, the condenser circulating pumps and other pumps. The four direct-current auxiliary sets consist of a generator driven by a Belliss compound engine, a generator driven by a three-phase induction motor designed for the full high-tension pressure of 6,600 volts and two batteries. The batteries, which form a stand-by for the excitation supply, are worked in parallel with the generators in the usual way, with motor-driven boosters for charging them from the 'bus bars. Each generator with its battery can be worked by itself and used for exciting any or all of the main generators when required. There is, therefore, a complete stand-by generator and battery for the excitation supply.

The four three-phase auxiliary sets consist of a generator driven by a Belliss compound steam engine, a synchronous generator driven by a direct current 225 volt motor, and two sets of static transformers. The motor-driven three-phase generator can be run reversed, taking current through the transformers from the high-tension supply or direct from the auxiliary three-phase supply, and delivering direct current to the exciter switchboard, and it can also be used, when required, for charging feeders. Each set of static transformers is delta connected, and the high-tension winding of each transformer is divided into two sections which can be connected up either in parallel or in series. The high-tension windings of the transformers are normally connected up in parallel and can then be connected to the high-tension switchboards. The high-tension windings can be connected up in series when it is desired to obtain a pressure up to 13,000 volts for testing purposes.

Overhead Cranes.—In each main engine-room bay and in the workshop a 20 ton overhead travelling crane is provided, all three motions of which are worked by series motors supplied with direct current at 220 volts. Each motor is controlled by a tramway type controller placed in the driver's cab and provided with fly-back handle. An over-winding switch is provided in connection with the hoisting motion, which cuts off the supply to the motor when the load has been hoisted to a fixed point. An automatic electric brake is provided as well as a mechanical brake. A 10 ton crane is also provided in the condenser bay, with lifting and lowering motion, driven by a series motor supplied with direct current at 220 volts, and the controller of which is operated by means of ropes from floor level. The travelling motions are worked by hand.

SWITCH GEAR.

The switch gear includes two main H.T. switchboards for controlling the 6,500 volt three-phase circuits, which are placed one at the west end of each of the main engine-room bays, an auxiliary switchboard for controlling the 650 volt three-phase circuits being placed on the same gallery as the main switchboard control panels, and two switchboards for controlling the 220 volt D.C. circuits placed one at the west end of each of the main engine-room bays on the floor level immediately under the front of the main switchboard control gallery (Fig. 11).

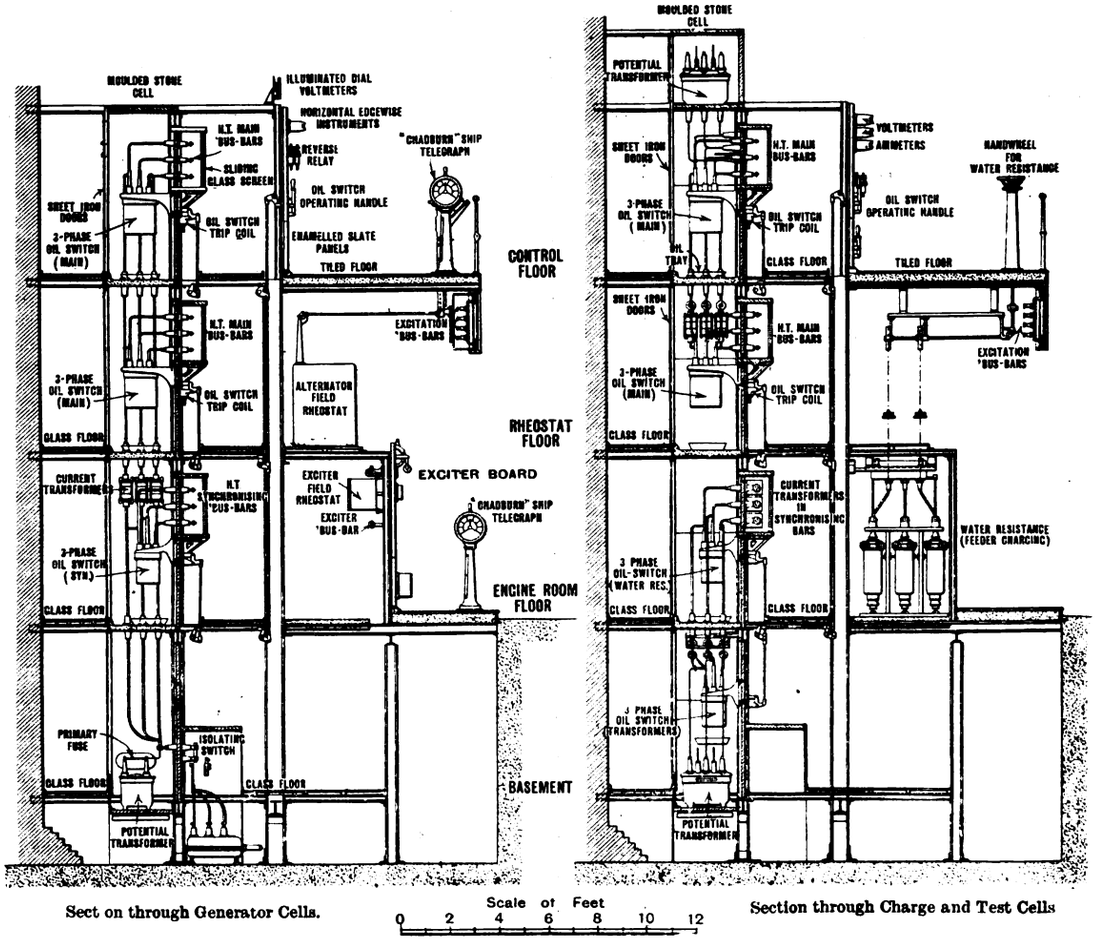

FIG. 9.—CROSS SECTIONS THROUGH SWITCHBOARDS AT PARK ROYAL GENERATING STATION.

The high-tension part of each main H.T. switchboard (Fig. 12) extends from the basement to a total height of 33 ft., and consists of a steel framework filled in with stone slabs. Each circuit runs from the bottom to the top of the board, and is separated from the rest by vertical stone partitions. The switches, transformers, &c., on each circuit are further separated from each other by four horizontal partitions which divide the whole structure into a set of fireproof cells. The control board is placed on a gallery about 14 ft. above the engine-room floor, and slightly in front of the H.T. portion of the switchboard. The main switches are worked from the control panels mechanically by rods and cranks. All the instruments are placed on the control panels, and are worked from transformers, so that all connections on these control panels are low-tension. Immediately in front of the control panels are placed the main generator field-regulating resistance columns, the engine governor and emergency valve switches, and also a set of signal columns and indicators by which the switchboard attendant can communicate with the drivers of the engines.

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Each main H.T. switchboard controls the four 750 kw. main generators in the bay opposite which it is placed, three 0·15 H.T. feeders, a 0·15 cable to an artificial load tank and some local branch circuits, namely, a H.T. distributor feeder to a local distributing centre, a H.T. circuit to one of the banks of auxiliary transformers, and, in the case of the north main board, the H.T. circuit for the

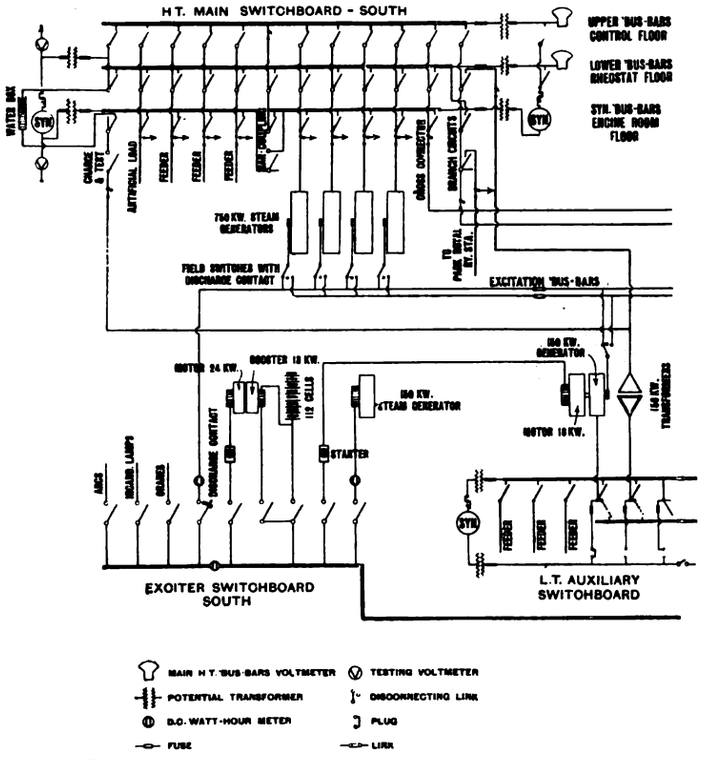

FIG 10.—DIAGRAM OF SWITCHING AND SYNCHRONISING CONNECTIONS.

induction motor-generator. The two main H.T. switchboards can be worked independently of each other, or can have their 'bus bars connected for working in parallel. Each board has a duplicate set of main 'bus bars and also a set of H.T. synchronising 'bus bars which are used in connection with the testing and charging of the feeders, as well as for synchronising the generators. Each set of main 'bus bars is placed in a stone chamber with wire-woven glass sliding doors in front running the whole length of the switchboard structure in front of the switch cells.

The circuit for each main generator or feeder starts in the basement in a cell (Fig. 13) which contains the three-core cable sealing and dividing box, to which it is connected by three-phase changing links. These links are arranged and shaped so as to enable any core of the cable to be connected to any one of the conductors of the switchboard circuit, in order that the phases of a circuit may at any time be arranged correctly and symmetrically with reference to the phases of other circuits irrespective of the position of the cores of the cable in the box. Above the phase-changing links a set of disconnecting links is provided which, when open, disconnect the cores of the cable from the switchboard circuit and connect them direct to earth. The links can be locked in the "open" or "earthed" position. On the cable side of these disconnecting links a set of glow tubes is connected to indicate when the cable is alive. The circuit then passes upwards and is branched and connected to three oil-break automatic switches, the lowest of which is directly connected to the synchronising 'bus bars, while the two upper switches connect to one or other of the two sets of main 'bus bars. The main 'bus-bar switches are used as selector switches and also serve as a stand-by to each other. The machines or feeders can be changed from one set of 'bus bars to the other through the machine's own switches, or through a separate bar-coupling switch. The necessary pressure transformers and series transformers for working the instruments are teed off or connected in the circuit on the cable side of the main switches, and these same transformers energise the relays in connection with the main switches.

Each main generator is provided on its control panel with a watt-hour meter, an indicating wattmeter, a power-factor indicator and an ammeter. Each feeder is provided on its control panel with three ammeters.

With regard to the automatic protection of the H.T. circuits, the main switches on each of the main generator circuits are provided with instantaneous reverse and with time-limit overload relays, which, however, can be neutralised when desired. Time-limit overload relays are also provided on the main feeder circuits, the cables cross-connecting the two main boards, the 'bus-bar coupling circuits, the branch circuits and the feeder H.T. synchronising selector switches which also connect the H.T. water box. The relays are mounted on the front of the control panels. When an overload or reverse current relay is called upon to operate, a plunger rises and is made to close a D.C. circuit, supplied from the battery, which energises the tripping solenoids in connection with the H.T. switch control mechanism. As soon as the main switch is tripped an auxiliary switch is automatically operated which opens the tripping circuit and, at the same time, closes another D.C. circuit which causes a signal lamp on the face of the control panel to light up. A green pilot lamp is mounted in front and in the centre of the control board, so as to show that the D.C. tripping supply is in order.

A charge and test panel is provided on each main H.T. switchboard for the purpose of testing and charging the main H.T. feeders, either by means of a water box consisting of three-phase series variable water resistances or from the auxiliary 650 volt switchboard through the step-up transformers. Ammeters are provided for indicating the charging current, and earth detecting voltmeters are connected to the synchronising bars and also to the main 'bus bars, so that a fault on the feeder being charged or on the network which is being supplied from the main 'bus bars will be indicated at once.

The synchonising 'bus bars are divided into two halves in the centre of each H.T. board, one half being normally used for synchronising the generator circuits and the other half for charging and testing the feeders. The two halves of the synchronising bars can be coupled together, and the feeder charging gear can then be connected through the synchronising bars to any generator which it may be desired to test, or the generator synchronising gear may be used in connection with the feeders. Each control switchboard is provided with two sets of synchronising gear mounted on swing panels at either end of the board. The synchronisers are worked from pressure transformers, one being normally used for generators and one for the feeders, and each including three lamps, a rotating synchroscope and a pair of paralleling voltmeters.

By means of a system of shafting and cams at the back of each control board a complete mechanical interlock has been provided in connection with the operating mechanism of the H.T. switches. The interlock is divided into two halves, corresponding to the divi-

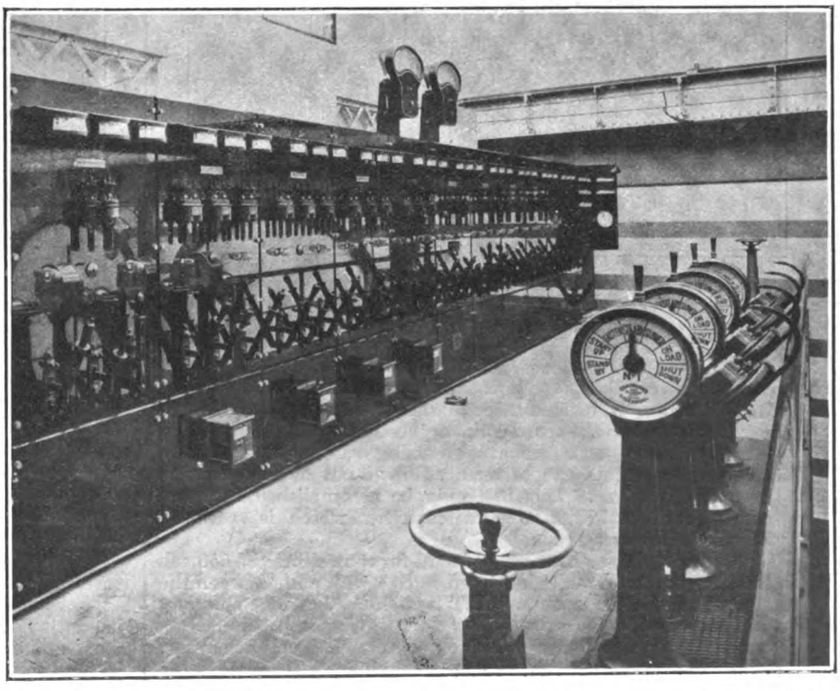

FIG. 11.—VIEW SHOWING PORTION OF NORTH MAIN CONTROL SWITCHBOARD AT PARK ROYAL GENERATING STATION.

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sion of the synchronising bars into generator and feeder sections. The mechanism of the switch for coupling the two sections of the synchronising bars is arranged so that when the two sections are uncoupled the two halves of the interlock are also uncoupled, and so that when the two sections are coupled the synchronising bars and interlock act as one unit.

The following are the principal results accomplished by the interlocking on each main H.T. board:—

The simultaneous connection of the step-up transformers and of the water resistance to the feeder charging bars is prevented.

The simultaneous connection of either synchroniser or of the water resistance to both sets of main, 'bus bars is prevented.

The closing of any synchronising switch on any generator or feeder panel locks off all other generator synchronising switches. The closing of any charging switch on any feeder panel locks off all other feeder charging switches.

The closing of the synchronising bar coupling switch can only be done with all synchronising and charging switches open, and when the synchronising bar coupling switch is closed only one synchronising or charging switch can be closed at a time throughout the whole board.

No generator or feeder main switch can be closed until the synchronising or charging switch of the same circuit is closed.

No generator or feeder main switch corresponding to one set of main 'bus bars can be closed unless the synchronising or charging gear is connected to, and therefore supplied from, the corresponding set of main 'bus bars.

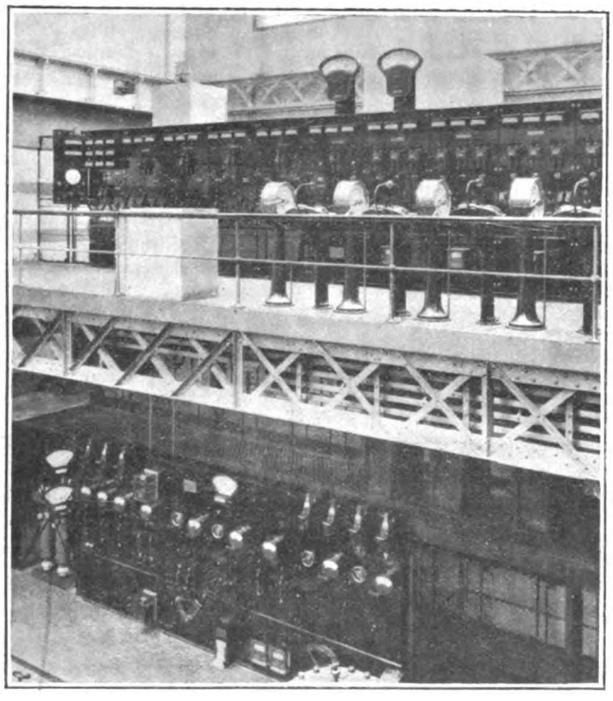

FIG. 12.—GENERAL VIEW OF SOUTH MAIN H.T. SWITCHBOARD AND EXCITER BOARD AT PARK ROYAL.

If any generator or feeder switch is opened it is at once automatically interlocked so that it cannot be again closed until its circuit has been connected through at least one synchronising or charging switch to the corresponding 'bus bars.

At any time, when all the synchronising switches are open, the interlock as a whole can be readily thrown out of gear, so as to leave switches free. This can only be accomplished, however, from a position behind the switchboards, which is accessible through locked screen doors.

The auxiliary three-phase switchboard for controlling the 650 volt alternating-current circuits is placed in line with and between the control panels for the two main H.T. switchboards. The auxiliary board is fitted with two sets of 'bus bars which can be coupled together when required. Each of the three-phase 650 volt generators and the L.T. side of each set of step-up auxiliary transformers can be connected to either set of 'bus bars through one or other set of contacts of a special double switch, which is fitted with an overload release and an interlock between the two sets of contacts. The auxiliary feeder circuits which supply the various three-phase motors driving auxiliary plant throughout the buildings are connected to the top set of 'bus bars through switches with overload releases. This arrangement of the auxiliary switchboard was designed to enable either the steam or motor-driven 650 volt alternator to supply from the lower set of 'bus bars for charging or testing purposes, while the other alternator or other bank of transformers (stepping down) supplies from the top set of 'bus bars the auxiliary motors.

Synchronisers are provided on swing panels to enable synchronising to be effected with either set of 'bus bars.

The two D.C. 220 volt exciter switchboards can be worked separately or in parallel, and each controls one of the auxiliary D.C. generators, one of the storage batteries, three feeders for working the D.C. crane motors and the arc and incandescent lighting of the power house, and an excitation circuit for the main and auxiliary three-phase generators. The excitation circuit from each of the D.C. exciter switchboards is run under the main switchboard-control galleries, and the field circuits of each three-phase generator can be connected to either of the two excitation circuits by means of change-over switches with discharge resistances operated from the front of the main switchboard gallery. There is no automatic protection between the exciter board and the excitation bars, but a switch is provided with a discharge resistance and contacts, so that if necessary the excitation to the fields of the alternators can be switched off collectively on the exciter board.

In a separate shed outside the engine-room two tanks, supplied with circulating water, are provided, each of which forms an artificial load of a capacity corresponding to the output of one of the main generators. The electrodes for these tanks can be raised or lowered by hand, or by means of small three-phase motors which can be run in either direction, and which are controlled by means of change-over switches placed in convenient positions on the main switchboard galleries.

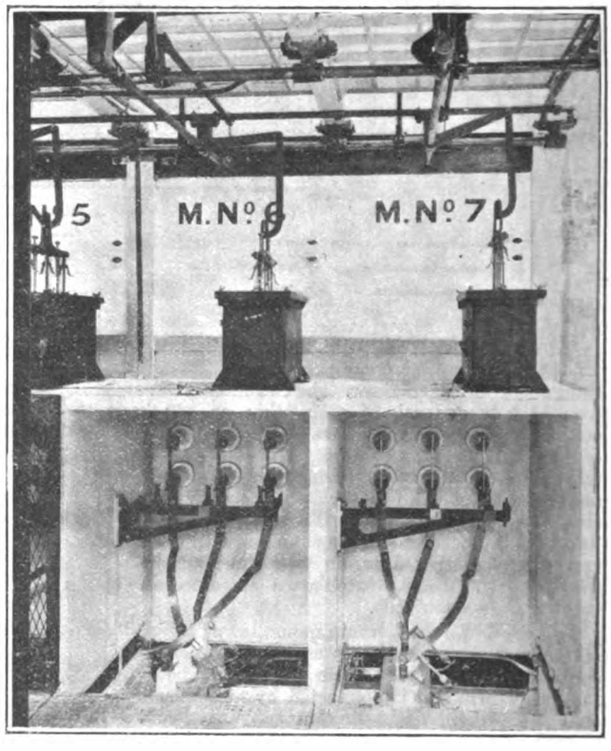

FIG. 13.—CELL IN BASEMENT UNDER H.T. SWITCHBOARD SHOWING PHASE-CHANGING LINKS.

A portable air compresser set, electrically driven by a D C. motor which can be worked from plugs in connection with the D.C. lighting circuits, is provided for cleaning the H.T. windings and switch gear about the engine room.

Lighting and Power Circuits.—The general lighting of the main buildings and also of the coal siding and the approach road, is carried out by 40 "Oriflamme" arc lamps. The lighting installation also includes about 200 incandescent lamps.

The feeder cables from the 650 volt A.C. auxiliary switchboard and from the D.C. switchboards are three-core and single cables respectively, rubber insulated, lead-covered and armoured with steel wire. For the branch circuits rubber-insulated and braided cable is used, drawn into heavy gauge Simplex steel conduit. With the exception of the offices, watertight fittings have been used throughout.

(*To be continued.*)

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ON THE PUPIN MODE OF WORKING TRUNK TELEPHONE LINES.*

BY SIR WILLIAM PREECE, K.C.B., F.R.S.

Summary.—The author gives a historical account of the efforts that have been made to overcome the inductive effect on long telephone lines. He more particularly discusses the Pupin method, and gives theoretical reasons for its success. Some practical details are also touched upon.

In 1896 I read a Paper before Section A at Liverpool on "Electric Disturbances in Submarine Cables," in which I dealt with the subject of long-distance speaking by telephone. I pointed out that disturbances were due to energy being in the wrong place. An alternating current wave, set up in a telephone transmitter by a complete sonorous vibration impressed on the diaphragm, flowing for the period *a g*, Fig. 1, if its voltage were indicated by *a b* when *positive* and by *d e* when *negative*, would possess in one received wave an energy proportional to the area bounded by *a b c e f g*, if it were wholly utilised, but would only describe the area *a a' d d' g* if the unshaded portion of the figure were proportional to the energy radiated or leaked away, absorbed as a charge, or dissipated as heat. The attenuated current thus indicated shows what radiation, leakage, capacity, hysteresis and resistance may do to absorb energy and deteriorate the clearness and loudness of speech as well as limit the distance to which ordinary speaking is practical. I had previously,† in 1887, pointed out that the product of the capacity (K) and the resistance (R) gave a law which approximately indicated the distance to which speech was possible on telephone circuits. It accurately indicates the distance on single-wire submarine cables. In 1890 I read a Paper giving the calculations on which the London–Paris telephone line, with its cross-channel cable, was designed and constructed in association with the French engineers. In 1892 it was determined to establish trunk telephone wires between the great commercial centres of Great Britain. All the calculations were based on the KR law. It is quite certain that this law is not absolutely true, for it neglects the factor of self-induction. The KR law is properly of the order KR/L, but experience has shown

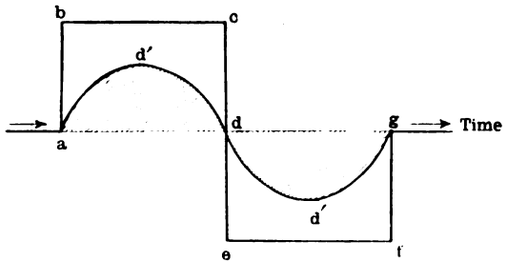

FIG. 1.

that inductance on short metallic loops is so small compared with capacity that it may be neglected. Mutual induction between the two wires compensates to some extent the self-induction in each wire. In long underground cables and long aerial wires, however, the influence of inductance becomes evident as the length of lines increase. On the other hand, capacity also increases owing to the variation of the mutual (wire to wire) capacity and the capacity of each wire to earth, which becomes an important factor with concentric cables or with any departure from symmetry. This is why "Hughes's twist" is so valuable and so superior to the "Cross" system so general in America. It not only completely prevents "cross-talk," but it secures a constant capacity with earth.

It is known that the effect of this electromagnetic induction is beneficial in one sense, as I pointed out in 1896, and it has been made more beneficial in another sense by Prof. Pupin (1899), who has shown how we can reduce the weight of copper used on trunk lines and also how we can extend the distance to which ordinary speech is practical.

Pupin's system is not so much the neutralisation of the effects of electrostatic capacity by those of electromagnetic induction as a system of hastening the discharge of pent-up energy without additional loss by breaking it up into many successive steps. In a long submarine cable discharge is a slow process and all in one operation. The KR is great and the frequency small. In a "loaded" line the discharge is much more rapid, for it is performed simultaneously in several successive stages, of much shorter length and with much less waste or distortion.

The factors of energy E and Q are pent up by capacity and inductance. Energy is wasted by resistance, leakage, induction, radiation, reflection and interference. This waste of energy means diminution of amplitude, attenuation of wave volume, and loss of speech, while electromagnetic induction improperly placed means distortion of wave form, external disturbances and loss of articulation.

The factors that are involved in the problem of long-distance speech are so numerous and so diverse that all attempts to solve them by mathematics, except on very general grounds, have proved fruitless and only approximately true. It has been only by practical experiment that success has been attained. The defect in the mathematical investigation of the problem appears to be the neglect of the prime and principal factor, *energy*, and the assumption that there is in Nature something analogous to *negative* energy. Energy, like matter, is always positive and it cannot be annihilated by a negative sign. But mathematical reasoning undoubtedly guided Prof. Pupin in going as far as he has. Our president, Prof. Silvanus Thompson, took out a patent on December 21, 1891, No. 22,304, where he very carefully considered the subject and very nearly anticipated Pupin.

The establishment of the telephone trunk system in Great Britain in 1896 showed the practical value of the KR law in determining the construction of an aerial system. The weight of copper used in the main trunk lines has been criticised, but the only fault committed was that I did not specify enough. Paris can speak with Liverpool, Manchester and Hull, but it cannot do so commercially with Glasgow and Edinburgh. London can speak with Aberdeen, Inverness and Dublin, but not with Cork. Pupin coils have not been applied permanently to the Post Office trunk lines, but careful experiments have been made to feel the way to do so and thus perhaps extend the range of Paris talks in Great Britain.

I designed a new form of cable and described it in my Paper read before Section A in Liverpool in 1896, but no one has as yet ventured to test its merits.

A cable, designed by Mr. Willoughby Smith, of four wires symmetrically twisted on the inside of a gutta-percha tube so as to leave an air space, failed telephonically from imperfect symmetry. It was laid across the Irish Channel, from Nevin to Newcastle. Concentric underground gutta-percha covered cables were laid in 1895 from the General Post Office to Nine Elms, and failed also from want of symmetry in the capacities between the conductors and earth. A magnificent underground trunk line for telegraphic purposes was commenced between London and Birmingham in 1897, but it was not completed while I was in office (I retired in 1899), and owing to its success it has now been extended, or is being extended, to Manchester, Liverpool, Leeds and Glasgow in the north, and to Plymouth and Dover in the south.

In 1899 Pupin proposed his coils, and by the enterprise of the American Bell Telephone Co. and its allies great progress has been made in the States in developing the system. Many very valuable experiments have also been carried out in Great Britain by the Post Office and by the National Telephone Co. It speaks well for the technical spirit of the age that splendidly equipped experimental laboratories have been established in London at the General Post Office, National Telephone Co.'s Central Station, the Eastern Telegraph Co.'s headquarters, Electra House, and in New York and Boston, in America, by the American Bell Telephone Companies. Very satisfactory advances have been made in Great Britain, and excellent reports of progress have been published by the Institution of Electrical Engineers in London. An admirable Paper on "Telephonic Transmission Measurements," by B. S. Cohen and G. M. Shepherd, was read before this institution on May 9th last, which elicited an excellent discussion.

I purpose to report the results of a careful inspection I made in New York in April last, of the very successful work done in this direction by the New York Telephone Co., under the able direction of their chief engineer, Mr. John Carty.

The factors that enter into the problem of trunk wire working are very numerous and complicated. They are *physical*, *commercial* and *personal*. It is, as I have said, not a question of mathematics, but of experiment.

What are the factors in long-distance speaking, in addition to the ordinary elements of electrical energy—viz., Electromotive Force, Resistance, Capacity, Inductance, Current and Time?

1. Eddy-current heat losses in diaphragms.
2. Hysteresis in coils, cores and circuits.
3. Change of wave shape due to storage and waste of energy in other forms.
4. Attenuation of waves due to dissipation of energy and its absorption.
5. Loss of the higher notes called "harmonics."
6. Reflection of waves from breaks and alterations in circuits.
7. Reduction of efficiency due to leakage, polarisation, radiation and induction to neighbouring bodies.
8. The reactions and interferences of neighbouring circuits.
9. The constant change of every condition of circuit elements by switching through to different towns and subscribers.
10. The variable formation of the human mouth, tongue and teeth of different users.
11. Defects of articulation and want of experience in handling the apparatus by the users.

* Read before Section G of the British Association at Leicester, August 5, 1907.

† On the "Limiting Distance of Speech by Telephone," *Proc.* Roy. Soc., Vol. XLII., February 17, 1887.

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12. The inefficiency of hearing and interpretation of the listener and the absence of silence about him.

13. The absence of telephonic education in both speaker and listener.

The remedies are self-education, selection of proper apparatus, symmetry of circuits, the proper distribution of the controlling factors, the restoration of stored-up energy, the alliance and mutual forbearance of users and suppliers.

It is clear from this incomplete enumeration of the factors involved that the problem of the reproduction of clear speech at a variable distance is a very complicated one. It has been solved by very patient plodding, by incessant experiment, and by judicious compromise.

The KR law as applied to submarine cables is very useful for calculating the speed of working, but inasmuch as trunk telephone circuits are aerial and telephonic currents alternating and very variable in form, self and mutual induction must play an important part in their propagation. It was found, however, by experiment that metallic circuits of copper wire suspended in air and constant in character were actually benefited by self-induction.

Hence in designing the trunk system of the Post Office in 1891 inductance* was neglected.

Ever since Faraday in 1853, while I was assisting him in his experiments, detected two waves in the underground conductors between London and Liverpool, I have regarded the propagation of intermittent electric currents, whether alternating or direct, in ordinary insulated conductors to be in the form of waves.

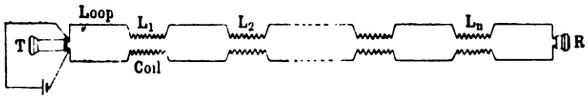

FIG. 2.

Cromwell Varley in 1870 made an artificial cable equivalent to one of 12,000 miles long, and showed in evidence 10 distinct currents in it flowing at the same time. I experimented in 1876 at the Silvertown Works on an artificial cable constructed for Mr. Stearn to duplex the Atlantic cable, and obtained evidence of several distinct waves present at the same time with beautiful effects of interference in duplex working. These were waves of energy in its electric form propagated with comparatively slow and variable velocity.

Hertzian waves developed in 1887 are disturbances of the æther of very high frequency, of the order of millions per second, having the velocity of light—viz., 186,000 miles per second. Telephonic oscillations in insulated copper conductors are of the order of hundreds per second, having a variable velocity of the order of a 1,000 miles per second. The length of a telephonic wave may be from 1 to 100 miles, but that of a Hertzian one may be from 1 ft. to 10,000 ft.

Prof. Pupin in 1900 and Duddell in 1903 established the existence of these waves in telephonic circuits and measured their lengths, their form and their damping.

Between the voice of the sender at one end and the sensation of hearing at the other end the energy passes through several forms, acoustic, thermic, electric, magnetic, kinetic and potential.

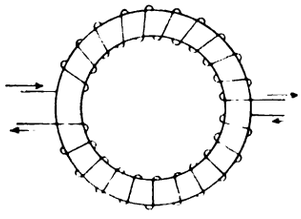

FIG. 3.

The relations of these changes are very varied and complicated. The elements of energy in its electric form are coulombs (Q) and volts (E). Currents are coulombs per second. Thus time is an essential element and the frequency of waves and therefore their length is a dominant factor in the solution of the question. When electrical energy is transmitted by an insulated metallic circuit like a telephone line we must first consider the capacity (K), resistance (R) and inductance (L) of the circuit.

The capacity (K) depends on its form, its length, the dielectric coating and the surrounding medium.

The resistance (R) depends on the metal used, its form and its mass. Copper is universally used for telephonic transmission.

The influence of inductance (L) depends on the electromagnetic conditions present in the field, on the form of conductor, and on the direction and rate of change of the currents.

The capacity absorbs energy. It holds up a certain portion of the quantity of the charge tending to attenuate the current but ready to restore it in reaction. The insulating medium gets warm by hysteresis.

The resistance which has to be overcome absorbs a portion of the energy which takes the form of heat and is lost.

The Pupin coil stores up another portion of the energy which, like a spring under pressure, is ready to react on the release of the forced condition and is restored. The frequency, within the region of ordinary speech, which may be said to have from 200 to 2,000 sonorous vibrations per second, is not changed, but as distance increases the fine harmonics which give the individual quality or *timbre* of voice disappear and only the low fundamental tones remain. Thus the length of a circuit allowing a practical talk is limited by the amount of capacity and resistance present. It is increased by the presence of induction when this induction is put in the right place and is of the right character and amount. It is aided by the human ear, which has a magical gift for interpreting into speech what appear to be the merest phantoms of sonorous vibrations.

The above diagram (Fig. 2) illustrates a complete telephone circuit with its Pupin coils. It is one of a pair of twin copper lines of No. 14 B. and S.G., weighing 65 lb. per mile, twisted about each other and insulated with dry paper, having a resistance of 13·7 ohms and a capacity of 0·065 microfarads per mile. Each coil has a pure soft iron ring core 3 in. in diameter, made of fine varnished wires to

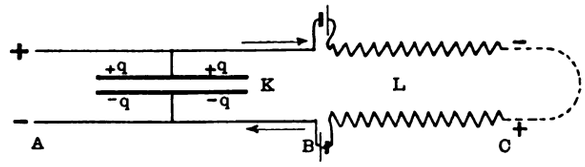

FIG. 4.

reduce hysteresis to the lowest possible point, and is wound with two wires which are connected as shown in Fig. 3. Mutual induction is thus eliminated and self-induction alone is active.

It has an inductance of 0·252 henry. Such an underground cable with 112 pairs of wires (loaded) has been laid between New York and Philadelphia, 90 miles long. Nineteen of these pairs are of No. 16 B. and S.G. for a short distance. The Pupin coils have been fixed at every 1¼ miles, and it works with a commercial efficiency which Mr. Carty calls a "14-mile talk." The standard of comparison is a mean circuit of 10 miles of No. 19 (1 mm.) copper wire in the City of New York, which is called the "10-mile talk standard."

Each individual section can be shown diagrammatically, thus: Fig. 4.

The straight lines indicate the two wires of the loop, the wavy line the inserted coil. The capacity of the loop is shown as a condenser and the E.M.F. of the coil as a battery cell. In the diagram they are shown separate, but in activity they act together to maintain the flow of energy and retain the form of wave. ABC represents *time*. It does not represent length of space or distance. AB and BC must be in tune.

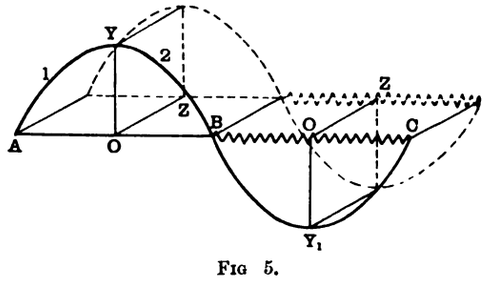

FIG 5.

In Fig. 5 (1) is the rise of the wave when energy is absorbed and held up.

(2) is the decay of the wave when energy is restored.

Thus in each section energy is held up as the wave is rising and given out again slightly impaired by hysteresis but reinforced by induction when the wave is falling. It is evident, from the clearness of speech, that the sum of all these actions results in a continuous flow of alternations without change of frequency when the limiting distance is not exceeded. When this limit is reached the waves are so attenuated that speech becomes impossible.

On the other hand, it must be pointed out that although capacity is greater than inductance in its influence on the current waves, they neither absorb energy permanently. They only hold it up for a time. They drag out or prolong the currents. Energy can be absorbed or it can change its form, but it can not be destroyed. This is the doctrine of the conservation of energy.

Resistance, radiation and leakage do absorb energy and dissipate it wastefully. Our first object is to prevent waste of energy, and our

* Inductance is the coefficient of mutual and self-induction. It is indicated by M or L and is really a length measured in centimetres.

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second object to direct the pent-up energy into a proper channel to maintain the amplitude and form of the waves. This is what Pupin has done.

If we represent the action in a Pupin section by Fig. 5, where AB represents the metallic loop and BC the double coil, AC being equal to one period of one short fundamental wave, then OY will represent the maximum positive E.M.F. acting during the period AB, and OY_1 that acting in the coil during the same period. o_2 represents the quantity of electricity (Q) flowing during the period; Q is assumed constant. It is a state of strain in the medium between the wires. A solid figure described by Q and E (the variable E.M.F.) would represent the energy propagated, except the minute losses in the section, which are inherent to the conditions of the circuit. These losses multiplied eventually absorb all the energy and the limit of speech is reached. The influence of the coils is clearly a time influence. It is a case of tuning. They break up a circuit into a series of sections in which the energy flows in virtually simultaneous steps instead of being prolonged and damped down as it would be in a long submarine cable. The frequency remains unaffected. It is clear that in each wave-length there are four distinctly marked points, a, a', d, d', where changes of phase affect the distribution of energy and its factors. It is as though Q remained for an instant in AB and E in BC. They then change partners with an action that continues the forward movement, but with a slight loss due to waste.

I regard the action as somewhat analogous to the transmission of mechanical impulses through a line of billiard balls in touch with each other. An impulse (Fig. 6) is imparted by a driven ball striking the first ball, which is compressed, as shown in the figure by the lower ball; its elasticity by its expansion transmits the impulse to the next ball, with a slight loss of energy, and so on successively through the series until the last ball is impelled away as though no energy had been absorbed. The impulse corresponds to the current, the elasticity to the E.M.F., and the ball to the Pupin section with its capacity (mass), its resistance to change

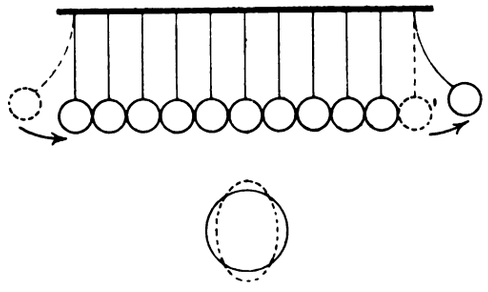

Fig. 6.

of form and its resilience. This is not unlike the action of air particles against the tympanum of the ear when carrying sonorous vibrations.

The size of coils and the distance apart is chiefly a question of experiment. It varies with every circuit. In fact, the solution of the problem is a case of experience and compromise. Sir John Gavey has obtained the best results with coils on long lines at $1\frac{1}{8}$ miles and at every 2 miles on shorter lines; Mr. Carty at every $1\frac{1}{4}$ mile on long lines, but at every $\frac{3}{4}$ mile on short lines. The former gets better results with no iron ore, the latter prefers fine iron-wire as a core. Mr. Gill, engineer-in-chief of the National Telephone Co., places them in certain definite cases at every mile and uses iron cores. These coils are enclosed in iron cylinders filled with resin oil and buried as shown in Fig. 7.

It certainly appears to me that iron must experience some hysteresis, though very minute, and, therefore, be a cause of loss of energy, and though it must enhance the strength of the currents by intensifying the lines of magnetic force it is of more consequence to reduce the loss of energy and prevent the attenuation of the waves.

If the coils are improperly placed or imperfectly designed they do more harm than good. Thus coils which are quite effective at every mile may destroy speech altogether if lumped together at every 4 miles.

Among the numerous disturbing influences are those of the instruments at each end.

Not only does the receiving apparatus act as a reflector and inductor, but it is a source of secondary radiation and it causes interference and attenuation. This is very much aggravated by the constant changes of local lines at each end. Hayes has diminished this disturbance by *tapering*, or the gradual reduction of the inductance of the loading coils as the terminal stations are approached.

Tapering is distinctly beneficial. Virtually, as all oscillograms show, it becomes a series of small waves of one frequency, probably, according to Kennelly, of about 800—upper G in the treble—which remains constant. There must be a slight loss of energy in each section of precisely similar percentage. The result is the curve of attenuation must be a logarithmic one, and its logarithmic decrement or attenuation constant is obtainable. The smaller this decrement is made the greater the length of the curve and the further speech can be carried. This is the function of the Pupin coil. The relative and continued attenuation of currents is shown by Fig. 8, where (1) is an unloaded line, (2) a loaded line without tapering, and (3) the same line loaded and tapered. This is due to Mr. Hayes, of the American Bell Telephone Co., who read an admirable Paper at the St. Louis Congress in September, 1904.

Through the courtesy of Mr. Gill I am able to exhibit some admirable models, which show the behaviour of the voltage and currents throughout the whole circuit, with their changes of phase and their variation of amplitude. They are based on calculation and not on experiment. The white-coloured line is the voltage (P.D.), and the red line the currents. They convey an admirable impression of the complicated character of the problem. The wave-length of the fundamental note, by loading, is reduced to one-third, and, of course, the velocity is reduced in the same proportion, but the strength of the received currents is increased from 2·7 to 3·80 milli-amperes. All disturbances are filtered out. Speech becomes clearer and louder.

The inductance coils are usually of three classes:—

Heavy, having	0·252	henry.
Medium ,,	0·176	,,
Light ,,	0·133	,,

Loading is not so efficient at present on aerial loops because it has not been so thoroughly thrashed out as on underground cables, but it is distinctly beneficial, and the solution of the more compli-

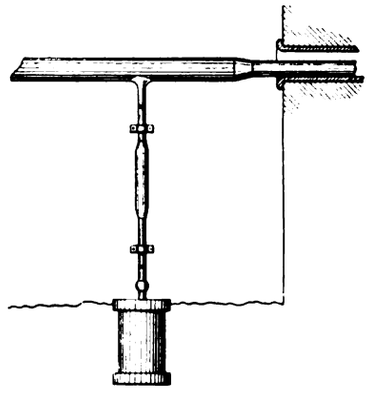

Fig. 7.

cated problem is well in hand. At present the dimensions of the Pupin coils for aerial loops, as well as the spacing, have to be determined experimentally for each circuit.

The United States Conference Standard cable is:—

Weight of copper (lbs.)	20
Diameter (mils)	36
Resistance per mile (ohms)	44
Capacity wire to wire (mfd.)	0·06
Capacity wire to earth (mfd.)	0·088
Insulation (megohms)	500
Effective limit (miles)	41·6

in terms of 10 mile-talk.

N.B.—Effective limit does not mean effective commercial conversation. This would approach 60 miles.

Our English standard cable is now nearly the same—viz., No. 20 copper wire, of 20 lb. weight per mile, having a diameter of 36 mils., a resistance of 44 ohms per mile, a capacity of 0·056 mfds, an inductance of 0·001 henry, and an insulation of 200 megohms. It would be a great advantage if this cable were made an International Telephone standard. Mr. Gill has done so with this object in view.

Sir John Gavey experimented on the underground cable which was commenced under my guidance when I was in office in 1897. The cable consists of 76 wires laid up in pairs. Each wire weighs 150 lb. per mile, having a resistance of 5·5 ohms at normal temperature (60°F.). Each conductor is insulated with paper twisted in pairs, each pair being insulated. There are 38 pairs arranged symmetrically and insulated in layers. The only insulation is dry paper and air, and the covering is lead. The diameter of the cable is $2\frac{1}{2}$ in. The capacity is 0·068 mfd. per mile and the insulation about 30 megohms per mile. It is drawn into 3 in. cast-iron pipes. It was designed and laid for telegraphic purposes, but with the idea that for long distances metallic circuits might be commercially valuable without mutual interference.

In the extension of the system to Glasgow the outer layer of conductors was lapped with copper foil to act as a screen, a practice that

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had proved very successful in a submarine cable from Bacton (Norfolk) to Germany. The length of cable from London to Birmingham is 115 miles, and, although unloaded, it was found possible to speak through it commercially.

The use of loaded lines is increasing rapidly. The equivalent range of speech has been increased in one case from 66 to 176 miles. This is an instance of an underground cable. Although in Germany they have found the ratio to be 1/4, in America it is thought that 1/3 is the outside commercial limit, and in Great Britain we find the range of a certain loaded line is 2·4 times that of an unloaded one.

I have been able to test (July 25, 1907) the relative efficiency of an unloaded and a loaded cable of what should be called the international standard pattern. I found that 8·3 miles on the former was equivalent to 20 miles on the other. This was 2·4 to 1. It was not a test of possible distance but of relative efficiency.

The result is not equally beneficial in aerial wires, for the conditions are more variable, especially in insulation and in atmospheric electrical troubles in countries like South Africa. Anyway, loaded lines will enable us to use less copper for long trunk wires—something of considerable advantage in these days of inflated prices in copper, and in countries like South Africa, where one long stretch of 1,010 miles has to bring, say, Johannesburg, to Cape Town.

The application of this principle to submarine cables has not yet reached a practical stage. Our President will have something to say on this. Prof. Pupin has the matter in hand on the other side of the Atlantic. The reaction coils must, however, be placed at such small distances apart that the manufacture of such a cable seems difficult and its maintenance problematic.

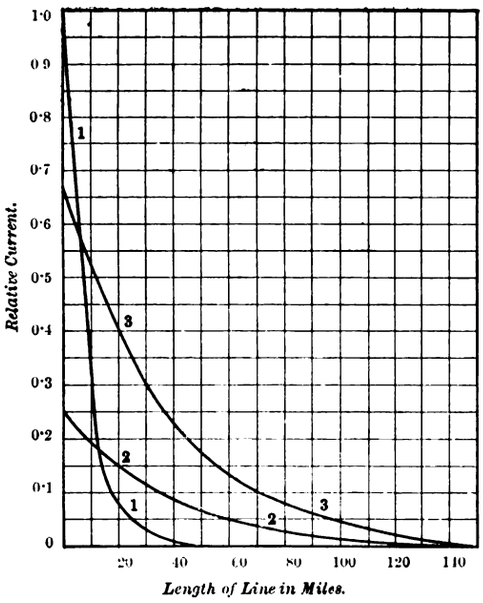

FIG. 8.

It is important to observe that in telephone circuits the frequency is not affected. If it were, speech would be impossible. It is attenuation that limits the distance. It is well known that in practice the higher notes (harmonics) superimposed on the fundamental notes (*which give the quality of sound*) are the first to disappear and that the last to remain are the low fundamental notes decreased in volume. The ear is so marvellously constructed that it adapts itself to all the perplexities of existence and it can interpret speech amid the turmoil of considerable external disturbances We know little of its internal structure and less of the physical actions that render it such an exquisite analyser of sonorous vibrations.

It has been assumed that the velocity of propagation of the current waves through the circuit is such that the action in each Pupin section is virtually simultaneous, and the action continues along the line. If we admitted geometrical length the physical explanation would be more complicated. A slower velocity in loaded cables means an increase to the limiting distance of speech. Hence the reason why the limit is reached so rapidly in cables and underground wires. On overground lines the distance to which it is possible to speak is limited only by the weight of copper. 2,000 miles is easily attained without coils.

The question of loaded underground cables against open unloaded aerial circuits is purely a financial question. The dominant factor is the price of copper. But the cost of maintenance, the reliability of working, and the freedom from troubles must weigh considerably in the balance. Every case must be decided on its own merits.

I cannot too often repeat the warning that telephone troubles arise principally from ignorance of the system of working, and that the principal source of trouble arises with the subscriber himself. The American knows this and does all he can to support the company which supplies him. The Englishman growls and writes to the Press and thinks he has done a clever thing. Some wiseacre has even proposed to establish a Users' Mutual Protection Society to maintain the present unfortunate antagonistic system between supplier and user. The best protectors are personal self-reliance and self-education.

THE PRESENT POSITION OF GAS AND PETROL ENGINES.*

BY DUGALD CLERK, M.INST.C.E., F.C.S.

Summary.—The author deals with the difficulties experienced in the construction of large gas engines, and does not look for their elimination with the present design. He describes his experiments made with the object of compounding gas engines, in which he hopes to be eventually successful. He concludes with a few remarks on petrol engines.

The present position of the internal combustion motor industry in Great Britain is one of sound commercial prosperity. At no previous time have the gas and oil engine builders had so many orders in hand, and never before have these motors been applied so successfully to so many different purposes.

Smooth success, however, is not interesting from the point of view of the scientific investigator or inventor; and, accordingly, I propose to discuss the present position with regard to existing difficulties rather than existing successes.

Engines of small and moderate powers are built in large quantities; their difficulties have been thoroughly overcome and they have attained to an almost fixed type. The larger part of the British gas-engine industry is occupied with such motors, generally under 100 H.P. per cylinder. The turn over in Britain at present of such engines is at the rate of some 300 engines per week. It is generally recognised that these engines are as reliable as the best steam engines of similar dimensions and much more economical in fuel consumption. The smaller engines mostly use coal gas, and the larger, producer gas evolved by means of modern suction producers using anthracite for fuel.

Experience in the construction and design of the large gas engine is accumulating. They are better understood in Britain than they were even three years ago. It is a remarkable fact, however, that engines which attained a reputation for success upon the Continent were not at first successful here. This is shown by the fact that the Koerting, Oechelhauser and Cockerill engines had all to be modified in their construction by the British engineers who undertook their manufacture here. This is also true of the Diesel oil engine. Alterations have been made in England to fit it for the conditions of practice here. All these engines have been much improved in the last few years, and they are now, no doubt, better able to compete with the steam engine with regard to reliability and freedom from breakdown.

Large gas engines of English design have also been built in greater numbers, principally by the Premier Co., Messrs. Crossley Bros. (Ltd.), and the National Gas Engine Co. English designers have always felt the desirability of keeping down cylinder dimensions as much as possible, and in this Continental designers have recently shown a strong tendency to follow them. This trend is due to a more general recognition of two facts: practical difficulties with large diameter cylinders due to unequal expansions resulting in cracking, and a better appreciation of the fact that increase in cylinder and other dimensions requires an increased expenditure in metal and workmanship in greater proportion than increase of power obtained. The large gas engine really presents two distinct problems. The first is to build engines of large power which will continue to run effectively and economically for long periods without breaking down, and the second is to build such engines at costs sufficiently moderate to enable the engines to effectively compete with the large steam engines in the matter of first cost. British engineers recognised for some time that the first part of the problem has been solved to some extent on the Continent, but many of them have felt that this solution has involved weights of material and costs of construction which are almost prohibitive, considering the moderate powers obtained. In fact, English engineers consider the large gas engine as it at present exists both too heavy and too costly for its power. Personally, I do not believe that sound and continued commercial success can be looked for with really large gas engines until some better solution be found for their present constructive difficulties. Apart from the questions of the engines themselves there are other

*Paper read before Section G at the meeting of the British Association, Leicester, on August 1, 1907.

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difficulties which prevent the equal competition of gas engines with steam engines for powers, say, greater than 400 or 500 horse. Coal gas is too expensive a fuel for large engines. Producer gas, evolved by the suction producer from anthracite, air and steam, effectively meets the wants of medium sized engines up to 200 horse, but the cost of anthracite handicaps engines of larger size, and equal competition will not be possible until better bituminous fuel producers are designed than those which at present exist. The work on the Continent has not aided the solution of the bituminous fuel producer problem. Practically all the large Continental gas engines are operated with blast-furnace gas. Some success has been attained in Britain as the result of strenuous and praiseworthy efforts by Dr. Mond, Messrs. Crossley and others; but it cannot yet be said that an entirely satisfactory bituminous producer has appeared. In my view, no bituminous fuel producer can be considered really satisfactory until it attains simplicity, lightness and the fewness of parts of the anthracite suction producer which now forms so large a British industry. Returning, however, to the engine difficulties, the large gas engine may be considered as combining the difficulties of hydraulic engineering work at considerable pressures with those proper to a boiler furnace or flue. The possible pressures to be resisted by such engines cannot be taken as less than 400 lb. to 500 lb. per square inch, and a heat flow through the cylinder and combustion chamber walls has to be provided for greater than that of most boiler furnaces. It is obvious that here we have contradictory conditions involved which become rapidly onerous with increase of dimensions. Thick castings are required to stand the high pressures, but to allow free heat flow from the flame within the cylinder to the water in the water jacket calls for thin castings. Engines of small dimensions do not involve any serious conflict, but where metal is required of about 3 in. thickness to resist internal pressures the temperature difference between the flame and water side of the metal becomes serious and great stresses are set up which ultimately lead to the cracking of the castings. Great attention has been paid to this phenomena of cracking, and in existing large gas engines the difficulty has been partly met by skilful design and special quality of metal used. Although much ingenuity and skill has been spent in this direction, yet it is found that a dimension limit is very soon reached. Cylinders, for example, of 51 in. diameter have been found to be too large. Nothing but the highest skill in designing and the greatest care in the choice of material and workmanship enables such cylinders and combustion chambers to withstand for any length of time the severe treatment to which they are exposed.

In a Paper which I had the honour to read at the Cambridge meeting of the British Association I directed attention to the question of the working fluid of these engines, and described experiments which I had made and engines which I had built with the aim of reducing the mean temperature in order to reduce heat flow. Good results were obtained with these engines, but I came to the conclusion that the methods of reducing temperature then adopted did not go far enough. For the last three years I have been attempting to reduce maximum pressures as well as temperature, without reducing mean pressures, in order to diminish the weight of the engines for a given power and secure moderate thickness of cylinders and combustion chamber castings. There are several ways of reducing temperatures and maximum pressures without reducing mean pressures, but all require much more accurate knowledge of the properties of the working fluid than we at present possess. One solution of the problem appears to lie in compounding, and I am now at work on this. Many attempts have been made to compound the gas engine by Dr. Otto, Messrs. Crossley, Mr. Butler, Messrs. Dick, Kerr & Co. and others, and I myself have also at various times built experimental compound engines. No success, however, has yet been attained There is no difficulty in getting some work from the low-pressure cylinder, but the additional work obtained was always too small in amount to justify the expense of the separate cylinder. The lack of success was mainly due to ignorance of the rates of cooling of the working fluid at different temperatures and pressures. Experiments made with closed vessels do not give much information on the necessary points. I found it necessary to make experiments of this nature on the engine itself in its working condition instead of on closed vessels. At the beginning of 1905 I designed a new method and performed a considerable number of experiments on a 50 H.P. gas engine, by means of which I obtained a cooling curve in the actual engine cylinder and much other information of a useful nature both from the scientific and the practical points of view. Fig. 1 shows two sections of this engine. Its action was modified by so altering the valve arrangements that at any desired moment both inlet charge valve and exhaust valve could be held closed, and with this device I was enabled to get diagrams from which a cooling curve could be calculated. One of these diagrams is shown at Fig. 2. It will be seen that the usual charging stroke—compression, explosion and expansion—is performed proper to the four-cycle gas engine; but when the exhaust period approaches, instead of opening the exhaust valve and discharging the gases at the proper point, the valves are all kept closed and no gases are allowed to escape from the cylinder. The energy stored up in the flywheel accordingly causes the piston to compress the whole contents of the cylinder into the compression space, and the temperature which had fallen by expansion rises again by compression. A point is touched by the indicator pencil on a vertical line at the compression end of the card. On expanding, a line below the first compression line is drawn; then the next in-stroke traces another compression line. In this way a series of compression and expansion lines are obtained, each terminating under compression at certain specific points. These points are successively lower in order. In this particular diagram it will be observed that before the ordinary compression line of the engine

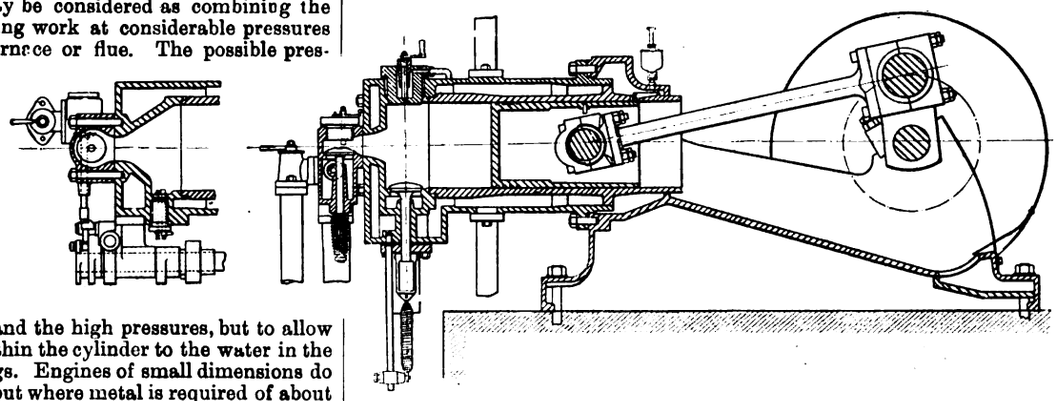

FIG. 1.

is reached six of these points are marked. If no cooling took place in the cylinder, obviously whenever the volume was restored to any particular point—that is, say, to the volume of the compression space—no fall of temperature would be visible between one revolution and another. The compression and expansion lines would coincide. The fall, as you see, is gradually decreasing from revolution to revolution. This gives an idea of the time taken to lose heat to the cylinder walls with all the engine parts in their ordinary state. The temperature fall from point to point, however, is not entirely due to heat loss. Some of the heat disappears as work done. A certain amount of the heat is converted into work at each reciprocation. This, however, can be allowed for, and a cooling curve obtained which shows the real temperature drop due to

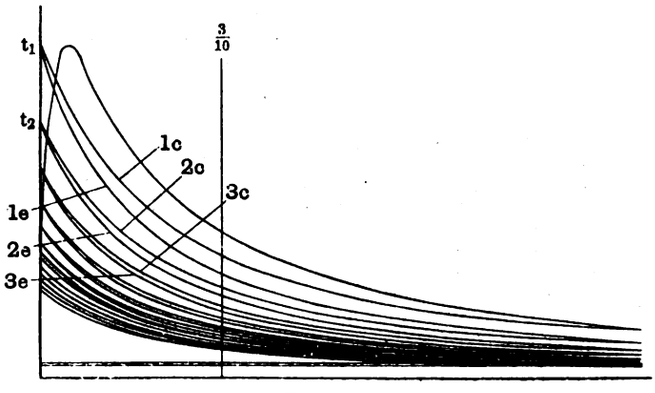

FIG. 2.

cooling upon the expanding and compressing lines. From this curve, by somewhat troublesome calculations which I need not enter into here, the apparent specific heat of the charge can be obtained for each expansion line. Tables I. and II. have been calculated from the numbers so obtained. These tables clearly show that the apparent specific heat of the working fluid, which consists of the products of combustion in the cylinder of this particular engine, increases considerably with temperature, so that the instantaneous value is about 28 per cent. greater at 1,000°C than it is at 100°C., while at 1,500°C. the increase amounts to 31 per cent. The mean apparent specific heat between 0°C. and 1,000°C. is 15 per cent. greater than it is at 100°C.; between 0°C. and 1,500 C. it is 20 per cent. greater. These apparent specific heat numbers enable me to obtain a curve of heat loss to the sides of the cylinder either for complete double strokes or for partial double strokes at the inner end of the stroke.

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Table I.—*Apparent Specific Heats (Instantaneous) in Foot-pounds per Cubic Foot of Working Fluid at 0°C. and 760 mm.*

Temperature.	Specific heat at constant volume.	Temperature.	Specific heat at constant volume.
Degrees C.	ft.-lb.	Degrees C.	ft.-lb.
0	19·6	800	26·2
100	20·9	900	26·6
200	22·0	1,000	26·8
300	23·0	1,100	27 0
400	23·9	1,200	27·2
500	24·8	1,300	27·3
600	25·2	1,400	27·35
700	25·7	1,500	27·45

Table II.—*Mean Apparent Specific Heats in Foot-pounds per Cubic Foot of Working Fluid at 0°C. and 760 mm.*

Temperature.	Specific heat at constant volume.	Temperature.	Specific heat at constant volume.
Degrees C.	ft.-lb.	Degrees C.	ft.-lb.
0—100	20·3	0—900	23·9
0—200	20·9	0—900	24·1
0—300	21·4	0—1,100	24·4
0 - 400	21·9	0—1,200	24·6
0—500	22·4	0—1,300	24·8
0 - 600	22·8	0—1,400	25·0
0—700	23·2	0—1,500	25·2
0—800	23·6	..	..

Fig. 3 shows four such curves. The curves (*a*) (*b*) represent the heat losses incurred in complete revolutions—that is to say, in complete double strokes. Here the surface exposed and covered alternately is that due to the whole sweep of the piston. The curves (*a'*) (*b'*) represent losses incurred at the upper three-tenths of the

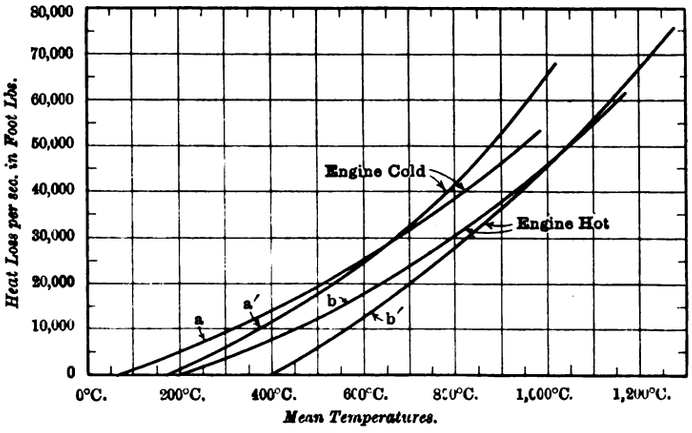

FIG. 3.

double stroke, while the piston moves from three-tenths stroke to the end, compressing into the clearance space, and then moves out again to the point of three-tenths of the outward stroke. The ordinates give heat loss in foot-pounds to the second and the abscissæ mean temperatures per total stroke or double three-tenths stroke This table gives interesting information enabling approximate calculations to be made dealing with the durability of the working fluid exposed to cylinder surface. It has enabled also important facts to be discovered as to the mean temperature of the cylinder walls and the heat flow with varying density. Curves (*a*) (*a'*) were calculated from experiments made with the engine running without load at 120 revs. per minute, jacket water kept at a mean temperature of 13°C. Curves (*b*) and (*b'*) are calculated from experiments made with the engine running at 160 revs. per min. with a load of 150 B.H.P and jacket water at 80°C. The curves are accordingly marked as "Engine cold," "Engine hot." Where the engine is running cold the mean temperature for the complete strokes of the walls is shown to be about 65°C., notwithstanding that the jacket water is 13 deg. For the three-tenths stroke, running cold, wall temperature 165°C. With the engine running hot, the whole stroke shows mean temperature of walls 190°C.; for the inner three-tenths 400°C. These numbers, giving quantitative values of heat loss for a given cylinder, enable the conditions within the cylinder walls to be realised with some accuracy. In this particular engine the walls of the combustion space are about 1¼ in. thick; and calculating the temperature gradient in those walls for the heat flows, given temperature difference, say, 700°C., between gas and interior of the wall, gives a temperature difference in the metal between the water side and the gas side of 60°C. A temperature difference of 1,000°C. between gas and inner wall gives temperature difference in the metal of 104°C. These differences are accentuated with greater metal thickness almost in proportion to the thickness; those with the higher temperature to the last calculation a thickness of 3¼ in. wall would give a temperature difference in the metal itself of over 300°C. These numbers throw an important light upon the problem of the large gas engine and enable me with some confidence to experiment upon the variations of indicator diagram and the transfer of hot gases from cylinder to cylinder required for successful compounding. The experiments show also many interesting and unexpected facts in connection with the behaviour of high-temperature working fluid in these engines. Much remains to be done, however, and I am continuing the investigation on three engines with the object of determining the laws of the working fluid within the gas-engine cylinder more completely. Time presses, and I would refer those interested in this matter to a Paper read by me before the Royal Society in March, 1906, and a Paper read before the Institution of Civil Engineers at the beginning of this year. Prof. Callender is also working on this problem of the quantitative laws of heat loss and efficiency in engines of different dimensions, and he has contributed an important Paper this year upon the subject to the Institution of Automobile Engineers. Prof. Hopkinson, too, of Cambridge, has thrown some light upon the subject by ingenious experiments made upon gaseous explosions within closed vessels, and he is at work upon other experiments which will undoubtedy increase our knowledge on this troublesome and complicated subject.

In modifications of the conditions of the working fluid combined with mechanical modifications of the engine using it, I hope to find in the near future some more satisfactory solution of the large gas-engine problem than at present exists. It appears to me that the problem is one more of working fluid than of pure mechanism. So far, however, the conservative attitude of British engineers towards large gas-engines has been fully justified. We are all much indebted to Mr. Humphrey for a very able Paper read before the Institution of Mechanical Engineers about seven years ago advocating the claims of the large gas engine. Like all pioneers, Mr. Humphrey was a little too sanguine as to the rapid development of these engines, but he was undoubtedly right as to the ultimate success to be expected from them. Progress in solving the large gas-engine problem has been somewhat slow, but it has been steady. There is no occasion whatever for discouragement, notwithstanding recent difficulties with a large gas-engine installation at Johannesburg, of which much has been written in the engineering publications. The difficulties at Johannesburg are, in my opinion, to a large extent, due to the daring nature of the experiment undertaken by an eminent firm of engineers whose experience was rather in steam engines than in gas. They very boldly attempted to solve at one stroke the difficulties both of the large gas-engine in itself and those peculiar to the bituminous producer. I have no doubt that if they be given time they will solve these difficulties, but the experiment was on too large a scale for most experienced gas-engine constructors and designers. I do not attach any importance to this partial failure. It emphasises, what I have always held, the necessity for precaution and much further study in connection with the large gas-engine problem. It appears to me, however, eminently unwise and unsafe to attempt to solve the numerous problems involved in too short a time. Gas-engine builders must be content with the slow growth of experience and the slower solution of these difficult problems.

The increasing interest in larger type of gas engines has clearly been shown in the last two years by Papers read at the Institution of Naval Architects and at the Institution of Civil Engineers. For the first time in the history of the Institution of Civil Engineers a Paper has been read this year, that by Mr. Milton, upon the marine gas engine problem, which is a valuable contribution to the understanding of the subject from the steam-engine designers' point of view. I am in agreement with Mr. Milton in most of the conditions which he lays down as necessary for success in a marine gas engine, but I regret that I do not coincide with him in considering that the particular type of engine which he proposes will solve the difficulties, although that type is one invented by me in 1878. Mr. Thornycroft read a very important and interesting Paper at the Institution of Naval Architects last year upon the marine gas-engine, describing motor vessels built by Messrs. Thornycroft driven by engines and anthracite suction producers of the Capitaine type. To Messrs. Thornycroft belong the honour of being the first to propel a sea-going launch and a canal boat in Britain by means of a gas engine driven by gas produced on board. Papers read this year before the Manchester Association of Engineers by Mr. Vennell Coster and the Institution of Naval Architects by Mr. McKechnie are also exceedingly interesting, but both writers greatly underrate the difficulties of the marine gas engine. Mr. McKechnie, indeed, contemplates engines on shipboard of over 16,000 H.P. in the immediate future. I fear it will be some years before we have gas engines of 16,000 H.P. working on land, and considerably later before we have them at work on sea.

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As I have already said, part of the large gas-engine problem depends upon the producer. A bituminous fuel-producer of a type suitable for use on shipboard has not yet been devised, and until such a producer is designed and thoroughly tested the anthracite suction producers of to-day will not allow any great extension of gas motive power to large sea-going vessels. Mr. Capitaine has, I am informed, applied an engine of 300 H.P. to a towing vessel on the Rhine, but as yet this movement is in its early infancy.

The great success of the suction producer in connection with stationary engines on land has enabled the power of gas engines in use to be very materially increased. Tests at the Royal Agricultural Society's show last year have proved that even small producer-driven engines only require 1 lb. of fuel per brake-horse-power per hour, including lighting-up and stand-by losses of the producer at night. Other experiments, some of them by myself, show very clearly that with a good suction producer we can obtain 85 per cent. of the whole heat of the fuel in the form of inflammable gas ready for delivery to the engine. Many tests have shown that the running consumption of many of these engines at full load does not exceed $\frac{3}{4}$ lb. of anthracite per brake-horse-power per hour.

So much for the position of the gas engine at present. I have only a few words to say about petrol engines. A complete Paper could be profitably devoted to the peculiarities and interesting points of the petrol engine, but I would only say that petrol engine construction now forms a very large and well-founded British industry. Petrol engines operating on the four cycle by virtue of high speed of revolution are able to give very large power for very small weight, and they give a very fair thermal efficiency considering their small dimensions. This question of efficiency is a fascinating one, but I have no space to deal with it here. Speaking as the owner of a motor car, I can say that the petrol engine as now developed is exceedingly reliable and very economical. Many of its points, however, are in urgent need of careful scientific study. To one point only will I refer, as experiments will throw important light upon the nature of the combustion occurring in these motors. This year the Royal Automobile Club has made a valuable set of experiments, at which I had the honour to assist, upon the exhaust gases given out by these engines under different conditions of running. The experiments clearly proved that, so far as visible smoke was concerned, many petrol engines now running on the road had attained absolute perfection. Speaking for the six-cylinder "Napier" car, on which I acted as observer during the test, I can truly say that nothing more perfect could be imagined in the way of absence of visible vapour or smoke. During a run of 150 miles on the open road I never once detected the faintest smoke coming from the exhaust pipe of the engines. In these tests, however, exhaust gas analyses were made, and it was found that, although many of the cars burned the petrol given to them in a most complete manner and evolved a minimum of carbonic oxide gas, yet some of them showed percentages of carbonic oxide in the exhaust greater than 2 per cent. It was resolved by the Royal Automobile Club to continue these experiments later in the year; but, meantime, as a matter of interest I thought it well to examine the exhaust gases of my own car—an 18 H.P. "Siddeley." The following results were obtained under different conditions:—

Table III.

	Percentages of CO in exhaust gases.		
	April 23rd.	May 7th.	July 3rd.
Engine throttle full open. Car climbing hill	3·6 per cent.	3·6 per cent.	2·2 per cent.
Engine throttle less than half open. Car running on level	6·9 ,,	4·2 ,,	2·4 ,,
Engine running without load. Car standing	0·5 ,,	0·4 ,,	1·8 ,,

From this it will be seen that, as at first adjusted, the carburetter of this "Siddeley" car was supplying an excess of petrol at the higher loads, so that no free oxygen was left in the exhaust. Consequently, carbonic oxide appeared when running with light load of 6·9 per cent and heavy load 3·6 per cent. Successive tests were made as given above. Undoubtedly, as will be seen, by altering the adjustment of the auxiliary air valve, the carbonic oxide was reduced to very nearly 2 per cent. It is highly desirable that the exhaust gases of these cars should contain a minimum of carbonic oxide, in view of the rapid increase of their use in large cities like London. In the open road, a little carbonic oxide rapidly diluted by air would do no harm, but in large cities, when horse traction is replaced almost entirely by petrol motor vehicles, it will be necessary to look into this carbonic oxide question with great care. It is quite certain that the problem can be effectively solved, because in investigating gas engine exhaust I have found that a good engine properly adjusted will not produce more than $\frac{1}{10}$ per cent. of carbonic oxide in its exhaust under any circumstances of ordinary running. Several of the cars tested by the Royal Automobile Club this year also showed remarkably low percentages of carbonic oxide, notably the Lanchester, Pilgrim and Albion, and it will be noted that in my own car, with the engine running slowly, waiting at the door of my house to start, the carbonic oxide attained a minimum. The problem is one of the carburetter—a much more difficult problem than appears at first sight. There are many interesting problems to be solved with regard to the petrol engine, but this one of the carburetter appears to me at the moment to be the most pressing.

In this Paper I have not dealt with the question of thermal efficiencies at all. The thermal efficiencies of all gas and internal combustion engines are very high compared with any other form of heat motor. In recent tests by the Thermo-dynamic Standards Committee of the Institution of Civil Engineers an ordinary "National" gas engine—the one referred to in this Paper and shown at Fig. 1—gave an indicated efficiency of 35 per cent. and a brake efficiency of as nearly as possible 30 per cent. The efficiency obtained from smaller petrol motors is somewhat less, but in tests made by Hopkinson it rises as high as 24·6 per cent. This is a very high efficiency for small diameter cylinder.

So far as I understand the question, although large increases in thermal efficiency are still probable, efficienceis are quite high enough at present for all practical purposes, and the main efforts of engineers and scientific men interested in the internal combustion motor should be directed to the solution of the large gas engine problem in such a way as to reduce weight and increase power of the unit; to improve the bituminous fuel producer; to apply the improved engine and producer to marine purposes and overcome the various difficulties there presented; in petrol engines to design carburetters capable of proportioning the charge more accurately than at present under all conditions of running, whether with light or with heavy loads.

The scientific problems I have already indicated broadly. I need not further refer to them here.

THE NATURE OF IONISATION—IONOMANIA.*

BY H. E. ARMSTRONG, F.R.S.

Summary.—In this Paper the author states that he considers the word "ionisation" is being improperly used, "dissociation" being really all that is usually implied.

In his imaginative work on the hypothetical entities termed electrons, in the opening sentence of the chapter which bears the heading "Ionisation of Gases," Sir O. Lodge tells us that "It is constantly necessary to speak of the air being 'ionised' by the passage of rays and many other processes. The term means the molecules are split up or dissociated into their constituent atoms."

The term certainly is used by many in this sense at the present day; yet inadvertently, I venture to contend.

The word "ion" was introduced in 1834 by Faraday in the immortal seventh series of his researches: it was never verbalised by him—I believe advisedly. He was content with "electrolyze." Why should not we be? Potentially one of the most valuable words in the scientific vocabulary, unless we can deprive it of ambiguity "ionisation" cannot be used by exact speakers. Faraday coined the words "anion" and "cation," because he felt, he says, that the terms "electronegative" and "electropositive" were much too significant for the use to which he would have to put them. His explanation is worthy of notice in these days of uncontrolled speculation and loose reasoning, "for though the meanings are perhaps right, they are only hypothetical and may be wrong; and then, through a very imperceptible but still very dangerous because continual influence, they do great injury to science by contracting and limiting the habitual views of those engaged in pursuing it." We moderns have no such scruples: our guiding principle seems to be that language is given to us to disguise our thoughts. Every vague conception as it arises must at once be embodied in an ambiguous new word, so that a reader of present-day "scientific" literature often finds himself in a maze of "jargonese." It will be necessary soon to request the Royal Society to maintain a dictionary of terminological inexactitudes as a key to its *Proceedings* and to the publications of scientific bodies.

Surely we have no need to imply more by the term "ionisation" than that the medium is in a state in which it will conduct electricity? We know no more! When a man and his wife have bought Cook's tickets and packed their luggage, they are ionised ready to travel; but nothing shows them to be divorced. If we have need to introduce the conception of atomic divorce, let us frankly say so and straightforwardly use the word "dissociation." We cannot do better than follow an example set us by Faraday and, as far as possible, seek to use only such terms as are at the same time "simple in their nature, clear in their reference and from hypothesis." (Footnote, § 666, Series 7.)

* Paper read before Section A of the British Association at Leicester, August 1907.

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I cannot discover, although I have read the Papers many times during the past 20 years for the purpose, that Faraday ever conceived of the ion as a restless wanderer, as a solitary fragment; on the contrary, he appears to have thought of the ion as always accompanied or conducted and as only delivered up at the boundaries—as separated during electrolysis, *e.g.* :—

§ 665. The chloride of lead is an electolyte and when electrolyzed evolves the two ions, chlorine and lead.

§ 827. If one ion be combined in right proportions with another strongly opposed to it in its ordinary chemical relations, *i.e.*, if an anion be combined with a cation, then both will travel, the one to the anode, the other to the cathode of the decomposing body.

§ 828. If, therefore, anion pass towards one of the electrodes, another ion must also be passing simultaneously to the other electrode, although, from secondary action, it may not make its appearance.

He distinctly recognised that "attraction of aggregation" lay at the root of electrolytic phenomena—thus he remarks :—

It is a remarkable circumstance that in gases and vapours, where the attraction of aggregation ceases, there likewise the decomposing powers of electricity apparently cease and there also the chemical action of quantity is no longer evident. It seems not unlikely that the inability to suffer decomposition in these cases may be dependent upon the absence of that mutual attractive relation of the particles which is the cause of aggregation.

Faraday, in fact, was a pronounced associationist, not a dissociationist. It cannot well be argued that the conception of dissociation was not in his mind; had he foreseen the need of any such explanation he would probably have had little difficulty in formulating it. In his time, chemistry and physics were united sciences and were ionised for joint service, able and willing to co-operate; now they are all but dissociated and chemistry is cold-shouldered by physics. The consequences of the lack of appreciation and understanding are most unfortunate; I believe really serious. Physicists soar in a mathematical empyrean and have no regard for the plain facts of chemistry. Although they have their being by it and live by it, organic chemistry is tabooed by them. The tangible test-tube has no charms in face of the galvanometer and electrometer: indulgence in speculative lucubrations on the wanderings of a spot of light is too fascinating an occupation.

During the past 20 years I have steadily maintained that the doctrine of electrolytic dissociation is destitute of common-sense. I have discussed the subject on several occasions and pointed out the inconsistencies, particularly in my address to the Chemical Society in 1895. I come here to-day, advisedly, to challenge those who accept the creed to reconsider the evidence on which their faith is based. It will not surprise me to be told that faith is something that cannot be based on evidence—merely a longing or desire to believe, felt with special acuteness when facts are inconsiderately in opposition to fancy.

So far as I am aware, the arguments on which the hypothesis is really based are : (1) the existence of Ohm's law and (2) the assumption that any electromotive force, however small, will condition sensible electrolysis. Fitzgerald disposed of the first in 1890 (B.A. *Reports*, p. 143; comp. my address, p. 1,131) by showing that a modified Grothus hypothesis would fit the facts. As to the second, as it is impossible to avoid some polarisation, the fact cannot be regarded as established. The Helmholtz experiment on which reliance is placed cannot be regarded as irreproachable, it being impossible theoretically to remove a gas entirely from solution by any solvent in contact with the liquid.

Mr. Whetham's thermodynamic missiles have no terrors for me; they are mere bombastic shells. To tell us that, whatever the process, such and such must be the case, is futile; what we are concerned with is the process. Unless I am altogether mistaken, thermodynamics can tell us nothing of this. Thermodynamic arguments at their best afford but scant comfort to those in search of explanations.

It is the great merit of Arrhenius to have recognised that electrolytic conductivity and chemical activity *se confonde*, as he puts it; that is to say, they are phenomena of the same order. All the conclusions arrived at carry us no further. The dissociation hypothesis was only a way of stating this generalisation; had Arrhenius been a chemist he would never have formulated it, as he would have realised that the hypothesis did not satisfy the postulates generally. At best it was an ingenious paraphrase of conventional language in stilted phraseology calculated to mislead the unwary.

Gradually, facts have been accumulated which, I believe, constitute a practically complete refutation of the hypothesis and serve to show that chemical interactions—as Faraday foresaw—are dependent on "mutual attractive relations of the particles," not on dissociation in the sense contended by the Arrhenius-Lodge school. This school assumes that the hydrolytic activity of acids is that of the dissociated hydrogen ions. Hydrolysis can be effected, however, by other agents—in the case of sugars, for example, by enzymes; but the dissociated hydrogen ions should be alike from whatever source they are derived and it is in accordance with this conclusion that acids may be used without distinction, differing only in the degree of activity which they manifest. Enzymes, however, act selectively: therefore their action cannot be ascribed to dissociated hydrogen ions. Moreover, there is evidence to show that enzymes become associated with the compounds which undergo hydrolysis under their influence; they are not only strictly selective in their action but are also and only controlled by substances which are of the same configuration as the compounds upon which they act. Evidence of this kind derived from inorganic sources must be taken into account. As there is much evidence that acids can combine with various hydrolytes, there is every reason to suppose that hydrolysis by acids also involves the association of the hydrolyte with the acid.

According to the dissociation hypothesis, the hydrolytic action of an acid should be repressed by salts containing the same anion—the contrary is commonly the case. The increased activity can be accounted for simply and satisfactorily on the assumption that the salt is hydrated in solution and that by withdrawing water it raises the concentration of the acid.

Much evidence has been accumulated of late showing that no special distinction is to be drawn between dilute and concentrated solutions and that properties vary continuously throughout all degrees of concentration. The difficulties met with in the past in dealing with concentrated solutions have arisen not only from the existence in them of polymerised molecules, but also from the circumstance that the formation of hydrates has been left out of account; and because solutions have been considered with reference to their volume instead of with reference to the mass of the solvent. The change in the solvent has not been sufficiently considered and the mistake has been made of assuming that liquids are comparable with gases: a preposterous contention.

It was suggested by Fitzgerald that if the molecules in an electrolyte drew one another apart at a rate proportional to the polarisation, the relation between the electric force and the decomposition would be a linear one, so that Ohm's law would be satisfied. In a forthcoming Paper in the *Proceedings* of the Royal Society on "The Discrimination of Hydrates in Solution," Mr. Caldwell and I have argued that the "ionised" molecules are complex, reversible systems formed of solvent and solute under the influence of the force of residual affinity—*e.g.*,

$$KCl + OH_2 \rightleftarrows KCl:OH_2 \rightleftarrows K\overset{H}{\underset{OH}{Cl}}$$

As such systems break down under the influence of the current, new ones to take their place must arise spontaneously in the solution; the molecules, therefore, would draw one another apart at a rate proportional to the polarisation.

Another point made by Fitzgerald is that :—

If dissociated atoms are going about in a liquid as in a gas it seems impossible but that they must diffuse at different rates; and that this is not observed seems conclusive evidence against the hypothesis, no matter what else the hypothesis may explain. Consider solution simply. Why does chloride of sodium dissolve in water? There must be some strong affinity between the two of a chemical or semi-chemical nature to break up the cohesion of the crystal; and it seems reasonable to assume that this same affinity keeps the molecules of sodium chloride moving about among the water molecules, so that they diffuse about. Now, if the forces drawing them about be independent of the nature of the molecule, most of the phenomena explained by gaseous laws are explained. Pressure of a gas depends, at any temperature, on the number of molecules and not on their kind. This is Avogadro's law, by which molecular weights are calculated; and if the forces drawing a molecule about in a liquid are independent of the kind of molecule, the very same law of pressure would hold, the pressure forwards of molecules of different kinds would depend on their number only and, in the same way as Avogadro's law, would enable molecular weights to be calculated.

The forces drawing a molecule about in a liquid are probably of two kinds, if, as I have contended elsewhere, the molecular composition of the solvent be modified in presence of the solute. ("The Origin of Osmotic Effects," R. Soc. *Proc.*, 1906, A. 78, 264.) In a concentrated region the number of solvent monads would be at a maximum and these would condition a flow of monads from less concentrated regions, which would tend to force out molecules of solute into these latter. In addition, molecules of the solute would be attracted outward by the force which caused it to dissolve—viz., that existent between it and the solvent. To a considerable extent, therefore, the forces drawing a molecule about would be independent of the kind of molecule.

I do not claim Fitzgerald merely as an advocate of views similar to my own. In this section I shall be understood when I say it is because he always seemed to me to be the least biassed and most capable among us of judging in such matters—perhaps the broadest, most generous and sympathetic mind of our generation.

In the July number of the *Philosophical Magazine* it is contended by Sutherland that electrolytes are completely ionised in solution—completely dissociated into ions, that is to say. The grounds on which he arrives at this conclusion are such that if he extend his examination of the problem he will probably find that, although not dissociated into ions, the molecules are all ionised in the sense that they

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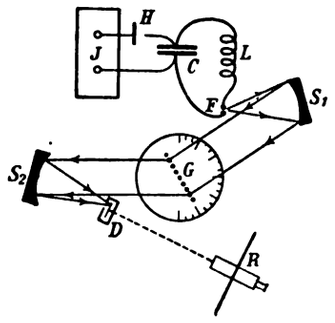
are all prepared to travel in turn—being somewhat in the condition of a crowd of excursionists waiting at a railway station ready to enter upon their journey as soon as the trains will take them on.

Far too little attention has been paid as yet to such observations as those made by Brereton Baker on the influence of moisture (coupled with acid or alkaline impurity) in conditioning chemical interchanges and their bearing on the problem of electrical conductivity in gases. The ocular demonstration given recently by Sir James Dewar of the presence of gaseous matter capable of determining the rotation of the radiometer at exhaustions considerably below those at which the conduction of electricity ceases should once more direct attention to the possible need of referring electrical conduction in gases to the presence of complex tripartite systems of charged molecules* rather than to that of atomised ions. Exact work in this direction would be most valuable at the present time; speculative discussion of uncertain results cannot determine the nature of the process of "ionisation," so called.

SHORT SOUND WAVES PRODUCED BY SPARK DISCHARGES.†

BY W. ALTBERG.

The shortest sound waves hitherto produced by acoustic means were those produced by Koenig with tuning forks, and by Edelmann with a Galton whistle. The wave-length of the former was 3·8 mm., and of the latter 2 mm. Lodge, on the other hand, produced audible notes by means of condenser discharges through large inductances. In this mode of producing acoustic vibrations, each whole electric oscillation is accompanied by two brightenings of the spark-



gap. Since every such brightening means an expansion and subsequent contraction of the air, the wave-length of the sound wave becomes $\lambda = \pi v\sqrt{LC}$ where v is the velocity of sound in air.

The author used this method for obtaining the shortest possible sound waves, and measured their lengths by means of diffraction gratings.

The arrangement used is shown in the diagram, where the condenser C is charged by the induction coil J, through the spark-gap H, and discharges through the inductance L and the spark-gap F.

The electric spark F, forming the source of the sound waves, is situated in the focus of the concave mirror H_1. The parallel acoustic beam then impinges upon a Fraunhofer diffraction grating G, the deflected ray is caught by another mirror S_2, and concentrated upon the pressure gauge D, whose readings are observed with a telescope R_2

The pressure gauge consists of a vertical strip of mica suspended at one arm of a lever whose fulcrum is borne by a quartz fibre. The sound waves impinge upon the mica through an oblong opening slightly bigger than the mica, and produce a deflection of the latter, balanced by the rigidity of the quartz fibre. The deflections are read by a mirror and scale.

The mirrors are silvered. They have a diameter of 8 cm. and a focal length of 15 cm. The diffraction gratings are constructed of rods of glass or steel in such a manner that the interval between successive rods is equal to their width. The author used five different gratings, with intervals ranging from 2 mm. to 12 mm. The induction coil had a spark-length of 20 cm., and was worked with a Wehnelt interrupter.

The spectrum turned out to be sharply defined, and the wave-lengths calculated did not differ by more than 2 per cent. in the different gratings. The inductance was varied from 30·4 to 17·5, and then 6·8, and lastly 0·78 million cm. The observed wave-lengths were 5·0, 3·9, 2·4, and 1·5 mm. respectively, the calculated values being 4·7, 3·6, 2·2, and 0·8 mm.

A variation of the capacity between 0·008 and 0·0004 mf. also showed an excellent agreement between calculated and observed values.

Maximum deflections of the pressure gauge were shown at wave-lengths of 2·8 mm. and 3·6 mm. For higher wave-lengths the opening of the pressure gauge becomes too small to absorb sufficient energy. The shortest wave-length which the author succeeded in measuring was 1 mm., which is an octave higher than Edelmann's shortest.

* It is not customary, I believe, to drag in dissociated ions to explain the action of a condenser: we are satisfied to think of the collection of a charge as dependent on the displacement and distortion—the polarisation—of the molecules in a viscous electrolyte of low conductivity.

† Abstracted from the *Annalen der Physik*, No. VII., 1907.

INFLUENCE OF THE SURROUNDING TEMPERATURE ON THE CANDLE-POWER OF AN INCANDESCENT ELECTRIC LAMP.*

BY F. LAPORTE AND R. JOUAST.

In the course of some researches undertaken at the Laboratoire Central d'Electricité on light standards and the influence of different atmospheric conditions on them, we were led to try if the temperature of the surrounding air had a measurable action on the physical constants of an incandescent electric lamp, and particularly on its candle-power.

An incandescent lamp consuming about 4 watts per candle-power was fixed in a stove with a transparent side. A photometer was placed at a certain distance from the stove, and equal illumination was obtained on its screen by moving the standard lamp Great precautions were taken to maintain the voltage across the lamp terminals constant, a potentiometer being used for this purpose. In order that the variation of temperature should have no influence on the resistance of the contacts both the main and voltmeter wires were soldered direct to the lamp terminals. The candle-power of, and the current through, the lamp were measured under the following conditions: (1) With the stove cold, at a temperature of about 15°C. (2) During the heating of the stove. (3) With the stove at a constant temperature of 115°C. (4) During the cooling of the stove. (5) With the stove completely re-cooled at a temperature of about 15°C.

The candle-powers measured were found to be practically constant, the greatest variation between the extreme readings not exceeding 1 per cent. The current through the lamp was found to be constant to within 0·05 per cent. of its mean value. These results are interesting to note, as certain experimenters have observed a variation of 0·1 per cent. in the candle-power of an incandescent lamp per degree variation of the surrounding temperature Besides, if the laws of radiation are applied to an incandescent lamp the increase in temperature of the filament produced by an increase of 100 deg. (which was used in this test) in the temperature of the surrounding air may be calculated. By taking T = 1,800°C. as the temperature of the filament in an incandescent lamp, Stefan's law for total radiation [total radiation $= K(T^4 - T_0^4)$], and the formula which, according to M. Guilleaume and the work of Lummer and Kurlbaum, represents the brightness of a black body ($= K'T^3(T - 650)^7$, it is found by equating the energy radiated in the two cases by the incandescent lamp that the temperature of the filament rises 0·5°C. when the surrounding temperature rises 100°C. The candle-power would thus increase 0·4 per cent. per 100 deg. of temperature variation, which would not have been observable with the experimental conditions under which we worked.

* Translated from the *Comptes Rendus*.

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THE BRITISH ASSOCIATION.

For the first time in its history the British Association has held its annual meeting in the town of Leicester; it is to be hoped that the experiment will be repeated. To most people the very name "Leicester" is significant of boots and hosiery, and truly enough it is a place of business. But it is also exceedingly rich in very charming historical associations, and its inhabitants are characterised by great hospitality. Everything possible, in fact, was done to secure the comfort and enjoyment of visitors. For many reasons, however, apart from these, the meeting of the Association which has just been brought to a successful conclusion is one that will stand out with much prominence for many years. To a certain extent it must be admitted that the British Association is mainly supported by, and composed of, amateurs; at all events this has been the case hitherto, and it must always be the case so long as the meetings are open to the man in the street who is prepared to become a "member" or "associate."

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A large number of the Papers and discussions must necessarily, therefore, be of a lower scientific or technical order than they otherwise would be. On the whole, this is probably not without its beneficial effects, for it serves as a stimulus to the public mind and allows the professional man to think and talk in a somewhat lighter vein. Hitherto this has been the accepted view of the work of the Association, and it is to be hoped that the nature of the meetings will never undergo any radical change. Nevertheless, there are signs that the great men of the scientific world are beginning to regard the matter in a more serious light, and the Leicester meeting was notable on this account. At no other public gathering in the world would it be possible to listen to so many eminent scientists as were present at the discussion on "The Constitution of the Atom" in Section A on Friday. Yet there was nothing of a "popular" nature in what they said—they were very much in earnest. On the previous day Lord KELVIN had been emphatic in his condemnation of the theory of an atom having a constitution; he persisted in regarding it as the smallest quantity of ponderable matter or of electricity. Now, although the respect with which Lord KELVIN'S opinions are held by the scientific world is not one whit less than it has ever been, yet it is a profound fact that his views on the constitution of the atom are not generally accepted by the modern school. It is true that Sir OLIVER LODGE holds very positive views on the constitution of the atom, but there is, nevertheless, a large number of capable men who have adopted an intermediate position, and are still much more advanced in their views than is Lord KELVIN. So far, of course, the entire matter is of a very abstract nature, but it is pregnant with the most astounding possibilities that have ever presented themselves to the imagination of the physicist. As yet, however, there seems no prospect of an early solution to the problem. What hope is there, indeed, when no two of half-a-dozen of the greatest workers can express coincident opinions? So far as the actual constitution of the atom is concerned nothing more is known definitely than was discovered by FARADAY, who found that the separation of matter was proportional to the separation of electricity, or, in other words, that each atom was equivalent to a certain quantity of electricity. But we still do not know how the electrons are arranged in the atom—how many are constitutional and how many are detachable. Indeed, there is reason to doubt whether such a distinction is valid. The optical effect of an atom in giving a particular spectrum may be likened to the acoustical effect of a bell which emits a particular note when excited. But, as Prof. LARMOR so ingeniously put it: Is the bell equivalent to the atom itself, or is it equivalent only to something attached to the atom? We do not know. Possibly the discovery of a "positive electron" will provide the key to the problem, but that is not yet.

Another matter of considerable importance and interest was that raised by Sir WM. RAMSAY, whose statement may be regarded by a section of the public as a definite assertion that the transmutation of the elements is *un fait accompli*. In all probability Sir WILLIAM had not the least intention of conveying such an impression, and yet he offered no explanation of his extraordinary experiments. It may be briefly stated that he exposed a solution of copper sulphate to the emanation, and that afterwards he discovered the presence of lithium. The experiment was repeated three times, and all the substances employed carefully examined for lithium before commencing. Yet the fact remained that, after exposure to the emanation, lithium was present, whereas it was apparently absent before exposure. We say "apparently," because we feel that these experiments ought to be accepted with the greatest caution, as, indeed, they were by the majority of those who heard them detailed. No one, of course, doubts for an instant that everything occurred exactly as related by Sir WM. RAMSAY, but, on the other hand, very few scientific men will admit that copper has been transmuted into lithium and possibly sodium. Where, then, did the lithium come from? That is a problem which admits of much speculation, but, so far, of no solution. It might, of course, have been in the copper solution all the time, or it might have been in the containing vessel; but if so, why was it not detected before the experiment was performed? Herein lies the difficulty; but we venture to offer a suggestion which is at least not without the bounds of probability.

Referring back to the discussion on the atom, and accepting for the moment the hypothesis that the atom contains constitutional as well as detachable electrons, it is surely conceivable that the detachable electron or electrons may at some time or other have been of the constitutional order. For instance, assuming that Sir WM. RAMSAY'S copper solution originally contained lithium, whose atoms, for some reason, contained only constitutional electrons, then it would be impossible to detect the presence of that lithium. But if the presence of the emanation so acted on the arrangement of the electrons as to cause one or more of them to act as the detachable variety, then lithium would at once be easy of detection. We leave the suggestion to the physicists for what it is worth.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Physikalische Technik. 7th edition. Vol. I., Parts I. and II. By Dr. J. FRICK, revised and enlarged by Dr. OTTO LEHMANN. (Braunschweig: F. Vieweg & Son.) Part I., 16 m.; part II., 24 m.

Part I. of the first volume of this elaborate work describes in great minuteness the arrangement and equipment of a representative physical laboratory for schools. The subject is divided into five main parts, dealing successively with the general lay-out and arrangement of the laboratory and the detailed arrangement and equipment of the large lecture-room, the small lecture-room, the offices and the workshops respectively. Although concisely written, the subject matter occupies no less than 630 large pages, which are illustrated by over 2,000 diagrams, drawings and views of apparatus. Nothing essential seems to have been overlooked, from the acoustics of the lecture-rooms down to the commonest tools in the workshops.

Part II., containing nearly 1,000 pages of text and almost as many illustrations as Part I., is descriptive of a very large variety of apparatus used in experiments and demonstrations relating to the statics and dynamics of solid bodies, liquids and gases, thermo-dynamics and the testing of materials. Electrical and chemical experiments are not included in this volume. In very many cases, the experiments themselves are described, and valuable hints are given in the text and in footnotes as to the best manner of obtaining the desired results. A feature of the book is the extensive list of manufacturers of the various apparatus and material; the price, too, of such apparatus is

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frequently quoted. The descriptions throughout are clear and to the point, and the editing has been done with care. Altogether, the volume under review is one of the best books on experimental physics we have seen, and it should be of great value not only to teachers of physics but to all those who are interested in one way or the other in the subject, the only slight drawback, from an English point of view, being that the book is printed in German characters.

Telegraph Secondary Cell Installations. By ARTHUR CROTCH. (London: Guilbert Pitman.) 2s. 6d. nett.

The sub-title of this book is "A Practical Work on the Charging and Management of Accumulators," but we fear that it is totally undeserving of this honour. Chapters I. and II. deal with continuous-current generators and continuous-current motors respectively, and contain matter that is given more satisfactorily in the hundred-and-one elementary text-books on electrical engineering. Chapter III. is devoted to alternating-current machines and Chapter IV. to transformers and motor-generators, but the author does not explain what the connection is between the legitimate subject matter of his book and alternating-current and transformers. After diligent search through 87 pages the patient reader is rewarded with Chapter VI., entitled "Evolution of the Secondary Cell," this being the first notable mention of the secondary cell.

At the end of Chapter VII. the author states that the efficiency in ampere-hours of a cell, under the best conditions, does not exceed 60 or 70 per cent., but we venture to think that not a few accumulator engineers will disagree with this view.

A comparatively small part of the volume is actually devoted to storage batteries, and this part may well prove useful to the telegraphist.

THE BRITISH ASSOCIATION AT LEICESTER.

(FROM OUR OWN CORRESPONDENT.)

Thursday, August 1st.

SECTION A.

At the conclusion of Prof. Love's presidential address a vote of thanks was proposed by Sir David Gill, seconded by Sir George Darwin, and carried unanimously. The first Paper taken was one by the Hon. R. J. Strutt, F.R.S., entitled "Helium and Radio-activity in Common Ores and Minerals." Evidently Mr. Strutt was somewhat surprised at being called upon so early in the proceedings, and explained that he had not even had time to write a Paper. However, he gave a brief *résumé* of some experiments which he had recently carried out, and the audience had to be satisfied. Perhaps in future years the arrangements made whereby representatives of the Press can obtain copies of Papers will be considered more carefully, but it must be confessed that they were lamentably deficient in certain sections this year. Of the six Papers down for reading in Section A not a single one was available, and very little effort appeared to be made to rectify the error. Perhaps it may not be out of place to remind officials that the welfare of the British Association is largely dependent on the publicity given to its proceedings.

Mr. Strutt's opening remarks dealt with the question as to whether radio-activity is a property of ordinary elements. It was certain that the radiation given off by common elements effected the ionisation of air, but he doubted, all the same, whether the element itself was actually radio-active. It was easy to detect a quantity of helium as small as 10^{-6} of a cubic centimetre, and therefore the helium produced in an ordinary element was easily detected. As a matter of fact 1 kilogramme of quartz on being pumped out gave no less than a cubic millimetre of helium, and he had worked with ease on only 100 grammes. Not only had the author extracted helium in measurable quantities from quartz, but he had also detected it in granite and many other common elements and ores. The question that he tried to settle was: Does the presence of helium in quartz prove that radio-active changes are going on within the substance? He did not think it did; indeed he was inclined to quite an opposite view. Most rocks contain radium and he was inclined to the opinion that this fact supplied the key to the phenomenon. In order to verify this supposition he made several experiments to determine the ratio of helium to radium in quartz, and found that it was the same as in the strongly radio-active minerals. In passing, he noted that strongly radio-active minerals contained 10^7 times as much helium and radium as quartz. A striking exception to the constant ratio rule was beryl, certain samples of which he had examined. These samples gave 10,000 times as much helium as quartz, but they gave no appreciable sign of radio-activity. From his experiments he came to the conclusion that ordinary elements gave no evidence of any production of helium.

Prof. E. Rutherford, F.R.S., in discussing Mr. Strutt's Paper, said he once visited a town which was lighted by natural gas, and at least 2 per cent. of this gas consisted of helium. He had been struck by the amount of thorium in the earth and would like to have a determination of the amount which could be detected. He was much puzzled by the peculiar behaviour of beryl, and suggested looking for thorium.

In his reply, Mr. Strutt said that it was necessary to have ten times more thorium than uranium in order to be able to detect it. He had found thorium in granite, but not sufficient in beryl to account for the strange behaviour of that mineral.

The next Paper taken was by Lord Kelvin, "On the motions of Æther produced by Collision of Atoms or Molecules, containing or not containing Electrions." He insisted strongly on the indivisibility of the atom whether it consisted of a particle of matter or of electricity, and he thus refused the hypothesis that the atom is built up of electrons, or "electrions," as he prefers, rightly, to call them. Another point of interest was his reversion to the term "resinous" as applied to negative electricity, and he explained that he did this merely to avoid confusion.

SECTION G.

At the conclusion of Prof. S. P. Thompson's Presidential Address a vote of thanks was proposed by Colonel Crompton, who said that Prof. Thompson was always affectionately referred to, by those who knew him, as "Silvanus." Prof. Hele Shaw, in seconding the motion, said that he was one of the first batch of students that Prof. Thompson ever had and he wished to thank him for the enormous benefit that experience as a student had given him. The president of that section had the happy knack of making all his students tremendously keen on physical science, and they themselves always referred to him as "Silvanus."

The only Paper down for reading in this section was that of Mr. Dugald Clerk on "The Present Position of Gas and Petrol Engines." Apparently the author is hopeful of being able to compound a gas engine successfully, for although his, and other people's, attempts have failed hitherto, he is still at work on the problem. In his conclusions, he maintained that the main efforts of engineers and scientific men should be directed to the reduction of weight and increased power of the unit. So far as gas engines for marine purposes are concerned this may be true enough, but for driving electric generators the gas engine has other and more serious faults. Its chief sin in this direction is large cyclic irregularity, and this must be cured, or at all events improved, before reduction of weight and increase of power are attempted.

This evening the Mayor of Leicester (Sir Edward Wood) held a reception in the Abbey Park, and as the weather was beautifully fine, though rather cold, the function was a huge success. Several thousands of visitors were present and the park presented a most brilliant scene. The illuminations were carried out on a most magnificent scale, the coloured fairy lamps numbering no fewer than 40,000 and the Chinese lanterns among the trees 3,000. These lamps were lighted by a staff of 210 men, the time occupied being 23 minutes. Not only were the lamps scattered about the grounds, but several were floated on the lake, and bridges spanning the river and lake were outlined. Boats carrying coloured lanterns patrolled the river and both banks of the latter were lined. The effect produced was exceedingly fine, while the music and supper provided greatly added to the success of a most charming evening.

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Friday, August 2nd.

SECTION A.

So far as physical science is concerned to-day's work has been of absorbing interest; the first item was a discussion on "The Constitution of the Atom." At yesterday's meeting of this section Lord Kelvin had entered an emphatic protest against this title, as he contended that the atom —whether of ponderable (gravitational) matter, or of electricity—was the fundamental unit, and therefore could not have a constitution. However, he was present on the platform throughout the discussion and contributed to it near the end. The debate was opened by Prof. E. Rutherford, F.R.S., who gave a brief historical sketch of existing knowledge regarding the constitution of the atom. He said that the fundamental idea dated from the time of Dalton, but that at the present day the chemist did not regard the atom as the smallest possible particle of matter. For the last 10 years physical researches had afforded experimental proofs of the atomic theory, and so far as it existed as a working chemical theory recent knowledge had not undermined it but had materially strengthened it. Coming down to purely physical work, he said that the electron must be looked upon as a sphere of electricity or as an electrified sphere. Its diameter was known to be of the order of 10^{-13} cm., and its sphere of action, 10^{-12} cm. He was sure that the electron had come to stay, and that it was a constituent of all matter. Nevertheless, the stability of the atom of matter was not affected by the liberation of one or more electrons. He then referred to Lord Kelvin's idea of a number of electrons being contained by a sphere of positive electrification, and to Prof. J. J. Thomson's idea of a similar arrangement, practically the only difference being that Thomson's electrons were revolving in rings, whereas Kelvin's were stationary. He was convinced that hydrogen played a most important part in electrical conduction, and dealt further with the question of an electron being tacked on to each hydrogen atom. So far as he himself was concerned, he believed in the existence of a positive electron, and he described briefly the work of a German savant who claimed to have discovered positive electrons. He thought it had not been isolated hitherto simply because everybody expected that it would have properties exactly opposite to those of the negative electron, or in other words, that it would be the mirror image of the negative electron. It might, on the contrary have entirely different properties and so elude the vigilance of those who were seeking it. With regard to spectrum analysis, he was of the opinion that it would not be of very great use in the investigation of the constitution of the atom. The spectrum of an element was probably not due to the element at all, but to the superficially attached electrons. Thus it might happen—and he inclined to the opinion that it did—that the spectrum due to the internal electrons of an atom—*i.e.*, to the element itself—existed only in the ultra-violet part of the spectrum and had never yet been observed. This would account for the variation of the so-called spectrum of an element with temperature. There was evidence for the radio-active point of view which showed that electrons in atoms were in violent motion, as otherwise they could not be expelled with the velocity of light.

The next speaker in the discussion was Sir Oliver Lodge, who at once avowed himself as the champion of the electric theory of matter. At all events he claimed that it was a splendid working hypothesis. He knew that everybody was not of this opinion, and Lord Kelvin himself did not hold it. In this connection he recognised that it was hazardous and interesting—painfully interesting—to differ from Lord Kelvin. He maintained the electric theory, because in whatever direction it was applied it did not break down, and, if it did not break down, then it was good enough until something better turned up. The inertia of matter, for instance, could be explained electrically, because when an electric charge was in motion it set up an electric field, and an exercise of force was required to stop or retard it. Radiation could also be explained, for, when an electric charge was accelerated, it radiated in the proper direction—that is to say, it imparted vibrations to the surrounding ether. With regard to instability, if the atom were considered as a revolving assemblage, then the corpuscles experienced a centripedal acceleration and radiated, whence instability was set up. He agreed with Prof. Rutherford that the difficulty of the whole matter lay in the positive charge, of the existence of which there was no evidence whatever.

Sir Wm. Ramsay, who rose next, said that from the chemist's point of view the interest lay in the satellites or detachable electrons, and not in the internal or constitutional electrons of the atoms. Hydrogen was not an element at all, but a compound of hydrogen and electrons. Chemists wrote H – to represent an atom of hydrogen, and H – H to represent a molecule, but he was not sure whether they ought not to write H – – H. In the same way, having regard to the electrons present, an atom of what was called hydrogen ought to be written H E, where E stood for an electron. When, however, they considered a molecule of so-called hydrogen, the question arose as to whether they should write it H E H E or H E E H. For himself, he thought the former way was correct. With regard to Prof. Rutherford's statement that loss of electrons had no effect upon an element, he would like to state that although that might be true, he had distinct evidence that increase of electrons made a difference. For instance, some time ago he sealed up some radium in a glass bulb through which only the β rays, or electrons, could pass. In proximity to this bulb he placed a number of elements, among which was nickel. This nickel, after being bombarded with electrons, proved to be coated with a radio-active skin, and precipitated a strongly radio-active substance in sulphuric acid.

Mr. F. Soddy expressed the opinion that the time had not yet come to believe in the electric theory of matter. Indeed, all the results of the last 25 years of research could be accepted without applying the electric theory of the constitution of matter. He ventured to say that none of the actual experimental results arrived at by chemists concerning this subject had been predicted by physicists. The "predictions" had been applied after the experimental results had been obtained. He could not accept the theory that the loss of energy by an atom produced a change in the matter of which that atom was constituted; at all events, this drain of energy produced no effect such as might be observed by chemists. He was convinced that the ultimate solution of these problems would come from the chemists.

Mr. G. A. Schott said that the new hypothesis of each hydrogen atom having only one electron was unworkable. On this basis there were not sufficient surface electrons to the atom to account for the number of lines in the spectrum of iron, for instance.

Prof. J. Larmor called attention to the fact that radio-activity was not the only cause leading to discussion in these matters. It merely constituted a new group of facts fitting into an old theory. Faraday was really the founder of the electron theory, and he enunciated it when he stated that the separation of matter was proportional to the separation of electricity. Clerk Maxwell, too, wanted to postulate electrons, but they would not fit into his scheme. He (Prof. Larmor) then referred to the beautiful bell analogy of the atom, and said that everything depended on whether the bell was hung on to something else, or whether it was really the atom itself.

Lord Kelvin could not believe that the mere motion of electrions gave the widely different properties and degrees of stability which we knew belonged to different kinds of matter. Nor could he believe that radio-activity was a mere residue of the kinetic energy of the atom, for if so, how could an electron be thrown off with the velocity of light? He preferred rather to regard the atom as a big gun loaded with a shell which again contained a charge, for when the electrion was thrown off it did not cause the bursting asunder of the atom any more than the firing of the gun effected its destruction. The electrion itself, however, did change its original nature, in exactly the same way as the shell broke into pieces when it exploded. His gun had probably been loaded before there were sun, stars or any of the things that we now know, and it only required contact with matter to release the trigger and fire off the shell.

Prof. Rutherford replied very briefly.

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The first Paper on the list was one by Sir Wm. Ramsay, entitled "On the Variability in the Products resulting from Changes in Radium Emanation." The author commenced by reminding his audience that radium, actinium and thorium all yield helium, and then proceeded to describe the results of experiments which are nothing short of remarkable. It is known, of course, that the emanation decomposes water with the liberation of excess of hydrogen, but where this excess of hydrogen comes from nobody knows. Sir William Ramsay exposed a solution of copper sulphate to the emanation for about a month, and at the end of that time the residue obtained gave the spectra of both sodium and lithium. The experiments were repeated three times, and the results were perfectly consistent in each case. The presence of sodium was not, of course, surprising, as the containing vessels used were composed of glass, but all the materials were tested for lithium and there was not a trace before the experiments were commenced. Nevertheless Sir William Ramsay expressed a doubt as to whether the quantity of sodium found could have all come from the glass, and he is going to undertake further investigations in this direction. His next experiment was with copper nitrate, when lithium was again detected after a solution had been exposed to the emanation. Fresh copper nitrate not so treated with the emanation showed no sign of the presence of lithium. In both cases, however, sodium sulphate was detected, but the treated substance showed just twice as much (1·6 milligrammes) as the untreated substance. On evaporating water treated with the emanation 0·3 milligramme of solid was obtained, while the inactive gas produced was neon with a trace of helium. Gases from the treated copper nitrate solution contained argon, with possibly a trace of neon. He remarked that 1 cubic cm. of emanation gives off $3\frac{1}{2}$ million times as much energy as 1 cubic cm. of a mixture of hydrogen and oxygen when exploded, and suggested that some of this vast amount of energy might account for the presence of the elements which he had found.

The Hon. R. J. Strutt confessed that he could not find any source of error in Sir William Ramsay's experiments to account for the presence of neon in the case of water and emanation. He made a rough calculation in order to determine how much air would be required to provide the amount of neon (0·5 cubic mm.) obtained by Sir William and found that it was about 100 cubic cm. In these circumstances, he was sure that there could not have been such a large leakage of air to the apparatus as would account for this quantity. He further mentioned that there was quite sufficient lithium in quartz vessels to give a very distinct spectrum.

Prof. Rutherford complained that the amount of radium in the possession of experimenters was deplorably small. There were only about two laboratories in the world that were in a position to repeat Ramsay's experiments, and if only an experimenter could have a gramme instead of 100 milligrammes at his disposal there would be a very great deal more work done.

Prof. H. E. Armstrong, F.R.S., put forward the suggestion that the so-called inert gases are in reality very active, and that they are not monatomic at all.

In reply, Sir William Ramsay said that helium, when passed through a bath of liquid hydrogen, gave up a considerable amount of krypton.

The next Paper was by Messrs. F. Soddy and T. D. Mackenzie on "Pseudo High Vacua," and the last by Prof. J. Larmor on "The Range of Freedom of Electrons in Metals."

In their Paper on "Pseudo-High Vacua," Messrs. F. Soddy and T. D. Mackenzie stated that the electrical characteristics of a high vacuum occurred in helium, purified by calcium and subjected to further purification by the passage of the discharge, at pressures between $\frac{1}{3}$mm. and $\frac{2}{3}$mm. of mercury, while in hydrogen the same held at about $\frac{1}{20}$ mm. These pressures were far higher than was commonly supposed. Pure helium conducted at pressures higher than $\frac{2}{3}$ mm. of mercury in the same way as common gases. Briefly, the behaviour of helium was precisely similar to that of argon, or a common gas like nitrogen at about one-tenth the pressure. This explained not only the extraordinary resistance at low pressure but also the extraordinary conductivity of the gas at atmospheric pressure. The absorption of helium, argon and neon in spectrum tubes after continuous running occurred mainly in the volatilised film of aluminium deposited from the electrodes. The gas could be mainly recovered by dissolving the film in mercury or by heating the tube. In the latter case it was re-absorbed, on running, with extraordinary rapidity. The portion causing the Campbell-Swinton effect was only a small fraction of the total.

In the evening Mr. W. Duddell, F.R.S., gave an admirable lecture on "The Arc and Spark in Radio-telegraphy." He commenced by explaining some of the fundamental properties of signalling by means of Hertzian waves, in order to bring out clearly the relative advantages and disadvantages of the two rival methods now in practical use for producing Hertzian waves for wireless telegraphy. After using and explaining a number of mechanical models, which all worked with admirable smoothness, he quoted the following test carried out on the Lodge-Muirhead installation at Hythe. The station at Hythe had to receive messages from Elmer's End at a distance of 58 miles overland, in spite of the fact that the Admiralty station at Dover, only $9\frac{1}{4}$ miles distance, was transmitting as powerfully as it could in order to produce interference, and that the regular communications were going on in the Channel between the shipping. It was found possible with a difference of wave-length of 6 per cent. to cut out the interference from the Dover station.

The arc method seemed eminently suitable for very high speeds of working. As the oscillations were quite continuous, they could be cut up into groups to form the dots and dashes of the Morse alphabet, so that there seemed no reason why as high a speed of working should not be obtained from the arc method of wireless telegraphy as is obtainable by automatic signalling on land lines; for the dot or shortest signal of the Morse alphabet, even at a speed of 300 or 400 words per minute, would last long enough to consist of many hundreds of oscillations of the current in the aerial, so that there would be plenty of oscillations in the group forming the dot to give good syntony. Turning to the spark method for high working speeds the dot of the Morse alphabet must at least occupy the average time required to charge the condenser or aerial and produce one spark, and preferably sufficiently long for several. In the spark method it was therefore essential to use a high rate of sparking for high-speed signalling. This difficulty had not become very serious with the present low speeds of sending. When using considerable amounts of power to transmit messages over long distances, and also a high speed of working, the practical difficulty in constructing apparatus suitable for sufficiently rapid sparking became serious. Mr. Marconi in 1905 claimed to have already reached a speed of 100 words per minute by the spark method, and lately there had appeared in the technical press examples of high-speed signalling by the British Post Office over a distance of 15 miles in which readable signals were received at a speed of 70 words per minute. Almost all the receivers that had been used in the spark method could be equally well used for the arc method; for the transmission in either case was effected by Hertzian waves traversing space, and the only fundamental difference consisted in the number of oscillations in each train of waves. However, in those methods in which a telephone receiver was used it was necessary to break up the continuous oscillations of the arc method into groups succeeding one another sufficiently rapidly to produce an audible sound in the receiver; for in the spark method the sounds heard in the receiver corresponded with the succession of impulses of the diaphragm, one for each spark at the transmitter. This chopping up of the continuous wave-train so as to produce audible signals in the receiving apparatus could be done either at the transmitting end or in the receiving apparatus. An example of this latter method was Poulsen's ticker. The question whether receiving apparatus could be arranged so as to receive messages both from stations equipped with a spark apparatus and from stations equipped with the arc apparatus was a matter of enormous importance at the present moment in view of the probable ratification of the Berlin Convention, which imposed an obli-

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gation on all commercial stations to intercommunicate without regard to the make or system of transmitting apparatus employed. He was of the opinion that there would be no difficulty in carrying this into effect provided that the stations using the spark method sent out long trains of waves, as they should do to obtain syntonic working, which was also called for by the Berlin Convention. An extremely interesting development which was now progressing rapidly owing to the possibility of producing continuous oscillations by the arc method was wireless telephony. Supposing that the intensity of the oscillations could be varied in a manner corresponding with the vibrations of the air which constituted sound and speech, then we should obtain at the receiving stations a train of Hertzian waves whose amplitude varied in a corresponding way; by allowing these waves to act on a telephonic receiver which was sensitive to the intensity of the waves we should obtain in the telephone a reproduction of the sounds. This had actually been carried into effect by employing an ordinary microphone to modify the current through the transmitting arc so as to vary the intensity of the oscillation current produced, and by employing what was known as a point-detector and a telephone at the receiving station. Another method which might be used consisted in causing the microphone to vary the frequency of the oscillations of the generator, and by arranging the receiver so that it was more or less strongly affected according to the frequency of the received waves. He was informed that such good results had already been obtained on the experimental stations for wireless telephony that it was proposed to equip stations at Oxford and Cambridge for the further perfecting of this application.

Monday, August 5.

SECTION A.

This section has now divided into two departments: (*a*) Mathematics and (*b*) General Physics. Most of the papers possessed of interest to readers of *The Electrician* have already been dealt with, the chief item of interest this morning being perhaps the report of the committee on electrical standards. In a paper on "The Density of Ether" Sir Oliver Lodge pointed out that the theory that an electric charge must possess the equivalent of inertia was clearly established by J. J. Thomson in the "Phil. Mag." for April, 1881, and that the discovery of masses smaller than atoms was made experimentally by J. J. Thomson, and communicated to Section A. at Dover in 1889. The theory that the corpuscles so discovered consisted wholly of electric charges was sustained by many people, and was clinched by the experiments of Kaufmann in 1902. The concentration of the ionic charge, required to give the observed corpuscular inertia, could be easily calculated; and consequently the size of the electric nucleus, or electron, was known. The old conception that a magnetic field was kinetic had been developed by Kelvin, Heaviside, FitzGerald, Hicks, and Larmor, most of whom had treated it as a flow along magnetic lines; though it might also, perhaps equally well, be regarded as a flow perpendicular to them and along the Poynting vector. The former doctrine was sustained by Larmor, as in accordance with the principle of Least Action, and with the absolutely stationary character of the ether as a whole; the latter view appeared to be more consistent with the theories of J. J. Thomson. A change in motion was well known to be surrounded by a magnetic field; and the energy of the motion could be expressed in terms of the energy of this concomitant field, which again must be accounted as the kinetic energy of etherous flow. Putting these things together, and considering the ether as essentially incompressible—on the strength of the Cavendish electric experiment, the facts of gravitation and the general idea of a connecting continuous medium—the author reckoned that to deal with the ether dynamically it must be treated as having a density of the order of 10^{12} grammes per cubic centimetre. The existence of transverse waves in the interior of a fluid could only be explained on gyrostatic principles, *i.e.*, by the kinetic or rotational elasticity of Lord Kelvin. And the internal circulatory speed of the intrinsic motion of such a fluid must be comparable with the velocity with which such waves were transmitted. Putting these things together, it followed that the intrinsic or constitutional vortex energy of the ether must be of the order 10^{33} ergs per cubic centimetre. Thus every cubic millimetre of the universal ether of space must possess the equivalent of a thousand tons, and every part of it must be squirming internally with the velocity of light.

In the course of his Paper on "The Transmission of the Active Deposit from Radium Emanation to the Anode," Mr. Sidney Russ explained that a comparison had been made between the amount of active deposit obtained on a wire charged positively and that obtained on the same wire charged negatively at pressures ranging from 0·001 cm. to 10 cm. Diffusion experiments—*i.e.*, experiments made with the wire and containing vessel maintained at the same potential—had also been made over this range of pressure. Whereas the amount of active deposit obtained on the negative electrode diminished as the pressure diminished, as had already been found by Makower, it was found that the amount obtained on a positive electrode increased as the pressure was diminished. A comparison had next been made of the quantity of active deposit obtained on positive and negative electrodes in different gases at pressures between 0·1 mm. and 1 mm. Experiments had also been completed in air and hydrogen, and the work was being continued for sulphur dioxide. It was found that whereas in air the amount of active deposit obtained on a negative wire was appreciably greater than on a positive wire over this range of pressure, in the case of hydrogen just as much active deposit was obtained on a positive wire as on the same wire charged negatively. Thus the quantity of active deposit which was directed by an electric field at these low pressures depended on the nature of the molecules with which the radium emanation was fixed.

In a report of a committee on magnetic observations at Falmouth Observatory it was stated that the mean values of the magnetic elements for the year 1906 were—declination 18 deg. 5·3 min. W., horizontal force 0·18790 C.G.S., vertical force 0·43344 C.G.S., inclination 66 deg. 33·7 min. N. The committee reported that the observatory at Eskdale Muir would be ready for occupation this autumn. It was clearly important for the sake of continuity that the Falmouth Observatory should be fully maintained until Eskdale Muir is in complete working order. To secure this the committee asked for reappointment, with a grant of £50.

Perhaps one of the greatest disappointments of this year's meeting was the very poor discussion which took place on Prof. Armstrong's Paper "On the Nature of Ionisation." It will be seen from Prof. Armstrong's Paper, which we publish elsewhere, that he makes a strong attack on the ionisation theory, and maintains that the meaning conveyed by the word "dissociation" is amply sufficient to cover existing knowledge. In opening the discussion, Sir Oliver Lodge said that Prof. Armstrong's Paper was really a vote of censure on Section A. He regretted that chemists laboured under a misapprehension with regard to the work which physicists had been doing in connection with the atomic theory. So far as he was concerned, he thought that recent physical research had given an immense stimulus to the original atomic theory, and that so far from destroying the atom, it had actually strengthened it. Prof. Armstrong had said that Faraday was content with the use of the term electrolysis, and if that was good enough for Faraday it was good enough at the present moment; he (Sir Oliver) did not agree with this at all. The purpose of research was to improve on Faraday's discoveries, and it would not do to stand still. No physicist could say whether atoms in solution were actually separated or whether they were only on the verge of separation, but in physics it was easier to treat them as being actually separated, although it might not be so for chemists. So far from physics giving chemistry the cold shoulder, as was suggested by Prof. Armstrong, he thought exactly the reverse was the case. This was to be regretted, because chemists could render invaluable aid to physicists and could tell them when they were going wrong. He firmly believed that physicists and mathematicians would ultimately found a working mathematical theory of chemistry. Other speakers then joined in the discussion, but most of them were chemists and their views were of little interest from the electrical aspect.

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SECTION C.

Among the Papers down for reading in Section C (Geology) was one on "The Distribution of Radium in the Rocks of the Simplon Tunnel," by Prof. J. Joly. The author stated that the principal classes of material which enter into the composition of the massif of the Simplon are: (*a*) The Jura-Trias sediments, lithologically often much alike and much interfolded; (*b*) the Palæozoic crystalline schists; and (*c*) the gneiss of Monte Leone and the Antigorio gneiss, both stated to be of Archæan age. These rocks throughout contain radium, and for the most part in quantities much above what hitherto has been ascribed to sedimentary or igneous rocks. Some 36 typical samples, taken from various points in the tunnel, have been examined. The poorest in radium are certain anhydrite rocks. Certain amphibolite schists go very high. The Antigorio gneiss rises from $10{\cdot}5 \times 10^{-12}$ and $8{\cdot}0 \times 10^{-12}$ grammes radium per gramme of rock at the Italian entrance, to $23{\cdot}7 \times 10^{-12}$ at 4,000 metres inwards. Some of the Archæan gneisses yielded very high results. Such quantities of radium, if generally distributed throughout the rocks of the massif, would be sufficient to disturb any forecast of the temperature which under normal conditions would be encountered at the level of the tunnel. It is suggested that the radium was, in fact, the source of the discrepancy between the predicted and the observed rock temperatures. As it is improbable that these results are unique, and apply only to this particular sedimentary accumulation and locality, they appear to point to hitherto unsuspected quantities of radium (and its parent elements) in the immediate surface materials of the earth.

SECTION G.

The first Paper on the list was that entitled "Pupin's Compensated Cable for Telephone Transmission," by Sir William Preece. This Paper we publish in full, and an abstract of it here is therefore unnecessary. Sir William, however, recounted one of his characteristic anecdotes, the point of which was to emphasise the importance of the frequency and wave form of the ideal vibration for telephonic transmission. He said that Hughes was exhibiting the telephone in Paris in 1881, and made the somewhat remarkable statement that the instrument would transmit the name of an Englishman better than that of the citizen of any other nation. To prove this, he shouted the names of Helmholtz, Galileo and Faraday into the transmitter, but the last-named was heard much more distinctly than the others in the receiver. He mentioned this to call attention to the fact that the resonance of the diaphragm was a most important factor.

In the discussion Sir Oliver Lodge said that the Pupin device had been predicted by Oliver Heaviside. Undoubtedly self-induction had a beneficial effect, but it also produced reflection. Notwithstanding the reflection, however, the advantage outweighed the disadvantage; in fact, he knew that if a self-induction of about 70 or 80 henrys were placed in the middle of a cable it would improve transmission. In the transmission of signals by electric waves the great difficulty was to keep the amounts of magnetic and electric energy equal. They started equal, and if they continued equal then the wave would travel with the velocity of light, and there would be no difficulty. The point was, however, that resistance had the effect of decreasing the quantity of magnetic energy, with the result that the electric energy went on alone and arrived at the other end as a sort of diffusion—just as heat "oozes" through a slab of metal. The remedy, therefore, was either to strengthen the magnetic energy or to weaken the electric energy. By introducing a leak they effected the latter, which was, however, not satisfactory. If it were possible to secure a conductor of infinite conductivity then there would be no loss of magnetic energy and the signal would travel with the velocity of light. Pupin's device had the effect of strengthening the magnetic energy.

Mr. S. G. Brown offered a strong objection to placing the self-induction in "lumps" along the length of the cable, as the reflection so caused was very serious. Moreover, it was a practical impossibility to place a Pupin coil at intervals of a naut along a submarine cable. He called attention to the device of winding an iron covering on a copper core so as to distribute the self-induction throughout the length of the cable. The latest development of this idea was to twist together two rods of copper and iron, each of a D section and insulated from each other. This arrangement was easy to manufacture and would be ideal if only the permeability of iron were higher. The iron at present employed had a permeability of 150, but if this could only be increased tenfold, he saw no difficulty in direct transmission of speech between New York and London; in fact, there was practically no limit.

The President (Prof. S. P. Thompson) remarked that he had devoted a good deal of attention to the subject and had come to the conclusion that the only real remedy was to distribute the self-induction along the entire length of the cable, owing to the fact that the capacity itself was also distributed. Years ago he advocated the employment of induction coils, but the cable companies refused to listen to him because the first Atlantic cable that had ever been laid was ruined by the action of some person who applied a long spark coil to make it speak! Willoughby Smith himself had found that an inductive leak at the end of the cable effected improved transmission, while Pupin had shown that the distances between the blocks of self-induction, as well as the frequency of the vibration transmitted, must be reduced. Prof. Thompson maintained that if a device were forthcoming which would treble the speed of a submarine cable there would be an enormous saving, even though the cable cost three times as much to manufacture. This was due to the fact that it would cost not more than one-third the money to lay as compared with the cost of laying three ordinary cables.

Sir William Preece, in his reply, stated that Pupin placed a coil at every mile of his cable. With regard to Sir Oliver Lodge's statements that self-induction placed in the middle of a telephone cable improved transmission he did not agree, as Pupin had tried bunching four of his coils at intervals of four miles, and could get no speech transmitted. Sir Oliver Lodge, however, here explained that he was referring to a telegraph and not to a telephone cable.

The next Paper was by Sir Oliver Lodge on "Tuning in Wireless Telegraphy." Most of the author's remarks were confined to the Lodge-Muirhead system of wireless telegraphy, in which the arc method of transmission is employed. Sir Oliver stated that it was possible to have too long a train of waves, as the latter half of the train might undo the work of the former half. This he explained on the principle of beats. The old idea of the polished sphere oscillators was dying out, and he now maintained that tuned stations should employ points kept in an atmosphere of ionised air, in order to secure conduction. Another important point was to employ an alternator which gave a broad-shouldered curve. With regard to the question of earth connection, if an untuned snappy spark were employed, then the aerial might be earthed, but for tuned sparks it was essential to have two capacities both insulated from earth. Moreover, the maximum radiating power depended upon the distance of the lower capacity from earth, as well as upon the height of the aerial system. The great advantage in doing away with the connection to earth was that all variations due to increasing or decreasing amounts of moisture, &c., which affected efficiency, were eliminated. From calculated and experimental determinations he had ascertained that the quantity of energy received was not greater than 10^{-9} of that sent out, and yet he had succeeded in sending signals over a distance of 300 miles with less than 1 H.P. at the transmitting station. He took great care to eliminate anything in the nature of a loose or uncertain connection.

The President, in inviting discussion, said he would call particular attention to the question of earth connection. Prof. Fleming, in his book, had asserted most emphatically that the earth connection was essential to the successful working of the Marconi system.

Sir William Preece contended that tuning depended simply upon a balance being obtained between capacity and self-induction, and in the Lodge-Muirhead system he maintained that the lower aerial and the earth constituted a capacity and that therefore the earth did come in.

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In his reply, Sir Oliver Lodge said he thought that the earth, or rather the sea and the sky, had a great effect upon transmission so far as long-distance work was concerned. There was, in his opinion, repeated reflection from sky to sea, so that the oscillations followed the curvature of the earth. He agreed with Sir William Preece that the lower aerial and the earth constituted a capacity, but he mentioned the significant fact that if the aerial were connected to earth, then tuning disappeared almost completely. His own experiments were made over distances not exceeding 300 miles, and for those distances a connection to earth was fatal if anything like syntony were required. A skilled operator could pick up the "tune" being emitted by a particular station in about a minute or two. In reply to a question by Prof. Trouton, he did not think that the different specific inductive capacity of the upper air effected refraction, thus causing the waves to follow the curvature of the earth.

The next Paper, by Mr. J. T. Morris, was entitled "Note on an Oscillograph Study of Duddell Arcs of Low Frequency," and provoked a very small discussion. Mr. Petavel called attention to the fact that he had noticed the formation of graphite on the negative pole of arcs burning under pressure, and in his reply Mr. Morris said that the Poulsen workers frequently had to clear out the soot which accumulated in the coal-gas apparatus.

The fourth Paper was by Mr. L. Gaster and dealt with "Developments in Electric Lamps." The author described briefly the various forms of metallic filament lamps which have been devised recently, and then offered for inspection the "Helion" lamp, which is a product of the United States. In appearance, the lamp is similar to an ordinary carbon incandescent lamp, and is constructed for 100 volts. According to Mr. Gaster, the filament consists of a hard carbon core on which silicon has been deposited, and the lamp works at a high temperature without the carbon and silicon uniting to form carborundum. The lamp gives 30 c.p. with a consumption of 35 watts, and its useful life is said to be from 600 to 1,000 hours. In the discussion on this Paper, Col. Crompton called attention to the remarkable regularity in the voltage of English supply systems, and said that this was one of the things which made the metallic filament lamps a possibility. He saw no reason why such lamps should not be made for 200 volt circuits, but the 5 c.p. and 8 c.p. lamps would have to be dropped. This was possible, because he thought that the smoke pall which hung over our large cities was getting thicker and thicker every year. For this reason people would want lamps of higher candle-power than hitherto.

The last Paper on the list was by Prof. E. G. Coker, and was entitled "The Equipment of the Engineering Laboratory of the Finsbury Technical Institute." There was, however, very little of electrical interest in this Paper, and the audience had become exceedingly small.

Tuesday, August 6th.

SECTION G.

Work was commenced this morning with a couple of Papers, entitled "Ferro-concrete and Examples of Construction" and "Some New Uses for Reinforced Concrete," by Messrs. J. S. E. de Vesian and W. Noble Twelvetrees respectively. It was stated that reinforced concrete poles had been used for some time past for carrying cables employed in power transmission systems in various Continental countries. An improved method of construction had recently been introduced by Messrs. Siegwart, of Lucerne, for the production of hollow poles by means of a special machine, the poles being made to any required length and taper, and the concrete reinforced suitably for the length and the load to be carried. Reinforced concrete standards for power-transmission lines were also coming into extensive use in the United States. A drawing was shown which gave full details of the standards for a three-phase power-transmission line, the standards being 49 ft. 7½ in. high, with a minimum clearance of 30 ft., and reinforced with 12 ¾ in. and ⅞ in. longitudinal bars, and a spiral winding of ⅛ in. steel wire. The author (Mr. Twelvetrees) considered that the utility of reinforced concrete for purposes such as those under consideration should appeal to the Post Office and railway companies, as well as to those concerned in electricity undertakings, since reinforced concrete was an ideal material for the construction of telegraph and telephone poles. An instance of enterprise in this direction had been afforded by the Pennsylvania Railroad, by whom a mile of telegraph poles were erected in the autumn of last year. The poles, from 25 ft. to 34 ft. long, were made of concrete, reinforced with 24 ¼ in. rods, and their transverse dimensions were 8 in. square at the bottom tapering to 6 in. square at the top, the corners being chamfered so as to give an octagonal cross-section above the ground. The work was hurried so as to have the line ready for inspection at a given date, and, in consequence, some of the poles were erected within five days after they had been made. Notwithstanding this hasty construction and the severe windstorms of last winter, it was stated that the poles were in almost perfect condition in May this year. This experience was sufficient to indicate the exceptional suitability of reinforced concrete for the purpose named.

These Papers were followed by a brief discussion, turning chiefly upon the durability of ferro-concrete, but no evidence was forthcoming that the embedded steel suffered deterioration.

Mr. W. Worby Beaumont next read a Paper on "The Origin and Production of Corrugation of Tramway Rails." He described corrugation as consisting of an approximately regular alternation of hard and soft, or of hard and less hard, patches of the surface rolled by the tramcar wheels. The surface of the hard patches was very slightly higher than the general surface, but it became sufficiently so to declare its existence by the noise made by the tramcar wheels as they rolled along the rails as though running over a rack with teeth of almost no assignable height. The author maintained that the repeated running of the heavily-laden tramway wheel over the rail gradually compressed the surface of the crown of the rail. Of this stress transversely the material relieved itself partially by the detrusion at the edges of the rail, where it formed a lip both on the outside and the groove side. This lip remained on the outside of the rail, but was worn off on the inside by the wheel flange. In the longitudinal direction the stresses arising from the compression of the surface material were not thus relieved and the result was the formation of an extremely hard surface in patches of various shapes and lengths. In order to remedy corrugation, he suggested the employment of lighter cars, harder rails, moderate speeds and larger wheels. As examples of corrugation he mentioned those which appear on the new tramway of the London County Council on the Thames Embankment between Blackfriars Bridge and the Temple Gardens.

In the discussion, Col. Crompton called attention to the fact that corrugation of rails was known long before electric traction became so common. There was a lot of it in India, except on the lines which had a gauge of 1 metre. For years, too, it had been evident in the tunnel on the Midland Railway between Bradford and Leeds, and the company had tried everything to prevent it, but had failed. The Darjeeling (India) railway which had an 18 in. gauge would not work at all until there was one free wheel on each axle, and he recommended a trial of this method. In his opinion, the main determining cause of corrugation was unequal slip, which in its turn might be caused by wheels fixed to the same axle having different diameters. Once a corrugation started it was bound to grow, because the wheel drove in the hollow and slipped on the ridge. He had noticed that corrugation was not confined to rails, but was appearing on the highways; this fact was due to the small wheels on motor cars. With regard to the author's suggestions, he thought there was not the slightest chance of having lighter tramcars and lower speeds; tramway authorities would prefer to tear up their rails and put fresh ones down as soon as corrugations appeared. As it was, the speed of the electric tramcar was already very low, and it would never do to make it still lower.

The President (Prof. Silvanus P. Thompson) said it appeared as though an effect like corrugation, which was periodic, ought to have a cause which was also periodic. What this cause was he was not prepared definitely to say, but he had a suspicion that it was due to the elasticity of the axle. If the wheels slipped unequally, then there would be for brief periods

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unequal and opposite torques applied to the two wheels fixed on the same axle. This would produce a torsional strain, which again would be relieved and applied in the opposite direction as the car moved forward. He asked whether corrugations got deeper, or whether they spread out in a longitudinal direction.

In his reply Mr. Worby Beaumont confirmed Col. Crompton's observation that corrugations were appearing on the highway; this he attributed to the use of steam rollers. These machines not only exercised a vertical pressure, but they also acted more or less like brooms. The heavy roller swept up an ever-increasing pile of material, which ultimately became too heavy to be moved forward; the roller then mounted it and commenced the formation of a fresh one on the other side. Thus the surface of the road consisted of a number of soft hollows and hard ridges, which were greatly accentuated by the passage of traffic. He did not think that the difference in the diameters of wheels could account for corrugation on rails, as the diameters were so very nearly alike, and the period would then be too great.

The next Paper was on "Modern Machinery and its Future Developments," by Mr. H. I. Brackenbury, but it contained nothing of electrical interest, and the audience numbered a bare dozen.

The last Paper on the list was on "Resistance Coils and their Comparison" by Dr. C. V. Drysdale. By the time it was reached, however, the Chairman decided to adjourn the Section and announced that Dr. Drysdale had withdrawn his Paper. This was much to be regretted, as the author had brought down a lot of very beautiful apparatus, and we have reason to believe that his Paper was of exceptional merit.

Wednesday, August 7th.

SECTION G.

Sections G and H are the only ones that have held meetings this morning, and the attendance at Section G was very poor.

Mr. R. S. Ball, in his Paper on "The Governing of Hydraulic Turbines," remarked that the employment of water power for driving dynamos had led to a highly scientific study of governing apparatus for water turbines. As a rule, the combined moment of inertia of a turbine working drowned and that of the electric generator was sufficient to prevent undue irregularity; but for impulse wheels, of the Pelton type especially, the addition of a separate flywheel became necessary in many cases, even with the heavy laminated core armatures now employed for the generators. The additional flywheel was sometimes placed between the turbine and generator and sometimes on the end of the shaft overhanging the bearing. The efforts of designers to control turbines directly from the electrical side of the plant, either by solenoids in series with the circuit, or through the field rheostats, had not been attended with any success, and for the most part had been abandoned. The hydraulic governor represented the best practice of the day for the close regulation necessary.

The next Paper was on "The Ice Problem in Engineering Work in Canada," by Mr. Howard T. Barnes.

During the morning a statement was issued to the effect that Lord Aberdeen, Lord Lieutenant of Ireland, had consented to become a vice-patron of the British Association during its visit to Dublin next year. The 1909 meeting will be held at Winnipeg.

Improvement in the Leclanché Cell.—*L'Electricien* states that Messrs. Siemens & Halske have lately patented a new form of Leclanché cell, the essential characteristic of which is the provision of a space in the upper part, round the central carbon electrode, for the collection of the gases. This space is separated from the cell proper by a horizontal layer of *papier mâché*, which is impregnated with paraffin wax, and is impermeable by gases. Above this layer the cell is provided with a cover unaffected by alkalis. In this way the ammonia set free by the ammonium chloride cannot escape into the surrounding air, and when a large amount is produced the increase in pressure causes it partially to dissolve in the liquid.

MOTOR-GENERATORS v. SYNCHRONOUS CONVERTERS.*

WITH SPECIAL REFERENCE TO OPERATION ON LONG-DISTANCE TRANSMISSION LINES.

BY P. M. LINCOLN.

Summary.—In this Paper the author deals more particularly with the case of long-distance transmission lines, and discusses the operation of synchronous converters, motor-generators using synchronous motors and motor-generators using induction motors. He shows that synchronous converters will usually be found the most advantageous.

In this discussion a comparison will be made between synchronous converters, motor-generators using synchronous motors and motor-generators using induction motors in regard to the following points, these points being placed, in the opinion of the writer, in the order of their relative importance: (1) Reliability, (2) voltage regulation, (3) corrective effect, (4) efficiency, (5) cost, (6) parallel operation, (7) starting.

These points will be taken up in the order named. As a matter of simplification, it will be assumed that the line voltage is too high for a revolving machine, and must be transformed before being utilised.

1. *Reliability.*—As to reliability, it is evident that the synchronous converter has a very decided advantage in that there is only one machine to get out of order, whereas either of the others involves two. Further, we are forced to use a low voltage on the synchronous converter, so that its insulation is normally called upon to stand a maximum of not more than 700 volts, whereas with the motor-generator sets other conditions may dictate a very much higher motor voltage, and, therefore, a lower factor of safety in insulation. Both the synchronous converter and the synchronous motor-generator set suffer the disadvantage that a momentary removal of the voltage from their terminals—a short-circuit on the transmission line, for instance—will cause them to drop out of step and make it necessary to start them over again. In this respect the induction motor-generator has an advantage, in that it will resume operation automatically after such a temporary cessation of incoming power.

As to "bucking," this is a fault that is more commonly attributed to synchronous converters than to direct-current generators, but the reason for it is that the converter is more widely used under conditions that will cause "bucking" than is the direct-current generator. The usual cause of "bucking" is the sudden occurrence and removal of heavy overloads—as, for instance, when a circuit-breaker blows. The ideal conditions for this occur on the average inter-urban road, where the sub-stations are relatively small compared with the maximum loads carried. A direct-current generator of the same size and exposed to the same conditions would probably give rise to about the same amount of "bucking." Exception is made in the case of the 60 cycle converter, which is admittedly somewhat more sensitive in this respect than the 25 cycle converter, chiefly on account of its necessarily short distance between brushes.

As a relative comparison of the reliability of the methods under consideration in railway work, the following is advanced as a personal opinion. The number given indicates the relative number of hours that the apparatus would be out of service within a given time on account of defects inherent in the apparatus:—

25 cycle synchronous converter	10 hours
Induction motor-generator	14 ,,
Synchronous motor-generator	17 ,,

2. *Voltage Regulation.*—The term will be confined to the changes that may take place in the direct-current voltage. The term embraces at least three distinct features:—

(*a*) *Automatic Change in Voltage with Change in Load.*—In this respect all methods under discussion are equal. Rising or drooping characteristics of an adjustable value can be obtained with either the synchronous convertor or the direct-current generator. The converter suffers the disadvantage that the power factor of the current supplied must vary with varying loads, whereas with the motor-generator sets the direct current voltage compounding adjustment is independent of the alternating-current circuit.

(*b*) *Ability to Adjust the Initial Voltage.*—It is in this respect that the synchronous converter suffers its greatest handicap. In the motor-generator sets the direct-current voltage is absolutely independent of the incoming alternating-current power. With the synchronous converter, on the other hand, the only way to adjust the direct-current voltage is to make a proportionate adjustment of its alternating-current voltage. There are several methods of accomplishing this end. One method is to insert a reactance in the alternating-current circuit of the converter. The disadvantage of this

* Abstract of the introduction to a discussion which took place at a meeting of the American Institute of Electrical Engineers.

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scheme is that the alternating current voltage is thereby made interdependent upon the power factor of the incoming alternating-current power, and that the high-tension line voltage is dependent upon the direct-current voltage adjustment to an extent depending upon the relative reactance in transmission line and in the local converter circuit. Another method is to use an alternating-current booster having the same number of poles as the converter and mounted upon the same shaft. Still another method is the use of taps on the transformer stepping down to the converter, or of an induction or other type of alternating-current voltage regulator. The addition of any of these means of voltage regulation makes the converter equal to the motor-generator set as far as ability to adjust initial voltage is concerned.

(*c*) *Variations in Direct-current Voltage with Variations in Incoming Line Voltage and Frequency.*—The difference between the converter and the motor-generator set in this respect consists in the fact that the converter responds only to changes in the incoming voltage and the motor-generator only to changes in the incoming frequency. This last statement may be modified slightly by recognising that the slip of the induction motor depends upon the voltage, but the normal variations of voltage are so small that this feature can be safely neglected. For a given percentage change in incoming line voltage there will be an equal percentage change in the direct-current converter voltage. For a given percentage change in incoming line frequency there will be a greater percentage change, nearly double, in the direct-current voltage of a motor-generator set. However, changes in incoming line voltage will under normal conditions be much greater and sharper than those in frequency, so that in this respect the converter will probably suffer by comparison with the motor-generator.

3. *Corrective Effect.*—By "corrective effect" is meant in general the results that may be obtained in respect to the voltage regulation of a transmission line by means of a change in the power factor of the current taken. Only the synchronous motor and the synchronous converter need to be considered, since the power factor of the induction motor is not adjustable. So far as corrective effect is concerned, the synchronous motor has a distinct advantage over the synchronous converter in that the corrective effects may be obtained without involving the direct-current voltage. In the converter the corrective effect and the direct-current voltage are interdependent. On the other hand, when a converter is adjusted for a rising direct-current voltage characteristic, the tendency is to correct, in part at least, for the transmission-line drop caused by its own load.

4. *Efficiency.*—In this respect the converter has a decided advantage. It is a case of the losses in one machine as against those in two, and, moreover, the losses in the converter are somewhat less than in either element of the motor-generator set. The full-load efficiency of a converter of, say, 500 kw. capacity may be put approximately at 95 per cent., the synchronous motor-generator set 89 per cent., and the induction motor-generator set 88 per cent. The all-day efficiency will be considerably less than the above As a reasonable estimate of the all-day efficiency under about 75 per cent. load, the following is submitted. In submitting these the writer has in mind units of 500 kw. capacity or thereabouts :—

25 cycle synchronous converter	93 per cent.
Synchronous motor-generator	85 ,,
Induction motor-generator	84 ,,

The following calculation based on the above is somewhat surprising. Assume a station using a 500 kw. unit an average of 18 hours per day at 75 per cent. average load. Assuming power to cost 0·5d. per kilowatt-hour, the saving in power bill of converter over motor-generator is £420 per year. Capitalised at 6 per cent. this represents £7,000. In other words one could afford to pay £14 per kilowatt more for converters than for motor-generators.

5. *Cost.*—In regard to cost the synchronous converter has an immense advantage. An approximate idea of relative cost is given in the following :—

Synchronous converter	60 per cent.
Synchronous motor-generator	100 ,,
Induction motor-generator	100 ,,

6. *Parallel Operation.*—The two points to consider in parallel operation are: (*a*) Proper division of direct-current load between units; (*b*) proper operation so far as alternating-current ends are concerned, such as freedom from "hunting," &c.

As to division of direct-current load, there is no question either on direct-current generator or converters. In fact, it is perfectly possible by proper adjustment to operate converters and motor-generator sets of both kinds all in multiple. As to operation on the alternating-current ends, the induction motor-generator is the least liable to trouble, since "hunting" or "pumping" cannot take place on that type of machine. The synchronous motor and converter are on a par in regard to hunting. However, with the modern construction of synchronous machines, including as they do heavy dampers, there is so little probability of hunting that it may be entirely neglected. The only places in which hunting is apt to occur are in cases where antiquated generators are used and where the ohmic line drop is very high. Neither of these is apt to occur in practice.

7. *Starting.*—In starting the desirable features are: (*a*) Minimum draught of current from line on starting from alternating-current end; (*b*) ease of synchronising.

(*a*) It is difficult to make any of the apparatus under discussion of such design that it will start readily from the alternating-current end. Good running characteristics invariably mean poor starting characteristics. The inherent starting characteristics of the synchronous motor and converter are bad on account of the large air-gap. The converter has the advantage of only having one-half the mass of the motor-generator to start. The induction motor-generator set has the advantage of better starting characteristics, but it suffers in comparison with the converter in having double the mass. If started from the collector rings, the converter suffers by liability of damage to commutator by burning and sparking. A draught of full-load current or less from the line is usually sufficient for starting any of the sets.

If it is essential to keep down starting current, a starting motor can be employed. In this case the converter again has the advantage of one half the mass as well as one-half the losses of the motor-generator set. The same advantage applies to starting from the direct-current end, but is partly offset in the converter by the shunting effect of the static transformers, if these be connected.

(*b*) In synchronising, the induction motor has a great advantage in not requiring snychronising at all. As between the converter and the synchronous motor, the converter suffers the disadvantage of having a commutator connected to the winding being synchronised, and therefore, liable to injury by careless manipulation.

Altogether, there is not much choice in the starting qualities of the three methods, but what there is would cause them to be arranged in the following order: (1) Induction motor-generator, (2) synchronous converter, (3) synchronous motor-generator.

Summary.—On three of the preceding seven counts, namely 1, 4 and 5, the converter has a distinct advantage.

On one more, 6, all methods are taken as being on a par.

On the remaining three, 2, 3 and 7, one of the other methods has the advantage. In one of these, 7, the disadvantage of the converter is not marked. The converter's disadvantage on the other two largely disappears with the addition of a means of voltage regulation.

This analysis, therefore, would seem to indicate that there are but few cases where the motor-generator should be used in preference to the synchronous converter.

CORRESPONDENCE.

PUPIN MODE OF WORKING TRUNK TELEPHONE LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest the advance proof of Sir W. Preece's Paper on the "Pupin Mode of Working Trunk Telephone Lines," and although this Paper is not likely to help those working on this question it deals with a subject of extreme importance to telephone engineers, and so a few remarks of a critical nature would, perhaps, not be out of place.

Firstly, it should be remembered that, although many investigators have attempted to solve the problem of increasing the inductance of a telephone line in a beneficial manner, Pupin was the first to be successful. The Pupin coil is something akin to the egg of Columbus. Sir W. Preece does not seem quite certain as to whether the iron-core coil is the best solution of the problem (see paragraph under Fig. 7). As far as the writer's experience goes, there appears no possible doubt as to the superiority of the iron-cored coil from both the technical and financial points of view.

As a fundamental point any two coils with equal inductances and with air and iron cores respectively must have turns and ohmic resistances proportional to 1 and $1/\mu$ respectively—*i.e.*, the iron-cored coil must have less ohmic resistance than the air coil in the ratio of the respective permeabilities. Now the Pupin iron-core coils are designed to work at permeabilities of very much less than 100, and at figures which, although giving a very large decrease in copper, to get the same inductance as an air coil, at the same time are so low as to reduce hysteresis to a negligible quantity; in fact, in one type of Pupin coil used by the National Telephone Co. the inductance is 0·17 henry, the ohmic resistance about 5 ohms, and the effective

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resistance at telephonic frequencies is only about 8 ohms, and this includes all hysteresis and eddy current losses. The coil is about 4½ in. in diameter by 2 in. deep, and can be said to have absolutely no external field and to be entirely unaffected by external disturbances. I have not heard of an air-core coil that can touch these figures.

With regard to the wave-length in telephone lines this can be taken as varying from a maximum of about 225 miles for a very heavy aerial line down to a minimum of about 9 miles for a highly loaded cable. These figures are, I think, truer limits than those given in this Paper.

Sir W. Preece mentions tapering by reducing the inductance of the loading coils. In practice this method has been found to be impracticable. Reflection losses are effectively reduced to a minimum by the aid of the subscriber's terminating line and apparatus and by the occasional use of suitably designed transformers.

Sir W. Preece refers to the importance of correct spacing of inductances and mentions that coils which are quite effective at every mile destroy speech altogether if placed at every 4 miles. This must not be taken as a general condition; it is, as a matter of fact, a very special case depending on the factors of the line and coils. In practice, coils are spaced at very varying intervals, and for some types of lines very heavy inductances at intervals as great as 8 miles are quite satisfactory.

The spacing adopted by the National Telephone Co. is in general the same as that used in America, and varies with the type of line to be loaded; no one spacing is found to meet all conditions. In practice about three standard spacings are employed.

Sir W. Preece's remarks on the ratio of improvement in conversation over loaded lines are perhaps open to misconception. Over here we are actually considering the loading of junction lines to give ratios greater than 1 to 3. I very much doubt the reliability of the German ratio of 1 to 4, although there is no question that such a ratio can very nearly be obtained.

One occasionally hears of the method of increasing the inductance of a telephone line by using composite wire of copper and iron, but very simple calculations will show the comparatively small improvement to be effected in this manner, and a comparison of this method with Pupin coils shows overwhelmingly in favour of the latter from practically every point of view. There are quite a number of points in this Paper to which I should like to have referred, but I know your space is limited.—I am, &c.,

B. S. COHEN.

Telephone House, Victoria Embankment, E.C., Aug. 7.

"SYNCHRONMASCHINEN FÜR WECHSEL- UND DREHSTROM."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 5th you published a review of my book, "Synchronmaschinen für Wechsel- und Drehstrom." I must ask you to allow me to reply to this *critique*.

As stated in the preface to my book, it is only a short and concise work on the wide subject of single and polyphase machines, and is designed to give the reader a survey of the methods of calculation and working properties of synchronous machines. For this reason it was impossible to do more than touch briefly upon certain points which are nevertheless important and interesting.

For example, on pp. 44 and 45 the very complicated behaviour of a conductor carrying alternating current is only considered in so far as it is necessary for the calculation. The statement that resistance to alternating current is 1·5 to 2·5 times that to direct current is accurate. Anyone requiring further information on this subject is referred to the article by Arnold and La Cour on the "Vorausberechnung und Untersuchung von Ein- und Mehrphasenstrom Generatoren" (Sammlg.-elektrotechn. Vorträge, Stuttgart, 1901). In this article measurements are given for actual machines, to which no objection can be made (*ibid.*, pp. 102, 104 and 108). Arnold and La Cour find, for example, that when the ohmic resistance per phase = 0·9 ohms, r. eff. = 1·6 ohms—*i.e.*, *1·78* times as great (r. eff. is the virtual resistance found on an alternating current circuit). This increase in resistance is a natural corollary to the embedding of copper coils in the armature iron. The influence of the iron is clearly shown in the formula at the bottom of p. 44:—

$$w_u = w_g\left(1 + \frac{(2\pi n\mu . l)^2}{12 w_g^2} - \ldots\ldots\right).$$

The statement that the frequency is not taken into account is therefore incorrect.

It is further stated by your reviewer that the calculations given by me of a 500 kw. dynamo only show an efficiency of 92 per cent. (exclusive of excitation). I thought that this estimate would be assented to by every engineer, seeing that the calculations were made as unfavourable as possible by bringing in all the losses and by making the armature losses a maximum. Hence $w_w = 1{\cdot}8\, w_g$. These results agree with measurements taken by me on a similar generator working in a large German central station.

With regard to my mention of the 20,000 kw. compound generator of the General Electric Co., this machine is mentioned in the *Elektrotechnische Zeitschrift*, 1903, No. 51, p. 1040.

The method given by me on p. 35 of demonstrating the amplitude of the field variations with reference to the influence of the teeth is quite new, so that the remark that the book contains no original matter is incorrect, although it was only intended to give, as already mentioned, a review of present practice.—I am, &c.,

Friedenau, bei Berlin. W. WINKELMANN.

[With regard to the first point raised in Herr Winkelmann's reply to our review, we must still maintain that his sweeping statement that the "skin effect" in the conductors of an alternator conduces to an increase in the resistance ranging from about 50 to 150 per cent. is wide off the mark. Dr. A. Hay, for instance, in his book on "Alternating Currents," p. 28, says "the skin effect with cylindrical copper conductors is, at ordinary frequencies, inappreciable until a diameter of about ½ in. is reached. . . ." Steinmetz, in his "Alternating-current Phenomena," 3rd edition, p. 139 et seq., mentions 5 per cent. increase for a copper conductor 1 cm. in diameter operating at 125 cycles per sec. Moreover, English dynamo designers, who cannot be accused of ignoring important details, are not, as a rule, in the habit of taking skin effect into account at all, except, perhaps, in low-voltage alternators with heavy conductors, and even then the allowance made falls far short of Herr Winkelmann's figures. The increase of 78 per cent. which we understand Arnold and La Cour have observed is remarkably high, and the only explanation we can suggest is that the machine tested was very exceptional.

With regard to the question of efficiency, Herr Winkelmann would have little trouble in finding English manufacturers ready to guarantee efficiencies from 1 to 2 per cent. higher than those which he has calculated.

The only passage in the *E.T.Z.*, 1903, p. 1,040. which might be construed into a reference to a 20,000 kw. generator occurred in a short remark by Dr. Fleischmann in the course of a discussion on a Paper by Herr A. Heyland. The reported remark by Dr. Fleischmann is somewhat obscure, however, and we by no means gather that he meant to convey that such a monster had been built. Herr Winkelmann must, therefore, allow us to be sceptical about this machine.—THE REVIEWER.

PARLIAMENTARY INTELLIGENCE.

LONDON ELECTRIC SUPPLY BILL.

In the House of Commons on Wednesday, on the order for the second reading of this bill,

Mr. F. L. HARRIS said the Committee which considered the 1906 Electric Power Bill of the London County Council recommended that in the present session alternative schemes should be submitted, and the London electric companies considered that to be a direct invitation to present some scheme, but they had been unable to obtain a hearing for their case until that evening. Anyone who had studied the subject must be convinced that the electrical enterprise of London was in a position which was intolerable, not only to electricity undertakers, but to the larger consumers. There was in London a system of duplication of machinery, mains and management, which had entailed enormous expenditure of capital. Upon that capital interest and dividends had to be paid, and

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these items had to come ultimately out of consumers' pockets. At present there were 29 electricity undertakings in London, 16 managed by borough councils and 13 by companies, and the capital involved was about £20,000,000. If a different arrangement had been adopted, one-third of the capital spent in London in electricity supply might have been saved. The purchase clause had told more perhaps than any other against the electrical consumer in the metropolis. No definite principle had been laid down as to the exact price at which the undertakings were to pass into the control of the local authorities. That uncertainty affected the raising of capital, dividends and the charge to the consumer. The present position was an exact opposite to what a reasonable system ought to be. Small stations were working in the summer time instead of large stations able to supply power in large quantities. There was duplication in almost every area where mains had been laid and generating machinery erected, and the management expenses overlapped, so that the cost of generation had been enormously increased, to the detriment of the consumer. There was no stimulus to the companies at present to improve their installations and to put in new machinery because they knew that their works were to be purchased at a price as to which they were at present in great doubt. There was no power existent for electric lighting undertakings to link up their stations in such a way as to enable the most effective generating stations to relieve the more costly ones. The bill promoted by the companies sought to remedy these defects. He moved that the order for the second reading of the bill be read and discharged and the bill withdrawn.

The PRESIDENT OF THE BOARD OF TRADE (Mr. Lloyd-George) agreed with the motion, and said that the subject deserved immediate attention. His own opinion was that it would be difficult, if not impossible, to arrive at a solution until the parties came to some common understanding upon general principles. It should not be impossible to do that, for it was a business matter, but the time for that had not yet arrived.

Mr. J. WARD denied that the bill carried out the recommendations of the committee of last year. At present the companies could be purchased, under the act of 1888, by the local authorities at "scrap-iron prices." Now the companies proposed to amalgamate and escape from that purchase clause. The companies ought not to be allowed to withdraw the bill until the House had expressed its opinion on it.

Lord R. CECIL said the question was of enormous importance to London and he hoped the President of the Board of Trade would endeavour to bring about the consultation between the parties of which he had spoken and make it a success. It was a scandal that the question of a cheap supply of electric power in London should have become the battle-ground of municipal parties and was threatened with delay and the possibility of defeat because the matter was not now considered as a business proposition but as a political question.

The motion for the withdrawal of the bill was agreed to.

ROYAL ASSENT.

On August 2 Royal assent was given to the following new Acts of Parliament:—Aberdeen Corporation Order Confirmation, Electric Lighting Orders Confirmation (No. 3), Tramway Order Confirmation, Sheffield Corporation, Middlesbrough, Stockton-on-Tees and Thornaby Tramways, North Metropolitan Electric Power Supply, Richmond (Surrey) Electricity Supply, Sunderland Corporation, Coventry Corporation, Manchester Corporation Tramways, Kingston-upon-Hull Corporation.

LEGAL INTELLIGENCE.

The Attorney-General of Victoria (ex rel. Melbourne Gas Co.) v. Melbourne Corporation.

Last week the Judicial Committee of the Privy Council (Lords Robertson, Atkinson and Collins, Sir A. Wilson and Sir A. Wills) delivered reserved judgment in this appeal from a judgment of the High Court of Australia reversing a decision of the Supreme Court of Victoria. The decision of the High Court of Australia, which was given at some length in our issue of Aug. 17, 1906, contained the material facts.

In delivering judgment Lord ATKINSON said that Melbourne Corporation were, by an Order of the Governor in Council, made under the authority of the Electric Light and Power Act, 1896 (59 Vic. No. 1,413), constituted undertakers for the supply of electricity, and the action was brought by the Melbourne Gas Co. to restrain the Corporation from continuing to charge their consumers, for electricity supplied, rates which were not uniform throughout the city. It was admitted that the Corporation supplied electricity under two different systems, at rates appropriate to each, but not identical. Under the first, the quantity used was charged for at a flat or uniform rate of 4½d. per unit. Under the second 7d. per unit was charged for such electricity supplied as was equal to a consumption for a period of 45 hours per calendar month at the highest rate of consumption during that month, and 2d. per unit for the remainder of the electricity supplied during the month. Both rates were less than the maximum rate authorised by the act and order, and it was admitted that it was optional with every customer, or intending customer, to choose the system under which he should be supplied, and that, as between the several customers under each system, no preference was given to one customer over the other, though under the operation of the second system different results worked out in the case of different customers, as must be the case where the amount consumed was taken into consideration in fixing the price. The question for decision turned on the construction of the 38th and 39th sections of the statute. The Supreme Court, considering that the case came within the principle of their previous decision in an action between the same parties, decided in favour of plaintiff, and granted the injunction restraining defendants from supplying electricity at other than a uniform rate, except so far as was authorised by the Electric Light and Power Act, 1901. By that previous decision the defendants had been restrained from supplying electricity for heating or power at a rate lower than the rate charged for lighting, and in consequence the Legislature of Victoria had passed the last-mentioned act. The High Court of Australia reversed that decision, hence the present appeal.

It was contended for plaintiff that, on the authority of "The Attorney-General *v.* Clarkson" (1900, 1 Q.B., 156), that the statute of 1901 amounted to a statutory declaration that, according to the true meaning of the act of 1896, only one uniform rate could be charged by defendants for the electricity supplied by them. After referring to "The Attorney-General *v.* Clarkson" and "The Attorney-General *v.* Fairley" which were cited for plaintiff, his lordship pointed out that the act of 1901 merely empowered defendants to do that which they had insisted they had under the act of 1896 the right to do, and by no means affirmed, expressly or impliedly, that the Court which held, on the construction of the latter statute, that they had no right to do that thing, were justified in so deciding. Cases constantly occurred where, if a Court, even of first instance, should put upon a statute a construction which would defeat its obvious purpose, or cause great inconvenience, the speediest and most effective remedy was to pass an act in a form similar to that of 1901 setting the matter right. Circumstances might not permit the delay necessarily involved in bringing the embarrassing decision before higher tribunals for reconsideration. The fact, however, that that remedy was at once applied by the Legislature of Victoria did not, in the absence of express words or clear intendment, preclude those superior tribunals from reviewing the decision of the inferior when the occasion arose. In the opinion of their lordships the contention of plaintiff on that point was entirely unsustainable. Sec. 13 (*a*) provided that conditions and restrictions might be inserted in, or prescribed by, the Order in Council made under the act with regard, amongst other things, to "the limitation of the prices to be charged in respect of the supply of electricity." Sec. 38 was practically identical with sec. 19 of the British Electric Lighting Act, 1882, but sec. 39, dealing with preference, differed in its wording from sec. 20 of the British act of 1882, relating to the same subject. In "The Metropolitan Electric Supply Co. *v.* Ginder" it was held by Lord Justice Buckley that the words "a supply on the same terms," used in sec. 19 of the 1882 act bore their natural meaning and included price. Sec. 39 was rather unskilfully drawn and clumsily worded, but their lordships thought that the "preference" prohibited in substance by it was "a preference" between customers dealing under similar circumstances, and not between customers dealing under two different systems of supply, either of which they were free to select, and therefore dealing under entirely different circumstances. That construction reconciled sec. 38 and 39 one to the other, and made them consistent, did no violence to any of the provisions of either, did not impose on defendants, as would the construction contended for by plaintiff, most embarrassing restrictions in the conduct of their undertaking, and at the same time promoted rather than hurt the interests of the consumers, while there was, in the view of their lordships, nothing in sec. 52 of the act which prevented its being adopted. Their lordships were, therefore, of opinion that the decision of the High Court of Australia was right and should be affirmed, and the appeal dismissed. The appellant must pay the costs of the appeal.

Liverpool District Lighting Co. v. Newall, Harrop and Gibson.

In the Liverpool Court of Passage last week plaintiffs claimed £45. 12s. damages, or alternatively £46. 10s. for breach of agreement.

It appeared that defendants as landlords of certain premises, entered into an agreement on Oct. 21, 1901, for wiring the premises on the "free" wiring system. Plaintiffs had a provisional order for the supply of electricity in and about the neighbourhood of Liverpool. As a convenience to their consumers the company puts in electric light installations subject to agreements being signed by the landlords and to an undertaking by the tenants to pay as rent for the installation 1d. per unit over and above the ordinary price of current. By the agreements the landlords undertake on the sale or letting of premises to require that the purchasers or tenants shall either ratify the agreement or permit the installation to be removed. In the present case defendants had signed the agreement, but on the sale of the premises the purchaser refused to bind himself by the contract entered into by the landlords, or to allow the removal of the installation, which he claimed as his property.

For the defence, it was stated that defendant Gibson, on signing the agreement, was given to understand that there would be no pecuniary liability attaching to the owners or landlords; that the tenant by paying 20 per cent. more than the ordinary price was covering the cost of the wiring installation. He believed that by signing the agreement he simply gave permission to plaintiffs to remove the installation; otherwise he would not have signed it. It was urged that during the five years the wiring had been in its cost had been almost paid off, and that if there was any damage it was only the value of the material, less the expense of taking it out. Permission had been given by defendants to remove the installation before the transference of the property, but plaintiffs had not immediately availed themselves of it.

The JUDGE (Mr. W. F. K. Taylor, K.C.) gave judgment for plaintiffs, awarding £20 damages,

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An electrical engineer, with experience in the design of d.c. generators, is wanted for a position in the engineering department of a large American manufacturing company. See an advertisement.

An instrument maker, lecture assistant and lecturer on electric wiring is required at the Royal Technical Institute, Salford. Salary £100 per annum. Forms of application, &c., from the director of studies (Mr. Ogilvie Duthie), Education Offices, Chapel-street, Salford. See advertisement.

There are vacancies for two premium pupils at Bedford Corporation electricity works. Particulars from the borough electrical engineer (Mr. R. W. L. Philips), Cauldwell-road, Bedford.

The following posts will be vacant at the City and Guilds Technical College, Finsbury, at end of September: Chief assistant in mechanical engineering department (salary £250, rising to £300), assistant instructor in engineering drawing (£100) and demonstrator of applied mechanics and mathematics (£100). Particulars from the College.

A teacher of electric lighting and power is wanted at Pudsey Technical School. Applications to the Secretary.

An electrical mechanician is required by the Uganda Protectorate Government. Two years' engagement, with possible extension. Salary £200 per year, with free quarters. Applications to the Crown Agents for the Colonies, Whitehall-gardens, London, S.W., by Aug. 12.

Mr. R. U. Bailey, of the Newcastle-on-Tyne Electric Supply Co., has been appointed shift engineer, and Mr. Geo. Scott, of Handsworth, has been appointed boiler-house foreman, at Summer-lane generating station, Birmingham.

Mr. W. E. Rogers has been appointed chief assistant electrical engineer at Dewsbury, at £150 per annum, and Mr. E. Milner has also been appointed shift engineer.

Mr. E. E. Stark, formerly engineer to the Waipori Electric Co., has been appointed acting city electrical engineer of Dunedin (N.Z.) at £700 per annum.

Mr. D. R. Maclachlan, B.Sc., A.M.Inst C.E., Wh.Ex., has been appointed head of the engineering department of the Woolwich Polytechnic. Mr. Maclachlan is at present chief assistant in the engineering department of the Leeds University.

Mr. Geo. Halstead, B.Sc., has been appointed lecturer and demonstrator in applied mechanics and engineering design at the University of Liverpool.

Mr. W. C. Stanley Phillips, B.Sc, has been appointed lecturer in electricity and physics at the Municipal Technical School, Birmingham.

For the position of burgh electrical engineer Stirling Borough Council received about 80 applications, and the following three gentlemen have been selected for interview: Messrs. J. W. Papworth (chief assistant electrical engineer, Kilmarnock), Wm. Drysdale (West Linton) and A. Whitie (station superintendent, Battersea.)

The position of electrical engineer to the Old Bleach Linen Co., Randalstown, Ireland, which was advertised in our last two issues, has been filled.

Indian Telegraphs.—The Government of India sanctioned the retirement, on 3rd inst, of Sir Sydney H. C. Hutchinson, Director-General of Telegraphs, and Mr. T. D. D. Berrington has been appointed his successor. The following transfers have also been ordered: Mr. F. E. Dempster to become officiating Deputy Director-General, Mr. C. Streathfield James to become officiating Director of Construction, and Mr. E. A. Kenyon to become officiating Deputy Director of Construction.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

University of Glasgow.—The new session commences on Oct. 17 and ends on March 16, 1908. The students usually spend the summer months in practical work, thus receiving their training on the "sandwich" system. Prospectuses of the courses for the degrees of B.Sc. and D.Sc. in engineering, mining and architecture and syllabuses of all classes, &c., can be obtained from the Assistant Clerk, matriculation offices, the University, Glasgow.

University of Manchester.—Complete theoretical and practical training is given in this university to students preparing for the higher positions in the electrical engineering profession. The subjects may be taken as part of the courses preparing for the B.Sc. degree in both the honours school of engineering and physics. A special course has also been arranged extending over three years and preparing for certificate in electrical engineering. The John Hopkinson laboratories and dynamo house are equipped with powerful modern machinery, and excellent facilities are afforded for educational and research work. The session commences Oct. 1.

Copies of a prospectus containing particulars of the lecture, laboratory and drawing courses in engineering and the course in physics (including electrical engineering), mathematics and chemistry, qualifying for the degrees in engineering and the engineering certificates, can be obtained from the Registrar.

University College, London.—The courses of instruction in mechanical, civil, municipal and electrical engineering begin on Tuesday, Oct. 1. The fee for the full three-year diploma course in engineering and the course for graduating B.Sc. in the faculty of engineering is 120 guineas. The college contains spacious mechanical and electrical engineering laboratories, workshops, drawing office, &c. Large extensions will be made in each of the engineering departments, the drawing office and the department of applied mathematics, &c. Particulars from the secretary (Mr. Walter W. Seton, M.A.), Gower-street, London, W.C.

Heriot-Watt College, Edinburgh.—In the day technical college there are courses in mechanical and electrical engineering, technical chemistry and practical mycology. The winter session opens Oct. 1, 1907, and closes April 16, 1908. The courses in engineering and chemistry are recognised by the University of Edinburgh as qualifying for the degree of B.Sc. and the chemistry courses are recognised by the Institute of Chemistry. The entrance examination begins on Sept. 23. Arrangements have been made with leading engineering firms in Edinburgh and elsewhere whereby students may combine their apprenticeship with their studies at the college. Prospectuses from the principal, Mr. A. P. Laurie, M.A., B.Sc.

City and Guilds of London Institute.—The entrance examinations of the Institute's Colleges are held in September. Particulars of the entrance examinations, scholarships, fees and courses of study may be obtained from the respective colleges or from the head offices of the Institute, Gresham College, Basinghall-street, E.C. The City and Guilds Central Technical College, Exhibition-road, W., is a college for higher technical instruction for day students not under 16 preparing to become civil, mechanical, or electrical engineers, chemical and other manufacturers or teachers. The College is a school of the University of London in the Faculty of Engineering. The City and Guilds Technical College, Finsbury, is a college for intermediate instruction for day students preparing to enter the engineering and chemical industries, and for evening students.

Glasgow and West of Scotland Technical College.—The session begins on Monday, Sept. 23, in the new buildings. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics. The courses of study extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session at prescribed university classes. There are new and well-equipped laboratories in the departments of physics, chemistry, technical chemistry, metallurgy, mechanics, motor-power engineering, electrical engineering, &c. The preliminary examination begins Sept. 16. Calendar (price 1s. 4d.) and prospectuses (gratis) from the Secretary.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars as to fees, &c., can be obtained at the Institute, St. John's street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Hartley University College, Southampton.—The next session begins Sept. 25. At this college there are day courses in civil, mechanical and electrical engineering. Prospectuses, &c., from the Registrar.

Technical Institutes for South London.—The Education committee of London County Council propose to acquire a site in South-east London, near New Cross or Lewisham, for an institute for classes in engineering and building. The new institution will be organised mainly as a school of building and engineering, with auxiliary classes in physics, chemistry, mathematics, &c. The

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committee recommend the expenditure on capital account of £7,000 in respect of a site, and the expenditure of £6,500 for the purchase of a site for new premises for the Wandsworth Technical Institute. The total capital expenditure involved for the two institutes (including purchase of sites) is £92,000—£50,000 on New Cross and £42,000 on Wandsworth. The Education committee also contemplate expenditure during the next five years of over £400,000 on the extension of the Council's institutes and over £80,000 on maintenance account in the form of grants to polytechnics for works of extension.

Aberdeen.—The Council decided on Monday to carry out the recommendations of their electrical engineer (Mr. J. Alex. Bell) to remove the copper strip and lay cables on the solid system on both sides of Union-street.

Alleged Theft of Tramway Cable.—At the West Riding (Yorks.) Police Court at Rotherham three men (named Robshaw, Glen and Mason) were committed for trial at the Quarter Sessions on a charge of stealing about 8 cwt. of copper cable (value £50), the property of the National Electric Construction Co.

Bath.—The Council have approved recommendations of the Electric Light committee to extend the time for the purchase of the electricity works by Mr. Schenk, provided £2,500 be deposited with the Council, to be returned if the latter make wilful default in completing the agreement, and also to modify the provisions of the draft agreement so as to definitely substitute allowances of £500 each in electric current per year for the two bonuses of £10,000 each.

The Council have authorised the purchase of under-feed stokers for two boilers, at £613. 15s.

Bray (Ireland).—Acting on counsel's advice, the Electric Light committee recommend the Council not to proceed with the proposal to sell the electricity undertaking.

Bridgend.—The Council recently decided to acquire the local generating station of the South Wales Electrical Power Distribution Co. and it has now been decided to apply for a provisional order. Penybont Council has also been asked to assent to the proposed order covering the parishes of Newcastle Higher, Coity Higher and Ewenny. The latter Council has replied by asking the Bridgend authority to consent to Penybont becoming partners in the undertaking.

Canary Islands.—The municipality of Santa Cruz has granted a 75 years' concession to a German merchant for establishing gas works, and the undertaking is likely to be completed about the end of the present year. Mr. Croker, British Consul, is of opinion, however, that as the use of the electric light is becoming so general in Santa Cruz, this fact may militate considerably against the success of the gas works project.

At Las Palmas the question of electric tramways is still under consideration, but so far little progress appears to have been made.

Cheltenham.—The L.G. Board have refused to reconsider the question of extending the period for the repayment of a loan of £68,225 for extensions of the electricity works.

The salary of the assistant electrical engineer (Mr. J. M. Robb) has been increased by the Council.

Customs Duties.—In a recent supplement to the Australian Customs Tariff Guide it is stated that ebonite forks and ebonite and glass rods cut into lengths for fitting into accumulators are admitted free of duty, but other ebonite rods are subject to 15 per cent. ad val. and other glass rods to 20 per cent. ad val.; armature slot troughs are subject to 12½ per cent. ad val., and dry cell batteries for pocket electric lamps (when imported separately) are duty free.

Derby.—The Council have decided to apply for an extension of time for constructing the tramways authorised by the 1901 act.

Dundee.—Now that the Royal assent has been granted to the new Corporation Bill the electrical engineer (Mr. Harry Richardson) has been instructed to obtain tenders for the supply and delivery of overhead equipment for the extension of the City tramways to Downfield and also down Union-street to the railway stations. The whole of the work is estimated to cost about £10,000. The erection of the overhead equipment is to be carried out by the electricity department's employés.

Egypt.—The extension of the tramways at Alexandria to Dekhela, 12 miles to the westward (where it is proposed to build a casino and summer residences), is under consideration, and it is also proposed to carry the lines along the quays and to the Nouzha Public Gardens, recently renovated by the municipality.

There has been during the past year a vast increase in the demand for electrical apparatus and fittings of all kinds. In 1905 the value of these imports was E£129,444, and in 1906 E£167,135, supplies coming from the United Kingdom, France, Germany and Austria-Hungary, the United Kingdom share being, in 1906, E£58,320, compared with E£63,557 in 1905. Mr. Acting Vice-Consul Greig calls the particular attention of British manufacturers to the large supplies of wires and cables, fittings, lamps, &c., which are being brought into Alexandria from Germany, and points out that there is a demand for electric fans of all sizes.

Austria-Hungary, Germany and France are responsible for the larger portion of electric incandescent lamps imported into Alexandria, the total value of which amounted in 1906 to nearly E£64,000, compared with about E£48,000 in 1905.

Electric Locomotives and Automobiles.—In a report of the trade of the United States for 1906 prepared by Mr. Seymour Bell, British Commercial Agent, it is stated that during the year 237 electric locomotives were built, and with regard to the manufacture and supply of electric automobiles 1,425 of these machines were manufactured in 1906.

Finchley.—On Friday last the Council considered the report of Mr. A. H. Preece on the electricity undertaking.

Mr. Preece expressed himself as being satisfied with the type of plant adopted. The expenditure upon feeders and distributing mains had, however, been somewhat abnormal. The present financial result was not entirely satisfactory, but he anticipated the accounts for 1907-8 would show a balance profit of £200, and therefore he did not recommend an increase in the price of current. Street lighting had not been profitable, but there was no doubt that it had led to a great deal of indirect saving, and might, with improved service, become a source of profit. Provided due regard is paid to capital expenditure as well as working expenses, the Council may feel perfectly satisfied they have embarked upon a sound and profitable business. The question, however, was whether all the energy required in the future should be generated locally, or a portion, at any rate, be purchased in bulk. If reasonable terms were at any time obtainable for a supply in bulk it might be desirable to accept them rather than continue expenditure upon a generating station which may not be required at all a few years hence. To deal with present demands, however, Mr. Preece advised the Council to borrow £12,000 for additional plant and £10,000 for feeders and distributing mains.

The Council, therefore, resolved to make application for sanction to borrow these sums, and the chairman of the Electricity committee (Mr. Todd) said the report answered those who suggested that the undertaking should be disposed of lock, stock and barrel, and it would remove doubts both inside and outside the Council.

Gloucester.—At the meeting of the Council last week the city electrical engineer (Mr. G. R. White) presented his annual report.

The electricity department was (he reported) making steady progress, and the revision of the charge made for current for traction was recommended. The actual cost of generation (excluding capital charges) was 1·08d. per unit and the tramways department was supplied at 1d. per unit.

Hampstead (London).—Main extensions are to be carried out at an estimated cost of £559.

Hartlepool.—On Wednesday a discussion took place at the council meeting respecting the agreement for the transfer of the powers of the Northern Counties Electricity Supply Co to the Cleveland and Durham County Electric Power Co.

Ald. HORSLEY moved that the agreement be sealed. The present plant was insufficient to provide the power required by the N.E.R. Co. and other large works in the neighbourhood, and the Council must not, by refusing to let the Cleveland and Durham Co. come in, stand in the way of the development of the industries of Hartlepool.

Mr. C. T. WATSON moved as an amendment that the Cleveland & Durham Co. be permitted to take over the remaining three years of the present lease to the Northern Counties Co., and that at the end of that time the Corporation consider the question of continuing the lease to them for 11 years, making up the 14 years provided in the agreement. He objected to handing over their birthright to the Cleveland & Durham Co.

By 11 votes to 7 it was decided not to approve the agreement.

Health Resorts.—To the overwrought scientist, professional and commercial man the question where to spend his well-earned holiday is frequently a tougher problem than many of the scientific or manufacturing difficulties with which he has to contend in the course of his everyday work. Anything that will enable him to come to a decision in the important matter of his holiday is to be welcomed, and when this takes the form of a well-illustrated guide-book which can be obtained for the asking the assistance is doubly welcome. We have received from the Guernsey Chamber of Commerce a booklet entitled "Gems of the Channel, Guernsey, Alderney and Sark," and the information which this booklet affords may very well serve to determine the health and pleasure seeker to turn his attention Guernseywards. We advise those who have not already decided on their holiday haunt to obtain a copy of this excellent publication free from the Secretary of the Chamber of Commerce, Guernsey.

Hornsey (London).—The Council are substituting electricity for gas lighting at the Highgate depot, the fire stations and firemen's dwellings and the clock tower at the Broadway, at an estimated cost of £211.

India.—The "Indian Electrical Mechanical and Textile News" states that Mr. J. M. Kerr, A.M.I.C.E., has completed his surveys in connection with the hydro-electric power scheme for Bombay City. The prospectus will probably be issued before the end of the current

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year. Three firms have been asked to quote for the construction of the dams, and, at the outset, three lakes will be formed at Lanavli, Wadhwan and Shirawta, which will give more than the 40,000 H.P., which, it is estimated, will be required in the early stages of the undertaking. Messrs. A. Dickinson & Co, of Birmingham, are consulting engineers for the scheme and Mr. R. B. Joyner is also retained in an advisory capacity.

Islington.—The central library is to be wired for the electric light.

Johannesburg.—The Municipal Council have, it is stated, decided to scrap the gas plant for generating electricity for traction, power and lighting.

Liverpool.—The new Corporation tramway offices in Hatton-garden were formally opened by the deputy chairman of the Tramway committee (Ald. F. Smith) on Friday.

Neath.—The Rural Council have resolved to purchase the local electricity works of the South Wales Electrical Power Distribution Co. for £7,000.

Obituary.—The death occurred on Saturday last at Rock Cliff, of Mr. Joseph Crosland, works manager of the Helsby Works of the British Insulated & Helsby Cables (Ltd.). Deceased, who had been ailing for some time, was in his 35th year. Mr. Crosland was the fourth son of Mr. and Mrs. James Crosland, of Lascelles Hall, Huddersfield, and came to Helsby in 1888 as an apprentice to the electrical business at the works of the (then) Telegraph Manufacturing Co. After occupying several important positions with that company he was appointed general works manager at Helsby, when the company was amalgamated with the British Insulated Co. under the title of the British Insulated & Helsby Cables (Ltd.). This position deceased held up to the time of his death. A keen business man and of a bright and genial disposition, Mr. Crosland was held in high esteem equally by the firm and their employés. He identified himself with all movements of a recreative character in the district, was one of the founders and most enthusiastic supporters of the athletic club and actively associated with its management, and was prominently connected with the golf club. The sympathies of all who knew Mr. Crosland are extended to his widow and three young children, and to the other members of his family. The interment took place at the parish church on Tuesday afternoon, and, in addition to the relatives, those present included Messrs. James Taylor, G. Crosland Taylor (directors of the British Insulated & Helsby Cables), D. Sinclair, general manager (Prescot), J. Brotherton manager, (Helsby), and A. Whalley (Liverpool), C. R. Sproule, E. A. Bayles, Longrigg, and other members of the staff at Helsby, and about 200 employés from the company's works, which were closed on the occasion of the funeral as a mark of respect to the deceased.

Paddington (London).—Last week the Council considered schemes submitted by the works committee for improving the lighting of a portion of Harrow-road.

Under the scheme the existing lamps are to be replaced by two-light No. 4 Vern burners; (1) initial cost £130, (2) actual cost £350; replaced by two-light inverted burners, (1) £190, (2) £330; replaced by three-light inverted burners, (1) £220, (2) £460; replaced by five-light inverted burners, (1) £280, (2) £720; replaced by six-light inverted burners, (1) £380, (2) £880. The committee considered that this portion of the road could be satisfactorily lighted with 24 electric arc lamps (half turned out at 12.30 a.m.) for £264 per annum (plus £10 initial cost for alterations to some of the existing lamp columns) against £190 per annum for lighting that portion of the thoroughfare with the present gas lamps at the increased price of gas. They accordingly recommended that arrangements be made with the Metropolitan Electric Supply Co. for lighting that portion of the road for 10 years.

The matter was referred back by a small majority.

Persia.—An interesting report has recently been received from Major C. Ducat, British Consul at Kerman, describing the new Central Persia telegraph line which was completed last year. Starting from Nasartabad-Sipi, the line was carried on to Robat, and was completed on March 13, 1907, the work having occupied three months. The line is a heavy one and carries three wires. A station en route was established at Dahaw-i-Baghi, and has been renamed "Hamilton," after the departmental officer who first discovered the place. With the completion of this line it is stated that the only important project of the kind remaining is to link up Bam with Bunder Abbas, putting Kerman and Bunder Abbas in direct land-line communication. At present this telegraphic communication has to go over two sections of land-line and one of cable.

Northampton.—The Council have decided to obtain powers to extend their tramways to Far Cotton at an estimated cost of £13,540.

Provisional Order Transfers.—Aspull Council notify that they intend to transfer their rights, &c., under their electric lighting order (1901) to the Lancashire Electric Power Co. for £250. The Council retain the right to re-purchase the undertaking after 28 years.

Abram Council also give notice of transfer of their order to the same company for £210, the Council retaining the right to re-purchase at the end of the first seven or any subsequent seven years.

St. Helens.—On Wednesday a resolution to increase the salary of the electrical engineer (Mr. E. M. Hollingsworth) from £400 to £425 per annum was referred back.

Surbiton.—It was reported to the Council last week that the application for a further loan for electric lighting had been referred by the L.G. Board to the Board of Trade for their consideration as to whether the agreement with Messrs. Callender's for working the electricity undertaking was one which the Board of Trade could sanction. The Board has signified its approval, and a L.G. Board inquiry will shortly be held into the application for the loan.

Walthamstow.—An adjourned L.G. Board inquiry was held here last week into the application of the Council for sanction to borrow over £17,000 for extensions of the electricity undertaking.

The consulting engineer (Mr. J. Enright) gave further evidence in support of the application, and the inquiry was again adjourned.

Wigan.—At the meeting of the Council on Wednesday Ald. Ashton moved—

"That in future the management of the electric light and tramways departments be delegated to two separate committees." The resolution was carried and the two new committees were appointed. The following resolution was also agreed to: "That the Local Government Board or the Board of Trade be requested to hold a local inquiry into the working and financial position of the Wigan electric light and tramways from their inception."

Works Driving.—The Skinningrove Iron Co. has placed an order with the Electrical Co. for a 455 kw. three-phase generator (which is to be driven by a gas engine) for supplying current for power and lighting.

Outings.—On Saturday last the employés of the Chloride Electrical Storage Co. held their annual picnic. The works at Clifton Junction were closed as far as possible for the day, and a large party journeyed to Morecambe, where breakfast was served, after which followed a drive of about 18 miles through Halton and Caton, returning for dinner, which was presided over by the general manager of the company (Mr. W. S. Naylor). A novel badge was worn by the men in the form of a white metal miniature of the company's well known "R" plate suspended by red and black silk ribbon. The outing proved one of the most enjoyable in the history of the company.

The annual outing of the employés of Woolwich Council electricity department took place on Saturday, when a numerous party journeyed to Southend.

Sports.—The West Ham tramway employés' sports took place on Friday last at the Boleyn Castle Grounds, Upton Park. The deputy mayor (Ald. T. W. Watts) distributed the prizes, and congratulated the manager of the tramways (Mr. H. E. Blain) and the staff on the success of the meeting.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Aberdeen.—The traffic receipts of the tramways department for the year ended May 31 were £71,771. 4s. 8d., including £71,605. 19s. 3d. from passenger fares and £165. 5s. 5d. from parcels. Advertising on cars and miscellaneous receipts brought the total to £72,605. 11s. 6d, or 11·39d. per car mile.

The traffic expenses were £16,733. 16s. 5d., electric current cost £9,631. 0s. 7d. (1·469d. per car-mile), maintenance and repairs £6,007. 13s. 3d., general charges £6,548. 9s. 1d. and with £1,783. 16s. 8d., allowance to Aberdeen Suburban Tramways Co., the total expenses came to £40,434. 16s. (6·34d. per mile). Interest amounted to £10,985. 1s. 11d., depreciation to £3,206. 18s. 4d., sinking fund to £3,515. 6s. 2d., and after paying preliminary and parliamentary expenses, &c., £13,422. 19s. 8d. was carried to renewal account. The total capital expended is £321,759. 2s. 8d., 17,676,008 passengers were carried, and 1,529,682 car miles (1,418,222 by Corporation cars, and 111,460 by Suburban Co.'s cars) were run.

In the report of the city electrical engineer (Mr. J. Alex. Bell), it is stated that the past year will be memorable from the repair point of view. Through the damage done to the electrical equipment of the rolling stock by the salt used on the track during the heavy snowstorms 81 cars were disabled in 11 days, and this record (Mr. Bell states) is not likely to be reached again. The repairs cost the department £287. Only 13 broken axles were recorded, but 50 axles were scrapped during the 12 months, due to flaws. The figure for re-wheeling has jumped from 30 cars last year to 49 this year. The addition of the car tops has also affected the life of the tyres.

Gloucester.—The accounts of the Corporation light railways show a total income of £15,032. 14s. 1d. for the year ended March, including £14,191. 12s. 5½d. traffic revenue (6·55d. per car mile).

Total operating expenses were £11,054. 12s. 2d. (5·102d. per car mile). Interest absorbed £5,982. 5s. 6d. Repayment of loans for the City portion of the undertaking to March 31, 1906, came to £1,733. 6s. 8d., and for year ended March 31 last to £2,259. 4s. 4d.; repayment of loans for the county portion for the year ended March last was £216. 13s. 5d., total £4,209. 4s. 5d. for repayments. The number of units consumed for traction and car lighting was 637,491, an average of 1·21 units per car

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mile. The percentage of operating expenses to receipts was 73 per cent. The capital expended is £130,783. 19s. 8d., an increase of £243. 17s. 9d. on the year.

Motherwell.—The capital expended on the electricity undertaking at May 15 was £75,213. 19s. 9d., an increase of £8,801. 12s. 8d. over 1906.

The past year's revenue was £10,138. 15s. 1d., including £3,704. 1s. 1d. from sale of current for lighting and £3,326. 11s. 3d. for power and £2,802. 18s. 3d. for public lighting. Expenses were £4,813. 4s. 1d. (including £2,950. 11s. 5d. for works costs), leaving a gross profit of £5,325. 11s. Interest absorbed £2,295. 14s. 6d. and sinking fund £2,300, leaving £729. 16s. 6d. net profit. 1,798,991 units were generated: 401,332 units were supplied to the public lamps, 333,274 units were sold for private lighting and 792,693 for power. There are 534 consumers (an increase of 50) representing the equivalent of 74,464 8 c.p. lamps connected. The total works costs were 0·68d. per unit, compared with 0·73d.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

Bristol Electrical committee invite applications from manufacturers for supply, delivery and erection of (*a*) one 300 kw. and two 500 kw. three-phase to d.c. converters (6,000 to 500 volts), with balancers and starters; (*b*) e.h.t. a.c. and l.t. d.c. switch gear; also supply and delivery, laying and jointing of (*c*) 24 miles (approx.) of 0·05 sq. in. three-core paper-insulated B.O.T. sheathed lead-covered cable, together with the necessary troughing and filling; and (*d*) the construction of the necessary converter station, inclusive of foundations. Specifications, &c., from the city electrical engineer (Mr. H. Faraday Proctor), Temple Back, Bristol. See also an advertisement.

The Joint Committee of Management of *Clonmel* (Ireland) District Lunatic Asylum are prepared to receive tenders for the following work in connection with the lighting of the asylum: Sec. 1, suction gas plant, gas engines and electric generators; sec. 2, accumulators, switchboard, underground mains, wiring and fittings; sec. 3, power-house building and foundation. Plans, &c., may be inspected (by appointment) at the asylum or at the offices of the consulting engineer, Mr. Louis J. Lawless, A.I.E.E., 27, Castlewood-avenue, Rathmines, Dublin, from whom conditions, forms of tender, &c., may be obtained. Tenders, addressed to the Resident Medical Superintendent, District Asylum, Clonmel, Ireland, by Sept. 7. See also an advertisement.

Portsmouth Council invite tenders for supply, delivery and erection of one h.t. switchboard, and of steam, exhaust, circulating water and sundry other pipework. Tenders to the town clerk (Mr. Alexander Hellard), Town Hall, Portsmouth, by noon Aug. 14.

Grimsby Corporation invite tenders for supply, delivery and erection of one 500 kw. continuous-current dynamo direct-coupled to a triple-expansion three-crank high-speed double-acting engine. Tenders to the borough electrical engineer, Mr. W. A. Vignoles, electricity works, Grimsby, by first post Monday, Aug. 19.

Barnes District Council invite tenders for two sets of mechanical stokers (for Babcock boilers) and feeder and distributor cables. Tenders to the clerk, Council House, High-street, Mortlake, by noon Monday, Aug. 12.

Stockport Tramways committee want tenders by noon Aug. 26 for the supply and erection of five sets of automatic point controllers for their tramways. Forms of tender from the Borough Electrical Engineer.

Dundee Corporation want tenders by Aug. 13 for construction of nearly 1 mile of double track tramway and supply of rails, &c. Specifications, &c., from the City Engineer.

Erith Council want tenders by Sept. 2 for supply and erection of electrically-driven air compressor, &c. Specification from the Clerk, Bexley-road, Erith.

The *Leven* Reform Co-operative Society want tenders for supply of a dynamo and for wiring the society's new premises. Schedules, &c., from Mr. W. Dow, Kirkcaldy, to whom tenders by Aug. 17.

The "Journal Officiel" for July 20 contains a notice inviting tenders for the supply and installation of the following electrical equipment for the Port of *Alexandria*: Five large trans-shipping engines, seven small trans shipping engines, six 4-ton cranes, 36 2-ton cranes, 25 windlasses, small plant and necessary accessories, and construction and installation of central power station. Conditions of contract, &c., from M. le Directeur des Ports et Phares, Alexandria, to whom tenders by Nov. 1.

TENDERS RECEIVED AND ACCEPTED.

Eastbourne Corporation have accepted the following tenders:—Babcock & Wilcox, new boiler, £2,030; Cowans (Ltd.), switchboard extension, £106. 10s.; J. H. Harrison, spray plant for cooling plant, £257. The full list of tenders received appeared in our issue for July 26.

The British Westinghouse Co. have supplied, through their representatives (Jessop & Co., of Calcutta and Howrah), a 50 kw. three-phase motor generator for the Lillooah shops of the East Indian Railway Co. and transformer house equipment for the same company's Howrah station.

Hampstead (London) Council have purchased from the British Electric Transformer Co. series gear and a 7½ kw. transformer at £56. 10s., and a 75 kw. transformer at £59. 7s. 11d., less £44. 2s. 1d. allowed for two transformers of 50 and 25 kw.

Walsall Council have accepted the tender of the Electrical Power Storage Co. for repairing and cleaning the Butt's-road battery at £35.

Chelmsford Council have accepted the tender of F. H. Dennis for wiring the Council chamber at £44. 16s. 9d. and for telephones at £11. 18s.

Islington (London) Council have accepted the following tenders: Fraser & Fraser, repairs to two boilers, £99; E. Le Bas & Co., repairs to pipes, £49. 9s. 6d.; J. Hopkinson & Co., valves, £70. 11s.

Derby Council have accepted the tender of the Key Engineering Co. for an air compressor at £40, and that of J. Tomlinson for the erection of a power station at £968. 10s.

Bristol Electrical committee have accepted the tender of R. Wilkins & Sons for the construction of three sub-stations at £1,563.

Hull Council have accepted the tender of the Lahmeyer Electrical Co. for a steam dynamo, at £4,564.

Wolverhampton Council have placed an order with Mountain & Gibson for a tramway snow-plough, at £702. 10s.

Ealing Council have accepted the tender of Geo. Sinclair & Son for a boiler at £3,069.

Cleckheaton Council have accepted the tender of W. T. Henley's Co. for the annual supply of cables.

The tender of J. S. Brown has been accepted for wiring the National Eisteddfod Pavilion (Swansea) at £127.

Hull Electric Lighting committee have accepted the tender of Körting Bros. for condenser and pipework at £625.

B. T.-H. Flame Arc Lamps—The British Thomson-Houston Co. have received an order from Messrs. Aveling & Porter, Rochester, for 95 new flame arc lamps for illuminating their works. The lamps are to have special compensators, each controlling two lamps and arranged with middle terminal so that single lamps may be switched on and off.

Boiler Contracts.—The Stirling Boiler Co. have recently received a number of important orders for boilers, including the following:—

Repeat order for a pair of boilers (hand-fired), complete with steam, feed, exhaust and blow-off piping and pumps, for the India State Railways (N.W. Railway); a repeat order for two boilers (hand-fired), fitted with superheaters, economiser, pumps, piping, &c., for the Buenos Ayres & Pacific Railway Co.; repeat order for four large boilers, fitted with chain-grate stokers and superheaters to raise the temperature of the

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steam to 320°C., for Copenhagen Corporation Oestre elektricitetsvaerk; and four boilers and stokers for the Cie L'Union des Gaz (Milan).

In addition to the above, the company has received a repeat order for eight boilers (to be fired by blast-furnace gas) from a firm in the north, besides orders for boilers for the utilisation of waste heat from furnaces at iron and steel works.

BUSINESS NOTICES.

Messrs. Hansard & Watson, Parliament Mansions, Victoria-street, Westminster, S.W., announce that they have dissolved partnership as from Aug. 1. Mr. Arnold G. Hansard, B A., M.I.E.E., will carry on the business under his own name, and will be responsible for all debts of the late firm.

C. R. Heap & Ed. F. Johnson, dealers in electrical and mechanical appliances, 28, Hatton garden, London, E.C., have dissolved partnership. Debts by Mr. Johnson, who continues.

Surface Condensers.—Messrs. Willans & Robinson (Ltd.), of Rugby, have acquired the rights for the use of the "Contraflo" type of surface condenser, in addition to the "Vacuum augmenter" system, which owes its introduction to the Hon. C. A. Parsons. Messrs. Willans & Robinson have during the past year or so obtained orders for over 50 complete sets of their ordinary type of surface condenser, and it is believed that the "Contraflo" and "Vacuum augmenter" systems will enable them to further extend this branch of manufacture.

BANKRUPTCIES, LIQUIDATIONS, &c.

Siemens Electric Appliances (Ltd.) is being wound up voluntarily. Claims to the liquidator (Mr. A. M. Hicks, 8, Belmont-road, Wallington, Surrey) by Sept. 30.

Claims against Harold S. Martin, electrical engineer, 13 and 16, Cumberland-street, Liverpool (late Martin & Stavert), who has executed a deed of assignment, are to be sent by Aug. 15 to Mr. A. A. Menzies, 51, North John-street, Liverpool.

Sales by Auction.—Messrs. Fuller, Horsey, Sons & Cassell have been instructed to sell by auction in lots (unless previously sold privately as a whole) at the Paragon Motor Works (Ltd.), London-road, King's Lynn, on Tuesday, Aug. 27, at 11 a.m., the entire contents ofthe works, comprising a costly collection of nearly new machine tools by best American and English makers, four electric motors and dynamos, electrical installation, shafting and belting, motor components and finished parts, a general assortment of stock, stores, &c. Catalogues at the works; of Mr. Johnson M. Wood, C.A., 95, Gresham street, E.C.; Messrs. Ford, Lloyd & Co., solicitors, 38, Bloomsbury-square, W.C., and of the auctioneers, 11, Billiter-square, London, E.C. Further particulars are given in an advertisement.

Messrs. Horne & Co., 8, Delahay-street, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on 22nd inst., at 11 a.m., some obsolete and unserviceable stores, including quantities of brass, copper, gunmetal, lead, tin, zinc and other metals; lathes and tools, instruments, electric cable, lamps, &c. The lots may be viewed at the Royal Arsenal, Woolwich, on the Monday, Tuesday and Wednesday previous to and on morning of the sale. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower; the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Plant for Sale.—Mr. A. Underwood, 3, Queen-street, London, E.C., has for sale three Crossley gas engines (70 B.H P. to 105 I.H.P.) and suction gas plant, three Crompton compound dynamos, battery of 132 cells, &c. See an advertisement.

Agents Wanted.—The directors of the Bastian Meter Co (Ltd)., invite applications from responsible firms willing to act as agents in defined districts throughout the United Kingdom. Communications to the chairman of the company, Bartholomew Works, Kentish Town, London, N.W. See an advertisement.

An old-established and well-known German firm of manufacturing electric motors and dynamos, transformers and electric cranes advertises that it is open to entertain proposals from firms with large connections throughout England and colonies with a view to representation.

Chartered Institute of Patent Agents.—The qualifying examination of persons desirous of being registered as patent agents will be held in November. Particulars have appeared in the "Illustrated Official Journal (Patents)" of July 10, and copies can be obtained from the Secretary, Chartered Institute of Patent Agents, Staple Inn-buildings, London, W.C. See also an advertisement notice.

CATALOGUES, &c.

Silent Chains.—The literature of Messrs. Hans Renold, of Manchester, is distinctive in being of uniform size and artistic in arrangement. Catalogue No. 5/9, of which we have received an advance copy, deals fully with the high-speed Renold chain and driving sprockets. Instructions for erection and care of chains in use are given and some excellent illustrations help to demonstrate the method of making a joint.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during July, 1907, and (*b*) during the current year from Jan. 1 to July 31, with the increases or decreases compared with the corresponding periods of 1906:—

Electrical machinery, (*a*) £44,068 (decrease £12,789), (*b*) £337,526 (increase £8,285); telegraph and telephone cables, (*a*) £21,751 (increase £9,741), (*b*) £172,825 (increase £79,063); telegraph and telephone apparatus, (*a*) £20,862 (decrease £16,255), (*b*) £151,136 (decrease £66,692); other electrical wires and cables: rubber insulated, (*a*) £3,025 (increase £338), (*b*) £48,030 (increase £9,433); with other insulations, (*a*) £6,081 (increase £5,475), (*b*) £46,976 (increase £5,470); other electrical goods and apparatus, (*a*) £56,190 (increase £21,684), (*b*) £321,174 (increase £44,953). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £107,909 (increase £20,983), (*b*) £740,141 (increase £72,227).

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from July 31 to Aug. 7, with the ports of destination:—

Africa—Beira, £297; Cape Town, £591 (including £23 telegraph material); Durban, £120; East London, £967; Mombasa, £817; Port Elizabeth, £34; Port Sudan, £185 (telegraph material); Sekondi, £151. *Argentina*—Buenos Ayres, £2,189 (including £594 telegraph material). *Australasia*—Adelaide. £278; Auckland, £15; Cairns, £80; Fremantle, £132; Hobart, £63; Lyttleton, £22; Melbourne, £1,196; Otago, £167; Perth, £69; Sydney, £686 (including £101 telegraph material); Wellington, £36. *Belgium*—Antwerp, £15; Ghent, £20; Ostend, £84. *Brazil*—Pernambuco, £6,380 (telegraph cable); Rio Janeiro, £4,800 (telegraph cable); Santos, £40. *Burma*—Rangoon, £137. *Canada*—Montreal, £53; Quebec, £68. *Ceylon*—Colombo, £158. *Chili*—Valparaiso, £359 (telegraph material). *China*—Shanghai, £530 (including £103 telegraph material); Tientsin, £363. *France*—Boulogne, £13; Rouen, £35. *Germany*—Bremen, £136; Cologne, £33; Hamburg, £116. *Holland*—Amsterdam, £140; Flushing, £90. *Hong Kong*, £3,637. *India*—Bombay, £2,495; Calcutta, £554; Madras, £24. *Japan*—Kobe, £277; Yokohama, £15. *Russia*—St. Petersburg, £81. *Spain*—Bilbao, £38. *St. Helena*, £10. *Straits Settlements*—Penang £20 (telegraph material); Singapore, £315. *Sweden*—Gothenburg, £113. *Turkey*—Constantinople, £120. *U.S.A.*—New York, £540 (telegraph cable). *West Indies*—Port Swettenham, £931 (including £823 telegraph material). Total (for eight days) £32,635, against £10,543 for three days last year (Aug. 1 to 3).

The exports of electrical machinery material, &c. (*a*) during July, 1907, and (*b*) during the current year from Jan. 1 to July 31, and the increases or decreases compared with the corresponding periods of 1906, are as follows:—

Electrical machinery (*a*) £95,774 (increase £33,712), (*b*) £548,707 (increase £48,384); telegraph and telephone cables, (*a*) £42,161 (decrease £24,090), (*b*) £596,332 (decrease £45,226); telegraph and telephone apparatus, (*a*) £19,007 (decrease £4,298), (*b*) £105,014 (increase £1,384); other electrical wires and cables, rubber insulated, (*a*) £22,825 (increase £4,901), (*b*) £155,955 (increase £56,922); with other insulations, (*a*) £14,910 (increase £7,054), (*b*) £128,613 (increase £52,349); other electrical goods and apparatus, (*a*) £37,915 (decrease £13,550), (*b*) £283,831 (decrease £20,976). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £136,819 (decrease £30,183), (*b*) £1,269,785 (increase £41,685).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

May 6, 1907.

10,457 DODD. Device for controlling Cummin's sanding apparatus.
10,469 HAHN. Electrical vapour apparatus.
10,470 HAHN. Connecting electrical vapour apparatus with the conductors.
10,505 BROOKIE. Multiple carbon arc lamps.
10,513 BECK & DEUTSCHE BECK-BOGENLAMPEN-GES. M.B.H. Protecting the support of arc lamps with laterally-supported electrodes. (Date applied for, 5/5/06.)*†
10,514 ROBERTSON & KLATZL. Electrodes.*
10,518 LANNING. Magnet boxes and armatures of magnets therein.*
10,522 LAWRENCE. Pocket magnetic compasses.*
10,537 HOUGHTON. Telephone transmitters.*
10,560 BROWNE. Electrically-controlled railway block signalling.

May 7, 1907.

10,579 BEILBY. Manufacture of sodium by electrolysis.
10,597 TAYLOR. Automatically operating electric switches for starting and stopping electrically-driven pumps.*

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10,625 MADALER. Electric transmission of images.
10,636 BLACK & BLACK. Electric traction installation using contact boxes.
10,638 CROWLEY & SOMERS. Coherers for use in wireless telegraphy.
10,639 CROWLEY & SOMERS. Wireless telephonic apparatus.
10,640 CROWLEY & SOMERS. Autographic telegraphs.
10,641 MITCHELL. Leakage detectors for surface-contact electric traction systems.
10,645 SCHULZ. Regulating multi-stage gas and steam turbines.
10,650 DAWSON & BUCKHAM. Electrical apparatus for transmitting and receiving signals.
10,662 WINTHER-HANSEN & BOUCHSEIN. Arc lamp.*
10,665 B.T.-H. Co. (A.E.G., Germany.) Switches, fuses and the like.
10,666 B.T.-H. Co. (A.E.G., Germany.) Electric switches.

May 8, 1907.

10,670 WALKER & SPRINGTHORPE. Life-guard for tramcars.
10,687 BROWN. Electrical block signalling system for railways.
10,694 LOCKE. Insulation for high-potential electric conductors.*
10,699 MARRIOTT. Pitch product for insulating electric cable trenches.
10,709 BRAUN. Electromagnetic brakes for railway and other vehicles. (Date applied for, 18/5/06.)*†
10,719 MAYES & FERRANTI LIMITED. Electric motor-starters.
10,741 BELLISS & MORCOM, JUDE & MORCOM. Turbines.
10,742 WARWICK. Wireless telephony.
10,758 OGLE. Fire-alarm systems.
10,763 FARQUHAR. Brakes for tramcars.
10,786 B.T.-H. Co. (G.E. Co., U.S.) Signalling systems and apparatus.

May 9, 1907.

10,819 LANDAU. Generation of steam and its application to turbines.
10,827 SIEMENS BROS. DYNAMO WORKS. (Siemens-Schuckertwerke G.m.b.H., Germany.) Systems for working electric motors.*
10,861 PUNGA. Direct-current armatures with multiple circuit multiple winding.*

May 10, 1907.

10,931 CAMPBELL. Incandescent lamp bulbs.*
10,936 BROCKIE. Arc lamp brake and focussing gear.
10,943 BROWN. Connecting up electric cables.
10,955 POTTER, jun. Telephone switch-operating mechanism. (Date applied for, 28/5/06.)*†
10,966 OGLE. Automatic fire-alarm systems.
10,969 FELTEN & GUILLEAUME-LAHMEYERWERKE ACT.-GES. Repulsion electric motors. (Date applied for, 14/5/06).*†
10,972 PORZELLANFABRIK KAHLA, FILIALE: HERMSDORF-KLOSTERLAUSNITZ. Insulators for electric conductors. (Date applied for, 14/5/06.)*†
10,979 SCHALLER. Current regulation in electric installations. (Date applied for, 14/5/06.)*†
10,991 DEWHURST. Signalling devices for tramways and railways.

May 11, 1907.

10,993 KAPLAN & BATAULT. Electric lighting of specula. (Date applied for, 14/5/06.)*†
10,996 MOUL. Arc lamps.
11,022 HIRST & LOESCHER. Lightning arresters.
11,044 TANNER & CLAREMONT. Electric cables and the bonding thereof.
11,066 LEITNER. Dynamos for train lighting.
11,070 B.T.-H. Co. (A.E.G., Germany.) Switch mechanism for controlling electric motors.
11,071 ALLGEMEINE ELEKTRICITÄTS-GES. Electrically-operated winding gear. (Date applied for, 12/5/06.)*†
11,072 MARGULIS. Plates for accumulators.

May 13, 1907.

11,079 SKIPWORTH & NEWBERY. Contacts for electric conductors.
11,086 SULLIVAN. Telephone receivers.
11,099 WHIPP. Double-pole loose-handle magnetic blow-out circuit breaker.
11,109 DUNN. Overhead spring type of tension for carbon brushes.
11,122 SZEK. Accumulator plates.
11,123 HUNGERFORD. Electric conductors.*
11,163 GIFFORD & DIXON. Lightning arresters.*
11,165 HIGHFIELD. Electrical distribution.
11,166 HIGHFIELD. Generating high-tension direct electric currents.
11,178 HADDAN. (Bergmann-Elektricitäts-Werke A.G., Germany.) Fastening metallic filaments in glow lamps.*
11,183 MAVOR, HIRD, & MAVOR & COULSON. Speed control of bodies driven by alternating-current motors.

May 14, 1907.

11,195 JONES. Holders for incandescent lamps.
11,197 EDMONDS, HAYWOOD & MCKENZIE & HOLLAND. Electrical contact maker.
11,218 LEDWICH. Trolley head.
11,219 QUIGGIN. Surface condensers.
11,229 HEWER & HEWER'S CAR BODIES. Covered car bodies.
11,262 NORTHRUP. Electrical measuring instruments. (Date applied for, 26/5/06.)*†
11,270 EBERHART. Turbines. (Date applied for, 16/5/06.)*†
11,285 SCHNEIDER. Trolley wheels.*
11,288 FYNN. Alternate-current motors.
11,289 O'BRIEN. Control of electric vehicles and trains.

May 15, 1907.

11,347 HEYS. (General Acoustic Co., U.S.) Telephonic dictating system and devices.*
11,353 DIGBY & BIGGS. Resistance of liquids and electrolytes.
11,362 BROCKIE. Magazine arc lamps.
11,383 BAUMANN. Prepayment electricity meters. (Date applied for, 16/5/06.)*†
11,402 RILLING. Electromagnetic ignition device.*

May 16, 1907.

11,425 LAIDLAW & LAIDLER. Electrical resistances.
11,450 MCCLELLAND, jun., & KRATT. Arc lamps.
11,459 & 11,520 TUCKER. Electric switches.
11,471 COWPER-COLES. Electro-deposition of metals.
11,475 SIEMENS-SCHUCKERT WERKE G.M.B.H. Operating devices for switches. (Date applied for, 16/6/06.)*†
11,476 KAY. Dynamo-electric generators and motors.
11,478 IMRAY. (Society of Chemical Industry in Basle, Switzerland.) Electrolytic oxidation of isoborneol to camphor.

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

23,152 LLOYD. Electrical ignition of internal combustion engines.
23,305 MORGAN CRUCIBLE CO. & SPEIRS. Commutators for electrical generators.
23,772 RITTER. Foundations for trolley standards and telegraph poles.
24,694 BERGLUND, HJORTH & LJUNGMAN. Microphones.
25,200 AICHELE. Electric driving of winding engines.
25,380 WILEMAN. Prevention or mitigation of skidding of vehicles propelled by electricity or any other motive power.
25,410 ORBAN. Celluloid boxes for secondary batteries.
24,422 RUTHENBURG. Magnetic separators.
25,984 SNEE. Wave-propelled or current motors.
25,994 KUZEL. Soldering incandescence filaments of incandescence lamps to conducting wires. (Date applied for, 20/1/06.)
26,086 STEIGER & BESANCON. Electric winding mechanism for clocks.
26,148 SIEMENS BROS. DYNAMO WORKS, JENKIN & LYDALL. Controller systems.
26,929 ROACH. Electric furnaces.
26,941 MEIROWSKY. Apparatus for forming insulation tubes.
26,983 SIEMENS BROS. & Co. & FERREIRA. Apparatus for detecting whether railway or like points are in their correct position and an electrical switch for use therewith.
26,990 NORGGERATH. Frequency-changers for electric currents. (Date applied for, 4/12/05.)
27,076 VON KELLER. Vapour electric converters. (Date applied for, 5/12/05.)
27,499 GEB. SIEMENS & Co. Manufacture of dynamo brushes, sliding contacts or the like from carbon. (Date applied for, 16/2/06.)
27,684 BRUUN. Electric time switch. (Date applied for, 29/3/06.)
27,714 AKTIEBOLAGET SVENSKA ELEKTRISKA URFABRIKEN. Electrical clocks. (Date applied for, 6/12/05.)
27,934 VON BROCKDORFF. Electric resistances. (Date applied for, 8/12/05.)
28,018 ALLGEMEINE ELEKTRICITÄTS-GES. Centrifugal pumps, fans, and the like. (Date applied for, 9/12/05.)
28,227 HOUGHTON & POTTER. Hand telephones.
28,342 THIROT & MAGE (called NOUGUIER). Electrolytic production of pure tin. (Date applied for, 26/3/05.)
28,562 FRIED. KRUPP A. G. Automatic starter for continuous current motors. (Date applied for 22/3/06.)
28,897 COWPER-COLES. Electrical deposition of iron.
29,201 ALLGEMEINE ELEKTRICITÄTS-GES. Meters for electricity. (Date applied for, 28/12/05.)†
29,317 GADDA & CONTI. Turbines. (Date applied for, 23/12/05.)
29,452 LIVINGSTONE & DICKINSON. Street or station indicator for electric tramcars and subway cars.
29,494 ISARIA-ZAHLERWERKE GES. Electricity meters for testing purposes. (Date applied for, 27/12/06.)
29,545 SCHEIBLER. Tool for examining electric conductors.
29,771 ALLMÄNNA SVENSKA ELEKTRISKA AKTIEBOLAGET. Multiple-unit controlling systems. (Date applied for, 2/1/06.)

1907 SPECIFICATIONS.

596 COWPER-COLES. Electric furnaces.
1,070 GRIFFITHS. Electric candle lamps.
1,085 COWPER-COLES. Magnetic separators.
1,658 GRÖNWALL, LINDBLAD & STALHANE. Electric smelting furnaces. (Date applied for, 26/1/06.)
1,801 DORMAN, SMITH & BAGGS. Switches.
2,555 HILTON & DAWSON. Trolley wheels.
3,247 FINK. Electrical contact device for the ignition of explosive charges.
3,757 BROWN, BROWN & GRESEY. Guards or cages for use with incandescent electric lamps.
3,904 LATOUR. Dynamo-electric machines. (Date applied for, 16/2/06.)
4,180 ALLGEMEINE ELEKTRICITÄTS-GES. Centrifugal pumps or compressors. (Date applied for, 20/2/06.)
4,263 ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT. Current collectors for electric vehicles. (Date applied for, 23/2/06.)
4,609 DUNOYER. Electromagnetic compass. (Date applied for, 5/3/06.)
4,814 SIEMENS & HALSKE A.-G. Manufacture of filaments from tungsten or mixtures thereof with other metals. (Date applied for, 10/3/06.)†
5,345 ALLMÄNNA SVENSKA ELEKTRISKA AKTIEBOLAGET. Electric furnaces. (Date applied for, 7/3/06.)†
5,849 MULLER. Magnetically releasable locking device for miners' lamps and the like.
5,946 FICHELSCHEER & BERGHEISER. Safety device for tram-cars.
6,527 ALLGEMEINE ELEKTRICITÄTS-GES. Instruments for registering the use of electric current in electrically propelled vehicles. (Date applied for, 27/3/06.)
7,861 WENNSTROM. Jewelled bearings for electrical instruments.

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COMPANIES' MEETINGS AND REPORTS.

ALUMINIUM CORP. (LTD.)—At the statutory meeting on Wednesday Sir James Sivewright said the company was formed to acquire certain freehold land and extensive water rights in Wales, to establish works for the manufacture of aluminium, &c. The original idea was to lease the water rights, but eventually freehold land was acquired with the whole of the water rights for £55,000. A portion of the works was under construction, and would be finished within 12 months, and the whole of the contract in connection with the North Wales installation would be completed within two years. Satisfactory arrangements had been made with the North Wales Power Co. for the supply to this company's main station at Dolgarrog of power equivalent to 1,600 H.P. Therefore, instead of having only 6,000 H.P., which was the amount mentioned in the prospectus, they would have 7,000 H.P. available in North Wales alone when their works there were completed. In addition, the board had made arrangements for the supply of power from the Newcastle-on-Tyne Electric Supply Co., and had acquired suitable land on the Tyne for their business. By the end of this year or early in 1908 the company should be able to put its product on the market, and the output should go on steadily increasing from that time.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—At a meeting of the ordinary shareholders on Friday a resolution was passed reducing the capital of the company from £660,000 to £489,512 by cancelling capital lost or unrepresented by available assets to the extent of 13s. 4d. per share upon the issued shares of each class, and for increasing the non-cumulative dividend upon the preference shares from 6 to 7 per cent. At a subsequent extraordinary meeting of the company the resolution was approved.

CENTRAL LONDON RAILWAY CO.—At the meeting on Wednesday Sir H. Oakley said the company's working costs had decreased, as had also the consumption of coal. By the adoption of an improved furnace they were enabled to burn a commoner coal, and to save both in the price and quantity consumed. There had been a steady and growing diminution in the number of passengers carried. The decrease in the half-year represented 2,000,000, or about 10 per cent. The money loss in direct fares was £16,000. On the other hand, expenses had been lessened by about £4,700, but there was an addition of about £374 for rates and taxes. There was no apparent reason for the decreased revenue except the intensely-increased competition that pervaded the whole of London. There was at least 20 per cent. more omnibuses and motor cars running between Holborn and the Marble Arch than there were a year and a half ago. The Board had been obliged to recognise that their average fare of 2d.—convenient, simple and nice as it was to carry on the work of the line—would have to be modified, because in the face of the competition, it was unprofitable. The change in fares came into force on July 1, and on the whole he thought he was justified in saying that that experiment promised to be satisfactory. They were receiving through the additional 1d. charged on some fares something like £60,000 or £70,000, without any additional cost, and that, to some extent, compensated for the loss in other directions. They also found that the loss was not continuing. Its ratio was diminishing, and it appeared they had reached the bottom of the change resulting from competitive fares.

GREAT NORTHERN & CITY RAILWAY CO.—At the meeting on Friday the Earl of Lauderdale referred to the competition of the electric tramways, and said the rates charged by the company were too low. The tramways were constructed at an infinitesimal cost, compared with the capital cost of their line, and they adopted the same fare for the same distance. The directors did not think the fare was one which would really pay, and they trusted that, as soon as an intelligent investigation of the actual expenses of working the tramways in London had been made, those responsible for the tramways would, by shortening their distances, ensure a remunerative rate. The most remarkable feature of the half-year's traffic was the large increase in 1d. fares and the decrease in the 2d. fares.

LIVERPOOL OVERHEAD RAILWAY CO.—For the half-year ended June 30 gross revenue receipts amounted to £38,246. 10s. 4d., and working expenses to £30,035. 6s, 7d. 5,423,595 passengers were carried, against 5,445,100 in June half of 1906. Passengers carried showed a decrease of 21,505, but total receipts increased by £463, and expenses were reduced by £265. The through traffic to Southport and Aintree in connection with L. & Y. Railway continues to make slow but steady progress. After paying working expenses and deducting interest on mortgage debentures and on calls paid in advance (£4 329. 8s. 2d.) and taking into account £4,246. 9s. 6d. from December 1906, £8,218. 5s. 1d. is available for dividend, and the directors recommend the dividend of 5 per cent. per annum on the preference shares (less tax), leaving £4,452. 8s. 1d. to be carried forward.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

CHISHOLM MFG. CO. (LTD.) (94,410.)—Reg. July 31, capital £10,000 in £1 shares, to acquire the business carried on at Birmingham as the Chisholm Mfg. Co., to acquire certain patents granted to G. Chisholm, and to carry on the business of electricians, manufacturers of electrical accessories, brassfounders, &c. First directors C. H. Williams and G. Chisholm (managing director). Reg. office, Providence Works, Fleet-street, Birmingham

FOSTER ARC LAMP & ENGINEERING CO. (LTD.) (94,371.)—Reg. July 29, capital £20,000 in £1 shares (5,000 6 per cent. cumulative preference), to carry on the business of arc lamp manufacturers, electrical engineers, electric lighting contractors, cable manufacturers, electric fittings, storage battery and carbon manufacturers, &c. First directors M. V. Ely and E. R. Grote (managing directors) and E. Dobson. Reg. office, Worple Arcade, Wimbledon.

NILMELIOR (ENGLAND) LIMITED. (94,441.)—Reg. Aug. 1, capital £5,000 in £1 shares, to acquire the sole agency for the British Empire for the sale of accumulators, magnetos, contact coils and other articles for the ignition of explosive engines and accessories thereto, and other goods manufactured by Société d'Electricité "Nilmelior," of Paris, and to carry on the business of dealers in electrical goods and appliances. First directors, A. Michel, R. Schoeller, W. R. Elderfield and W. H. White.

RHONDDA TRAMWAYS ELECTRIC SUPPLY CO. (LTD.) (94,470.)—Reg. Aug. 2, capital £100 in £1 shares, to build, construct and equip a generating station for producing electrical energy, to supply electricity to the Rhondda Tramways Co., to adopt agreements with the Rhondda Tramways Co. and the National Electric Construction Co., and to carry on the business of electricians, electrical engineers, &c. Reg. office, Queen Anne's Chambers, Westminster, S.W.

STATUTORY RETURNS.

CAMBORNE ELECTRICITY SUPPLY (LTD.)—The capital in return to May 23 is £10,000 in £1 shares, of which 607 have been taken up. £605 has been received, leaving £2 in arrears. Mortgages and charges, nil.

FLADBURY ELECTRIC LIGHT & POWER CO. (LTD.)—In return to June 6 capital is £2,000 in £1 shares, of which 855 have been taken up and paid for in full. Mortgages and charges £300.

STANDARD ELECTRIC CO. (LTD.)—Return to July 22 gives capital as £10,000 in 5,000 preference and 5,000 ordinary shares of £1 each, of which 3,077 preference and 5,000 ordinary have been taken up. £1 per shares has been called up on 4,177 and 10s. per share on 400, resulting in the receipt of £4,377. 3,500 shares are considered as fully paid. Mortgages and charges £3,500.

TWICKENHAM & TEDDINGTON ELECTRIC SUPPLY CO. (LTD.)—Return to May 23 gives capital as £25,000 in 5,000 shares of £5 each, of which 127 have been taken up. £5 per share has been called up and £635 has been received. Mortgages and charges nil.

URBAN ELECTRIC SUPPLY CO. (LTD.)—The capital in return to May 23 is £650,000 in 80,000 ordinary and 50,000 preference shares of £5 each, all of which have been taken up and paid for in full. Mortgages and charges £275,000.

WOODHOUSE & BAILLIE RIVIERA CO. (LTD.)—Return to May 13 gives capital as £50,000 in 16,000 first preference, 20,000 second preference and 14,000 ordinary shares of £1 each, of which 14,700 first preference, 4,000 second preference and 4,000 ordinary have been taken up. £1 per share has been called on 14,700 first preference, resulting in the receipt of £14,660, leaving £40 in arrears. £8,000 is considered as paid on 4,000 second preference and 4,000 ordinary. Mortgages and charges nil.

MORTGAGES AND CHARGES.

LOWNE ELECTRIC CLOCK & APPLIANCES CO. (LTD.)—Particulars of £1,000 debentures, created by resolution of May 13, 1907, have been filed, pursuant to sec. 14 (4) of the Companies Act, 1900. Property charged, company's undertaking and property, present and future, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (Aug. 8).—Bank rate 4 per cent. (since April 25, 1907), Price of silver 31$\frac{15}{16}$d. per oz. Consols 81$\frac{3}{8}$—81$\frac{7}{8}$ for money, 81$\frac{7}{8}$—82 for account; 2$\frac{1}{2}$ per cent. annuities 79$\frac{3}{4}$—80$\frac{1}{4}$. Consols Pay Day, Sept. 2; Stocks and Shares Continuation Days, Aug. 13 and 27; Ticket Days, Aug. 14 and 28; Pay Days, Aug. 15 and 29; Mining Share Carry-over Day, Aug. 12.

BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared interim dividends for the half-year ended June 30 on the ordinary shares at the rate of 9 per cent. and on the preference shares at the rate of 7 per cent.

COMPANIES REGISTERED IN 1907.—The editor of the "Investors' Guardian" has prepared an analysis of the registration of new companies at Somerset House, London, during the first half of 1907, the compiler claiming that evidence is found in this list of new companies of a recovery in joint-stock activity. So far as the electrical industry is concerned there is no evidence given, but, on the contrary, the figures show a large falling off in the capital invested in joint-stock electrical enterprise. For the six months, January—June, 1907, the electrical industry stands for £1,431,030, compared with £2,088,055 for the first six months of 1906, and £3,206,425 for 1905. The total number of companies registered during the six months increased from 1991 in the first half of 1905 and 2,255 in 1906 to 2,479 in 1907, and the total capital issues for the same periods show very large increases, so that, as far as joint-stock enterprise is concerned, the electrical industry shows a considerable set-back.

ELECTRIC EQUIPMENT & SECURITIES (LTD.)—A meeting of this company was held on Wednesday, but the proceedings were private.

METROPOLITAN ELECTRIC SUPPLY CO. (LTD.)—The directors have declared an interim dividend of 3 per cent. per annum.

TYNESIDE TRAMWAYS & TRAMROADS CO.—Dr. J. T. Merz stated at the meeting on Tuesday that there was an increase of £693. in traffic compared with the corresponding period last year. The receipts per car-mile were 8·8d., against 8·3d. A dividend at the rate of 2 per cent. per annum was declared.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	July 31	1,628	+ 9	9	13,728	- 16
Airdrie	,, 26	180	- 12	29	6,499	+ 4
Anglo-Argentine	,, 29	16,137	+ 2,631	30	494,097	+ 51,488
	Aug. 5	16,755	+ 2,149	31	510,852	+ 53,677
Ashton-under-Lyne Corp	,, 3	399	+ 21	19	7,497	+ 758
Ayr Corporation	,, 3	421	- 16	12	4,666	- 175
Baker St. & Waterloo Ry.	,, 3	2,270	+ 1,061	5	12,415	+ 5,717
Barnsley	July 26	168	...	29	4,775	- 6
Barrow	,, 26	333	+ 16	29	7,227	- 52
Bath Electric Trams, Ltd.	,, 31	905	- 145	31	23,590	- 636
Birkenhead Corporation	...	...	...	...	...	...
Birmingham Corporation	Aug. 3	6,135	...	18	107,747	...
Birmingham & Mid.	July 19	846	...	28	22,323	...
Blackburn Corporation	,, 31	1,105	+ 9	§18	20,439	+ 777
Blackpool Corporation	Aug. 1	1,902	- 160	17	19,982	- 1,765
Blackpool and Fleetwood	,, 3	1,319	- 99	5	5,802	- 1,864
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 4	2 864	+ 625	18	41,699	+ 2,080
Bournemouth Corporation	July 31	2,203	+ 362	¶17	29,967	+ 526
Bradford Corporation	Aug. 3	4,809	- 80	18	81,572	+ 278
Brighton Corporation	,, 4	1,147	- 234	18	16,613	- 1,740
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 2	5,321	- 185	4	16,487	- 659
Buenos Ayres & Belgrano	...	...	...	...	...	...
Buenos Ayres Elec. Trams	...	...	...	...	...	...
Burnley Corporation	,, 3	1,377	+ 78	18	21,043	+ 203
Burton Corporation	,, 5	322	- 29	18	5,331	- 281
Bury Corporation	July 28	1,157	...	17	18,780	...
Calcutta Tramways Co.	Aug. 3	¤46,594	+ ¤1,517	4	¤183,578	+ ¤16,533
Camborne-Redruth	,, 3	133	- 1	31	3,657	+ 34
Cardiff Corporation	,, 3	2,254	+ 15	18	40,345	+ 2,286
Cavehill	July 26	126	- 10	29	2,188	+ 97
Central London Railway	Aug. 3	4,828	- 366	5	26,619	- 1,945
Charing C., Euston & H'stead	,, 3	2,375	...	5	12,820	...
Chatham & Dist. Lt. Rys.	,, 1	774	+ 38	‡31	21,582	+ 1,802
City & South London Rly.	,, 4	2,904	+ 622	5	15,651	+ 3,232
City of Birmingham	July 26	2,830	...	29	81,333	...
Colchester Corporation	Aug. 1	235	- 24	...	...	...
Cork Electric Trams Co.	,, 1	547	- 22	31	14,151	- 472
Croydon Corporation	,, 2	1,472	- 74	18	25,924	- 1,638
Devonport & Dist. Trams	July 26	500	- 23	29	13,244	- 17
Dover Corporation	Aug. 3	280	- 57	18	4,221	- 612
Dublin & Lucan Railway	,, 2	153	+ 6	5	702	+ 18
Dublin United	,, 2	7,159	+ 1,498	‡5	34 587	+ 8,232
Dudley Stourbridge	July 26	854	- 103	29	24,316	- 608
Dundee Corporation	,, 31	1,108	- 83	11	12,701	+ 311
East Ham Council	Aug. 3	927	+ 9	18	16,601	- 392
Exeter Corporation	...	...	...	...	...	...
Falkirk and District	July 31	301	...	...	...	...
Gateshead & Dist. Trams	,, 26	1,019	- 25	29	29,194	+ 670
Glasgow Corporation	Aug. 3	16,873	+ 407	9	157,782	+ 1,892
Glossop	,, 3	135	- 13	31	4,202	+ 49
Gravesend—Northfleet	July 26	274	- 6	29	6,922	- 4
Great Northern & City Rly.	Aug. 3	1,557	+ 28	5	8,318	+ 155
Gt. Northern, Piccadilly, &c.	,, 3	3,880	...	5	20,970	...
Greenock & Port Glasgow	July 26	747	- 32	29	19,376	- 51
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 26	345	- 35	29	8,125	- 473
Hastings Elec. Trams Co.	Aug. 1	1,304	+ 454	5	5,145	+ 2,015
Hong Kong	,, 3	7,481	- $23	17	...	+ $34,486
Huddersfield	,, 3	1,664	+ 75	18	28,741	+ 1,084
Hull Corporation	,, 3	2,464	+ 57	18	42,925	+ 2,005
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	July 31	146	- 5	18	2,568	+ 158
Ipswich Corporation	Aug. 3	488	- 59	18	7,449	- 625
Isle of Thanet Co.	,, 3	1,360	- 120	44	19,427	- 533
Jarrow	July 26	135	...	29	3,499	...
Keighley Corporation	Aug. 1	177	- 16	5	786	+ 23
Kidderminster & District	July 26	153	+ 7	29	3,277	- 153
Kilmarnock Corporation	Aug. 3	177	- 20	11	1,992	- 25
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 1	1,179	+ 353	31	35,243	+ 8,498
Lancashire United	July 31	1,339	+ 233	31	37,652	+ 9,801
Leamington	,, 26	177	- 55	29	4,457	- 735
Leeds Corporation	Aug. 3	6,888	+ 410	18	118,351	+ 4,561
Leicester Corporation	,, 3	2,346	+ 18	5	11,492	- 260
Leith Corporation	,, 3	553	+ 15	‡12	6,485	+ 61
Lincoln Corporation	July 27	120	...	...	...	...
Liverpool Overhead Rly.	Aug. 4	1,657	+ 97	5	8,482	+ 649
Liverpool Corporation	July 27	11,483	- 3	30	322,073	+ 4,145
*London County Council	,, 27	31,507	+ 4 450	17	530,130	+ 10,829
London United	Aug. 2	7,691	+ 599	‡31	193,303	+ 4,909
Lowestoft	,, 3	364	+ 3	44	7,661	+ 919
Maidstone Corporation	,, 3	143	+ 7	18	2,016	- 57
Manchester Corporation	,, 3	14,995	+ 774	18	266,061	+ 21,029
Mersey Railway	,, 3	1,874	+ 156	5	9,223	+ 862
Merthyr	July 26	202	- 8	29	6,045	+ 307
Metropolitan Dist. Railway	Aug 4	7,201	+ 115	5	38,799	+ 124
Metropolitan Elec. Trams	July 26	5,161	+ 1,341	29	129,452	+ 27,696
Middleton	,, 26	429	+ 18	29	10,160	- 182
Nelson Corporation	Aug 3	154	+ 20	19	2,780	+ 38
Newcastle-on-Tyne Corp.	,, 3	4,110	+ 26	18	75,270	+ 325
Newport (Mon.)	,, 3	703	+ 27	18	13,074	+ 1,567
Northampton Corporation	,, 2	453	- 37	‡18	7,837	- 393
Oldham, Ashton & Hyde	July 26	661	+ 59	29	17,459	+ 225
Oldham Corporation	Aug. 4	2,016	+ 20	19	36,952	+ 2,368
Perth (N.B.) Corporation	...	...	...	...	...	...
Perth (W.A.) Elec. Trams	,, 2	1,327	- 48	31	41,263	- 1,514
Peterborough	July 26	130	- 27	29	3,531	- 151
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	Aug. 3	2,409	- 196	18	36,334	- 1,819
Potteries	July 26	1,903	+ 97	29	54,582	+ 1,439
Preston Corporation	...	...	...	...	...	...
Rotherham Corporation	Aug 1	597	+ 69	‡18	10,447	+ 1,528
Rothesay	July 26	664	- 36	29	5,745	- 290
Salford Corporation	Aug. 5	5,027	- 111	18	85,824	+ 1,517
Sheerness	July 24	68	- 3	29	1,605	- 42
Sheffield Corporation	Aug. 4	5,635	+ 131	19	105,240	+ 4,454
Singapore Trams	,, 3	$5,097	+ $1,111	18	$171,890	+ $3,885

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	July 31	1,193	+ 52	...	...	...
Southend Corporation	,, 31	563	- 8	18	6,917	- 362
South Metropolitan	,, 26	912	+ 370	29	22,133	+ 2,911
Southport Tramways	,, 26	374	- 28	29	8,253	- 545
South Staffs	,, 26	869	+ 18	29	25,864	+ 1,796
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	Aug. 4	1,560	- 132	18	26,014	- 272
Sunderland and District	July 31	564	+ 123	31	13,666	+ 1,751
Swansea Trams	,, 26	1,013	+ 101	29	24,882	+ 884
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 26	49	- 1	29	1,219	- 87
Tynemouth and District	,, 26	419	- 20	29	6,546	- 687
Tyneside Trams Co.	,, 31	466	- 19	31	14,206	+ 644
Victoria, Elec. Supply Co. of	June 30	641	+ 5	14	11,870	+ 84
Wallasey District Council	Aug. 3	977	+ 23	18	15,403	+ 300
Walsall Corporation	,, 3	536	- 19	31	15,315	...
Warrington Corporation	,, 1	383	+ 15	18	6,774	+ 243
West Ham Corporation	,, 1	2,343	+ 34	18	42,879	+ 1,100
Weston-super-Mare	July 24	329	- 22	29	3,006	- 382
Wolverhampton Co.	,, 26	473	+ 25	29	13,017	+ 686
Wolverhampton Corpn.	,, 31	853	+ 12	2	1,706	+ 24
*Worcester	,, 26	314	- 37	29	7,880	- 254
Wrexham	,, 26	117	+ 1	29	2,923	- 36
Yorkshire W.R. Trams	Aug. 4	1,220	+ 312	31	34,837	...
Yorkshire Woollen District	July 26	1,233	+ 46	29	27,958	+ 1,353

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., Aug. 7.	Rate % Yield. £ s. d.	Dividend Due.	Business 6 Days to Aug 7. Highest.	Business 6 Days to Aug 7. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	Anglo-Argentine Ord. Shares	8⅜–8⅝	4 12 6	Ap, Oct	8 17/32	8 13/32
5	2/9	Do. 5½ per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	6¼	6 1/16
St.	6%	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3⅜–3⅝	2 19 6	May ..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5	5 0 0	My, Nv	4⅛	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 —132	4 3 6	Mr, Spt	..	..
St.	6%	Do. Pref. Ord. Stock	111 —114	4 7 6	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock.	103 —106	4 14 6	Ja, Jul	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 —102	4 8 0	Ja, Jul	101¼	..
5	3/0	Buenos Ayres & Belgrano Ord.	4⅛–4⅜	3 11 9	Ap, Oct	4⅜	4 1/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4⅞–5⅛	5 14 0	Ap, Oct	..	..
5	3/0	Do. "B"	4⅞–5⅛	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 —97	5 3 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 —103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	101 —103	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7⅛–8	5 0 0	Mr, Spt	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5⅛–5⅜	4 13 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —105	4 5 0	Ja, Jul	104	..
St.	..	Cape Electric Tram Shares	7/16–7/8	.. ..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —98	5 2 0	My, Nv	96	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	83 —88	5 14 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 — 82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛–1 1/16	3 15 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 1/16–1 1/16	4 10 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	95 — 98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —19	5 1 0	Ja, Jul	97	..
St.	4½%	†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 —103	4 7 6	Fb, Aug	..	..
St.	4%	Perth E. Trams. 1st Mt. Db. Stock	100 —104	4 16 0	Ja, Jul	..	..
..	3%	Sao Paulo Tramway, Light & Power Co. $100 Stock	113 — 122	6 7 0	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	43⅞–45⅞	5 5 0	Ju, Dec	24	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅜–5⅛	5 14 0	Mr, Spt	..	..
10	4/63	†Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞–8⅛	5 16 6	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	95 —97	4 12 9	Ja, Jul	96¼	..
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅜–7⅜	5 3 3	Ap, Oct	7⅛	7⅛
5	2/3	Do. (80,001 to 100,000)	6¼–7⅛	..	..	7 1/16	6 15/16
5	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 —53	4 11 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼–2⅜	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	89½–29½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ 96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —106	5 13 0	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	96	..
1	0/3	River Plate Electricity Co. Ord.	⅝–¾	3 6 9	April ..	⅝	..
1	1 2/3	Do. 6 per Cent. non-Cum. Pref.	¾–1	6 0 0	May ..	⅞	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 —98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5⅛	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101⅞	4 19 0	Ja, Jul	..	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., Aug. 7.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS 6 DAYS TO AUG. 7. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 – 11	6 6 0	Mar, Sept,	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	10 – 10⅛	4 5 6	Feb, Aug	10⅛	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	1 ⅛ – 10⅝	5 11 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	99 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 – 100	4 10 0	May, Nov	100	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞ – 8⅞	5 14 6	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	7⅛ – 8⅛	4 6 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	99 – 102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross(W.End & City)El.Sup.Co.	3⅜ – 4½	5 18 0	Feb, Aug	3⅝	3⅝
5	2/3	Do 4½ per Cent. Pref.	3¾ – 4¼	5 3 0	Feb, Aug	4⅛	4
St.	4%	Do. Do. Deb. Stock (red.).....	95 – 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¼ – 3⅝	6 0 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3¼ – 4¼	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 104	4 6 6	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 – 9⅛	6 6 0	Feb, Aug	9	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11¼ – 12¼	4 18 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	121 – 124	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 – 99	4 11 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	3⅜ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 4⅞	5 4 11	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	..	..
10	6 0	† Do. 6 per Cent. Cum. Pref.	10½ – 11⅝	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 – 109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	94 – 97	4 12 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord	4⅞ – 5⅜	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅝	4 11 0	Mar, Sept	..	..
St.	4½%	† Do. 4½ 1st Deb. Stock (red).....	96 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ – 7¼	6 4 0	April, Oct	..	..
5	5/0	†Kensington & Knightsbridge Ord.....	8¼ – 9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ – 7	4 5 9	Jan, July	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	100 – 103	3 17 9	April, Oct	..	..
3	2/4⅜	London Electric Supply Ord.	1⅜ – 2⅜	5 12 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4¾ – 5¼	5 14 0	Mar, Sept	4⅝	4⅝
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	93 – 96	4 3 8	Jan, July	..	..
5	3/0	†Metropolitan Electric Sup. Ord.	5⅜ – 6½	6 8 0	April. Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ – 5⅜	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 – 107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	88 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 – 18⅝	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord.(£9 paid)	9⅜ – 9⅝	4 15 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	93 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅜ – 7	5 16 4	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛ – 5½	4 16 0	Feb, Aug	..	..
100	4%	† Do. 4 per Cent. Mort. Deb. red. 1907.	97 – 18	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	† Do. 4½ per Cent. Deb.	97 – 99	4 11 10	Jan, July	..	..
10	6/0	Notting Hill Electric Ord.....	11½ – 12⅝	6 0 0	March ..	..	..
5	4/6	Oxford Electric Ord.	5⅜ – 6½	5 12 0	March ..	5⅝	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 – 97	4 2 6	Jan, July	..	..
5	5/0	†St. James' & Pall Mall Elec. Ord.	7⅜ – 8¼	6 1 0	Feb, Aug	..	..
5	3/6	† Do. 7 per Cent. Pref.	6 – 7	5 0 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86 – 91	3 17 0	Jan, July	89	88¾
5	..	Smithfield Markets Electric Sup. Ord...	⅞ – 1⅛	..	Feb	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	2 – 2⅛	6 0 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝ – ¾	3 6 9	..	..	..
1	0/8¾	Do. 7 per Cent. Cum. Pref.....	1⅛ – 1⅜	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 – 103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1½ – 2¼	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	95½	..
5	6/6	Westminster Elec. Sup. Ord.	9¼ – 9⅝	6 3 0	Mar, Sept	9½	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5½	4 2 0	Jan, July	5¼	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	88 – 93	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ – ⅝	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	1⅛ – 1⅛	4 17 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	92 – 97	4 13 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db Stk.	94 – 97	4 13 0	Jan, July	..	..
10	9½%	†Bristol Tramways & Carriage Ord.	14 – 14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8⅛ – 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 – 99	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2¼ – 3	..	June, Dec	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.....	7 – 7⅛	8 0 0	Feb, Aug	7⅛	7⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 103	4 17 0	April, Oct	100	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 – 81	5 11 0	May, Nov	..	..
St.	4%	Central London Ordinary Stock.....	73 – 75	5 6 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	91 – 93	4 6 0	Feb, Aug	..	..
St.	4%	Do. Deferred Stock	53 – 56	7 2 8	Feb	£4	..
100	4%	Do. 4 per Cent. Debs.	102 – 105	3 16 0	Jan, July	102½	..
St.	4%	Charing X.Euston&Hmpstd Per.Db Stk.	81 – 84	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm.Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 – 101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	45 – 47	4 5 0	Feb, Aug	46½	46⅜
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 – 121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 – 118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 – 105	3 16 0	May, Nov	104	..
10	6/0	†Dublin United Trams. (1896) Ltd. Ord...	13¼ – 14½	4 4 0	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Pref.....	12⅜ – 13⅝	4 7 0	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	1⅜ – 2¼	..	Feb, Aug	..	..
10	4/0	†G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co.4½ 1 b.St	98 – 101	4 9 0	April, Oct	..	..
10	9%	†Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	† Do. 6 per Cent. Pref.	9½ – 11	5 9 1	Mar, Sept	..	..
St.	4½%	† Do. 4½ per Cent. Debs.	97 – 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1½	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	94 – 97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1½ – 1¾	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6½ – 7⅝	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 – 86	4 13 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜ – 8⅜	5 14 3	Jan, July	8⅛	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 – 88	4 11 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅜ – ⅝	..	April ..	..	..
1	0/6	† Do. 5 per Cent. Cum. Pref.	⅞ – 1⅛	5 7 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾ – 1¾	..	May	..	..
1	0/9	Potteries Electric Traction Ord.	⅝ – ⅞	7 3 0	April Oct	..	..
1	5%	Do. 5 per Cent. Cum. Pref.	⅝ – ⅞	6 8 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 – 98	4 11 9	May, Nov	..	..
1	0/6	†S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅞ – 1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	84 – 88	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London...	64 – 67	7 9 0	June, Dec	64⅛	64¼
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛ – 3⅝	—	..	3¼	3⅛
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – 90	5 0 0	Jan, July	..	..

SHRE.	LAST DIVIDEND	NAME.	Price Wed., Aug. 7.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS 6 DAYS TO AUG. 7. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅝ – ¾	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅞ – 1	8 16 0	April, Oct	..	..
1	5/4⅜	Babcock & Wilcox Ord.....	3⅜ – 4	5 0 0	April, Oct	3⅝	3⅝
1	0/7½	Do. Pref.....	1⅜ – 1⅝	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅞ – 7¼	6 18 0	July, Feb	..	..
5	3/0	† Do. 6 per Cent. Pref.	5⅝ – 6⅛	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 104	4 6 6	Jan, July	..	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	87 – 91	4 19 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	Feb, Aug	1⅛	1⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	59 – 64	6 5 0	Jan, July	63	..
2	..	Brush Electrical Engineering	⅛ – ⅜	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜ – 1⅜	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 – 74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9⅛ – 10⅛	7 2 6	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜ – 5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105 – 107	4 4 0	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1 7/16 – 1 9/16	5 12 6	May, Nov	1⅝	..
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb. (red.).	95 – 100	4 10 0	Feb, Aug	..	..
1	1/2½	Chadburn's (Ship) Telegraph Ord.	1⅛ – 1⅜	8 0 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	5 7 0	April, Oct	..	..
3	2/..	*Crompton & Co. (Nos. 1 to 54,000)	1⅞ – 2⅛	7 1 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	93⅛ – 96⅜	5 3 6	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝ – 1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	4 16 0	Sept	1⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1⅜ – 1⅝	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼ – 2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	⅞ – 1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1¼ – 2¼	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	3/16 – 7/16	..	Jan, July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	8 13 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 8⅜	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 95	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11½ – 12⅜	6 0 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5½	4 2 0	Feb, Aug	5⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½ – 107¼	4 3 6	Mar, Sept	107¼	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14⅜ – 15⅜	6 9 0	Feb, Aug	15⅜	15
100	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April. Oct	..	..
1	1/2⅝	Richardsons, Westgarth & Co., Ltd. Ord.	2/16 – 2/16	7 14 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1/16 – 1	6 0 0	May, Nov	1/16	..
St.	4½%	J. o. 4½ per Cent. Perp. Deb. Stock ...	93 – 96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	12/0	†Telegraph Construction & Maintenance	31½ – 32½	5 10 9	Mar, July	31⅜	31½
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	99 – 102	3 18 3	Jan, July	101½	100
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.	2 7/16 – 2 7/16	5 16 0	..	2⅜	2 5/16
1	0/6	† Do. 5 per Cent. non-Cum. Preference	1⅜ – 1 7/16	4 4 6	..	1⅜	1⅜
St.	5%	† Do. 5 per Cent. non-Cum. Preferred	109 – 112	4 9 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 – 104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	105½ – 107½	4 4 0	June, Dec	..	..
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9¼ – 9⅝	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	—	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅜ – 4⅛	..	Apr, Oct	4 1/16	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 – 88	5 2 0	June, Dec	..	..
St.	15/0	†Anglo-American	61 – 64	6 1 0	F,My,Ag,N	..	..
St.	30/0	† Do. Preferred	107 – 108	5 11 0	F,My,Ag,N	108½	107½
St.	13%	Do. Deferred	17⅜ – 17⅝	9 19 0	F,My,Ag,N	17⅝	17⅜
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 – 94	4 4 6	Jn,Ap,Jy,O	92½	92⅜
10	5/0	Cuba Submarine Ord.....	7½ – 8½	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15½ – 16¾	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜ – 3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 – 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100%-103%	4 7 3	Jan, July	..	..
20	6/6	†Direct United States Cable xd & Dnnu	1 1/8 – 1 1/8	5 19 0	Ja,Ap,Jy,O	..	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 – 101	4 9 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	134 – 137	5 2 0	Ja,Ap,Jy,O	137	135
St.	17/6	Do. 3½ per Cent. Pref. Stock	88 – 90	3 17 9	Ja,Ap,Jy,O	89½	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 – 105	3 16 6	May, Nov	104½	103½
10	2/6	Eastern Extension	13½ – 15⅝	5 5 0	Ja,Ap,Jy,O	15⅜	13½
St.	4%	† Do. 4 per Cent. Deb. Stock	102 – 104	3 17 0	Feb, Aug	103½	102½
100	4%	†Eastern & S. African 4% Mort. Deb. 1909	98 – 100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	9 ½ – 10⅛	4 1 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71.	34 – 36	6 19 0	Jan, July	34⅜	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99 – 101	4 9 0	June, Dec	..	..
25	52/6	Indo-European.....	56 – 58	5 12 0	May, Nov	..	..
100	£1	Mackay Companies Common	64 – 68	5 18 6	Jan, July	..	..
100	£1	Do. Preference	67 – 69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞ – ⅝	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	99½ – 100½	3 19 6	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10⅜	8 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛ – 1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 – 101	3 19 0	Jan, July	..	..
10	..	West India & Panama	7/16 – 9/16	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅜	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6½ – 7½	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 – 102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	13⅜ – 13⅝	5 3 0	Mr,Jn,O,D	13⅝	13½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 – 103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 – 92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 – 104	4 15 0	Mar, Sept	..	..
5	£0	†Chili Telephone	6⅝ – 7⅛	5 12 6	August ..	6⅝	..
1	0/4½	Monte Video Telephone Ord.	1/16 – 1/16	4 14 0	Nov	7/8	..
1	0/6	Do. 5 per Cent. Pref.	⅞ – 1	5 0 0	May, Nov	..	..
St.	6%	†National Co. Pref. Stock	107 – 108	5 11 0	Feb, Aug	107½	108½
St.	6%	† Do. Def. Stock.....	105 – 107	5 12 0	Feb, Aug	106½	105
10	£0	† Do. 6 per Cent. Cum. 1st Pref.	11 – 13	4 12 0	Feb, Aug	..	..
10	£0	† Do. 6 per Cent. Cum. 2nd Pref.	9½ – 11½	5 4 0	Feb, Aug	10½	..
5	2/6	† Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅜ – 5⅝	4 11 0	Feb, Aug	5⅜	5⅜
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	95½ – 97½	3 12 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100½ – 102½	3 18 0	Jan, July	102	..
1	0/9⅜	Oriental	1⅛ – 1⅜	5 2 0	April, Oct	1⅜	1⅜
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜ – 1⅝	4 10 0	April. Oct	1⅜	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 – 94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db.Stk.(red.)	98 – 101	4 9 0	Jan, July	..	..
5	£0	†United River Plate.....	6¼ – 7¼	6 18 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅜	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜ – 4⅜	6 6 3	Jan, July	..	..
10	6/2	Globe Telegraph & Trust.....	10⅜ – 11½	4 17 9	Ja,Ap,Jy,O	11	10⅝
10	4/0	Do. 6 per Cent. Pref.....	13⅜ – 14	4 6 0	Ja,Ap,Jy,O	13⅜	13⅜
10	6%	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

The Treasury and University Colleges.

IN allocating grants to the universities and university colleges the Treasury have, this year, made several new departures. Hitherto it has been the custom to specify the amount of the annual grant as for a period of five years, but this time it is for two years only. This, however, appears to be but a temporary expedient, for the permanent Advisory Committee intimate that by April, 1909, when a fresh re-allocation is to take place, they may be in a position to make recommendations which will enable the Treasury to place this matter on a "relatively permanent footing." Another innovation takes the form of a fixed maximum grant of £10,000 a year to any one institution. So far as existing institutions are concerned, there is only one that will be affected by the new regulation, and that is Victoria University, Manchester, which received £12,000 last year.

THIS question of State-aided universities is of special interest at the present moment, in view of the attitude adopted by the venerable institutions at Oxford and Cambridge. Unquestionably, both modern and ancient universities are doing admirable work, but there is, nevertheless, a certain element of danger in either type trying to compete with the other. However important, wealthy and influential a modern university may become, it is utterly hopeless for it to endeavour to rival either Oxford or Cambridge. Conversely, too, it is open to discussion whether Oxford will be serving its most useful function in founding a technical school. The new universities are most admirably suited to the work which they are performing, and are rendering really distinguished service to the nation: but it is work of a totally different nature from that which is being done at Oxford and Cambridge. The newer colleges should, therefore, persevere in their aim of imparting a sound professional training to a man who has his living to earn, at the same time enabling him to devote sufficient time to the acquirement of that culture which is so essential to the enjoyment of life.

Islington's Electricity Undertaking.

ONE of the most serious objections which can be raised against the control of an electricity undertaking by a municipality is the possibility of a change of policy arising from an alteration in the constitution of the Council. The Islington electricity undertaking may be instanced as a case in point. Previous to last November permission had been obtained from the London County Council to borrow £21,000 in order to extend the lighting mains and to carry out an extension of the public electric lighting, whereby the incandescent gas lamps in 15 miles of streets were to be displaced. It was argued by the Council in power at the time that a proportion of the cost of laying the new mains would be borne by the private lighting account, and that, taking this into consideration, the ultimate cost of illuminating the streets concerned would be less than that of gas lighting. On the other hand, it was clear that, if the total cost had to be borne by the public lighting—which, of course, would not have been the case—then electric lighting would cost more than gas lighting. At all events the scheme was sanctioned, contracts were let, and some of the work had been executed, when the constitution of the Council was completely changed at the elections in November. Then the new Council appointed a committee to report upon the position of the electricity undertaking, and the street lighting in particular; and as a result of this report it has been decided to abandon that part of the scheme which has not been completed, to remove in some cases the arc-lamp

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columns which have already been erected, and to take back cables and other materials into store. Although the scheme may have been too ambitious in the first place, proceedings such as these are not calculated to promote the welfare of the electricity undertaking, and they are not likely to result in an increase in the number of private consumers.

Tantalum Electrolytic Rectifier.

ELECTROLYTIC rectifiers have, in spite of their theoretical interest, not found much practical utilisation, chiefly on account of the fact that aluminium loses its efficacy as a current-stopping anode as soon as the cell gets heated. This difficulty appears to have been overcome in Germany by the use of tantalum. An article by G. SCHULZE, abstracted in to-day's issue, gives some interesting facts and figures concerning the behaviour of tantalum in an electrolytic cell traversed by an alternating current. When the tantalum is an anode it resists an E.M.F. of some 600 volts before it allows a current to pass. A great advantage over aluminium is that this valve action takes place no matter what the electrolyte may be. The most efficient electrolyte appears to be dilute carbonate of potash. A valuable feature is the practical independence of heating shown by this cell. This is hardly outweighed by the instability of the solid layer of oxide or carbonate, since this layer takes several minutes to disintegrate perceptibly. The high price of tantalum is a serious difficulty as regards first cost, but possibly this may be reduced in the near future.

It is interesting to note that there is now a substantial agreement between the various investigators as regards the mechanism of the valve action. Immediately adjoining the metallic anode is a solid but porous structure of an insoluble compound of the metal formed in the liquid. The pores of this structure are filled with condensed gases, which, not being ionised, act as a perfect insulator. Any current traversing this layer can only be conveyed by free electrons forced out of the pure metal by a high potential gradient. No such electrons can be forced out of the electrolyte, since it does not contain any. Hence an electron current is only possible, as a rule, from the metal into the liquid. The metal, in fact, must be a cathode if the current is to pass. If it is an anode, the valve action sets in, and is only overcome when the potential gradient is high enough to split electrons off the electrolytic ions to which they are attached. This splitting is easily done by metallic atoms, but these are prevented from acting in this manner upon the electrolyte by the gaseous layer.

Train Lighting.

THE methods adopted by the various railway companies for the illumination of passenger trains are usually discussed very freely immediately after a railway accident. Notwithstanding the fact that electrical methods of train lighting have the official support of the Board of Trade, several of the leading railway companies still use gas on many of their most important trains, although the danger arising therefrom is generally admitted. On another page of this issue we give an abstract of a Paper by Mr. H. HENDERSON, describing the various electrical systems which have been experimented with, and giving some interesting figures regarding the annual cost per coach of electrical, ordinary gas, and incandescent gas systems. Although these figures show a small saving in favour of incandescent gas, this saving would probably be off-set in practice owing to the smaller amount of attention required by electric systems. The present use of gas is, however, only temporary, for the electrification of the railways, when effected, will inevitably result in the universal adoption of electric lighting.

The Pacific Cable.

ONCE again this country has to pay heavily for being the proud possessor of a share in the Pacific Cable. It is true that the deficit this year, £54,924, is less than that of last year by over £17,000, but it is still a large amount, and no less than £15,257 of it has to be contributed by this country. This financial improvement is, of course, gratifying to the taxpayer, but it is due in large measure to circumstances which are not, we hope, likely to recur. Hence it must not be expected that the rate of decrease of the annual deficit will be maintained. The total revenue from traffic receipts during the year was £113,516, so that practically out of every three words which were transmitted by the cable two were paid for by the sender and one by the Mother Country and the Contributing Colonies.

University of Edinburgh.—Sir John Jackson has endowed a "Prof. Tait Memorial Fund," of the value of £200 per annum, for the encouragement of physical research.

Personal.—It is announced that the King has been pleased to confer a knighthood of the Order of the Bath, Civil Division, upon Sir Archibald Geikie, secretary of the Royal Society.

Proposed Memorial to the late W. E. L. Gaine.—The *National Telephone Journal* states that at a recent informal meeting of the W. E. L. Gaine Memorial Fund Committee the question of the form in which Mr. Gaine's memory should be perpetuated was considered. The suggestion which received the greatest favour was that, if the sum at the disposal of the committee were sufficiently large, one or more beds at a hospital or sanatorium for consumptives should be endorsed, to benefit any unfortunate member of the Company's staff.

Electric Traction on Main Lines.—A short time ago (*The Electrician*, Vol. LIX., p. 299) we gave an account of the electrification of part of the New York, New Haven & Hartford Railroad Co.'s main line in the vicinity of New York. This company's first electrically hauled train left the Grand Central Station at New York on the morning of July 1st. Thirty-five locomotives have been provided, each capable of exerting 1,000 H.P. and of pulling a train of 10 coaches 75 miles an hour. It will be remembered that these locomotives are adapted for use either with direct or single-phase current.

Telephony in Vienna.—It is announced that the Vienna Postal Authorities intend to greatly extend the telephone system so as to ultimately provide for 100,000 subscribers. There are now about 23,000 telephones in use in the city, and there is considerable delay before would-be subscribers can be connected, owing to the inadequacy of the main cable system. The new plans provide for an increase in the number of exchanges from two to nine and for the laying of a large number of interconnecting lines. Two of the exchanges will have accommodation for 15,000 subscribers each, while each of the remainder will have provision for 10,000 subscribers.

Cable Interruptions.	Date of Interruption.
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Brest—Dakar	July 22, 1907
Kotonou—Libreville	July 18, 1907
Accra—Lagos	Aug. 11, 1907

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Hydro-electric Station in Germany.—According to *Le Genie Civil*, a barrage has just been erected on the river Queis, in Upper Silesia, in order to avoid the disastrous effects of the sudden rises of this river. Part of the power which will be available is to be utilised for working a hydro-electric station. It is hoped that the revenue obtained from this station will partially compensate for the cost of the barrage. The volume of water which can be utilised is $35{\cdot}3 \times 10^6$ cubic ft., the normal fall is about 100 ft. and the height of the barrage is about 140 ft. The station will contain five generating sets, each of 525 kw. capacity. The dynamo voltage will be 10,000. Energy will be supplied to towns and villages, within a radius of about 30 miles, at 1·9d. per unit for light and 0·69d. for power.

Wireless Telegraphy Notes.—A wireless telegraph station was established at Abo (Finland) in 1906 for the use of the Russian Government.

In a report by Mr. Consul Carew-Hunt on the trade of New Orleans for 1906, it is stated that the wireless telegraph station erected at St. Augustine (Jacksonville) has proved a great success, and is in constant communication with vessels. There are two wireless telegraph stations in operation at Key West (Florida), one for the United States Navy Department, and the other exclusively for commercial purposes.

The public journals announce that the "Central News" is authorised to state that "a Transatlantic wireless telegraph service will be opened by the Marconi Company in September." Also that "the number of stations will eventually be increased to cope with the large volume of business expected." There is no definite indication that the Marconi Company are the authors of this "authorisation."

Tramways and Light Railways Association.—The August number of the *Official Circular* of this Association states that a deputation, has waited upon the Chairman of the Board of Inland Revenue (Sir Henry Primrose) with reference to the Report on Income Tax Assessment adopted by the Council of the Association. The Committee on Brakes report that arrangements are in progress for calling witnesses on this subject before the Committee. These witnesses will be divided into "manufacturers" and "users," so that the two sides of the question will be heard. With reference to an application to the Postmaster-General requesting that the question of the insertion of fuses and heat coils in telegraph circuits be submitted to an arbitrator appointed by the Board of Trade, it is announced that the Postmaster-General has concurred in the application, but it is not expected that the arbitration can take place before October.

Improvement of Marshy Land by Electrical Means.—The *Electrotechnischer Anzeiger* gives a report of a Paper on this subject read by M. Caro before the eighth Congrès International d'Economie held at Vienna. The author, in conjunction with Herr Frank, of Charlottenburg, elaborated a system, which consists in utilising the thermic energy of the peat, the gas of which is extracted in special generators. The gas thus obtained may be utilised in several ways—*e.g.*, for the generation of electricity. The gas generators treat peat containing up to 50 per cent. of water, and fix, in the form of ammonium sulphate, all the nitrogen present in it. As is well known, sulphate of ammonia is very useful for manuring purposes. When the amount of nitrogen present is not too small, the production of the ammonium sulphate is quite sufficient to cover the operating expenses, so that the gas obtained is a net profit. With this gas, which is very pure and quite suitable for use in gas engines, it is possible to produce electrical energy very cheaply. The marshy land thus treated is also more suitable for agricultural purposes.

Electric Traction in Sweden.—The *Elektrotechnischer Anzeiger* describes a scheme put forward by Mr. R. Dahlander, engineer-in-chief of the Swedish State Railways, for the introduction of electric traction. Mr. Dahlander foresees the employment of electricity as motive power on all the lines in the south part of the kingdom, as far north as Falun. Large waterfalls will be used as a source of energy and several of these have already been acquired by the State for £140,000. Five large central stations will be erected at the following points. At the falls of Karse to the east of Gothenburg; at the falls of Trollhäta; at the falls of Motalastrom to the east of Wenersee; at the falls of Hammarby, and the falls of Aekarleby. These central stations will furnish the energy necessary for the operation of about 1,250 miles of track. The first cost of the mains and central stations is estimated to be about £3,360,000. It is considered that the substitution of electricity for steam will lead to an annual saving of £24,800, and at the same time the greater frequency of the train service will give a large increase in the receipts.

"Faraday House Journal."—We have received the August number of this periodical, which contains many interesting features. The technical articles are "The Effect of Wave Shape on Rotary Converters," by Mr. A. B. Clark; "The Diesel Oil Engine," by Mr. E. S. Ritter; and "Some Notes on Recent Improvements in Radio-Telegraphy," by Mr. J. Goodman. The number also contains a great deal of information about the movements and doings of old students both in this country and abroad. It appears that one has deserted electrical engineering and entered the ranks of the poets. A review of his work is published in this number, in which the reviewer says: "At first sight the combination of poet-electrician is incongruous, but those who are familiar with recent developments in the modern theory of electric ions will admit that supreme imaginative insight is required in both callings." It is interesting to note that the course at Faraday House has been re-arranged to enable students who desire to do so to pass the necessary examinations for the B.Sc. in Engineering at the University of London.

Obituary.—We regret to record the death of Prof. Emil Petersen, professor of chemistry in the University of Copenhagen. Prof. Petersen, who was 51 years old at the time of his death, was a pupil of Prof. Jörgensen, and was well-known for his researches in physical and analytical chemistry.

We also regret to record the death of Sir John Milburn, which occurred on Saturday at Guyzance, Acklington. He was an extensive shipowner and colliery proprietor, and was for a time chairman of Palmer's Shipbuilding Co. His interest in electrical work was chiefly in connection with electric power companies. He was chairman of the Newcastle and District Electric Lighting and the Northern Counties Electricity Supply Companies and a director of the Cleveland & Durham Electric Power Co. He took a leading part in the promotion of the Administrative County of London and District Electric Power Bill in 1905.

The death is announced of Alderman Sir David Evans, K.C.M.G., a director of Callenders' Cable & Construction Co.

The death is also announced of Ald. W. Potter, for many years chairman of the Electricity Committee at Taunton.

British Association.—The following is a complete list of the Papers, &c., of electrical interest which were read at the meeting of the British Association at Leicester:—

"Helium and Radio-activity in Common Ores and Minerals," by the Hon R. J. Strutt; "On the Motions of Æther produced by Collision of Atoms or Molecules containing or not containing Electrions," by Lord Kelvin; "The Present Position of Gas and Petrol Engines," by Mr. D. Clerk; Discussion on "The Constitution of the Atom"; "On the Variability in the Products resulting from Changes in Radium Emanation," by Sir Wm. Ramsay; "Pseudo High Vacua," by Messrs. F. Soddy and T. D. Mackenzie; "The Range of Freedom of Electrons in Metals," by Prof. J. Larmor; "The Arc and Spark in Radio-telegraphy," by Mr. W. Duddell; Report of the Committee on Electrical Standards; "The Density of Ether," by Sir Oliver Lodge; "The Transmission of the Active Deposit from Radium Emanation to the Anode," by Mr. S. Russ: Report of a Committee on Magnetic Observations at Falmouth Observatory; "On the Nature of Ionisation," by Prof. H. E. Armstrong; "On the Distribution of Radium in the Rocks of the Simplon Tunnel," by Prof. J. Joly; "Pupin's Compensated Cable for Telephone Transmission," by Sir Wm. Preece; "Tuning in Wireless Telegraphy," by Sir Oliver Lodge; "Note on an Oscillograph Study of Duddell Arcs of Low Frequency," by Mr. J. T. Morris; "Developments in Electric Lamps," by Mr. L. Gaster; "The Equipment of the Engineering Laboratory of the Finsbury Technical College," by Prof. E. G. Coker; "Ferro-Concrete and Examples of Construction," by Messrs. J. E. de Vesian and W. Noble Twelvetrees; "The Origin and Production of Corrugation of Tramway Rails," by Mr. W. Worby Beaumont; "Modern Machinery and its Future Developments," by Mr. H. I. Brackenbury; "The Governing of Hydraulic Turbines," by Mr. R. S. Ball; "The Ice Problem in Engineering Work in Canada," by Mr. H. T. Barnes.

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ELECTRIC TRACTION ON RAILWAYS.*

III.—REMARKS ON THE CHOICE OF ACCELERATION AND MOTORS.

BY PHILIP DAWSON.

(*Continued from page 666.*)

In order to facilitate the decision as to the best speed to be adopted, as well as the choice of a proper rate of acceleration for any given service, curves can be plotted which are based on the fundamental relations which exist between the various quantities involved.

The curves which will be considered allow for 20 second stops at stations, which for electric suburban service need not, on the average, be exceeded. They have been plotted out on the basis of the total weight to be hauled, expressed in tons of 2,240 lb. each. Five sets of curves can, with advantage, be plotted, the number of each set depending on the different lengths of run considered, one curve of each set having to be drawn out of each different length of run.

These curves are plotted as follows:—The abscissæ in each case represent various rates of acceleration, whilst the ordinates represent different quantities for each set of curves, as set out below.

Curve 1.—Maximum speed which must be obtained.

Curve 2.—Watt-hours consumed on train for traction only, per ton-mile.

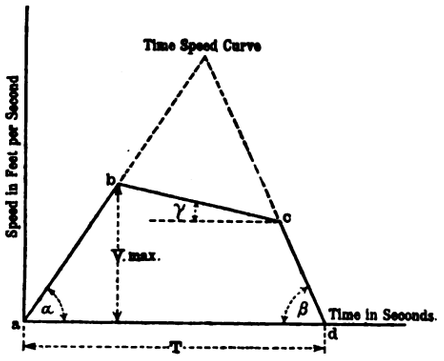

FIG. 1.

Tan α Acceleration.
Tan β, Braking retardation.
Tan γ, Coasting retardation.
Area, a, b, c, d; Distance run, L.
T, Running time in seconds.

Curve 3.—Average horse-power of motors required per ton of train during the time they are at work.

Curve 4.—Horse-power of motors per ton of train, based on their capacity of continuous output required.

Curve 5.—Time during which motors are actually doing work in per cent. of total time.

Before entering into a discussion of the results shown by these curves and describing the methods of using them, the data and calculations necessary for plotting them will be considered. For this purpose various assumptions are necessary, one of which is that the train resistance is constant. For the purpose of plotting these curves it has been taken at 8·33 lb. per ton of train to be hauled. The question of train resistance will be considered by itself later, when it will be shown that the figure that has been assumed is a very fair average for railway service where no very high rates of speed are obtained. This figure at once enables us to derive the retardation due to coasting, and which will amount to 0·12 ft. per second per second.

It is furthermore assumed that the acceleration is constant during the whole period of acceleration, which is fairly true for some forms of single-phase motors, such as the Winter-Eichberg type, but not so true for continuous-current motors. The inaccuracy introduced by this assumption of constant acceleration is not great in the case of short runs and high speeds, which are just the conditions where the choice of acceleration becomes most important.

The braking used is regarded as constant, and its value for the curves here discussed is taken at 2 ft. per second per second, except for accelerations exceeding 2 ft. per second per second, when the retardation due to braking is taken to be equal to the rate of acceleration.

With these remarks we will now consider the curves in their order.

1. *Curve of Maximum Velocity.*—Fig. 1 is a sample time speed curve from which it will at once be seen that for a given run at a predetermined average speed within given limits, no matter what acceleration or retardation be used, the area $a\,b\,c\,d$ must remain constant.

In this figure V max is the quantity to be determined in terms of the known quantities T, α, β, γ and L, where

T = time of run in seconds.
tan α = acceleration in feet per second per second.
tan β = retardation due to braking in feet per sec. per sec.
tan γ = " " coasting " " " "
$L = \int_o^T v\,dt$ = area of polygon = length of run in feet.

A consideration of the relations which exist between the various quantities analytically considered gives us the following value for the maximum speed in terms of the known quantities.

$$V_{max.} = T\frac{\tan\alpha\tan\beta}{\tan\alpha+\tan\beta} - \sin\alpha\sqrt{\frac{T^2\frac{\tan\alpha\tan\beta}{\tan\alpha+\tan\beta}-2L}{\sin(\alpha+\gamma)\cos(\alpha+\gamma)+\frac{\sin^2(\alpha+\gamma)}{\tan(\beta-\gamma)}}},$$

and it is from this equation that curves $V_{max.}$, Fig. 3, have been obtained.

It will at once be seen that, assuming a constant retardation due to coasting and a constant retardation, within limits, due to braking of, say, 2 ft. per second per second or equal to the acceleration if this is greater than 2 ft. per second per second, a curve will result which tends at either extremity to become parallel to the speed and acceleration axes—*i.e.*, that for a given average speed and length of run, there is a minimum and maximum top speed. It will be noticed that there are kinks in these curves corresponding to the longer runs, and that whereas the maximum speed with increased acceleration at first decreases, beyond a certain limit the reverse takes place. The diagram Fig. 2 shows the reason for this. For clearness, no coasting, but only acceleration and braking, are shown in one case, whereas there is a certain amount of coasting in the two other cases.

In this diagram it will be seen that the maximum speed which has to be obtained does not uniformly increase as the acceleration decreases, and the kinks above referred to are thus accounted for.

(2) The next curve to be considered is the curve Y, giving the watt hours per ton mile. This might be called the curve of ratio of total work to useful work, and is based on the following equation:

$$Y = \frac{V_{max.}}{2L}\left(\frac{1}{gR}+\frac{1}{a}\right),$$

where R = resistance to traction in lbs. per ton of train,
g = acceleration due to gravity in feet per second^2,
a = acceleration at starting (taken as constant) in feet per second^2,
L = length of run in feet,
$V_{max.}$ = maximum speed attained in miles per hour.

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The useful work performed in moving the train over the length of the run is expressed as follows:—

Useful work = WRL ft.-pounds, in which W = weight of train in tons.

The total work actually performed by the motors is limited to the time they are accelerating and current is on, for in our diagram we have not allowed for keeping current on after maximum speed is reached, as after that coasting has been resorted to.

Under these conditions, if S = distance covered during period of acceleration in feet we have

$$S=\frac{V^2_{max.}}{2a}$$

Total work consists of work required to overcome the inertia of the train—that is to say, that required for acceleration plus that required to overcome track resistance.

$$\text{Hence, total work of motors}=\frac{W}{2g}V_{max.}+WR\frac{V_{max.}}{2a}$$

and the ratio we are seeking is expressed by

$$\frac{\text{Total work}}{\text{Useful work}}=Y=\frac{V_{max.}}{2L}\left(\frac{1}{gR}+\frac{1}{a}\right),$$

and the total amount of energy supplied in the form of watt hours per ton mile can be ascertained from Y, if an overall efficiency is fixed, including all losses between the point at which the energy

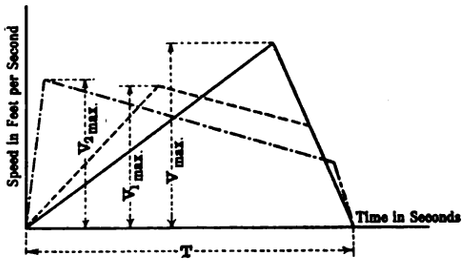


Fig. 2.

$V_{3max.} > V_{1max.}$ $V_{2max.} > V_{1max.}$

is supplied to the motors and that at which the tractive effort is exercised on the wheels.

Admitting this efficiency to be 70 per cent., if the curve for a given length of run with the ratio Y in ordinate and acceleration in abscissæ has been plotted, then the watt hours per ton mile can be ascertained, which in this case requires the scale on which Y is indicated to be multiplied by 23·8 in order to obtain watt hours per ton mile.

The next curve which can be plotted is one which, for preliminary investigations, is of the greatest use, as it enables a very close approximation of the size of motor which will be required for any given service. This is the preliminary basis used to determine the size of motor and, as will be seen hereafter, the running curves, based on a preliminary assumption; we are then in a position to verify whether the motor proposed will actually fulfil all conditions; if not, another motor must be substituted and fresh calculations made.

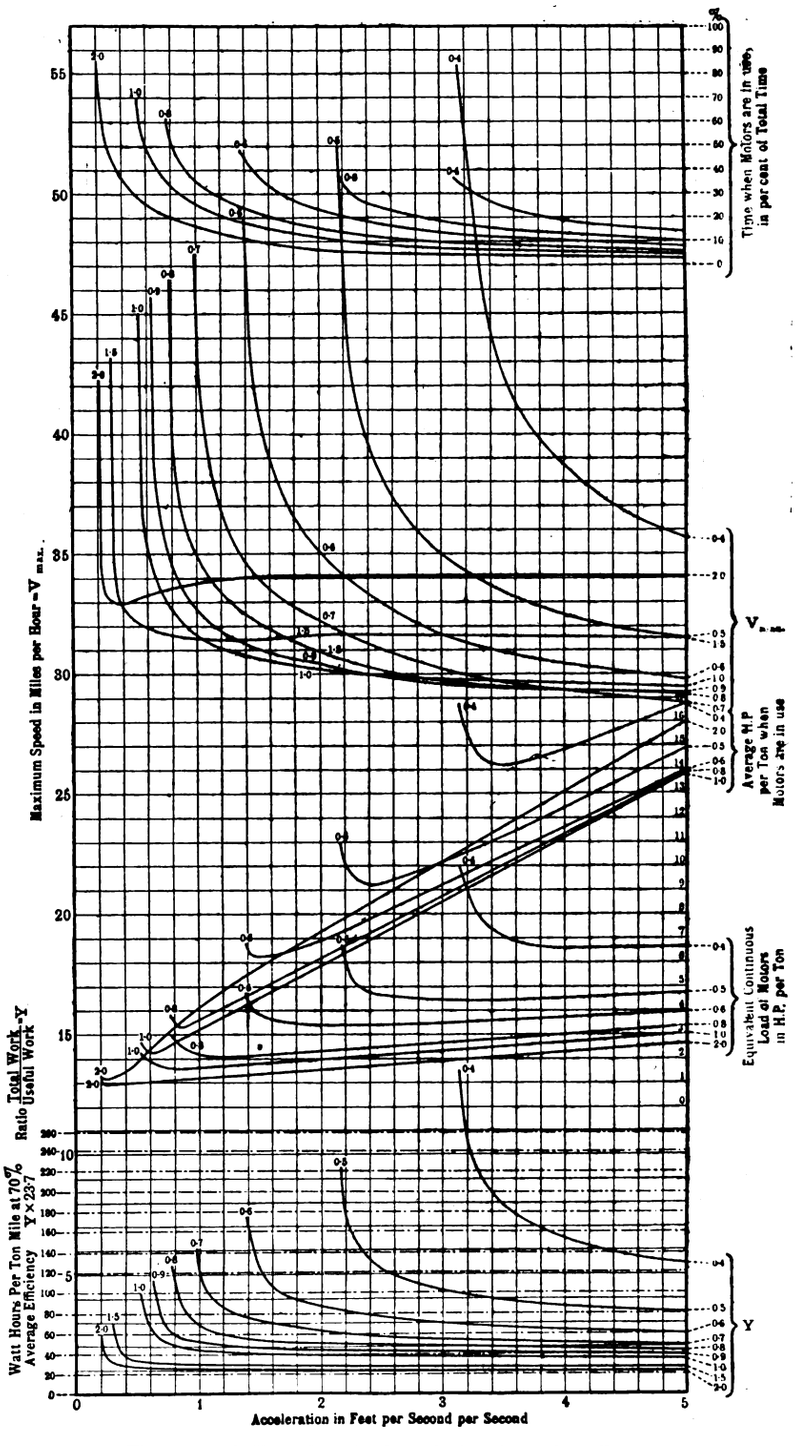
This curve gives the required equivalent continuous output of the motors, based on their theoretical capacity. It is temperature rise above all other things which prescribes the size of motor necessary for any given service. All the curves have been designed on the basis of 20 second stops at stations.

The formula is based on the fact that the rise in temperature is proportional to the root mean square of the mean effective currents. Constant voltage and constant acceleration are assumed.

The equivalent continuous load in horse-power is designated by HP_e, t = time motors giving out energy, T = time taken for run. Hence we get the following formula:—

$$HP_e=\sqrt{\frac{HP^2\times t}{T+20}}.$$

Taking different values for t, according to the acceleration


Maximum Speed in Miles per Hour = $V_{max.}$
Time when Motors are in use, in per cent of Total Time
Average H.P per Ton when Motors are in use
Equivalent Continuous Load of Motors in H.P. per Ton
Ratio Total Work / Useful Work = Y
Watt Hours Per Ton Mile at 70% Average Efficiency = Y × 23·7
Acceleration in Feet per Second per Second

The figures indicate length of run in fractions of a mile.
Schedule speed, 20 miles per hour, including 20 second stops at stations.

Fig. 3.

used, curves can be plotted as shown on the diagram already referred to (Fig. 3).

This curve is of great assistance in determining in a preliminary way the size of motor, as from it can be ascer-

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tained the horse-power per ton of train which the motors must be capable of giving out continuously.

This rating must not be confounded with the rating usually adopted for traction motors and which is the capacity for one hour with open covers, without the temperature rise exceeding a given limit. This rating according to the design, size and type of motor, may be anything from two to three and a-half times as great as the continuous rating referred to above, and depends on the type, capacity and make of motors.

The last set of curves are those giving the length of time the motors are taking current expressed as a percentage of the length of time the trains are in service, and to a certain extent may be used as a guide to ascertain generally the effect of various accelerations on the load factor. It is simply the plotted result of $\frac{t}{T+20}$.

Having described the curves and the method of obtaining them, a brief discussion as to their mode of use becomes

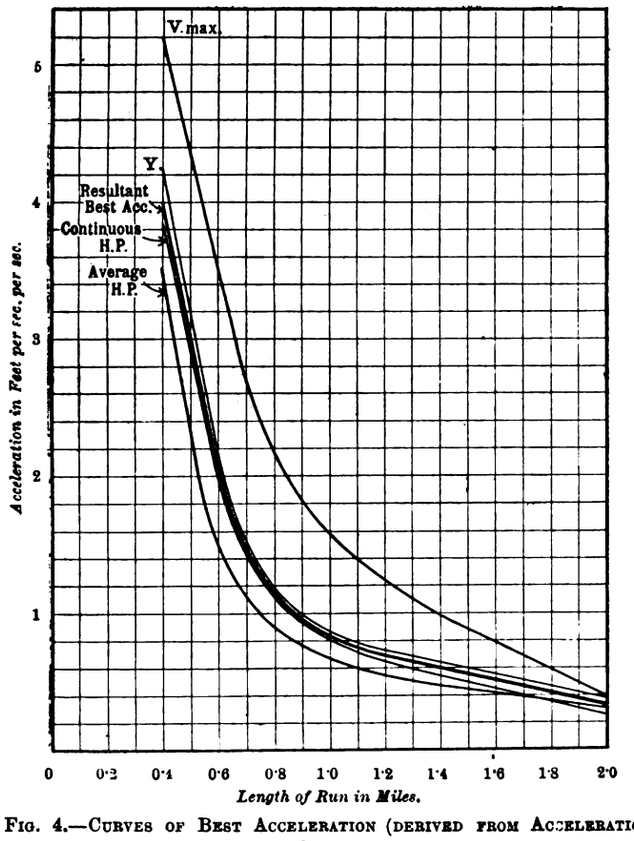

FIG. 4.—CURVES OF BEST ACCELERATION (DERIVED FROM ACCELERATION CURVE).

Schedule speed, 20 miles per hour with 20 second stops.

Resultant curve—is a curve recommended for use in selecting acceleration for provisional calculations.
V max.—is a plot of points on V max. curve where slope is 15 deg.
Y—is a plot of points on Y curve where slope is 15 deg.
Continuous H.P.—is taken from minimum points of continuous H.P. curves.
Average H.P.—where motors are in use, is taken from minimum points of average H.P. curves.

necessary. Let it at once be stated that, although only one set of curves has been discussed, these must be plotted for all the average travelling speeds and stops at stations which it is proposed to consider; thus, if 30 instead of 20 second stops are going to be made, new curves will have to be plotted, and for every average speed of say 12, 15, 20, 22, 25, 30, 35 and 40 miles an hour, if these are the speeds decided upon, and curves similar to those shown in Fig. 3 must be drawn as well as for the distances between stations. It will thus be seen that, although these curves considerably facilitate preliminary investigations, the question of settling the average speed, acceleration, size and type of motor, &c., in case of railways must of necessity involve a large number of laborious and careful calculations if satisfactory and economical results are to be obtained.

Method of Preliminary Determination of Best Accelerations for Given Average Speed and Time.—For the purpose of choosing the best acceleration for any given speed and given length of run, we will commence by examining the curves marked Y, which give the watt hours per ton mile.

It will at once be noticed that the shorter the run the greater the necessity of choosing a high rate of acceleration. It will also be observed that the tendency for all curves is eventually to become parallel to the abscissæ side, or, in other words, that beyond a certain point acceleration can be increased without any practical benefit arising as regards reduced energy consumption.

A curve of the values which may be considered limiting ones in practice as regards this question may be plotted (Fig. 4), and shows that for runs of a mile or more very little benefit as regards economy of energy is to be gained by a high rate of acceleration.

We will now consider the maximum speed curve. It is evident that for local services it is advisable for many reasons to keep this as moderate as possible consistent with the average speed between stations set forth being easily maintained. It will be seen that with the exception of long runs between stations amounting to 0·8 mile and above there is an acceleration which corresponds to a minimum of maximum speed, whereas in the remaining curves it is the maximum accelerations which give the minimum of maximum speed. An examination and comparison of this maximum speed curve with the Y or watt hour consumption curve will show that the acceleration which gives good results from an energy consumption point of view are also satisfactory from a maximum speed point of view.

The next and very important curves are those which are designated respectively as the equivalent continuous load and average load during the time motors are giving out energy, expressed in horse-power per ton of train to be hauled. As already mentioned, when the derivation of these curves was discussed, they are only approximate, but are useful in guiding the experienced railway engineer in the choice of the size and type of motor to be used. An approximate size, type and number of motors per train once preliminarily settled, more exact calculations have to be made and diagrams, based on the actual motor test curves, drawn, in order definitely to demonstrate whether the motor preliminarily settled upon is the most suitable from all points of view for performing the train service under consideration. But without a guide, such as the curves under discussion, it would be very difficult to settle even on a preliminary size and type of motor which would in any way approximate to that which after calculation could be shown as capable of carrying out the work required of it.

With these few introductory remarks we can now consider the two horse-power curves, which respectively give the average horse-power and the continuous capacity of the motor in horse-power.

This curve at once indicates that the highest accelerations, although theoretically the most economical in power consumption, are not necessarily the best from all points of view, and the longer the distance between stops the more clearly this is shown. This is more clearly shown on the curve of average horse-power while motors are giving out energy, and if the actual maximum motor output were to be considered this would be still more evident. In other words, high rates of acceleration mean large motors and large maximum energy consumption.

In choosing the acceleration for any given case a mean will probably have to be struck between the best acceleration from an energy consumption point of view, and from that of not being forced into the use of excessively large

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motors. As a method of deriving the most suitable type of traction motor will be considered later, it will suffice here to point out that it is entirely a question of heating, and of getting a proper comparison between the continuous capacity, the one hour rating and the overload capacity.

The final curve to be investigated is that giving the time that the motors are actually giving out energy, expressed in per cent. of total time of service. This curve is useful to a certain extent as an indication of what sort of load factor a given service may be expected to involve. It further shows that too high a rate of acceleration is not advantageous from the point of view of generating costs, and serves to indicate the large and varied number of factors which must be considered when deciding what service, and what acceleration and type of motor, should be used in connection with the electrification of any given railway, and demonstrates how important it is to make an exhaustive and thorough investigation from a theoretical as well as a practical point of view when railway problems present themselves.

In conclusion it may be remarked that in deciding on any acceleration it is always wise to take one slightly higher than that which would result by using the smallest motor, so as to give a sufficient margin of elasticity for working the service.

(To be continued.)

NOTE ON AN OSCILLOGRAPHIC STUDY OF LOW-FREQUENCY OSCILLATING ARCS.*

BY J. T. MORRIS.

Summary.—The Author gives the results of a series of experiments made for the purpose of observing the effect on direct and alternating-current arcs of a change in the medium in which the arcs are burning, and also the effect on such arcs of a transverse magnetic field.

The present note collects together a few observations which have been made on direct and alternating-current arcs chiefly with the object of studying the effect of a change in the medium in which the arc is burning and also to examine the effect, if any, produced on the arc by the application of a transverse magnetic field. It should be borne in mind that in no case were frequencies of more than 1,000 investigated.

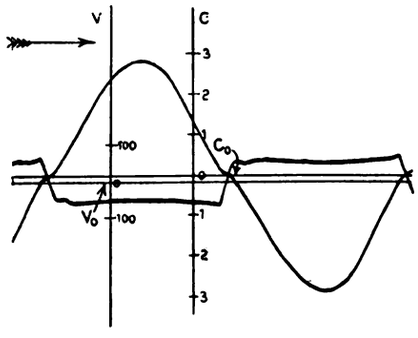

FIG. 1.—Frequency = 60 ∽ per sec.

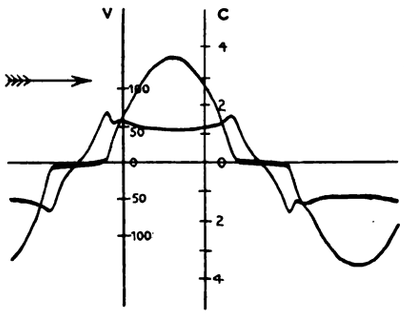

FIG. 2.—Frequency = 60 ∽ per sec.

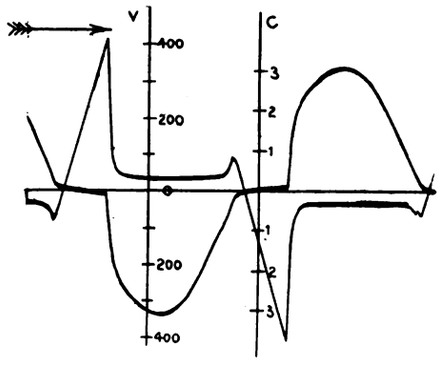

FIG. 3.—Frequency = 60 ∽ per sec.

The work of Mrs. Ayrton, Blondel, Duddell, Simon and others on alternating and direct-current arcs is so well known by those interested in this subject that it is needless to do more than refer to it.

In view of the great interest that has recently centred on the production of electric waves by means of oscillations in direct-current arcs, the following experiments, which are somewhat fragmentary, were started last autumn in order to study at low frequencies the action of the separate factors which contribute towards the successful operation of the Poulsen arc.

EFFECT ON ARC OF CHANGE OF MEDIUM—COAL-GAS AND AIR.

Alternating Arcs.—The fact that an arc is more easily extinguished when burning in coal-gas than in air has been quite recently turned to account in more ways than one. Notably is this the case in the Poulsen arc. There are, however, minor applications, such as its use in certain forms of interrupters for induction coils, as in the "Moto-magnetic" interrupter. The author himself has found that the mercury jet interrupter, which is usually worked in paraffin oil and alcohol, is more efficient and far less trouble to use if the paraffin oil or alcohol be replaced by an atmosphere of coal-gas.

To further investigate this action of arc extinction these experiments were carried out and the oscillograms taken. In all experiments described below the arcs were taken between horizontal electrodes and the length of the arc, except in those cases where it is specifically stated otherwise, was adjusted to 1 mm.—this being correct to a tenth. The alternating-current had a frequency of 60∽. Where carbon electrodes were used they were solid and of 12 mm. diameter.

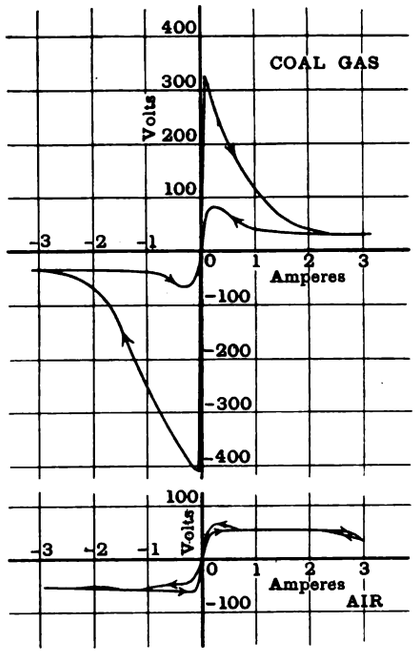

FIG. 4.—WITHOUT MAGNETIC FIELD.
Solid carbons, 12mm. diameter, coal-gas and air, 440 volts, A.C. 60 ∽ 1·7 amps.

In Fig. 1 is shown the behaviour of a 440 volt arc alternating in air. Fig. 2 has its voltage wave on the correct side of the zero with respect to the current, but in all other cases the current wave has been reversed intentionally in the oscillograms to prevent confusion between the volt and ampere waves. (Fig. 2 shows a 110 volt arc under similar conditions.)

In Fig. 3 will be found the corresponding oscillograms for an arc under the same conditions, but working in coal-gas. (In reality this oscillogram was taken with the arc in a magnetic field—the slight modification this produces will be referred to later.) The notable feature is the dissymmetry of the voltage wave that is produced when coal-gas is employed, the voltage rising to 370 volts before the resistance of the arc breaks down. From these oscillograms have been plotted the "dynamic characteristics" for the arc shown in Fig. 4.

The dynamic characteristics were first made use of by M. Blondel in 1891, and recently their use has been greatly extended by Dr. Simon. It will be seen that the chief difference lies in the behaviour

* Paper read before Section G of the British Association at Leicester, August 5, 1907.

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of the arc while the current is *increasing* from zero to its full value. Another way of expressing this result is to say that the approximate resistance when the arc is starting in air is some 600 ohms, whilst in coal gas it is some 6,000 ohms. These diagrams have

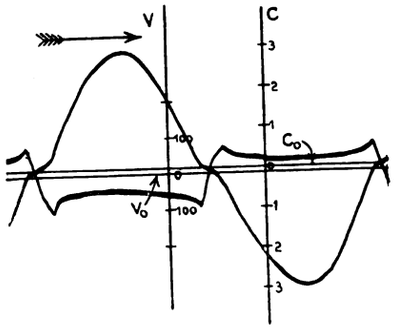

FIG. 5.—Frequency = 60 ∽ per sec.

been called by Dr. Simon hysteresis loops, and, in general—other things being equal—the greater the area enclosed the more efficient is the arc for the purpose of producing oscillations.

Effect of Addition of Transverse Magnetic Field.—The above experiments were repeated with no modification save that the arc

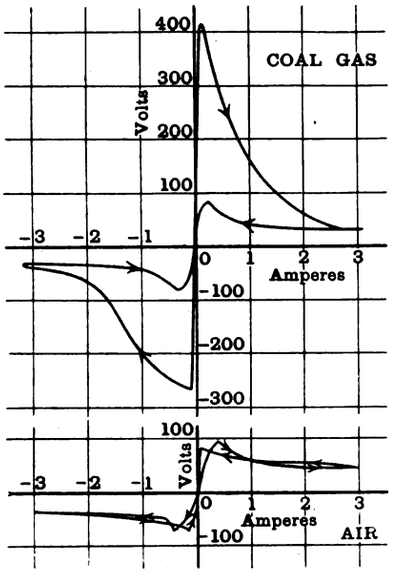

FIG. 6.—WITH MAGNETIC FIELD.
Solid carbons, 12 mm. diameter, coal-gas and air, 440 volts A.C. 60 ∽ 1·7 amps.

operated in a transverse magnetic field of about 3,300 C.G.S. The magnetic field at once produced the well-known two jets of greenish-yellow flame, accompanied by the characteristic noise. In coal-gas it was noticed that these two jets of flame were absent. These experiments were conducted in a mica-walled enclosure, through which coal-gas was slowly passing so that the arc could be inspected meanwhile. The oscillograms are shown in Figs. 3 and 5, and the dynamic characteristics in Fig. 6. On examination the effect produced by the magnetic field will be found to be small. Comparison of Figs. 4 and 6 shows, however, that the characteristic in air with magnetic field is steeper than when the field is absent. Further, that the average maximum voltage when the current is stopping is greater with a magnetic field than without.

Coal-gas	No field	74 volts.
Coal-gas	Strong field	83 volts.
Air.....	No field	61 volts.
Air.....	Strong field	77 volts.

Possibly this result may be explained by the fact that when the current is stopping, the current-carrying part of the arc—being bowed—is longer and therefore requires a greater voltage for the same value of current.

Pulsating Direct-current Arcs.—Similar experiments have been carried out with solid carbons in air and with a copper positive pole and carbon negative pole in air and coal-gas. Oscillograms for the copper carbon electrodes are given in Figs. 7, 8 and 9, whilst Fig. 10 shows the dynamic characteristics.

The effect of the introduction of the magnetic field has been largely to increase the divergence between the characteristic for increasing and decreasing currents. As this result, however, is only based on a single experiment, too much weight must not be attached to it. At some future date the author hopes to be able to confirm this result.

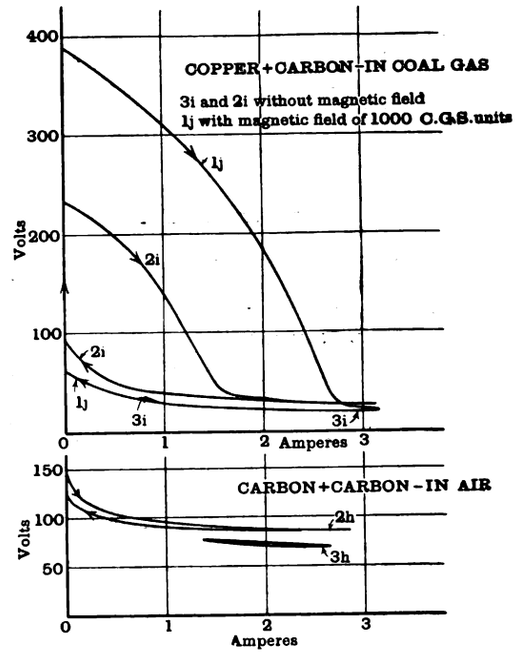

FIG. 10.—PULSATING DIRECT CURRENT ARCS.
240 D.C. + {120/80} A.C. 1·7 amps.

Arc in Amyl Acetate.—In some experiments on which the author has recently been engaged on the production of Hertzian waves, he has used the oscillator of Laugwitz, in which aluminium electrodes are used in paraffin oil, and has found that the substitution of amyl acetate for the paraffin oil is a considerable improvement. It therefore seemed of interest to conduct set a of experiments on arcs in amyl acetate between aluminium electrodes. Figs. 11 and 12 are oscillograms for the arcs on 400 volts alternating, Fig. 11 being an arc of 0·02 of a millimetre and Fig. 12 an arc 0·05 of a

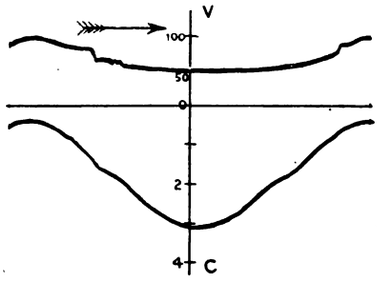

FIG. 7.—Frequency = 60 ∽ per sec.

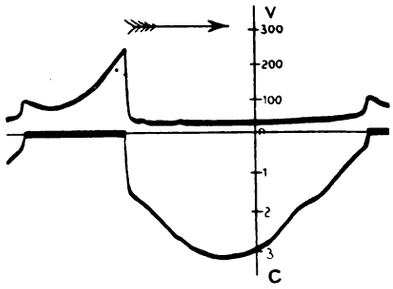

FIG. 8.—Frequency = 60 ∽ per sec.

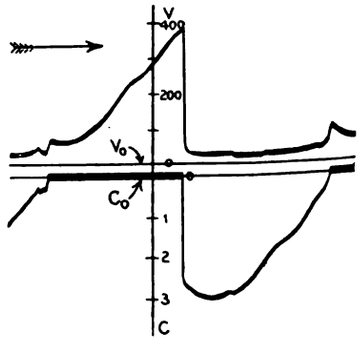

FIG. 9.—Frequency = 60 ∽ per sec.

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millimetre in length. Their dynamic characteristics are shown in Fig. 13, as is also the characteristic for a small pulsating current.

Duddell Arcs.—Comparative experiments in air and coal-gas were attempted on the Duddell arrangement of an arc (shunting a

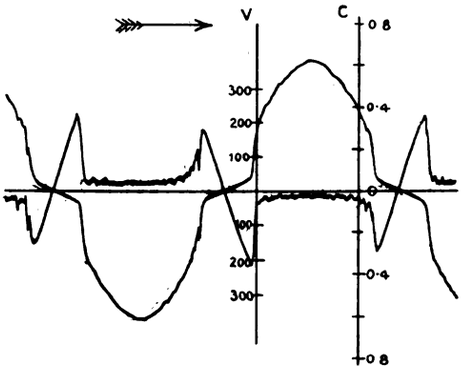

FIG. 11.—Frequency = 60 ∽ per sec.

direct-current arc with a capacity in series with an inductance) with copper-positive and carbon-negative electrodes. Figs. 14, 15 and 16 are typical oscillograms obtained for coal-gas. The collected comparative results of the voltage and the various currents are given in

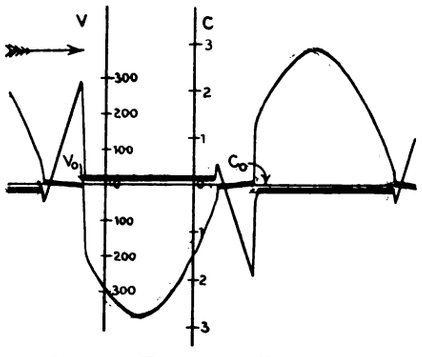

FIG. 12.—Frequency = 60 ∽ per sec.

Figs. 17 and 18, below which are also given the watt curves. A refers to quantities in the capacity-inductance circuit, B to quantities in the arc itself and C to those of the main circuit—D being the voltage on the circuit. The above-mentioned effect will again

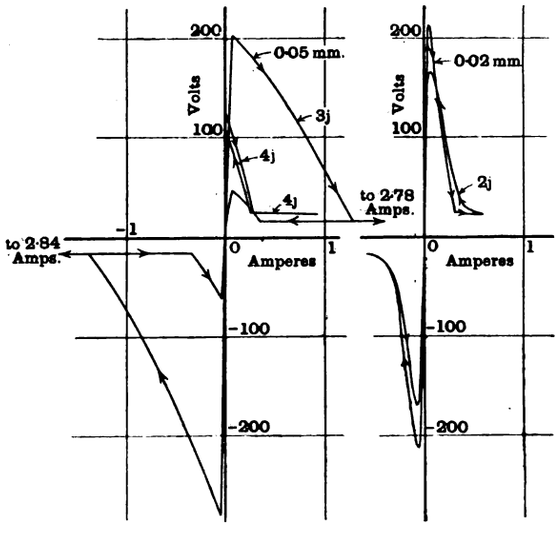

FIG. 13.—ELECTRODES: ALUMINIUM 6MM. IN AMYL ACETATE.
400 volts A.C. 60 ∽ (4j is for 240 volts D.C.+112 A.C.)

be noticed (due to the introduction of coal-gas), a higher value being attained by the voltage before the current rushes through the arc. Further, it will be seen that the current in the arc itself is practically zero for half a cycle.

PRODUCTION OF REGULAR PULSATIONS IN DIRECT-CURRENT ARCS BY MEANS OF A MAGNETIC FIELD.

For a long time past it has been known that when a direct-current arc is suddenly extinguished by the application of a transverse magnetic field it goes out with what may be called an abrupt shriek or wail. This fact suggested to the author that the current through the arc was pulsating, and so after some preliminary experiments the following arrangement was devised.

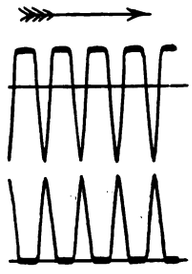

FIG. 14.

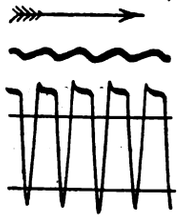

FIG. 15.

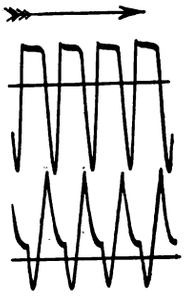

FIG. 16.

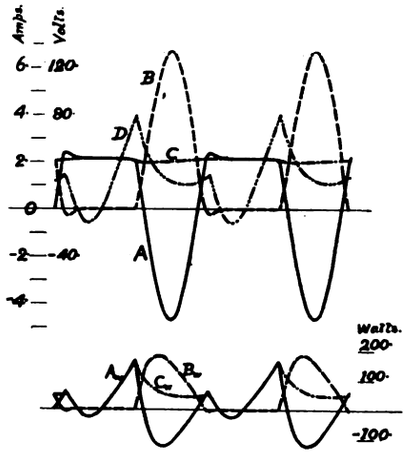

FIG. 17.—COPPER CARBON ARC IN AIR. Frequency = 750 ∽ approx.

The previous horizontal arrangement of carbons was used, but in this case the carbons were bevelled on their upper sides at their extremities, so that the projection of each carbon in a vertical plane formed an angle of 40 deg. from the horizontal. When an arc was struck between these at a pressure of 480 volts direct current, having a non-inductive resistance in series, the current

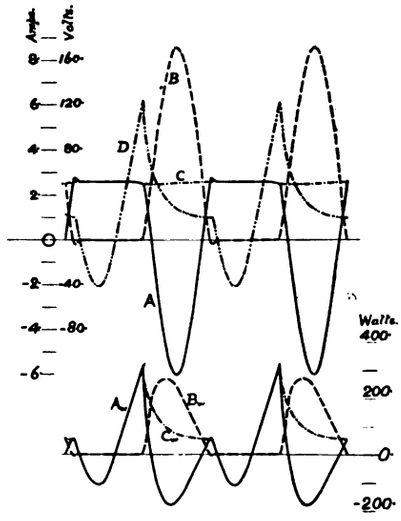

FIG. 18.—COPPER CARBON ARC IN COAL GAS. Frequency = 750 ∽ approx.

through the arc pulsated with a frequency which was higher the stronger the magnetic field in which it was burning. Oscillograms of the oscillations are given in Figs. 19, 20, 21 and 22 for approximate field strengths of B = 80, 120, 300 and 800 respectively, the

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frequencies produced being 57, 210, 1,800, and 4,300. These show a rapid rise in frequency with increase of field intensity.

Possibly, by correctly adjusting the field, this action might be made use of to intensify the oscillation produced in an oscillatory circuit connected to it; but these experiments must only be regarded as preliminary. It should be noted that, as far as the evidence in the author's experiments goes, it was not possible to preserve

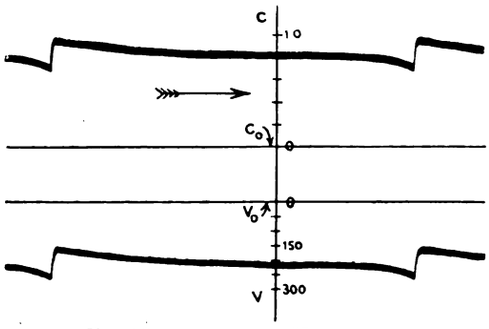

FIG. 19.—Frequency = 57 ∽ per sec.

oscillations of constant frequency for more than half a minute at a time. An examination of the arc showed that on the positive pole the arc formed a number of separate glowing *spots* in a vertical plane, while the negative electrode had a much shorter but continuou ly bright *line*. This effect reversed when both poles and field were reversed.

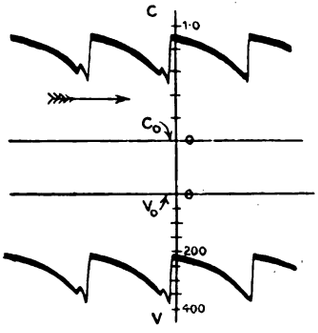

FIG. 20.
Frequency = 210 ∽ per sec.

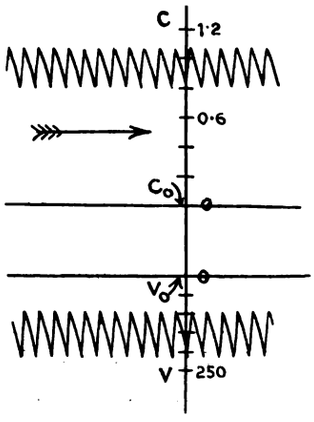

FIG. 21.
Frequency = 1,800 ∽ per sec.

It would appear that the production of these oscillations can be explained simply if one considers the tendency of the arc to shorten together with the fact that a curved arc in the magnetic field will require a greater voltage for the same current than a straight arc.

It is conceivable that in some forms of circuit-breakers having magnetic fields which blow out the arc, this oscillatory action

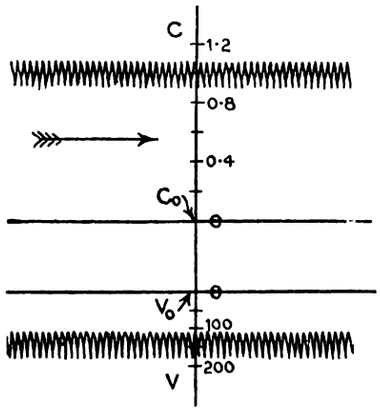

FIG. 22.—Frequency = 4,300 ∽ per sec.

might be distinctly dangerous should the strength of the magnetic field not be properly proportioned.

The author cannot conclude without expressing his sincere thanks to Mr. A. G. Warren—a senior student of the East London College—for the valuable and painstaking assistance he has rendered in connection with these experiments.

GREAT WESTERN RAILWAY.—ELECTRIC POWER AND LIGHTING AND THE ELECTRIFICATION OF THE HAMMERSMITH & CITY RAILWAY.

(*Continued from page 670.*)

SUB-STATIONS.

The Royal Oak sub-station is equipped with four 400 kw traction motor converter sets, worked in parallel with a battery having a one-hour discharge rate of 1,680 amperes, in conjunction with reversible boosters. The sub-station also contains two 200 kw. motor-converters for D.C. lighting and power purposes. The Shepherd's Bush sub-station (*see* Figs. 14 and 15) is equipped with seven 400 kw. traction motor-converters worked in parallel with a battery having a one hour discharge rate of 840 amperes, in conjunc-

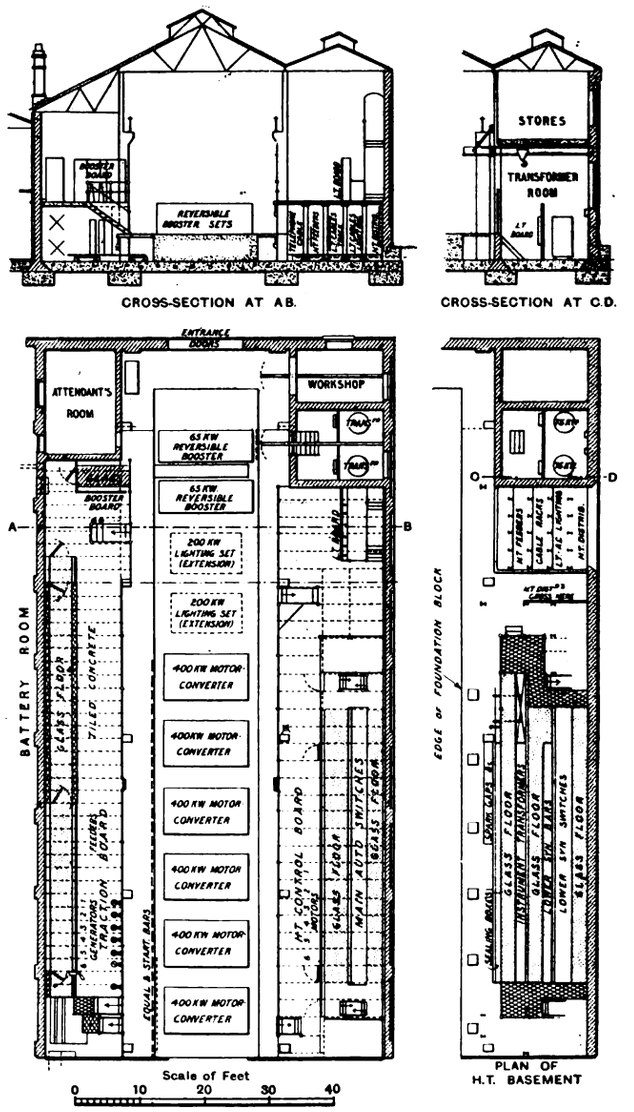

FIG. 14.—GENERAL ARRANGEMENT OF SHEPHERD'S BUSH SUB-STATION.

tion with reversible boosters. The Old Oak Common sub station is equipped with one 400 kw. and two 200 kw. motor converter sets for D.C. lighting and power purposes.

From each of the three sub-stations H T. distributor feeders are run from the H.T. 'bus bars to the various distributing centres. All three sub-stations are designed so that they may be developed on the same lines, and Royal Oak, being the most representative sub-station, is most suitable for a detailed description.

The Royal Oak sub-station is built in three bays, and is 109 ft. long by 52 ft. 6 in. wide and 35 ft. high from floor level to the peaks of the roof in the centre bay, with a basement 4 ft. deep. The motor-converters and reversible boosters are placed in the centre bay, over which a 10 ton hand-worked travelling crane is provided. One of the side bays contains the H.T. switchboard and the other the L.T. switchboard. At one end of the space reserved for the H.T. switchboard a transformer room is provided, which forms one of the

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distributing centres and is equipped with static transformers for supplying alternating current at 220 volts for local lighting, including the lighting of the sub-station. The transformer room is equipped with an overhead runway and a set of pulley blocks. Next to the transformer room a workshop is provided which is also equipped with an overhead runway and a set of pulley blocks. Adjoining the same end of the sub-station is the battery room, which forms the basement of a large building used by the Great Western Railway for stationery stores.

We have recently given a full description of the Peebles-La-Cour motor-converter (*The Electrician*, Vol. LVI., p. 956), and it will be remembered that it consists of a H.T. motor arranged like an induction motor mechanically coupled to and also electrically connected with a D.C. generator, connections being made between tappings from the rotor and the D.C. armature. While the machines can be started up on the H.T. side in much the same way as if they were induction motors, they behave when the D.C. machine is fully excited like synchronous machines and are capable of being reversed so as to generate A.C. current, exactly as in the case of synchronous motor-generators. This peculiarity is of special advantage in the present instance for reasons which are explained below. The D.C. generators which are used for traction have compound windings.

The reversible boosters are of the well-known Highfield type, consisting of three machines—the motor, the booster and its exciter. These booster sets are in duplicate, the continuous capacity of each booster being 180 kw.

with the Park Royal switchboards. The main H.T. feeder switches are provided with time limit overload and instantaneous reverse-current relays, and the H.T. distributor switches are provided with overload relays. All the H.T. motor switches are provided with overload relays. Ample room is provided for extensions of the H.T. switchboard as additional motor-converters are installed.

The L.T. switchboards, placed on the opposite side of the sub-station to the H.T. switchboard, are divided into four sections, one for controlling the traction circuits, a second for controlling the lighting circuits, a third for a milking booster and its connections to the battery room and the fourth for controlling the Highfield reversible boosters. The conductors between the machines and feeders and the terminals on the L.T. switchboards are bare copper rods, supported by porcelain insulators carried on steel racks. It will be convenient to refer to the special features in connection with the machines and switchboards in describing the method of operation of the sub-station plant as a whole.

The motor-converters are normally started up from the H.T. side, the rotors being provided with slip-rings and with starting resistances which are placed in the H.T. switchboard basement, and which are controlled by handles, which can be operated from the floor level near each machine. A voltmeter, mounted in a convenient position just above the starting switch handle, is connected across one leg of the star resistance and indicates when the machine has reached synchronous speed and the slip-rings can be short-circuited. A set of pilot lamps, placed in a box with ground-glass

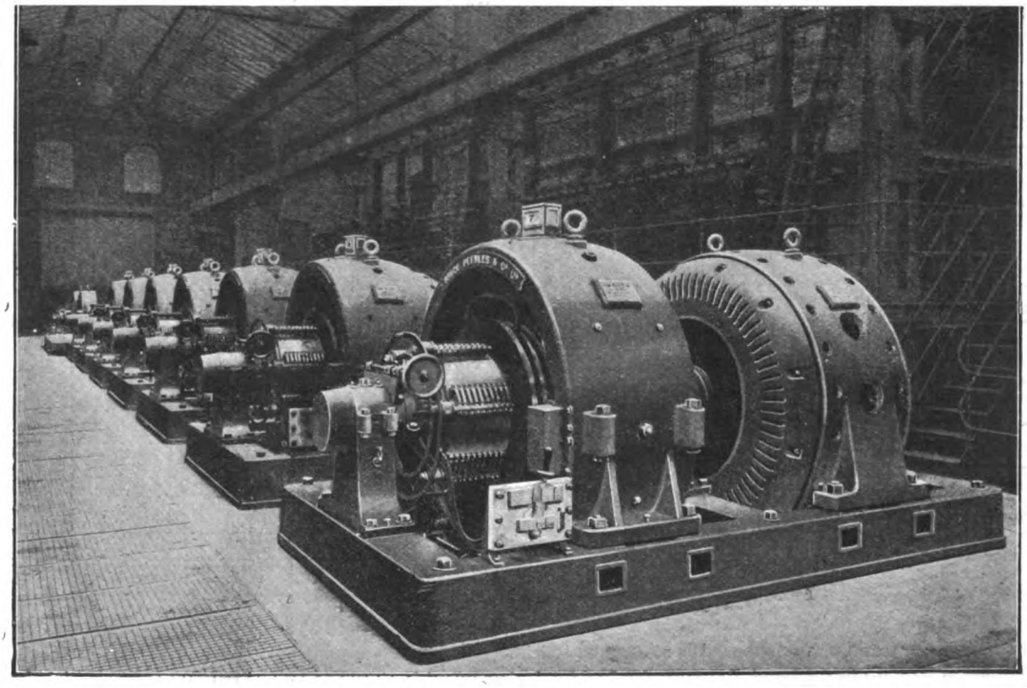

FIG. 15.—VIEW SHOWING INTERIOR OF SHEPHERD'S BUSH SUB-STATION.

The battery consists of 290 of the Tudor Company's HZ.35 cells contained in lead-lined wood boxes, the capacity being 1,680 amperes at the one-hour rate.

The H.T. switchboard is generally similar in construction and design to the Park Royal H.T. switchboards, which have been described above. The incoming H.T. feeders are connected to the centre of the board, the traction motor converters being connected to the one end and the lighting converters and the H.T. distributors to the distributing centres at the other end. The portions of the board which control the incoming feeders and the traction motor-converters are provided with duplicate 'bus bars as well as with a set of synchronising bars. The H.T. distributors and the lighting motor-converters are connected to an extension to the upper set of main 'bus bars. This extended portion of the upper main 'bus bars can be divided into two sections, each of which controls one of the pair of H.T. distributors which supply each distributing centre and one of the lighting motor-converters. The outer section can be connected to the main 'bus bars by means of a ring main. Either of the two sections can, therefore, be shut down without cutting off the supply from a distributing centre. Section switches are also provided in the main duplicate 'bus bars to facilitate cleaning operations. The general construction of the switchboard and the design of the gear for feeder charging and synchronising and the interlocking of the switches was all arranged on the same principle as that which has already been described in detail in connection

sides, is fitted on the top of the generator magnets to indicate when the machine has become excited. The 400 kw. traction motor-converters can also be started up from the D.C. side from the battery, and for this purpose a common D.C. starter is provided, worked from the L.T. switchboard gallery. The starting resistance is connected between the equaliser bar and a special starting 'bus bar, and a change-over switch is mounted on the bed-plate of each machine to enable the negative terminal to be connected either to the equaliser bar or to the starting bar. The D.C. machines are connected to the 'bus bars through reverse-current circuit-breakers.

A feature of special interest is the method of using the battery not only to equalise the load on the motor-converters, and therefore on the main H.T. generators, by taking the peaks of the traction load, but also, in cases of emergency, for maintaining both the alternating and direct-current lighting supply The battery is connected (*see* Fig. 16) through one of the reversible booster sets to the traction board, being connected between the positive 'bus bar and the equaliser bar, with the result that the total current returning from the track to the generators and the battery passes through the generator series windings, which are provided with diverter resistances. In the negative 'bus bar a main diverter resistance is provided through which the total current returning from the track passes, and the series winding on the booster is connected across a variable proportion of the main diverter resistance. It is

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arranged so that when the H.T. supply to the sub-station is interrupted the battery can run the motor-converters reversed, taking current on the D.C. side and delivering H.T. alternating current to the H.T. switchboard, from which it is transmitted, as before, to the lighting distributing centres. As soon as the motor-converters are reversed from the battery a reverse relay in the positive 'bus bar of the traction board operates a change-over switch, which short-circuits the series windings of the generators and alters the connections to the series winding on the booster, so as to produce level compounding with variations of the load instead of over-compounding. In case the traction load be too great to be maintained by the battery under these conditions, it is arranged that a maximum automatic circuit-breaker, connected between the battery and the track feeders, shall open should the current from the battery exceed a pre-determined amount. A resistance is connected as a shunt across the terminals of this circuit-breaker, so proportioned that when the circuit-breaker is opened sufficient current can be supplied to the trains to keep the lamps alight until the power for driving the trains can be supplied again. Thus the battery is able to maintain the alternating-current supply to Paddington, the railway stations and other important points, until the supply from Park Royal is restored A direct connection to the D.C. lighting board also enables the D.C. lighting supply to be maintained from the battery only when required.

The switch gear for each of the reversible boosters includes a motor-starting switch, field-regulating switches for the booster and exciter, a single-pole switch for cutting the booster in or out of the main circuit, and maximum automatic circuit-breakers for the motor and exciter. The two circuit-breakers and the cut-in switch are mechanically interlocked, so that the opening of either of the circuit-breakers opens the other and causes the cut-in switch to short-circuit the booster.

At the distributing centre (Fig. 17) each feeder is connected through a hand-operated oil-break switch to the primary windings of a group of three single-phase step-down transformers. The three transformers of each set are connected in delta both on the primary and secondary sides. The secondaries from each set are connected through an L.T. automatic switch to a set of L.T. 'bus bars. The two groups of transformers in each distributing centre are, therefore, only connected in parallel on the L.T. side. The normal ratio of transformation is from about 6,300 to 110 or 220 volts, one or other of these two pressures being required to suit the wiring of the buildings, which has been done at different times. Means are also provided for altering the ratio of transformation within small limits by tappings taken to additional terminals on the H.T. side. The capacity of each set of three transformers is chosen to suit the maximum demand at the different distributing centres. The second set of transformers is provided as a stand-by, but the two sets can be worked in parallel on the L.T. side when required. In order to avoid the expense of having a man at each distributing centre to change over from one set of transformers to the other in case of failure or other trouble, it is arranged that the whole of the distributing centres can be controlled from one or other of the three sub-stations. This is accomplished in the following way (*see* Fig. 18).

The two H.T. distributors carried from the sub-station to the distributing centre being connected independently one to each group of transformers, the primaries of each group can be switched on and off at the sub-station. As both sections of the extended 'bus bars at the sub-stations are connected to the same set of main 'bus bars, the primaries and secondaries of the two groups of transformers at a distributing centre must always be in phase, and there is, therefore, no difficulty in paralleling at the distributing centre by

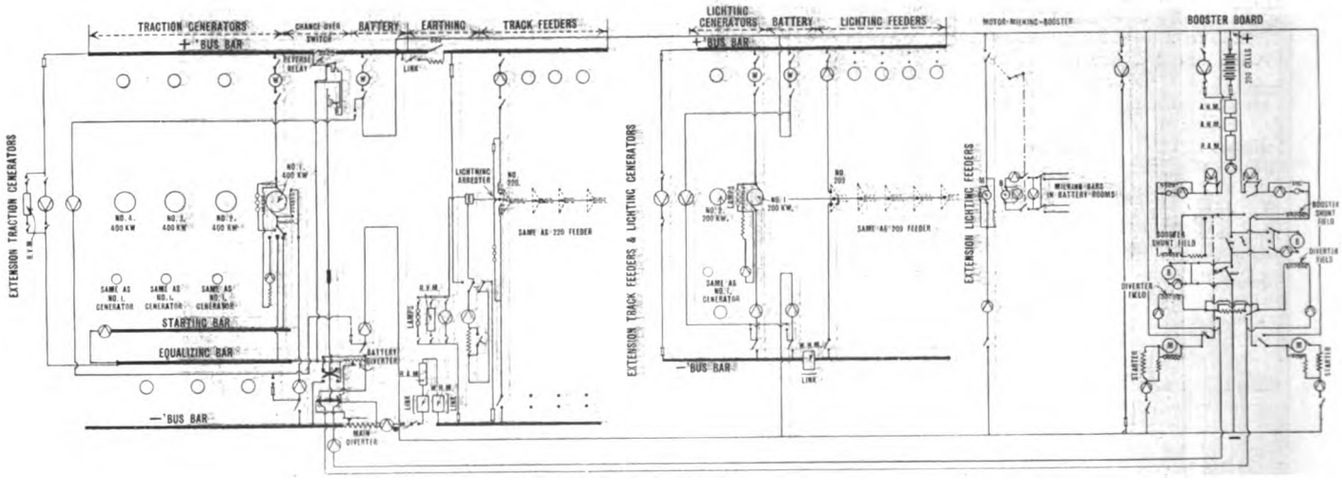

FIG. 16.—DIAGRAM OF CONNECTIONS AT ROYAL OAK SUB-STATION.

The negative 'bus bar of the traction switchboard is connected to earth through a resistance, which allows about 100 amperes to pass when the positive side of the system is earthed, owing to accidental connections to the conductor rails on the track or in any other way. An earth recording voltmeter is provided to give a continuous record of the potential of the negative with reference to earth, and means are also provided for testing the leakage current from the positive and negative conductor rails.

The other instruments and switch gear in connection with the D.C. switchboards do not call for special mention.

DISTRIBUTING CENTRES.

There are 11 distributing centres in which the 6,500 volt three-phase current from the sub-stations is stepped down to either 220 or 110 volt three-phase current for the lighting and power circuits. Each centre consists of a brick chamber, the usual dimensions being about 20 ft. by 12 ft. by 9 ft. high, five of these buildings being placed above ground, four in the neighbourhood of Paddington Station being in the form of underground chambers, and the remaining two forming the transformer rooms at Shepherd's Bush and Royal Oak sub stations. Two H.T. distributors are carried from one or other of the sub-stations to each distributing centre, being connected at the sub-station end by a maximum current automatic cut-out. One of these H.T. distributors is connected to the left-hand section and one to the right-hand section of the extended sub-station 'bus bars which have been described above. Where more than one distributing centre is fed by one pair of feeders leaving the sub-station, the distributing centres are worked in parallel, the left-hand and right-hand feeder at every distributing centre being connected to the left-hand and right-hand section respectively at the sub-station. means of the automatic cut-in switch which connects each set of transformers to the L.T. 'bus bars on the secondary side. As soon as one set of transformers is energised from the sub-station, the automatic switch is closed on the L.T. side by a solenoid made alive from the transformers As soon as the switch is closed, the solenoid is cut out of circuit and the L.T. switch is held closed by a catch. This catch is tripped by a no-voltage coil, so that when the supply to the set of transformers is cut off at the sub-station and the transformer voltage dies out, the automatic switch is tripped. When the two sets of transformers have been switched into parallel, opening the switch at the sub-station in the primary circuit of one would not disconnect it at the distributing centre unless the no-voltage coil on the L.T. automatic switch were open-circuited, because the secondary windings would be kept energised from the L.T. 'bus bars. In order to overcome this difficulty an Andrews discriminating transformer is connected, so that when only one set of transformers is delivering power to the 'bus bars a relay circuit is brought into action which open-circuits the tripping coil of the L.T. automatic switch of the other, or idle, set of transformers, and so disconnects them. With this arrangement it is therefore possible to switch in or out from the sub-station either set of transformers in any order, paralleling them when required for changing over, or for taking the peak load. The H.T. switch gear at the distributing centre is of a very simple nature, and is contained in stone cells with iron doors, placed at the end of the distributing centre remote from the entrance. The H.T. circuit in the form of bare copper rods to each set of transformers is connected to the H.T. distributor terminal box through phase-changing links, glow tubes being provided as in the case of the other H.T. switchboards. A voltmeter worked from a step-down transformer is provided for each H.T. circuit. In

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those cases where the H.T. distributors are carried on to supply another distributing centre in parallel, the circuits for the outgoing H.T. distributors are teed off the circuits of the H.T. distributors from the sub-station just before the oil switch.

The two sets of transformers are placed one on each side of the chamber, are air-cooled without cases, and are supported by wheels on rails on foundation blocks of such a height that the transformers can be readily wheeled off on to a special truck which is provided to take them out of the chamber.

The L.T. switch gear, which includes, in addition to the L.T. automatic switches, a voltmeter, two ammeters and an indicating wattmeter for each set of transformers, is carried on a steel framework which entirely screens off the transformers and the H.T. circuits, a door being provided in the centre to give access to the H.T. end of the chamber. Between the L.T. switchboard and the door the L.T. distributing boards are placed for the L.T. distributing network. The D.C. 600 volt supply from the sub-station is also brought into this end of the chamber in the case of some of the distributing centres.

Cables.

Between the generating station, the sub-stations and the distributing centres, about 87 miles of H.T. three-core cable and about 14 miles of L.T. concentric cable have been laid, in addition to between 8 and 4 miles of single L.T. cable used in the form of jumper cables in connection with the conductor rails.

Each H.T. feeder between the generating station and the sub stations has three cores of 0·15 sq. in. sectional area, insulated with paper, lead-sheathed and armoured with galvanised wire. The H.T. distributors are similar cables of 0·05 and 0·0125 sq. in. sectional area. The L.T. direct-current and alternating-current cables are

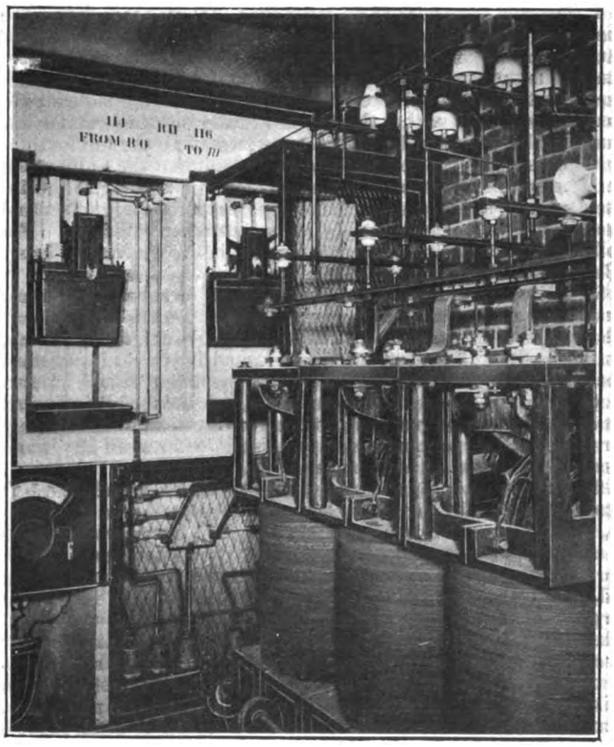

Fig. 17.—Distributing Centre. View of One-half of H.T. End.

concentric paper-insulated lead-covered cables, no armouring being provided on these cables as was done on the H.T. feeders in order to meet the requirements of the Board of Trade.

The trunk multi-core and the branch telephone cables are also paper-insulated and lead-covered.

All the H.T. three-core, L.T. concentric and telephone cables are laid in Howard asphalte troughing, a separate trough being used for each cable. These troughs are filled in with bitumen and covered with a layer of asphaltic concrete, ironed over all the troughs, which are placed side by side, so as to form a water-proof covering. The trenches in which the troughing is placed are excavated about 2 ft. deep, and have a 4 in. layer of concrete laid on the bottom, to form a bed for the troughing. Where the cables have to cross under any railway lines, a trench is excavated which is floored with concrete, and brick walls are built up on the side, on the top of which are laid old rails covered with concrete and a damp-proof course, to form a floor for the sleepers and rails. In this way all weight and pounding from the passing trains is kept off the cables. The culverts so formed are provided with ventilating inlets and outlets and inspection manholes at convenient points. The number of culverts in which the cables pass under the rails is 29. The route chosen for the feeders has, as far as possible, been at the side of the line, so that any repairs, examination or jointing can be done with greater ease. In certain places, however, more particularly between Westbourne Park, Royal Oak and Shepherd's Bush, it has been necessary to lay the feeders in the 6 ft. way. At one point, where the route of the cables crosses the proposed new line between Acton and Shepherd's Bush, a bridge, formed of old girders, has been provided to support the cables in such a way that when the cutting for the new railway is made it will be unnecessary to disturb

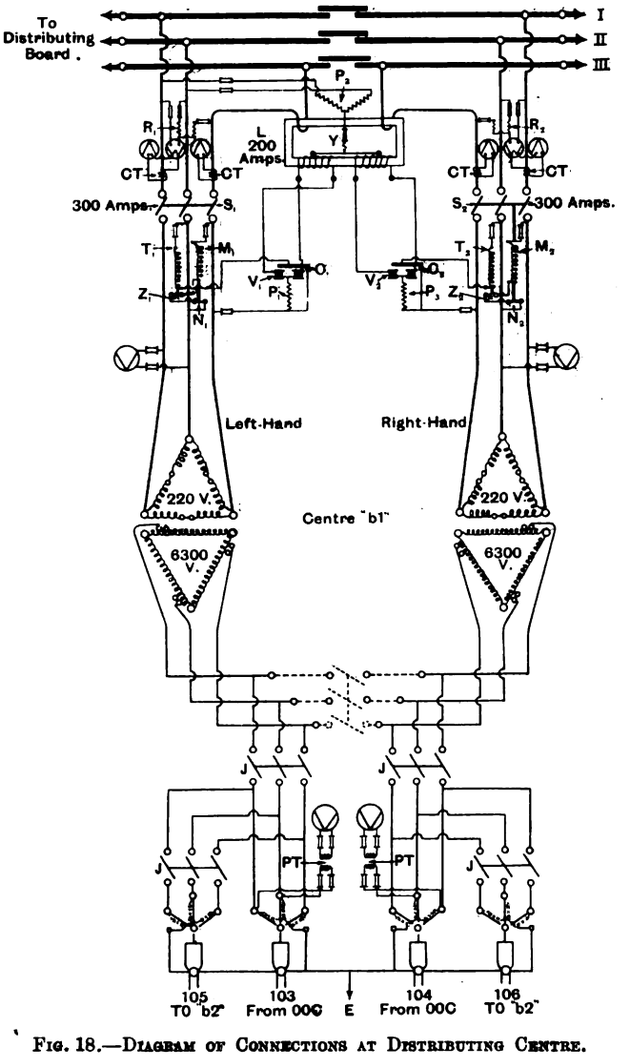

Fig. 18.—Diagram of Connections at Distributing Centre.

S_1 S_2, Main, L.T. 3-Pole Oil Switches. M_1 M_2, Closing Solenoids for S_1 and S_2. T_1 T_2, Tripping Solenoids for S_1 and S_2. N_1 N_2, Switch operated by Closing Solenoids for cutting out same when Main Switch is in "on" position. R_1 R_2, Wattmeter Star Resistance for Neutral Point P_1 P_2 P_3, Relay Resistances. V_1 V_2, Reverse Current Relays. C_1 C_2, Contacts actuated by Relays V_1 and V_2, breaking Circuit of Tripping Solenoids T_1 and T_2. Y, Switch for disconnecting Relays. Z_1 Z_2, Switches operated by Tripping Solenoids T_1 T_2 to close Closing Solenoid Circuits. J, H.-T. Oil-Break 3-Pole Switch, C T, Current Transformer. P T, Potential Transformer. L, Discriminating Transformer.

them. At points where the cables are laid across railway bridges, the cables have been laid on steel plates fixed to the bridge girders, the ends of the plate being built into the concrete bed of the cable trench at each end of the bridge, but left free for a few feet between the bridge structure and the anchoring point, so as to minimise as far as possible the effect of vibration.

All the laying and jointing had to be done without interfering with the traffic, and great care had to be taken to avoid accidents. It is satisfactory to be able to state that not a single life was lost in carrying out this part of the work.

There is one point of special interest in connection with the way in which the cables were jointed. The usual method of jointing the cables after they are laid was departed from, as it was considered that a much better joint would be made if more space was given to the jointer than is possible after the cables are laid and where there are a number placed side by side. The method adopted in the present instance was to leave the last 20 ft. or 30 ft. of each length of cable unlaid until the end had been jointed to the next length of

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cable to be laid in the same trough. The ends of the two cables to be jointed were laid on a temporary platform placed over the trench and protected by a jointer's tent, or by a special arrangement of tarpaulins where the clearance was limited, and all jointing was done where there was ample room and things could be kept clean. Where the cables were laid through the subway underneath the main lines between Westbourne Park and Royal Oak, the lengths of cable were so arranged that the joints came opposite the refuges provided in the walls of the subway, where the jointing could be done with safety.

In making a H.T. three-core joint, the separate cores, each with its own insulation, are arranged in a vertical plane, the copper conductors being butt-jointed and connected by copper sleeves run in with solder. Each copper joint is then insulated with alternate layers of mica and paper, and bound with tape. The outer insulation is then applied over the three cores together, the whole joint being finally bound up with tape, spaces being left to allow the compound with which the lead envelope is filled to run in between the cores. The lead envelope is connected at each end to the lead sheathing of the cable by means of a plumber's wiped joint. The continuity of the armouring at the joints is maintained by copper strips, clipped to the armouring beyond the wiped plumber's joint. The overall width of the joint is a little less than the width of the trough ordinarily used for the particular size of cable, so that it could be lowered into position wherever the joint came in the trough, and the laying of the next length of cable could be proceeded with. The completed joint, being of greater height than the trough, is protected by a piece of inverted trough, the two troughs being jointed together and filled with bitumen.

The three-phase current is transmitted from Park Royal by six H.T. feeder cables as far as an inspection chamber adjoining the sub-station at Old Oak Common. From this point five H.T. feeders are carried on to another inspection chamber at Westbourne Park. From Old Oak Common inspection chamber two H.T. feeders supply the Old Oak Common sub-station. From the Westbourne Park inspection chamber four H.T. feeders are carried to supply Royal Oak sub-station and three to supply Shepherd's Bush sub-station.

The inspection chambers referred to above are small brick buildings in which a simple arrangement of plugs and switches is provided, so that each sub-station can be supplied with high-tension electricity direct from Park Royal, and also from one of the other two sub-stations, and so that any incoming feeder can be joined to any outgoing feeder. In this way it is possible to keep one or more cables as spare in any section and connect them to the spare cable in the next section or to any other sub-station as may be necessary. Phase-changing links and glow tubes are provided at the inspection chambers similar to those described in connection with the main switchboards.

The H.T. distributors are run in pairs to the various distributing centres from the 'bus bars at the sub-stations, as has already been explained in describing the sub-station plant.

The L.T. concentric cables are also run in pairs from the L.T. switchboards at the sub-stations to the various points at which the current is distributed for lighting and power purposes. The conductor rails on the Hammersmith & City Railway and the lines in connection with it are fed by concentric cables from the sub-stations at Royal Oak and Shepherd's Bush, four 1·25 sq. in. cables being laid from the former, six 1·25 sq. in. cables and two 0·75 sq. in. cables being laid from the latter sub-station. The two 0·75 sq. in. cables supply overhead conductors in the car sheds at Hammersmith as well as the conductor rails outside it. The method of connection between the concentric cables and the conductor rails will be described when dealing with the track work.

(To be concluded.)

Three-phase Railway from Pontedecimo to Busalla.—*L'Industrie Electrique* states that the Italian Government have just contracted for the conversion of the railway from Pontedecimo to Busalla to electric traction. The three-phase system is to be employed, the frequency being 15 and the voltage at the trolley wires 3,000. Current will be generated by two 5,000 kw. turbo-alternators running at 900 revs. per min. The generator voltage will be 13,000. There are to be three sub-stations for stepping down the voltage. Locomotives weighing 60 tons will be used. Each locomotive will be equipped with two 750 kw. eight-pole motors. The speed will be either about 28 or 14 miles per hour, according to the arrangement of the motors. The locomotives are to be capable of drawing a train weighing 380 tons at a speed of 28 miles per hour on a gradient of 1 in 30.

ON THE MOTIONS OF ETHER PRODUCED BY COLLISIONS OF ATOMS OR MOLECULES CONTAINING OR NOT CONTAINING ELECTRIONS.*

BY LORD KELVIN, O.M., G.C.V.O., F.R.S.

§ 1. By atom is meant an indivisible element of ponderable (gravitational) matter, or of electricity; by molecule, an assemblage of two or more ponderable atoms, held together by mutual attractions balanced by mutual repulsions.

§ 2. In the atomic theory of electricity, electrion means an atom of resinous electricity, commonly hitherto called negative electricity. It is at present commonly assumed, and I believe in all probability rightly assumed, that all electrions are equal and similar.

§ 3. An ancient hypothesis, which has had large consideration among philosophers in all times, assumes that there is only one kind of atom, and that groups of equal and similar atoms constitute the chemical elements with all their marvellous variety of quality. But, though no doubt some important and interesting differences of quality, such as the difference between ordinary and red phosphorus, are due to differences of grouping in assemblages of one kind of atom, it seems extremely improbable that differences of grouping of atoms all equal and similar suffice to explain all the different chemical and other properties of the great number of substances now commonly called chemical elements. It seems, indeed, almost absolutely certain that there are many different kinds of atom each eternally invariable in its own specific quality, and that different substances, such as gold, silver, lead, iron, copper, oxygen, nitrogen, hydrogen, consist each of them of atoms of one invariable quality, and that every one of them is incapable of being transmuted into any other.

§ 4. The sole properties of an atom are:—(1) its mass (being the measure of the inertia of its translatory motion), (2) its law of mutual force between itself and every other gravitational or electrical atom in the universe, varying according to the distance between them. As to the mutual force between ponderable atoms, we have strong reason to believe that this law practically is the Newtonian law of universal gravitation for all distances exceeding the millionth of a centimetre. For distances considerably less than the millionth of a centimetre, the Newtonian law of attraction according to the inverse square of distance merges into repulsions resulting in mutual pressure of two bodies resisting joint occupation of space. For smaller distances we have attraction again, in the inevitable theory of Boscovich, constituting cohesions and chemical affinities.

§ 5. The assumption that the mutual force between two atoms depends merely on the distance between their centres implies that each atom is utterly isotropic. An aeolotropic atom, that is to say, an atom having different attractive and repulsive forces in different directions, is conceivable, and may possible come in future to have a place in atomic theory. Hitherto it has been universally assumed that every atom, whether gravitational or electrical, is thoroughly isotropic, and I do not propose at present to enter upon any theoretical consideration of aeolotropic atoms.

§ 6. I do not propose to enter on any atomic theory of ether. It seems to me indeed most probable that in reality ether is structureless, which means that every portion of ether, however small, has the same elastic properties as any portion, however great. There is no difficulty in this conception of an utterly homogeneous elastic solid, occupying the whole of space from infinity to infinity in every direction. We sometimes hear the "luminiferous ether" spoken of as a fluid. More than 30 years ago I abandoned, for reasons which seem to me thoroughly cogent, the idea that ether is a fluid presenting appearances of elasticity due to motion, as in collisions between Helmholtz vortex rings. Abandoning this idea, we are driven to the conclusion that ether is an elastic solid, capable of equi-voluminal waves, in which the motive force is elastic resistance against change of shape.

§ 7. We now meet the question: Is ether incompressible? We should be compelled to answer: Yes, it is incompressible, if it is subject to the law of universal gravitation. But presently, when we try to account for motion produced in ether by ponderable or electrical atoms moving through it, we shall feel ourselves persuaded that ether is compressible.† Believing this, we are forced to believe that it is non-gravitational. Thus we find ourselves settled in the conviction that ether is compressible, and that ether experiences no gravitational forces between its parts.

§ 8. Suppose now that an atom, whether ponderable or electrical, disturbs ether solely by attracting it or repelling it with a force varying according to distance; and that, with no other mutual influence than this, the atom and the ether jointly occupy the same space. If ether were incompressible, this attraction or repulsion would be utterly ineffective; and the atom would move through the space occupied by the ether, without giving any motion to the ether, and without itself experiencing any influence of force due to the

* Paper read before section A of the British Association at Leicester August 1st, 1907.

† "Baltimore Lectures," Appendix A; Appendix B, § 3.

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ether. Hence, in order that atoms may take energy from motions of ether, and that ether may take energy from motions of matter, we must suppose the ether to be compressible and dilatable; and to be compressed or to be dilated, or compressed at some distances and dilated at other distances, in virtue of the force exerted on it by the atom.

§ 9. While assuming ether to be compressible, we suppose its resistance to compression (positive or negative) to be so very great that the velocity of condensational-refractional waves in pure ether is practically infinite, and that the energy of whatever of such waves may be produced by collisions of atoms or electrons is practically *nil* in comparison with the energy of the equivoluminal waves, constituting radiant heat and light, which are actually produced by those collisions. It is only under the *enormous* forces of attraction or repulsion exerted by atoms on ether that augmentation or diminution of its density is practically influential.

§ 10. By purely dynamical reasoning, it may be proved to follow from the hypotheses of §§ 4, 6, 8 and 9, that an atom (supposed for a moment to be infinitely small), kept moving through ether at any velocity, q, greater than v, the velocity of light, produces no disturbance in the ether in front of a cone having its vertex at the atom, and semi-vertical angle equal to $\sin^{-1}\frac{v}{q}$,* but that the moving atom produces, in its rear wholly within the cone, an ever-growing disturbance of ether, and therefore requires the application of a continual pull forward to keep it moving uniformly at any constant velocity exceeding the velocity of light. In 1888, Oliver Heaviside† arrived at a corresponding conclusion by purely mathematical work, from Maxwell's electromagnetic formulas, without any dynamical foundation; and in 1897,‡ still without assuming any dynamical or chemical properties of ether and atoms, he corrected an erroneous hypothesis, that no force, however great, could give an atom a velocity equal to the velocity of light, which has been somewhat extensively adopted within the last 10 years in speculations and reckonings regarding radio-activity.

§ 11. Purely dynamical reasoning‖ on our physical assumptions of §§ 4, 6, 8 and 9, teaches us further that:—

(*a*) No force is required to keep an atom moving uniformly through ether at any velocity less than the velocity of light.

(*b*) To start an atom suddenly into motion from rest, causes a spherical pulse to travel outwards with the velocity of light, from the place in which the atom was when it was receiving the supposed velocity.

(*c*) The magnitude of this spherical pulse is a maximum in the plane through the centre perpendicular to the line of motion, and is zero at the two points in which the spherical surface is cut by that line.¶

(*d*) This spherical pulse carries outwards through infinite space a finite quantity of energy, l, due to a part of the work, w, done by the force which was applied to the atom to start it in motion. The sharper the suddenness the greater is l.

(*e*) If at any time a resisting force suddenly stops the atom, work is done on the ether, in virtue of which another pulse carries away an amount of energy l'; and work is done on the stopping agent amounting to $w-l-l'$.

(*f*) If the suddenness of the stopping is equal and similar to the suddenness of the starting, the second pulse is equal and similar to the first, and l' is equal to l.

§ 12. To understand clearly the meaning of (*e*) take an example Let three equal and similar electrionless atoms, A, B, C, be given in a straight line, A moving with velocity q towards B, and C moving towards B in the contrary direction with a velocity just so much less than q that B is left at rest after its collision with C. The initial distances are such that the collision between A and B precedes the collision between B and C. Amounts of energy equal to l and l' are carried away into infinite space in the pulses produced by the two collisions. In the arrangement now described, the suddennesses of the starting and stopping of B are not precisely equal and similar; and because of their difference l' would generally be somewhat less than l: but the law of force between the atoms might be such as to render l' equal to or greater than l, for certain ranges of values of q.

Take an analogous case of collisions between three ideal billiard balls each perfectly elastic. The clicks of A on B, and of B on C, cause losses of energy, l, and l', carried off through air by sound waves.

§ 13. Consider now the collisions in a non-electrified monatomic gas; that is to say, an assemblage of single atoms each having within it its neutralising quantum of electrions, except a small proportion from which the electrions may have been temporarily knocked out. For simplicity we shall first take the case in which a single electron is the electric neutralising quantum for each ponderable atom. The collisions will keep the electrions continually in a state of vibration within the atoms, except in the comparatively rare case of an electrion knocked out of an atom, or in the infinitely rare case of the relative motion of an atom and electrion being reduced exactly to zero by a collision.

§ 14. The law of force between the electrion and atom may be such that the centre of the atom is the only position of stable equilibrium for an electrion within it.

§ 15. Or the law of force may be such that there are any number, i, of concentric spherical surfaces within the atom, on each of which an electrion may rest in equilibrium radially stable; and $i-1$ intermediate surfaces, on each of which an electrion would be in equilibrium radially unstable.* In the statistical average of collisions, the electrion may, immediately after a particular collision, be ranging in non-sinusoidal vibration, through several spherical surfaces of stable and unstable equilibrium, losing energy by sending out irregularly reciprocating waves through ether. Before the next collision, the electrion may probably have settled down into very approximately sinusoidal vibrations in and out on each side of any one of the surfaces of radial stability.

§ 16. This last condition we may suppose to be generally prevalent during the greater part of the free path between successive collisions. We may, indeed, suppose it to be more frequently the immediate result of a collision than the wilder vibration described in §15, which, however, must undoubtedly be an occasional, though probably a rare, condition, immediately after a collision.

§ 17. We are not bound to assume that a single electrion is the saturating quantum of any particular ponderable atom; nor are we bound to suppose that it is electrically neutralised by any integral number of electrions.† The most general supposition we can make s that, with j electrions, the atom and electrions act externally as a vitreously electrified body, and, with $j+1$ electrions, the atom and electrions act as a resinously electrified body.

§ 18. It seems to me, indeed, exceedingly probable that the persistence of the two-atom molecule in the common diatomic gases O_2, N_2, H_2, Cl_2, is due to the impossibility of electrically neutralising the ponderable atom by any integral number of electrions. Suppose, for example, that one electrion suffices to electrically neutralise two atoms of nitrogen. A monatomic nitrogen gas (N), if non-electrified as a whole, would have half of its atoms without electrions, and, therefore, vitreously electric, with electric quantity equal and opposite to half that of a single electrion. Each of the other half of its whole number of atoms would have one electrion within it, and, therefore, its external action would be resinous, with half the potency of a single electrion. Thus, there would be a strong electric attraction between the atoms destitute of electrions and the atoms each containing one electrion within it. This attraction would tend to bring the atoms together in pairs, N_2, each pair containing one electrion of which one position of stable equilibrium would be at the middle of the line joining the centres of the two ponderable atoms. It seems quite probable that this is the real condition of ponderable atoms and electrions, in the ordinary diatomic gases.

§ 19. The dissociation of a considerable number of such pairs of atoms would be exactly the "ionisation" by which, following Schuster's and J. J. Thomson's theory of the conduction of electricity through gases, the latest developed theories of radio-activity explain the specially induced electric conductivity of diatomic gases, such as Lenard found to be produced in air by ultra-violet light traversing it, and Becquerel found in air all round an apparently inert piece of metallic uranium, or a uranium salt.

§ 20. But, to give electric conductivity to a monatomic gas, the "ionisation" could not be anything else than dissociation of electrions from ponderable atoms. This kind of dissociation might be produced in a very hot gas by mere impacts between the atoms of the gas itself, with the large translational velocities to which high temperatures are due. Or it might be produced by extraneous bodies, such as the "a" or "β" particles shot out with high velocities from radio-active substances. We are now, however, chiefly concerned with the motions of ether produced by collisions of atoms, in circumstances less abnormal than those in which dissociations and re-combinations are largely influential.

§ 21. The pulses described in §§ 11, 12, as due merely to mutual collisions between ponderable atoms (without consideration of electrions whether present or not), constitute a kind of motion in the ether which, if intense enough to produce visible light, would, when analysed by the spectroscope, show a continuous spectrum without the bright lines which when seen prove the existence of long-continued trains of sinusoidal vibrations of particles of ether, in the eye perceiving them, and therefore also in the source, and in all the ether between the source and the eye. On the other hand, the vibrations of electrions referred to in §13 would, if intense enough, produce bright lines in the spectrum.

§ 22. There is another kind of vibration in the source which

* "Baltimore Lectures," Appendix B., §§ 6, 7.
† Heaviside's "Electrical Papers," Vol. II., pp. 494, 516.
‡ Heaviside's "Electromagnetic Theory," Vol. II., Appendix G.
‖ "Baltimore Lectures," Appendix B., §§ 4 .... 7.
¶ "Baltimore Lectures," Lec. VIII., p. 88; Lec. XIV., p. 197.

* "Plan of an Atom to be capable of Storing an Electrion with Enormous Energy for Radio-activity," by Lord Kelvin, *Phil. Mag.*, December, 1905.
† "Aepinus Atomised," §§ 5, 6; Baltimore Lectures, Appendix E.

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might produce, and which probably does produce, bright lines in the spectrum. If there are two or more ponderable atoms in the molecule of a glowing gas, not dissociated by the violence of the collisions, each atom of the molecule must have a vibratory motion, of which an isolated ponderable atom is incapable, and these vibratory motions of the atoms of a group must give rise to bright lines in the spectrum, when the frequency of the vibrations in any one, or in all, of the vibrating modes, is between 400 million million and 800 million million per second, if we take this as the range of frequencies for visible light.

§ 23. The spectroscopic phenomena to be accounted for in a dynamical theory of light include continuous spectrums, with large numbers of bright lines superimposed on the more or less bright background of continuous spectrum. Even when every care has been taken, in artificial sources of light, to eliminate influence of more than one of the substances commonly called chemical elements, the number of bright lines is generally very large: indeed, we are not sure that we have been able to count the whole number of those which are presumably due to any single element.

§ 24. In a glowing monatomic gas, with just one electrion to each atom, and only the central position of stable equilibrium for the electrion in the atom, there could be only one bright line in the spectrum. But, in reality, every one of the known monatomic gases—mercury vapour, argon, helium, neon, krypton, xenon,—gives a highly complicated spectrum with a large number of bright lines. We infer that, if there is just one electrion to each atom, it has many positions of stable equilibrium; or that there are many electrions, with only the central position of equilibrium for one of them alone; or that there are many electrions, and many stable positions for one of them alone in the atom.

§ 25. It seems as if only by the third supposition—many electrions and many positions of stable equilibrium—we can imagine the great number of bright lines, and the great complexity of their arrangement in the spectrums of the monatomic gases.

§ 26. But we can feel little satisfaction in this or any other attempt to discover details of dynamical theory unless it gives some reasonably acceptable explanation of the laws of arrangement of trains of bright lines in the spectrums of different chemical elements, which have been experimentally discovered by Runge, Kayser, Rydberg, Schuster, and others.

REPORT OF THE BRITISH ASSOCIATION COMMITTEE ON PRACTICAL STANDARDS FOR ELECTRICAL MEASUREMENTS.*

The main work during the year has been the completion of the work with the ampere balance. The general results are referred to in some detail below. The final measurements confirm the opinion expressed in last year's report that an accuracy of a few parts in 100,000 might be reached. It appears that the result is probably accurate to 1 in 50,000. Interim reports on the ampere balance, indicating the progress of construction, adjustment and use of the instrument, have been submitted to the Association since 1904.

The committee are now pleased to report that the balance continues to give complete satisfaction. During the past year it has been much used for determining the E.M.F. of the normal Weston cadmium cell and the electrochemical equivalent of silver. A description of the instrument, its construction and adjustment, and the results obtained with it in the cadmium cell determinations, has been prepared and submitted to the Royal Society for publication in its *Transactions* by Prof. Ayrton, Mr. Mather and Mr. F. E. Smith. An account of the work on the electrochemical equivalent of silver is well advanced and will be published shortly.

In all some 71 observations have been made on a certain cadmium cell (No. 2), using both sets of coils on the balance, and 13 observations in which one or other of the two sets was employed. The agreement between the individual results obtained with the two sets of coils is remarkable, the average difference from the mean amounting only to 6 parts in 1,000,000. The whole series of observations extended over a period of 19 months (September, 1905, to April, 1907), and during that time the coils of the balance were reset five times. No determination made has been omitted except those in which the observations were of such a nature that a decision to disregard the result was arrived at before its computation. Such occasions were rare.

Of the 71 observations made, 7 are within 1, 14 are within 2, 28 are within 5, 53 are within 10, 66 are within 15, and 70 are within 20 in a million of the mean. Only one determination out of the whole 71, and this one of the earliest, differs from the mean by so much as 1 part in 59,000. The above facts constitute important evidence of constancy in both balance and cell. In fact, both current weigher and cell proved to be much more constant and reliable than the standard resistance, although the latter was very carefully made and annealed with a view to ensuring permanency.

Expressed in terms of the international ohm as realised at the National Physical Laboratory, and of the ampere as given by the new current weigher, we find that the value of $C \times R$ for the normal Weston cadmium cell is $1{\cdot}01830_5$ at 17°C. This assumes that the value of g at Teddington is 981·19, a number probably correct to within 3 parts in 100,000. An uncertainty of this amount in g introduces a possible error of $1\frac{1}{2}$ parts in 100,000 in the value of the ampere, and, as all other probable errors are smaller in magnitude, it is important that a more accurate determination of g be made.

To realise the volt with an accuracy approaching that of the ampere, as now known, it is necessary that an absolute determination of resistance of corresponding precision be undertaken. Through the kindness of the Drapers' Company of London it is hoped that such a determination by means of a Lorenz apparatus may be completed at the National Physical Laboratory before the end of next year. At the present time the uncertainty in the absolute value of the international ohm approximates to 4 in 10,000. From the above value of $C \times R$ for the cadmium cell together with the ratio of Clark to cadmium—viz.,

$$\frac{\text{Clark at 15°C.}}{\text{Cadmium at 17°C.}} = 1{\cdot}406_6,$$

the E.M.F. of the Clark cell at 15°C. becomes $1{\cdot}432_3$.

The committee recognise very fully the skill and devotion of Mr. Mather and Mr. Smith, on whom the work of carrying out the experiments has fallen, and have invited these gentlemen to become members of the committee. Papers by Mr. F. E. Smith, of the National Physical Laboratory, dealing with the use of the silver voltameter and the preparation of the Weston cadmium cell, are nearly ready for publication. Some preliminary work has also been done on the design for the Lorenz apparatus, the funds for which are being found by the Drapers' Company. The proposed design embodies new features of importance.

With regard to the proposed Conference on Electric Units further consideration led to the conclusion that a year's delay was desirable, and, in consequence, the meeting was postponed from October, 1906, to October, 1907. With a view to a preliminary agreement on the matters to be raised, correspondence has passed during the year between the secretary, acting as director of the National Physical Laboratory, and the heads of standardising laboratories in other countries. The conference will probably deal with the drawing up of an international convention relative to electric units, which should include the draft of a form of law which might be adopted generally in the various countries represented, and the consideration of the steps necessary to secure uniformity in the carrying out of the laws in different countries, and to arrange for determinations necessary for this purpose. The necessary invitations for the conference are being issued by His Majesty's Government.

To secure uniformity in carrying out the law it will be necessary that specifications for constructing and using a mercury unit of resistance, for setting up and working a silver voltameter, and for preparing a standard cell, be approved either by the conference itself or by some body nominated by the conference for this purpose. With a view to aiding discussion, very detailed specifications dealing with the voltameter and the cell have been prepared by the National Physical Laboratory and issued to other standardising institutions. These are printed in Appendixes II. and III. It is not suggested that the final specifications need be so full or so detailed, but it was thought well that all information necessary to assist in criticising the results should be included.

The work on the silver voltameter and Weston cell still continues, and, in view of the deliberations of the conference, it is probable that further expenditure will be required. The accounts show that a balance of 10s. 8d. remains from the grant of £50 made last year. The grant has been spent on the purchase of material and appliances for the research.

In view of the importance of bringing the work of re-determining the values of the fundamental units to a satisfactory conclusion the committee recommend that they be re-appointed, with a grant of £50, and with the addition of the names of Mr. A. P. Trotter, Mr. T. Mather, F.R.S., and Mr. F. E. Smith, that Lord Rayleigh be chairman and Dr. Glazebrook secretary.

* This report was issued during the meeting at Leicester. The committee consists of Lord Rayleigh (chairman), Dr. R. T. Glazebrook (secretary), Lord Kelvin, Profs. W. E. Ayrton, J. Perry, W. G. Adams, and G. Carey Foster, Sir Oliver J. Lodge, Dr. A. Muirhead, Sir W. H. Preece, Profs. A. Schuster, J. A. Fleming and J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Prof. S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir A. W. Rücker, Prof. H. L. Callendar and Mr. George Matthey.

APPENDIX I.

NOTES ON THE PRESENT CONDITION OF THE WORK ON ELECTRIC UNITS AT THE NATIONAL PHYSICAL LABORATORY. By F. E. SMITH.

(From the National Physical Laboratory.)

1. *The Ohm.* (*a*) *Absolute Unit.*—The value of a resistance in absolute measure is still subject to considerable uncertainty; the most satisfactory value is obtained from the mean observed ratio of the international

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ohm to the absolute ohm.* A provisional design has been prepared for the Lorenz apparatus which the Drapers' Company are kindly presenting to the National Physical Laboratory, and experiments to test the more important features of the design are in progress. It is hoped to realise the ohm in absolute measure to 1 part in 100,000. The experience gained in the construction of many of the fittings of the ampere balance will greatly facilitate the work.

(*b*) *International Unit.*—Further comparisons of some of the mercury standards of the National Physical Laboratory were made in October and November, 1906. There appears to have been no change in any of the tubes which affects the resistance of the contained mercury columns by as much as 1 part in 100,000. The following table gives the observed differences in 1903 (the year of their construction) and in October and November, 1906 :—

Mercury standards compared.	Observed difference in int. ohms in 1903.	Observed difference in int ohms in 1906.
M – P	0·00069$_4$	0·00068$_5$
M – T	0·00088$_6$	0·00089$_2$
M – U	0·00094$_7$	0·00095$_3$
M – V	– 0·00029$_8$	– 0·00030$_1$
M – X	0·00001$_3$	0·00002$_3$

2. *The Ampere.* (*a*) *Absolute Measure.*—When the ampere balance was designed it was hoped by means of it to measure a current in absolute value to 1 part in 10,000, but it will be seen from the report on the balance that the evaluation of a current of nominal value 1 ampere is subject to an error which appears to be not greater than 1 part in 50,000.

(*b*) *International Unit of Current.*—The International Conference on Electric Units at Charlottenburg (1905) reaffirmed the definition of the international ampere in terms of the deposit of silver in a silver voltameter or coulombmeter, but expressed the opinion that the information before it was insufficient to enable it to propose any alteration in the formerly accepted value for the ampere, or to lay down exact directions in respect to the silver voltameter.

The Rayleigh type of voltameter has been used in a large number of investigations, but the researches of Rodger and Watson, Richards, Kahle, and others have shown that this voltameter as generally employed gives results which may vary as much as 1 part in 1,000. In the research at the National Physical Laboratory a reproducible type of voltameter was sought, but after making a large number of observations on various forms it was found that, subject to certain easily attained conditions, all the forms give identical results to 1 part in 100,000. As the Rayleigh type is the simplest to erect, and produces the least variation in the current strength, it is proposed that this form be specified. The conclusions arrived at in the research differ appreciably from those of most other observers, and attempts have been made to experimentally reproduce the condition under which they worked. In part we have been successful, but there are still anomalous results for which we can at present offer no explanation. It is certain, however, though the complete chemistry of the silver voltameter or coulombmeter is unknown, that a reproducible type can be specified, and that the international ampere can be defined in terms of the deposit of silver with very great accuracy, certainly to 1 part in 100,000.

The Standard Cell.—For the past five years experiments have been made at the National Physical Laboratory on Clark and on Weston cadmium cells, and two years ago a provisional specification of the cadmium cell was published. It is gratifying to know that the specification proved of value, for in 1906, 51 cadmium cells were submitted for test at the National Physical Laboratory, and all of these were prepared on the lines of the specification. The cells were intended for commercial use, and they were packed with small crystals of cadmium sulphate to be more portable; also we have reason to believe that in some cases the mercurous sulphate had not been properly washed, and in other cases the solution of cadmium sulphate was slightly acid. Nevertheless the E.M.F. of these cells agreed with the N.P.L. cells to about 2 parts in 10,000, the N.P.L. cells having the lower voltage. Standards more carefully set up have been submitted by two observers for comparison with the N.P.L. cells in accordance with the offer made in the British Association *Report*, 1905. The cells prepared by one of these observers—Mr. Tinsley of Beckenham—differed from the N.P.L. cells by about 0·1 millivolt, or 1 part in 10,000. Mr. Mather also submitted a number of cells, and these had approximately the same mean E.M.F. as those from Mr. Tinsley. The N.P.L. cells were the lower in voltage, and freshly prepared cells agree with old ones.†

In May, 1907, 12 Weston cadmium cells set up by Dr. Wolff at the National Bureau of Standards, Washington, were compared with a number of the cells of the National Physical Laboratory, and a mean difference of 3 parts in 1,000,000 was measured. Dr. Wolff's cells were, we believe, set up quite independently of the N.P.L. specification, which makes this remarkable agreement all the more gratifying.

APPENDIX II.

Specification for the Practical Application of the Definition of the International Ampere.

(From the National Physical Laboratory.)

In the following specification the term silver voltameter (or coulometer) means the arrangement of apparatus by means of which an electric current is passed through a solution of silver nitrate in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment, and by noting this time, the time average of the current, or, if the current has been kept constant, the current itself, can be deduced.

In employing the silver voltameter to measure currents of about 1 ampere the following arrangements should be adopted: The kathode on which the silver is to be deposited should take the form of a platinum bowl about 10 cm. in diameter and 7 cm. in depth. The mass of the bowl is conveniently about 80 grammes. The anode should be a plate or disc of pure silver coated with a deposit of electrolytic silver, the mass of the latter being about 50 per cent. greater than the mass of silver to be deposited on the kathode. The plate or disc of silver should be of about 6 cm. edge (or diameter) and 3 mm. or 4 mm. in thickness. Its total area will thus approximate to 60 sq. cm. The anode should be supported horizontally in the liquid near the top of the solution by a silver rod riveted through its centre. To prevent the disintegrated silver which is formed on the anode from falling upon the kathode, the anode should be inserted into a cup of filter paper separately supported. The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of the nitrate to 85 parts of water. The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. If the value of the current is desired and the measurement is one of high precision this external resistance should be from 50 to 100 ohms; in other cases the resistance should not be less than 10 ohms.

Method of making a Measurement.

1. *The Solution.*—The silver nitrate should be purchased as pure and recrystallised twice; the recrystallisation is preferably done by evaporating a saturated solution in a flask over a water bath. The mother liquor should be drained away and the crystals dissolved in pure freshly distilled water. Prolonged contact of the crystals or of the solution with impure air must be avoided. The solution should be neutral to sensitive litmus paper. If the silver nitrate is recovered from much-used or contaminated solutions, or from an acid solution, the recovered salt should be fused (preferably in an electric oven) and afterwards dissolved, and the solution filtered before the recrystallisation processes; otherwise it may be necessary to recrystallise more than twice. During electrolysis in the volta-meter herein specified the silver nitrate solution does not change in composition as a result of the electrolysis by an amount which is detectable by any tried means, but, owing to the presence of impurities in the atmosphere, the solution should not be used more than once if great accuracy is desired.

2. *The Anode.*—The anode should be prepared by cleaning the silver plate or disc with sandpaper or a scratch-brush. It should be washed with distilled water and supported so as to form the kathode of a silver voltameter. The anode of this latter should be a silver bowl or a platinum bowl coated with silver, and the liquid should be a 15 per cent. solution of silver nitrate in water; this solution need not be specially pure. If the anode bowl is of platinum coated with silver and of the dimensions already specified, it is convenient to employ about 350 cubic cm. of the solution and support the silver plate or disc horizontally in the liquid near the top of the solution. A convenient current for depositing silver on the plate is 0·3 ampere. The plate is washed with distilled water and dried in an electric oven.

The cup of filter paper should be about 5 cm. deep and of a diameter a little greater than that of the silver plate. It is made by folding a large filter paper (such as Schleicher and Schull No. 595, 24 cm. diameter) over a glass cylinder (such as a bottle) of appropriate diameter and securing the upper portions of the folds of the paper with sealing wax or with platinum wire. The cylinder is removed and that portion of the paper which is above the seals is cut away. The upper parts of the internal folds are also secured with sealing wax or with platinum wire.

3. *The Kathode.*—The platinum bowl should be cleaned with a strong solution of sodium hydrate, followed by washings with water, strong nitric acid, and distilled water. It is then made the anode of a silver voltameter, the liquid being a 15 per cent. solution of silver nitrate (an impure solution serves) having a volume of about 350 cubic cm. The kathode should be a clean silver plate supported near the top of the solution. With a current of about 1 ampere the circuit should be completed for 10 minutes at least, after which the kathode and liquid are removed from the bowl. The bowl is washed with water and afterwards cleaned with strong nitric acid; washings with distilled water, strong nitric acid, and distilled water follow in the order named, and the bowl is dried in an eletric oven at about a temperature of 160°C. It is removed to a desiccator and when thoroughly cool it is weighed. A bowl of similar size and of approximately the same mass is convenient as a counterpoise.

4. *The Circuit.*—The platinum bowl is placed in position in the intended circuit and 300 cubic cm. of the solution of silver nitrate are placed in it. The anode is placed inside the filter paper cup and the latter suspended by platinum wires which are insulated from the anode and from the rest of the circuit. The anode and filter paper cup are supported so that the silver plate or disc is covered by the solution; the connections to the remainder of the circuit are then made. Contact is made at a key and the time noted. The current is allowed to pass for an interval depending on the precision desired, and the time of breaking contact must be observed. For measurements of high precision from 7 to 10 grammes of silver should be deposited. During the passage of the current the voltameter should be covered over to exclude light.

5. *Deposit of Silver.*—The solution is removed from the bowl and the deposit rinsed with about 100 cubic cm. of distilled water. The washing water is poured into a clean glass crystallising dish and the operation of washing is repeated three times. The bowl is then nearly filled with distilled water and left for at least three hours; it is rinsed three times, the last of these washing waters remaining in the bowl for 10 minutes. This should give no milkiness when added to a neutral solution of

* See table in the Brit. Assoc. *Reply* for 1893.

† In Mr. Mather's cells electrolytic mercurous sulphate was used; in Mr. Tinsley's cells the mercurous sulphate was prepared by the chemical precipitation method.

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sodium chloride in water. The bowl is dried in an electric oven at a temperature of about 160°C. If any loose silver is observed in the solution outside of the filter paper cup, or in the washing waters, these liquids must be filtered, the filter paper dried, and the loose silver added to the bowl before drying the deposit. The bowl is cooled in a desiccator and weighed again. The gain in mass gives the silver deposited.

6. *Calculation.*—To find the current in amperes this mass, expressed in grammes, must be divided by the number of seconds during which the current has been passed and by 0·001118. The result will be the time average of the current if, during the interval, the current has varied. In determining the constant of an instrument by this method the current should be kept as uniform as possible and the readings of the instrument observed at frequent intervals of time. These observations give a curve from which the reading corresponding to the mean current (time average of the current) can be found. The current, as calculated from the voltameter results, corresponds to this reading.

Notes on Observations.—If this specification is carefully followed the mass of silver deposited for the passage of 1 coulomb through the voltameter is constant within the limits of the errors of measurements of the highest precision. It is certainly constant to 1 part in 100,000. The specification is possibly too rigorous for many practical needs, and for such a simplification is possible. The solution of silver nitrate may be prepared from purchased silver nitrate, provided it is free from acid. The anode may be a plate of pure silver without electrolytic silver deposited thereon. The remainder of the specification must be followed.

Effect of Pressure.—The observations may be made at any ordinary atmospheric pressure, or exceptionally low pressures, as the mass of silver deposited when the silver voltameter is under a pressure of 76 cm. of mercury is the same as when under any low pressure to 2 cm. of mercury, and possibly without these limits.

Effect of Temperature.—This specification is based on observations at or about a temperature of 17°C. Observations at other temperatures have been made and are being continued; if there is a temperature coefficient to the silver voltameter it is exceedingly small. This specification is based on the results of a large number of measurements made at the National Physical Laboratory.

APPENDIX III.

Preparation of the Weston (Cadmium) Standard Cell.

(From the National Physical Laboratory.)

Definition of the Cell.—The cell has mercury for its positive electrode and an amalgam of cadmium, consisting of 12½ parts by weight of cadmium to 87½ parts of mercury, for its negative electrode. The electrolyte consists of a saturated solution of cadmium sulphate, and solid cadmium sulphate is contained within the cell. A paste consisting of solid mercurous sulphate, mercury, and cadmium sulphate rests on the positive electrode.

Preparation of the Materials.

1. *Mercury.*—Commercially pure mercury should be squeezed through wash-leather and passed in the finely divided condition in which it emerges through dilute nitric acid (1 part of acid to 6 parts of water) and mercurous nitrate solution, and afterwards through distilled water. These liquids are conveniently contained in long glass tubes. The mercury is then distilled twice in vacuo. Mercury suspected of any abnormal contamination should not be employed.

2. *Cadmium Amalgam.*—A current is passed from a thick rod of pure commercial cadmium to distilled mercury, the intervening liquid being cadmium sulphate solution rendered slightly acid with a few drops of sulphuric acid. The kathode is weighed before electrolysis commences, and again afterwards; the percentage of cadmium in the amalgam is then calculated. More than the requisite amount of cadmium should be deposited and the percentage reduced to 12½ by the addition of mercury. To prevent the anode slime having access to the kathode the anode should be contained in a filter paper cup, as in the Rayleigh form of silver voltameter. Contact with the kathode is made by a platinum wire sealed into a glass tube, the wire being thus protected from direct contact with the cadmium sulphate solution. An approximate estimate of the quantity of cadmium deposited is obtained from the readings of an ammeter placed in the circuit. The amalgam, with very dilute sulphuric acid flooding its surface, is melted over a water bath and stirred to ensure homogeneity. It is then ready for use.

3. *Cadmium Sulphate.*—Procure commercially pure cadmium sulphate, $CdSO_4 . 8/3H_2O$. Powder in a mortar and dissolve in distilled water until a saturated solution results; filter the solution through a fine-grained filter paper until it is quite clear. The liquid should then be placed in a large crystallising dish and slowly evaporated at a temperature of about 35°C., when, provided that dust is excluded, many transparent crystals of $CdSO_4 . 8/3H_2O$ will result. In this way about five-sixths of the solution may be evaporated (the mother liquor may be used for a preliminary washing of the mercurous sulphate, the manufacture of which is described hereafter). The recrystallised cadmium sulphate should be washed with successive small quantities of distilled water, until after standing for 10 minutes no trace of acidity can be detected in it with sensitive congo-red paper; the crystals, still moist, are transferred to a stock bottle. To prepare the saturated solution the crystals are crushed in a mortar and agitated with distilled water. The latter may be warmed to 35°C.

4. *Mercurous Sulphate.*—Add 15 cubic cm. of pure strong nitric acid to 100 grammes of pure mercury contained in a crystallising dish, and place on one side until the action is over or nearly over. Transfer the mercurous nitrate thus formed, together with the excess of mercury, to a beaker containing about 200 cubic cm. of dilute nitric acid (1 of acid to 40 of water by volume); a clear solution should result. Prepare about 1 litre of dilute sulphuric acid (1 of acid to 3 of water by volume), and while the mixture is hot add the acid mercurous nitrate solution to it. The solution should be added as a *very* fine stream from the narrow orifice of a pipette and the mixture violently agitated during the mixing. Mercurous sulphate is precipitated and rapidly settles to the bottom of the vessel when the stirring ceases. Decant the hot clear liquid and wash the precipitate twice by decantation with dilute sulphuric acid (1 of acid to 6 of water by volume). The precipitate should then be filtered. (A small Buchener filter funnel and a filter flask is very convenient for this latter operation.) Wash the precipitate three times with the dilute sulphuric acid (1 to 6), and afterwards wash six or seven times with saturated cadmium sulphate solution to remove the acid. After each washing the liquid should be removed as completely as possible by the filter pump. When these operations are complete the mercurous sulphate is flooded with saturated cadmium sulphate solution and left for one hour; the solution is then tested with congo-red paper. In general no acid will be detected, and the mercurous sulphate is ready for use. It is placed in a stock bottle, together with some saturated cadmium sulphate solution, and should be kept in the dark. If acid is detected the washing must be continued. When the cells are required for observations of the highest precision the apparently neutral mercurous sulphate should not be immediately used. It is placed in a bottle with saturated cadmium sulphate solution, and at the end of one week the latter is tested for acidity. The sulphate is given another washing with the solution, and may then be used if only a trace of acid is detected.

One of the following methods of preparation may, if desired, be substituted for the foregoing:—

1. *Electrolytic Method.*—This preparation is conducted in a darkened room. Pure distilled mercury forms the anode and platinum foil the kathode, the electrolyte being dilute sulphuric acid (1 volume of acid to 5 volumes of water). The mercury is placed in the bottom of a large flat-based beaker, and about 20 times its volume of the dilute acid is added. Contact with the mercury is made by a platinum wire passing through a glass tube, and the kathode is suspended in the upper portion of the liquid. During electrolysis the electrolyte must be continually stirred, an L-shaped glass stirrer being very efficient, the foot of the L moving close to the surface of the mercury. A convenient current-density is 0·01 ampere per square centimetre of anode surface. The mercurous sulphate so prepared is filtered and the greater part of the mercury removed; it is then washed with dilute sulphuric acid and saturated cadmium sulphate solution in a manner already described for the previous preparation.

2. *By Means of Fuming Sulphuric Acid.*—Place distilled mercury in a crystallising dish so as to just cover the bottom. Add sufficient fuming sulphuric acid to flood the surface of the mercury to a depth of about 2 mm. Cover with a clock glass and place on one side for 48 hours. Mercurous sulphate is formed and appears in the crystalline form. Carefully add the salt to hot dilute sulphuric acid (1 to 6) and well agitate. Decant the hot liquid. If any caked masses of the sulphate are left these should be rejected or crushed in an agate mortar. Wash three times by decantation with hot dilute sulphuric acid, and afterwards filter and wash with saturated cadmium sulphate solution in the manner already described. Set aside with cadmium sulphate solution for one week at least, test for acidity, and wash as described for the first preparation.

The Mercurous Sulphate Paste.—The mercurous sulphate is mixed with about one-fourth its volume of powdered recrystallised cadmium sulphate, and about one-tenth its volume of pure mercury. (When the electrolytic sulphate is used, or that prepared with fuming sulphuric acid, no mercury need be added.) To the mixture of mercurous sulphate, cadmium sulphate, and mercury sufficient saturated cadmium sulphate solution is added, so that when well mixed the whole forms a thin paste.

Setting up the Cell.—That type of H-form of cell which may be hermetically sealed is the most convenient; if the lower end of each limb is slightly constricted the contents of the cell are less liable to be disturbed. The platinum wires inside the glass vessel are amalgamated by passing an electric current from a platinum wire anode through an acid solution of mercurous nitrate to each of the wires in turn as a kathode. The vessel is washed out twice with dilute nitric acid, several times with water, and finally with distilled water; it is dried in an oven. A small pipette is used for the introduction of the amalgam, and a small thistle funnel for the insertion of the paste and crystals. The main stock of amalgam is flooded with very dilute sulphuric acid, and it is melted over a water bath; a little of it is introduced into one of the limbs of the H vessel. After the amalgam has solidified this limb must be washed out several times with distilled water, care being taken to avoid wetting the interior of the other limb. A little distilled water is added and the amalgam is melted by immersing the limbs of the H vessel in hot water. After the solidification of the amalgam it is washed once more with distilled water. Into the other limb sufficient mercury is introduced to cover the amalgamated platinum wire; then the paste is added, care being taken not to smear the sides of the vessel. Finally, powdered crystals of cadmium sulphate are introduced into each limb, and saturated cadmium sulphate solution is added. The cell may be immediately sealed with the aid of a blowpipe, but the contents must not be abnormally heated thereby. The cadmium amalgam introduced should cover the amalgamated platinum wire; the depth of the paste should be from 0·5 cm. to 1 cm., and the depth of the layer of crystals about 0·5 cm.; 24 hours after the cell has been set up it may be used. Its E.M.F. at 15°C. is 1·0185 volt. The E.M.F. at any other temperature may be obtained from the formula given by the Phys. Tech. Reichsanstalt, viz.,

$$E_t = E_{20} - 0{\cdot}000038(t-20) - 0{\cdot}00000065(t-20)^2,$$

or from the formula obtained at the National Physical Laboratory,

$$E_t = E_{17} - 0{\cdot}000034_5(t-17) - 0{\cdot}00000066(t-17)^2.$$

This specification is based on observations made at the National Physical Laboratory.

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A NEW METHOD OF ARTIFICIAL LOADING FOR TRANSFORMERS.*

BY A. F. GUSTRIN.

In the case of large transformers, the permissible continuous load is only limited by the heating of the active material. In order to determine the maximum continuous load corresponding to a given temperature rise, or the temperature rise corresponding to a given continuous load, the transformer must be subjected to a prolonged test. For economical reasons a direct loading is generally out of the question, and various methods of artificial loading have been devised—methods. that is to say, by means of which the normal losses in the transformer may be maintained with the expenditure of an amount of power which is the equivalent of the losses only.

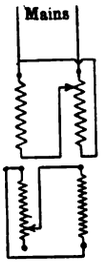

FIG. 1.

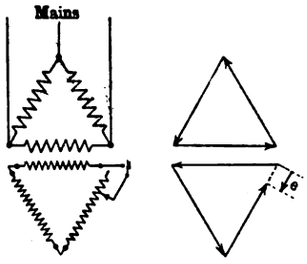

FIG. 2.

In some of these methods, the normal iron losses are produced by connecting the transformer to a source of alternating E.M.F., while the copper losses are maintained by continuous currents circulating in the two windings. Thus three sources of power become necessary, two supplying continuous currents to the windings, and the third an alternating current to one of the windings. The method, therefore, is unsatisfactory from the point of view of simplicity. The final temperature rise may also be approximately determined by the following method. The transformer is first run for a time on open circuit, the P.D. of supply being higher than the normal working P.D. by an amount such that the increased iron losses equal the normal total losses. The transformer is next short-circuited, and is loaded so as to make the copper losses equal to the total losses. By alternating the two methods of loading at suitable intervals, a steady state is ultimately reached. The disadvantage of the method is the necessity of periodically switching over from a high to a much lower voltage, and the fact that the open-circuit loading has to be carried out with a voltage about 50 per cent. in excess of the normal working voltage.

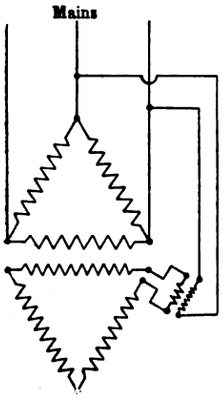

FIG. 3.

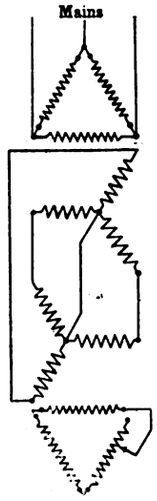

FIG. 4.

The ideal method of artificial loading is undoubtedly the so-called *loading-back* method,† in which a circulation of power takes place between two transformers similar in every respect. Even this method, however, has its disadvantages: it requires the use of *two* similar transformers, and of either an auxiliary transformer or else special testing coils.

The author has devised a method of applying a similar test to a *single* transformer. This method may be termed the *self-loading* method. Its application to a single-phase transformer is shown in Fig. 1. Both primary and secondary are divided into two sections connected in parallel, and one section of each winding is weakened by leaving out a suitable number of turns. The two sections of the secondary are connected so that their E.M.F.s oppose each other, and similarly the two sections of the primary are connected so that their ampere-turns are in opposition. It is evident that owing to the paralleling of the two sections of the primary, the primary P.D. must be reduced to half its normal value in order to maintain the normal induction in the core.

The method could be applied in the form just explained to a three-phase transformer, but would be somewhat complicated. A much simpler arrangement is shown in Fig. 2. Both primary and secondary windings are delta-connected, and a certain number of turns is left out in one phase of the secondary. The extreme simplicity of the connections in this case shows that the self-loading method is eminently suitable for use with three phase transformers. The vector diagrams of the primary and secondary E.M.F.s are shown to the right of Fig. 2, and it will be seen that there is a resultant E.M F. of amount *e* in the secondary which disturbs the balance and is sufficient to give rise to the full load currents in both windings.

Instead of reducing the number of turns in one phase of the secondary, a small auxiliary transformer may be employed as shown in Fig. 3. The method is also easily applied to the case of two similar transformers, the connections being arranged as in Fig. 4.

A slight disadvantage of the self-loading method is the fact that the three phases are unequally loaded. The amount of unbalancing is, however, not serious.

In designing the test coil which forms the turns to be omitted in one phase of the secondary it is sufficient to calculate approximately the full-load voltage drop and to arrange the number of turns in the test coil for an E.M.F. somewhat in excess of the drop. The final adjustment of the currents may then be carried out by a small variable resistance included in the circuit. When—as is frequen ly the case—the windings are wound in numerous sections, it may be unnecessary to provide any special test coils, the omission of one section of the winding serving the purpose of the test equally well. The self-loading method has been practically tested by the author with satisfactory results.

* Abstracted from the *Elektrotechnische Zeitschrift*.

[† The connections being arranged as in the well-known Sumpner efficiency test.—ED. *E.*]

BOOKS RECEIVED.

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"The Electrician" Handy Copper Wire Tables and Formulæ. Compiled by P. B. Down. (London: "The Electrician" Printing & Publishing Co.) 2s. 6d. net.

"Prüfung elektrischer Maschinen und Transformatoren." By Friedrich Weickert. 2nd edition. Vol. L. of "Bibliothek der gesamten Technik." (Hanover: Dr. Max Jänecke.) M. 1.80.

"Der Schalttafelwärter." By Emanuel Stadelmann. Vol. XLVIII. of "Bibliothek der gesamten Technik." (Hanover: Dr. Max Jänecke.) M 2.40.

Magnetic Track Brake.—Mr. J. F. Simpson, manager of the Preston tramways, has lately patented a new magnetic track brake, by the use of which it is claimed that skidding of the wheels will be rendered impossible. The essential feature of this brake is an electromagnet, suspended by springs attached to the frame of the car. This magnet is free to move endwise, and its upper surface rises from each end to the centre. When it becomes excited it is pulled down on to the rail, a roller attached to the car-frame is pressed on one of the inclined planes and the rolling friction is thus increased. It is stated that with a coefficient of friction of 25 per cent. and an inclination of the planes of 1 in 3, an initial magnetic force of 1 ton will give a total pressure of 3·9 tons on the rail. This brake may also be applied mechanically by drawing the magnets longitudinally in the direction opposite to that in which the car is moving.

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THE PEAK LOAD IN ELECTRICITY SUPPLY.

Although on most electricity supply networks the peak load does not assume quite such an important position as it did some years ago when the remainder of the load was practically unimportant, it still takes up an unpleasantly prominent position on most load curves, and receives attention from time to time in the technical Press as that part which is more or less undesirable. It is looked upon as the part of the load which is most easily obtained, and the part which is the least profitable. In a sense this is so. This part of the load is most readily obtained because people are accustomed to buying light, but have not been accustomed to buying power. The lighting load comes on as a matter of course, whereas the power load has to be developed with a good deal of care. There does not seem, however, any particular reason why the lighting load should be avoided, provided it is realised that the charge for a lighting load must always be heavier than that for a load which is maintained for longer hours. There must

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necessarily be a difference in price; the only objection to having such a properly proportioned price is that the consumer of light for short periods feels aggrieved that he should not get it at a very low rate. That there should be a difference in price at all is a point which our gas friends generally find difficult to grasp, simply because in the manufacture of gas a means of storage on a large scale is commercially possible, and the question of a peak load does not come into account.

Among the many suggestions that have been made for filling in the valleys so as to produce a more or less constant load during the daytime is that of a restricted hour supply. The objection to the power load usually obtainable is that it is apt in many cases to run through the period of the peak. Consequently the peak is not thereby diminished, except relatively, and does not become unimportant until the power load obtained is large in comparison with the lighting load. If, on the other hand, a sufficiently large restricted hour load could be obtained, the result might be a material improvement. There are several industries, chiefly of an electrolytic kind, which for their success depend entirely upon a cheap supply of power. For instance, the electrical manufacture of nitric acid or nitrates, calcium carbide and steel, can only be carried out with commercial success if very cheap power is obtainable. It might, therefore, be worth while for certain supply companies favourably situated to consider the lowest rate at which they could profitably give such a supply.

Two difficulties, however, present themselves. The first is that in many industries of this kind, if work is carried on for, say, 20 hours per day, it is found more profitable to work during the full number of 24 hours, and in some cases it would be difficult to shut down for four hours out of the 24. The second difficulty is that if a manufacturing concern were to consider a supply on this basis they might find it preferable to put down a generating station of their own and to run this for the full 24 hours per day, unless the terms offered by a supply company were sufficiently favourable to offset the disadvantage of having to shut down for a certain period per day. There is one factor, however, which is always of importance in such cases—namely, that it is frequently better to avoid putting down a private generating station, so that the capital which might be required for this may be used more directly in the actual business of manufacture, and it is quite possible that this factor may prove sufficiently important to create a demand for a restricted hour supply.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

A Manual of Hydraulics. By R. Busquet. Translated by A. H. Peake, M.A. (London: Edward Arnold.) Pp. 312. 7s. 6d.

A passage from the author's preface may be used to describe the object of this work: "The book itself is not purely a descriptive work, designed merely for popular use, nor is it an abstruse treatise suitable only for engineers versed in higher mathematics. It is a text book of applied hydraulics, in which complete technical theories and all useful calculations for the erection of hydraulic plant are presented. In it no recourse is made to other operations than those of arithmetic and elementary geometry. It has been our aim to make the science of the hydraulic power industry available for all engineers, architects and contractors, who may be called upon to study and carry out installations of this description." In our opinion the book is scarcely entitled to be called a "text book of applied hydraulics," but its actual scope is well indicated by the translator, who writes in his preface: "This book expounds the principles underlying the use of water power, and discusses the application of these principles to almost every type of hydraulic prime mover in commercial use, showing the relative merits of and the circumstances favourable to each type."

Chapter I., after a preliminary discussion of pressure and work, gives a very full discussion of Bernoulli's theorem, then of flow through orifices and flow over a dam or weir; Chapter II. deals with flow of water in pipes, and contains a full discussion of a distributing network; Chapter III., flow of liquids in open canals; Chapter IV., water-wheels and turbines; Chapter V., the last, is devoted to the construction of a waterfall, and gives details of calculations regarding the dam, gates, &c.

The limitations the author sets himself lead in many places to a rather cumbrous method of treatment. For example, the flow over a weir is readily deduced from the formula for discharge through a small orifice, if a knowledge of the A B C of integration (the integral of x to the power n with respect to x) be presupposed. The author's treatment does not seem to be quite so satisfactory. Many important problems are omitted, evidently because of this limitation.

Text books of applied hydraulics, of the scope laid down in the author's preface, are not plentiful, more especially now that Prof. W. C. Unwin's "Encyclopædia Britannica" article, "Hydraulics," can no longer be bought separately. The present work should therefore be a welcome addition to the number.

Engineering in the United States. By Frank Foster. (Manchester: The University Press.) 1s. net.

This volume is really a report to the electors of the Gartside Scholarships on the results of a tour in the United States undertaken by the author. It is an interesting piece of work, but contains little that was not common knowledge to engineers in this country before Mr. Foster was elected a Gartside scholar. We even venture to state that its production will be of infinitely greater value to Mr. Foster himself than to the persons who read the report. This is, of course, the rule in the making of many books, but as a Gartside scholar must not be more than 23 years of age the rule is specially applicable. The author is obviously of an observing nature and he has placed before the public a brief and entertaining account of his 12 months' tour in the States, but he should have been rather more careful of laying down his own particular view of a problem as the only correct one. Perhaps it is lack of literary experience which has led him into expressing his own opinions in a rather too positive fashion, and it may be for the same reason that some of his metaphors are hopelessly mixed.

With regard to electric tramways the author says "continuous street speeds of 30 miles an hour would be quite reasonable, after people got used to the cars." How people are going to get used to the cars he does not explain, and the prospect of electric cars careering along Fleet-street, say, at 30 miles an hour, is not exactly inviting.

Altogether, Mr. Foster's ideas are rather Utopian—he demands, for instance, that dwelling-houses should never overlook a factory, as such a situation has a demoralising and degrading influence on the workers. "No man," he says, "should live within half a mile of his workshop." Where works are situated in the middle of a big city there may be some truth in this statement, but it certainly does not apply to works like those of the Westinghouse Company, at Trafford-park, and to scores of others in this country.

To those in search of a few hours' light reading we recommend Mr. Foster's report, which, although lacking in discretion, gives much evidence of enthusiasm and is therefore of a particularly refreshing nature.

Soldering, Brazing and the Joining of Metals. By Thomas Bolas. (London: Dawbarn & Ward, Ltd.) 6d. net.

This book forms No. 10 of "The Home Worker's" series of practical handbooks, and the present edition, which is the third, has been thoroughly revised and some additional notes included. The information which it contains is very practical, and will be of great assistance to the amateur in the art of soldering. The book is very comprehensive, dealing with

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soft soldering, wiped joints, brazing, soldering precious and refractory metals, decorative soldering and joining together of metals without soldering.

Table of Properties of Copper Wires for the Principal Gauges in Use in Different Countries. Prepared under the direction of H. M. HOBART.

We have received a copy of this table, which is arranged for hanging on a wall, being 24 in. by 18 in. in size. It gives the cross-section, resistance at 0°, 20°, 40°, 60°, 80° and 100°C. of a kilometre and 1,000 ft. length of wire, and also ohms per kilogramme, ohms per pound, &c. The wires are arranged according to their diameters, and particulars are given for wires in S.W.G., B.W.G. and B. & S. gauges. In addition, particulars are given for wires of diameter of even millimetres and even decimals of an inch. Distinctive colours are used for each particular gauge, so that it is very easy to pick out any particulars from the different columns of the table.

TANTALUM ELECTRODES.*

BY GÜNTHER SCHULZE.

Summary.—The author gives an account of experiments upon tantalum electrodes as electrolytic rectifiers, and finds that they are formed more rapidly than aluminium; that the action takes place in all the electrolytes examined; that the valve action is extremely high, sometimes approaching 1,000 volts; and he gives an explanation of the valve action taking place in the rectifiers.

In almost all electrolytic cells used for the rectification of alternate currents the effective electrode is composed of aluminium. The investigation of such cells shows that an electric current deposits upon aluminium anodes immersed in various electrolytes a thin, firm and finely porous skin, and that in this skin, where it joins the aluminium, there is a dielectric gaseous layer, which supports a potential gradient of some 8 million volts per millimetre as long as the aluminium is anode, but a much smaller gradient when it is cathode.

Somewhat similar phenomena are the dielectric layers on "unpolarisable" electrodes, such as zinc amalgam in zinc sulphate and cadmium in cadmium sulphate, as also the passive states of iron and chromium. Magnesium is capable of resisting some 100 volts as anode, but requires careful handling and special electrolytes.

Siemens & Halske in 1904 patented the use of tantalum, niobium and vanadium instead of aluminium in electrolytic rectifiers. It is claimed that the electrodes are more rapidly formed and resist higher gradients. The present investigation deals specially with tantalum in this respect.

1. *Material and Experimental Arrangement.*—Three tantalum rods were supplied by Messrs. Siemens and Halske. The surface was polished, and the cross-section square, with rounded edges. Their average length was 8 cm., their sectional area 1·24 sq mm., their density 17·24, their conductivity $6{\cdot}1 \times 10^4$, and its temperature coefficient 0·0039. The rod under examination was introduced from below into a cylindrical glass vessel of 2·6 cm. internal diameter, and cemented with Chatterton compound, sealing wax, or (for high temperatures) a mixture of red-lead and linseed-oil varnish.

Chatterton compound was found the most suitable, being only attacked by phosphates. At higher voltages sealing wax was useless, since under the influence of the current the electrolyte oozed between the sealing wax and the tantalum. The rubber tube used successfully for aluminium electrodes could not be used on account of the smallness and square section of the tantalum rods.

The other electrode was a piece of platinum foil. The temperature was, as a rule, that of melting ice. The measurements included the current and voltage and the capacity of the dielectric gaseous layer by Maxwell-Thomson's absolute method with a rotating interrupter. The voltages were measured at the cell terminals, and differ only by a few volts from those at the dielectric layer.

2. *Aluminium Electrodes.*—It is useful, for purposes of orientation, to summarise the behaviour of aluminium anodes. The gaseous layer has a characteristic maximum thickness for each electrolyte. In some electrolytes this layer decreases in thickness very slowly after breaking the current, in others very rapidly There is a maximum loss of potential for each electrolyte, limited by the occurrence of spark discharges across the gaseous layer. As the current density increases, the loss of potential increases very rapidly in the gaseous layer to the maximum, after which it is nearly independent of the current density. On heating there is less increase of loss of potential with the current density, and the maximum is lowered as a rule.

The whole phenomenon can only occur where an insoluble aluminium compound is formed. It does not occur, therefore, in the aqueous solutions of bases, or of haloid acids and salts, &c. The sulphates are intermediate, since the $Al_2(OH)_6$ formed is not very soluble. The phenomenon is well marked in most compounds of Mn, Cr, P, As, Sb, C, and especially boron. The potential gradient in the gaseous layer is, however, independent of the electrolyte.

The fact of the thickness of the gaseous layer being independent of the electrostatic pressure points to the assumption that the gas is strongly condensed, like the gas absorbed by charcoal.

The maximum gradient in the gas in the effective direction is 8,000,000 volts per millimetre, and in the ineffective direction 100,000 volts per millimetre. This agrees with the potential gradient of spark discharges found by Earhardt and Hobbs at very small spark gaps. According to J. J. Thomson the electricity is in this case conveyed by the free negative electrons of the electrode metals. According to his calculations the gradient mentioned suffices for liberating negative electrons from metals. This applies to the case when the aluminium is a cathode. But when it is an anode, such a liberation of electrons is impossible, since the electrolyte contains no free electrons, but only electrolytic ions. These, on account of their very much greater mass, require a very much higher gradient for conduction than the electrons. Hence this may attain the enormous value of 8·2 million volts before spark discharge sets in.

3. *Tantalum Electrodes.* (*a*) *Formation.*—Valve electrodes are more quickly formed of tantalum than of aluminium. The final potential is attained after a few minutes.

(*b*) *Electrolytes.*—In contradistinction to aluminium, no electrolyte could be found which does not produce the valve action with tantalum. This may be chemically explained on the ground that tantalum is capable of forming insoluble compounds with nearly all substances, and these compounds provide the scaffolding for the gas layer. But hydrofluoric acid, and a mixture of that and nitric acid, in which tantalum is supposed to be soluble, were not examined. Most of the experiments made were qualitative, the tantalum rod being dipped into the electrolyte from above. But in many cases sparks crossed to the non-submerged part of the rod, and showed the tantalum spectrum, whereas sparks in the liquid only showed the spectrum of the electrolyte. The author gives maximum voltages for 40 electrolytes of various concentrations. They range from 70 volts in concentrated KHO and very dilute bichromate of potash to 620 in dilute sodium acetate and 650 in very dilute sodium or potassium carbonate. Most of the subsequent experiments were made with K_2CO_3, which enables the tantalum anode to withstand 800 volts under favourable circumstances.

(*c*) *Concentration of Electrolytes.*—With K_2CO_3 and NaOH the influence of the concentration of the electrolyte upon the "static characteristic"—*i.e.*, the relation between current density and voltage—was investigated by filling in electrolytes of different concentrations without disturbing the electrodes. At small concentrations the current, after the maximum voltage is attained, passes in numerous small sparks with slight crepitation, the sparks covering the whole surface of the tantalum. The higher the concentration the less is the number of sparks and the greater their size and noise. At great concentrations there is, as a rule, only one spark, which tends to fix itself in one place. This behaviour of the sparks is explained by the fact that at the instant of discharge the whole quantity of electricity rushes to the spot where the spark is passing. The less the concentration the less is the amount of electricity supplied to the spark, and the sooner it is extinguished. But this does not explain the great change in the maximum voltage, or the maximum thickness of the gaseous layer as depending upon the concentration. This is more probably due to a change in the firmness, solubility, and structure of the porous solid skin with the concentration.

(*d*) *Temperature.*—The aluminium rectifier suffers from the disadvantage that it becomes ineffective when heated. A similar effect was looked for in tantalum by heating 0 02 per cent. solutions of K_2CO_3 successively to 25, 50, 75, and 95deg., and cooling to the same steps. The only effect produced in tantalum is that the maximum voltage is only attained with a greater current. The maximum itself is barely perceptibly influenced. The remanent current is much smaller than that of aluminium in ammonium borate (the best electrolyte). It is just this current which produces most heating.

(*e*) *Interruptions.*—Though tantalum has an advantage over aluminium in the way of temperature, it has a disadvantage owing to the sensitiveness of the gaseous layer to interruptions. In aluminium the thickness of the gaseous layer in ammonium borate is so constant that no diminution could be discovered in the few minutes required for measuring the capacity. In tantalum such measurements are impossible, since the dielectric resistance of the gaseous layer rapidly deteriorates. This instability increases in general with the dilution and the maximum voltage. The capacities given in the following table were obtained by absolute measurements at 56~ and 130~ per second. From the difference

* Abstracted from the *Annalen der Physik.*, No. 7, 1907.

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of the capacities of the two periods the resistance given in the table and the corresponding pure capacity were calculated. The table shows, for both cases, a rapid diminution of the resistance after interruption. The capacity increases quickly at first, and then more slowly, and appears to approach a final value.

0·1 *per cent.* K_2CO_3, *formed at* 300 *volts.*

Time since break.	Capacity of gas layer. Mfd.	Resistance of gas layer. Megohms.	Thickness of gas layer if $\epsilon = 1\mu\mu$.
0	0·0670	0·817	29·6
10 seconds	0·0745	0·570	26·7
20 ,, ...	0·0770	0·380	25·8
30 ,, ...	0·0780	0·280	25·5
2 minutes.....	0·0850	0·133	23·4
4 ,, ...	0·0950	0·108	20·9
6 ,, ...	0·1070	0·100	18·6
8 ,, ...	0·1220	0·098	16·3

0·025 *per cent.* K_2CO_3, *formed at* 700 *volts.*

0.....	0·0318	1·0	62·6
10 seconds	0·0320	0·86	62·2
20 ,, ...	0·0321	0·76	62·0
30 ,, ...	0·0323	0·67	61·6
2 minutes.....	0·0385	0·29	51·7
3 ,, ...	0·0513	0·20	38·8
20 hours.....	0·1330	0·032	15·0
40 ,, ...	0·1650	0·040	12·0

(*f*) *Properties of the Solid Skin.*—The solid layer increases continuously with the quantity of electricity transmitted, as may be seen by the interference colours of the deposit. Thus, under 160 volts, the polished tantalum assumed after a while a violet hue, which subsequently turned blue, green, and all the colours of Newton's rings in succession. The thickness of the gas layer remained constant at 18$\mu\mu$ (the dielectric constant ϵ being supposed $=1$). The solid skin has a very small resistance, and this accounts for the fact, discovered by Corbino, that prolonged action does not affect the valve effect.

(*g*) *Properties of the Gaseous Layer.*—On account of the rapid decay of the solid layer the capacity had to be measured by an almost instantaneous null method. This was done at a high potential for various frequencies. A decided difference in the behaviour of aluminium and tantalum appears in the matter of the thickness of the gaseous layer. In aluminium the thickness increases more rapidly than the voltage, in tantalum less rapidly. At the higher voltages the gradient is therefore less in aluminium but greater in tantalum. The thickness increases very slowly in the case of tantalum.

The author summarises his conclusions as follows :—

1. Tantalum electrodes are formed more rapidly than aluminium electrodes.
2. They show valve action in all electrolytes examined.
3. The highest valve action may be obtained in the carbonates of the alkalies, sometimes approaching 1,000 volts.
4. In all electrolytes, the effectiveness is greatly reduced by concentration.
5. The deleterious effect of breaks is greater in tantalum than in aluminium.
6. The deleterious effect of heat is much lower in tantalum.
7. The relation between thickness of the gaseous layer and voltage resisted is different in tantalum and in aluminium, supposing the layers to have the same dielectric constant in both.
8. There is no satisfactory agreement between the potential gradient near an (ineffective) tantalum cathode and the gradient deduced from sparks between electrodes very close together.
9. Disruptive observations made with mercury in place of the electrolyte give the same results as in the case of aluminium.
10. The valve action is also great in vanadium and niobium, as well as aluminium and magnesium, but occurs in other metals also under favourable conditions.

Improvements in the Control of Electric Cars.—Mr. S. C. Wyckoff, in a letter to the *Scientific American*, suggests that inventors should apply their brains to perfecting a "short-stop" for electric cars. Pressure by the motorman's foot ought simultaneously to set the air brakes on the wheels of one truck, send a reversing current into the motor on the other truck, sand the tracks, and pull back the lever of the controller to "off." Raising the foot ought to cut off the reverse; lifting a lever ought to release brakes. This leaves the car ready to start again.

STANDARD CELLS.*

BY K. E. GUTHE AND C. L. VON ENDE.

Summary.—The authors give results of experiments on both Clark and Cadmium cells, having regard to the materials used in construction. Good agreement was obtained whether the mercurous sulphate and amalgam were prepared electrolytically or otherwise, and whether the cadmium sulphate crystals were clear or cloudy.

1. According to recent investigations, electrolytically-prepared mercurous sulphate seems to be superior to chemically-prepared sulphate as the depolariser in standard cells,† and the first results of a series of observations on cadmium cells‡ containing this substance showed for a period covering several months a remarkable agreement in their E.M.Fs. For this reason one of the authors made use of Clark and cadmium cells with electrolytic mercurous sulphate for the determination of the E.M.Fs. of standard cells by absolute measurement.§

These cells have been transported from Washington to Iowa City, being carefully protected against mechanical disturbances. During the past winter, however, they stood for some weeks in diffused light, and were exposed for a few days to large temperature variations. A comparison of the cells after this time showed that the E.M.F. of the cadmium cells had decreased relatively with respect to that of the Clark cells, but accurate measurements could not be made at that time on account of lack of sufficiently sensitive instruments. The comparisons reported on in this Paper were made with a calibrated Wolff potentiometer and a galvanometer allowing with certainty a reading to the fifth decimal place.

The cells were placed in a thermostat whose temperature could be kept constant at 25°C. within 0·02 deg. The temperature was measured by means of a thermometer subdivided into fiftieths of a degree and calibrated at the Bureau of Standards. Table I. shows the relative change of the E.M.F.s of the cells in the interval of a year. The R series are Clark cells with electrolytic mercurous sulphate, C_3 and K_{10} cadmium cells with chemically prepared sulphate and the rest cadmium cells with the electrolytic material. More detailed information as to the construction of these cells may be found in the *Bulletin* of the Bureau of Standards, Vol. II., p. 60. Some of the cells have been set up by Prof. Carhart, some by Prof. Hulett. As reference value in the following table the E.M.F. of the Clark cell as determined by absolute measurement was chosen—namely, 1·42040 volts at 25°C.

Table I.—*Old Cells.*

—	Date of construction.	Sept. 17, 1905.	Oct. 15, 1906.	Nov. 28, 1906.	Jan. 12, 1907.
R_2	May, 1904	1·42040	1·42040	1·42040	1·42040
R_4		40	40	40	41
C_3	Nov., 1903	1·01857	1·01842	1·01844	1·01842
E_2	Jan., 1904	31	04	01	1789
F_8	Feb., 1904	27	19	22	1822
F_9		28	08	07	1799
K_6	July, 1904	33	24	25	1826
K_{10}		33	11	12	02
O_1	Feb., 1905.	33	23	23	24
O_2		33	19	22	21

The change in most of the cadmium cells amounts to about 0·0001 volt. Since the potentiometer was carefully calibrated and the thermometer correction known, this change is larger than the possible error in the apparatus. The relative values of F_8, K_6, O_1 and O_2 have remained about the same as last year, but for the others the decrease has been larger and quite irregular.

2. To decide whether a change had taken place in the Clark cells chosen as reference standards it became necessary to construct new standard cells. At the same time we wished to ascertain how closely such cells would agree in E.M.F. if constructed by different observers, and with material from different sources. No such comparative investigation has yet been published so far as we know.

Prof. Hulett kindly sent us some of his electrolytic mercurous sulphate and we prepared two different lots, following closely the method published by him. We shall designate these two as lot 1 and 2 respectively. The sulphate was made from pure mercury in an acid prepared by mixing one part of concentrated sulphuric acid of specific gravity 1·84 with six times its volume of distilled water. The current density was between 2 and 3 amperes per 100 sq. cm. The first lot consisted of very fine crystals; the second was stirred longer after the breaking of the current and was, therefore, coarser.

* From the *Physical Review.*

† Wolff, *Trans.* Amer. Electroch. Soc., 5, 49, 1904. Carhart and Hulett, *ibid.*, 5, 59, 1904. Hulett, *Zeitschr. f. physik., Chem.*, 49, 483, 1904; *Phys. Rev.*, 22, 321, 1906. Compare also Reichsanstalt, *Zeitschr. f. Instr. Kunde*, 26, 120, 1906.

‡ Carhart, *Trans.* Internat. Electr. Congr., St. Louis, Vol. II. 125, 1904

§ Guthe, *Bull.* Bur. Standards, Vol. II., 33, 1906.

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Table II.—*Clark Cells.*

—	Date of construction.	Oct. 14, 1906.	Oct. 20, 1906.	Oct. 26, 1906.	Nov. 6, 1906.	Nov. 20, 1906.	Dec. 5, 1906.	Dec. 24, 1906.	Jan. 17, 1907.
a_1	Oct. 13, 1906	1·42025	1·42029	1·42037	1·42041	1·42043	1·42044	1·42045	1·42045
a_2		..	...	..	40	43	44	45	45
a_3		24	30	38	42	43	45	44	45
b_1	Oct. 19, 1906	..	38	39	38	38	38	38	..
b_2		..	37	40	39	38	38	38	38
b_3		..	37	39	38	38	37	38	38

Table III.—*Clark Cells.*

—	Date of construction.	Oct. 14, 1906.	Oct. 18, 1906.	Oct. 20, 1906.	Oct. 26, 1906.	Nov. 6, 1906.	Nov. 23, 1906.	Dec. 5, 1906.	Dec. 24, 1906.	Jan. 19, 1907.
a_4	Oct. 13, 1906	1·41968	1·41992	1·41992	1·41994	1·41982	1·41980	1·41981	1·41980	1·41982
a_5		80	1·42004	1·42003	99	80	80	81	81	80
a_6		87	06	05	1·42005	93	91	91	91	91
b_4	Oct. 19, 1906	..	..	1·42056	1·42057	1·42056	1·42053	1·42054	1·42055	1·42054
b_5		..	..	56	57	56	53	54	54	54

Table IV.—*Cadmium Cells.*

—	Date of construction.	Nov. 3, '06.	Nov. 6, '06.	Nov. 10, '06.	Nov. 12, '06.	Nov. 17, '06.	Nov. 23, '06.	Nov. 28, '06.	Dec. 5, '06.	Dec. 13, '06.	Jan. 19, '07.
c_1	Nov. 2, 1906	1·01840	1·01838	1·01836	1·01835	1·01835	1·01834	1·01833	1·01831	1·01829	..
c_2		38	36	35	34	35	35	34	32	30	1·01829
c_3		39	37	36	33	33	32	32	31	28	28
d_1	Nov. 9, 1906	..	..	1·01842	1·01840	0·01834	1·01827	1·01823	1·01815	1·01811	1·01805
d_2		..	..	42	42	37	33	31	24	19	13
d_3		..	..	46	40	28	19	14	10	06	03
d_4		..	..	47	45	35	24	19	11	07	02

The sulphate was filtered in a Gooch crucible and after the acid had been thoroughly drained off, was washed repeatedly with alcohol and saturated zinc or cadmium sulphate solution. We found it necessary to be very careful in washing, especially with the finest crystals. After the last washing with the salt solution the top layer was removed and the paste prepared in the usual manner.

The mercury was either distilled by Hulett's method* or distilled twice in vacuo in an ordinary mercury still.

The zinc amalgam was prepared in the usual way by dissolving zinc in mercury. In some of the cadmium cells we used an amalgam prepared electrolytically.

Clark Cells.

3. Two series were set up, the a and b series. In the a series the zinc amalgam contained 9 per cent. of zinc. Our mercurous sulphate No. 1 was used in the a series. In the b series the amalgam contained 10 per cent. of zinc, and Hulett's mercurous sulphate was used. Mercury distilled by Hulett's method was used in cells a_1, a_2, b_1 and b_2, the other mercury in a_3 and b_3. The zinc sulphate crystals were recrystallised from a neutralised solution of Schuchardt's chemically-pure sulphate and the solution in the cells made from these crystals.

In Table II. the E.M.Fs. as determined on different days are tabulated. The values for the cells with the very fine mercurous sulphate were at first somewhat low, but increased rather suddenly between the ninth and fourteenth day, then slower until they reached little higher value, but still agreeing well with that of the old Clark cells. The b cells, the mercurous sulphate of which had not been as difficult to wash, had immediately after construction a value agreeing within 0·00008 volt with that of the old cells and have remained constant ever since.

The great difference in the size of the mercurous sulphate crystals had apparently no great influence upon the final value of the E.M.F.; the two different samples of mercury behaved exactly alike electrolytically.

We also prepared some cells in which the directions were not followed very closely. In a_4, a_5 and a_6 the mercurous sulphate (Hulett's) was not thoroughly freed from alcohol, which produced a lowering of the E.M.F. by over 0·00040 volt without an appreciable change in course of time. Cells b_4 and b_5 were prepared with our mercurous sulphate No. 1, thoroughly washed, but it was mixed with about the same bulk of zinc sulphate crystals, and the paste made very thin. These cells had from the start an E.M.F. 0·00015 volt higher than the normal value and remained perfectly constant.

It is apparent that the treatment of the mercurous sulphate plays a much more important rôle than the sulphate in itself: a_1, a_2 and a_3, as well as b_4 and b_5, were made with our sulphate, but the former cells show quite a different behaviour from that of the latter; the same is true of the cells in which Hulett's sulphate was used.

After a few weeks a_3, a_4 and a_5, as well as b_4 and b_5, were placed for three hours on a circuit of 1,000 ohms external resistance, November 4th and November 23rd respectively. It was hoped that, if free acid had been present, this treatment would change the E.M.F. After opening the circuit the E.M.F. had dropped about 0·00040 volt, but it returned in about two hours to about its original value and remained constant after that.

* Hulett and Minchin, *Phys. Rev.* 21, 388, 1905.

Cadmium Cells.

4. The cadmium sulphate crystals were obtained from three different solutions; of these A was made from Merck's pure cadmium sulphate, B from Baker's chemically-pure material and C from mixed turbid crystals picked out from either A or B. In the c series lot 2 of our electrolytic mercurous sulphate washed with alcohol and saturated cadmium sulphate solution (made from selected clear crystals) was used. The amalgam contained 12·5 per cent. cadmium, and was made by dissolving Kahlbaum's cadmium (käufflich) in warm mercury.

Since it is rather troublesome to obtain a sufficient number of perfectly clear crystals from a small bulk of cadmium sulphate solution, we used also somewhat turbid crystals. The crystals in c_1 were selected large clear crystals from solution C, in c_2 small selected, somewhat turbid crystals from solution B, and in c_3 large selected crystals, somewhat cloudy, from A and C.

In the d series Hulett's mercurous sulphate was used, treated the same way as ours in the c series. In d_1 and d_2 selected clear crystals were used from solution C, in d_3 and d_4 small crystals which had been formed at the bottom of the crystallising dish from solution A and which were washed a few times with distilled water, after the mother liquor had been filtered off. No attempt was made to select the crystals for these cells. The solution in the cells was always made from the crystals used in filling. d_1 and d_3 contain the same amalgam as the c cells, d_2 and d_4 electrolytically prepared amalgam.

Table IV. shows that the cadmium cells c gave at first a value for the electromotive force of nearly 1·01840 volt, which dropped, however, within a few days by about 0·0001 volt, and remained fairly constant after that. The drop in the d cells is, however, considerably larger than in the c cells, and especially pronounced in d_3 and d_4. The different methods of preparing the amalgam does not seem to have an effect upon the E.M.F.*

5. In a general way this investigation corroborates Hulett's recently published results,† that Clark cells containing electrolytic mercurous sulphate when set up with proper precautions will have an E.M.F. of 1·42040 volts at 25 deg. C. within a few one-hundred thousandths of a volt and remain constant in course of time. The cadmium cells show immediately after the setting up of an E.M.F. of 1·0184 volts, closely agreeing with the value given by Hulett.

There is, however, one notable difference. Hulett's A cells, set up October 21, 1905, have an E.M.F. of 1·01843 volts and

* Towards the end of December, 1906, we exchanged Clark cell b_1 and cadmium cell c_1 for a Clark and cadmium cell constructed by Dr. Wolff at the Bureau of Standards. Wolff's Clark cell has an E.M.F. 0·00006 volt lower, and his cadmium cell an E.M.F. 0·00003 volt lower than ours of the same type. Dr. Wolff writes that he has found practically the same difference in his comparisons at the Bureau, which shows that the cells have not been affected by transportation.

† Hulett, *Phys. Rev.*, 23, 166, 1906.

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have kept this value for at least six months, later results not having been published. His old cells (F series) are now about 0 00011 volt lower. Hulett, therefore, drew the conclusion that in the course of time the E.M.F. slowly decreases, and described a number of very interesting experiments which seem to show that the system in the cathode leg of the cells is not in equilibrium. But the F cells, though originally of the same high value, decreased to their present low value within a week, and have remained, with one exception, constant since then. A similar rapid decrease is noticeable in the J and K cells on which Prof. Carhart* has reported. Hulett explains this difference in behaviour by a difference in the depth of the paste. We have made the paste in the cells over 2 cm. deep, but, nevertheless, the initial decrease is rapid. This difference in the behaviour of Hulett's and our cells can hardly be due to the mercurous sulphate, and we are at a loss to explain it, unless it is to be found in the unstable equilibrium between the cadmium sulphate solution and the rest of the material at the cathode, or in a difference in the method of construction of which we are not aware. Our results do not extend over a sufficiently long period to decide the question whether or not there will be a continuous slow decrease of the E.M.F. in course of time.

After the satisfactory results obtained with the Clark cells the apparent difficulty for different observers to set up cadmium cells, which remain constant from the start and are practically identical in their electrical behaviour, seems to indicate that there is still some factor of uncertainty in the method of construction for the latter and this demands further investigation.

The large changes in the E.M.F.s of the old cadmium cells mentioned above, are, possibly, not due to a continuous gradual decrease in course of time but to sudden changes brought about by the severe treatment to which they were subjected. It is, however, very gratifying to know that the causes for such changes have had no influence whatever upon the E.M.F. of the Clark cells, since the latter agree so closely with the newly prepared cells.

CONCLUSIONS.

1. The E.M.F.s of standard cells set up with electrolytic mercurous sulphate by different observers and from different sources agree under otherwise perfectly equal conditions within a few one hundred-thousandths of a volt.

2. Mercury twice distilled in an ordinary vacuum still gives the same results as mercury distilled by Hulett's method.

3. Amalgam prepared in the usual way gives the same results as electrolytic amalgam.

4. Clear and cloudy cadmium sulphate crystals produce no difference in the electromotive force of the cadmium cells.

5. Clark cells with electrolytic, coarsely grained mercurous sulphate have immediately after construction an E.M.F. of 1·4204 volts at 25°C., within a few one hundred-thousandths of a volt and remain constant in course of time.

6. We have been unable to construct cadmium cells which do not show an identical decrease in E.M.F.

* Carhart, l. c.

TRAIN LIGHTING.†

BY H. HENDERSON.

Summary.—In this Paper the author deals with the important question of the lighting of railway carriages by electricity. After giving particulars as to the cost of equipment and maintenance he proceeds to describe the various systems which have been proposed and, in a few cases, adopted.

† Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers.

The lighting of railway carriages has recently been very much under discussion owing to remarks made concerning fires in accidents presumably caused through the gas used for lighting the carriages. In two recent cases—viz., Catesby Tunnel, on the Great Central Railway, and Grantham—the Board of Trade inspector called special attention to the serious danger from the gas becoming ignited and assisting any fire which may have been started. He then brought up the question of electric lighting, considering this quite safe in such cases. It is on account of this prominence that the Paper is put forward, and without doubt the lighting of carriages by electricity is, at the present time, receiving more consideration than in the past. To within the last two years or so only one system of self-contained carriage lighting was much used on British railways—viz., Messrs. Stone's, of Deptford. Now, however, there are in use and under trial about nine systems.

The essential points necessary in carriage lighting by electricity are: (1) Each carriage must be independent (except in the case of "block" trains, where carriages are grouped to one unit). Such carriages, with their own lighting plant, can travel on any line, no matter how far it may be from a central point, and their lighting will always be available. (2) Lighting must be continuous, thus necessitating the use of storage batteries. (3) Voltage at the lamps must be constant for all speeds of the dynamo. (4) Current must always leave dynamo in one direction, irrespective of direction of rotation. (5) Dynamo must be totally enclosed to protect it from water and dust.

Nos. 1 and 2 are accomplished by giving each carriage, or group of vehicles, a complete outfit of dynamo, batteries and the necessary automatic switch gear. No. 3 is the most important part of the whole arrangement. In the oldest system of self-contained lighting this is obtained by mechanical means, but in the later systems the arrangements are all electrical. No. 4 is necessary, owing to the use of the batteries, and is carried out usually by revolving the brush gear or by working a change-over switch by centrifugal governors, which at the high speeds do not operate. The standard voltage is 24, but voltages of 16, 30 and 50 are also in use. The low voltage has been chosen on account of the vibration affecting the lamp filaments.

For the maintenance of lighting, batteries are combined in either single or double systems. The former is chiefly used on coaches where all or half the lights are required together, the lamps being wired on two circuits, so that half the lights may be used if desired. Since the batteries must be charged up to nearly their full voltage, it follows that, when the dynamo is supplying lamps and charging at the same time, a resistance must be inserted in the lamp circuit to reduce the voltage. As either half or full lights are always on, the value of the resistance can be accurately calculated and set. All the systems use lamp resistances. This arrangement is satisfactory so long as all or half lights are required. If, however, individual lighting is required, as in sleeping or dining carriages. recourse must be had to double batteries, one battery receiving a charge whilst the other floats on the lamps. The latter battery is connected to the main voltage through a resistance which prevents it receiving a charge, and some systems discharge this battery to the lamps in addition to the dynamo current. If a double battery is not used on such carriages, then each lamp or group of lamps requiring to be switched must have a resistance inserted when the dynamo is running, the resistance being cut out when the battery is in use.

It is commonly assumed that no extra coal is used in running a train fitted with self-contained electric lighting sets. This matter, however, can hardly be ignored in working out the cost of the different systems. Sir William Preece had said he was of opinion that the power generated cannot be less than twice that consumed in the lamps—that is, the total efficiency is about 50 per cent. Taking an eight-compartment coach with two 10 c.p. 30 watt lamps in each compartment, the power required is 480 watts, or about 0·64 H.P., giving 1·28 H.P. at the carriage axle if 50 per cent. efficiency is taken. The coal required on such trains usually averages about 2 lb. per horse-power per hour, and for 1,600 hours, at 8s. 6d. per ton for coal, the cost would work out at 15s. 6½d. Also the cost of hauling the additional weight of the electrical over the gas equipment—viz., about 10 cwt. per vehicle—would be about 5s. The cost for maintenance of the apparatus varies with different companies—from £4 to as much as £15, while the average is about £7 to £9. The higher prices are due entirely to the comparatively small percentage of electrically-lighted stock on some of the railways. One firm, however—viz., Messrs. Vickers & Maxim—offer to maintain completely 50 coaches or over at the rate of £3. 19s. 6d. per annum per coach. Taking this figure the annual cost would work out at :—

Electric Lighting.			
Interest at 4 per cent. on capital cost	£6	0	0
Annual cost of maintenance	3	19	6
Estimated cost of fuel	1	0	6½
	£11	0	0½
Ordinary Gas Lighting.			
Interest at 4 per cent. on capital cost	1	18	2
20,900 cubic ft. of oil gas at 13s. 7d. per 1,000 ft., including cost of cleaning, lighting and repairs, and also capital cost on gasworks, mains, &c.	14	3	10
	£16	2	0
Incandescent Gas Lighting.			
Interest at 4 per cent. on capital cost	2	16	0
7,000 cubic ft. of oil gas at 13s. 7d. per 1,000 ft., including cost of cleaning, lighting and repairs, and also capital cost on gasworks, pipes, &c.	4	15	1
Cost of mantles at 6d. each (six per 1,000 ft.)	1	1	0
	£8	12	1

In spite of this difference in the cost, electric lighting has great advantages, as a magnetic switch, called a distance switch, can be made to operate from a switch in the guard's van, so that all or half the lights can be put on for use in tunnels and cut off when running in the open. Thus a considerable saving can be effected, since gas would require to burn continuously, and also no time is lost in filling up gas reservoirs, or cleaning the gas globes. With all the systems now in use cheaper capital costs must follow, and for a new

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railway electrically-lighted vehicles should be run as cheaply as by gas. The author first describes a system designed by Mr. J. H. Holmes in 1889 and tried on the Midland Railway. The following more modern systems were then described;—

STONE'S SYSTEM.

This is the pioneer system of self-contained carriage lighting sets, and was first tried on the Great Northern Railway (Ireland) in September, 1895, and on the London, Tilbury & Southend Railway in November, 1895, the latter railway having used it from that date for all its carriages. This is the only system in which mechanical methods are used for the regulation of the voltage at various speeds above a predetermined value. The dynamo is specially hung, as shown in Fig. 1. It is attached by a loose hinge to an adjustable link, and is thus free to swing towards, or away from, the driving pulley on the axle. The suspending link and belt are adjusted so that the belt draws the dynamo out of the position in which it would naturally hang, thus putting a definite tension on the belt just sufficient to absorb power equivalent to the electrical power required. Thus, when the pull on the belt (owing to the increase in the speed) exceeds the weight on the belt due to the one-sided suspension of the dynamo, the latter will automatically be

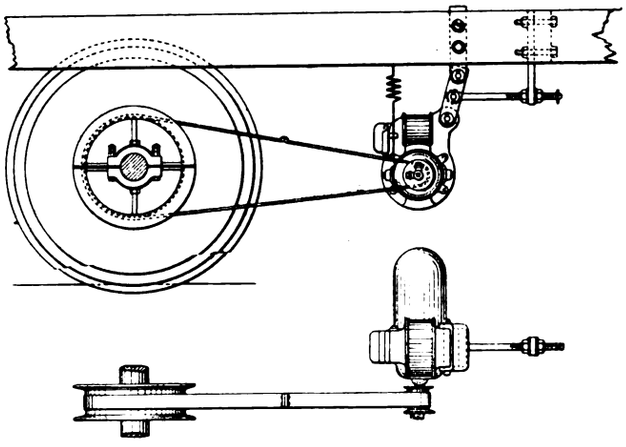

FIG. 1.—METHOD OF SUSPENDING DYNAMO.

drawn towards the driving pulley on the axle, thus allowing the belt to slip, whilst the armature will continue to revolve at its normal speed. The belt tension can be regulated to suit requirements by means of a tension screw. This system uses two batteries, and the switching is so arranged that one battery serves to regulate the voltage at the lamp terminals, whilst the other receives a small charge. When the coach runs in the opposite direction the connections of the batteries are automatically reversed, and the battery last charged becomes the regulating battery and the other one receives the charge. A resistance is also used in series with the lamps. If the train has very long runs in one direction during daylight, the main switch has two extra contacts, so that when the lamps are off the resistance is short-circuited, the current generated being then equally divided between the two batteries. The automatic switches, by means of which the above-mentioned operations are carried out, are attached to a switchboard at the commutator end of the dynamo. The main movable contacts are attached to a rocking arm, which is carried round in the direction of rotation as far as certain stops

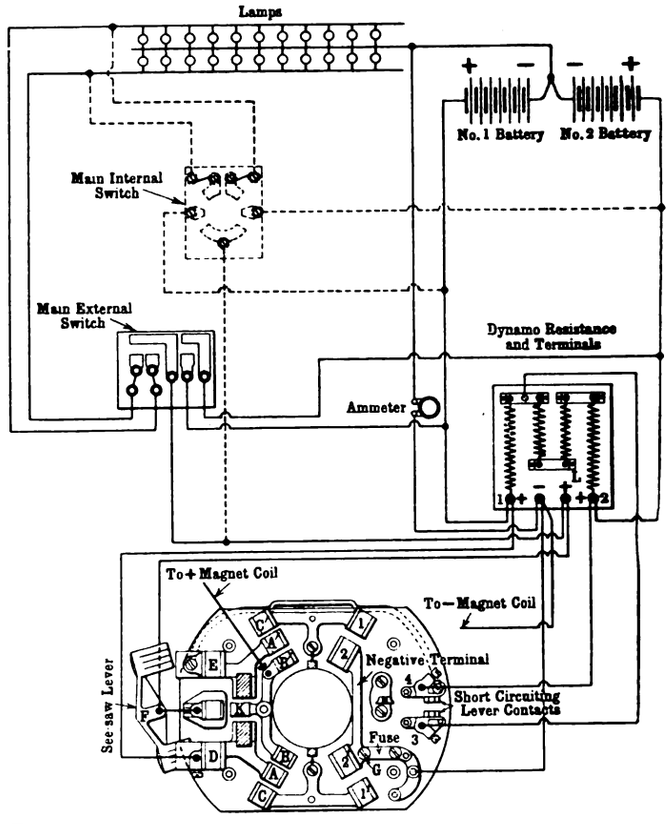

FIG. 2.—DIAGRAM OF CONNECTIONS FOR "A," "B," "C," "AR" AND "CR" DYNAMOS.

will allow, and changes over a see-saw switch. The rocking arm is connected to a centrifugal governor which operates a knife switch for opening and closing the circuits. This motion also operates a carbon break in the field circuit which saves the contacts on the rocking arm from arcing when the switch is withdrawn by the governor. Fig. 2 shows the actual connections from the switchboard. Supposing the dynamo is running in the direction of the hands of a watch looking at the governor end, the rocking arm will be turned to the right and face contacts C, A and B and 2 and 1. As the speed increases, the rocking arm contacts will close A (against one side of which it is in contact) to B, thereby exciting the field, from No. 1 battery. If the lamp voltage is 24 then, when the dynamo is generating 24 volts, the governors are adjusted to complete the contacts, and C is now joined to A and B and No. 2 to

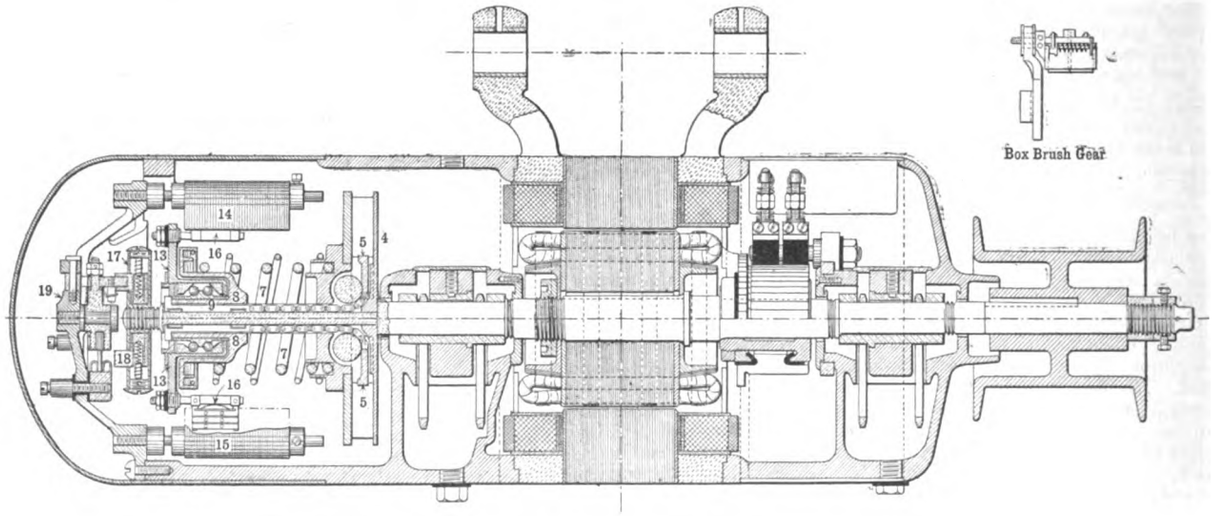

FIG. 3.—WORKING DIAGRAM, SHOWING GENERAL ARRANGEMENT OF DYNAMO.

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No. 1, at the same time opening contacts 3 and 4, and connecting the see-saw switch to E. Current will now pass from bottom brush through C to A and B. From B it passes round the magnet circuit. From A it passes to D, and on to terminal marked +1 on the resistance terminal board; thence to the positive of No. 1 battery, and, if the lamps are off, part will go through the resistance to No. 2 battery, returning through the common negative to "—" terminal on resistance board and back contacts 2 and 1 to top brush. When the dynamo runs in the opposite direction, the rocking arm will be carried over and connected to the other set of contacts. The friction gear for turning the rocking arm is very ingenious. It consists of two plungers, which press lignum vitæ blocks on the back end of the rocking arm, which is in the form of a channelled ring. These blocks are pressed on to the ring by springs, gripping it and carrying it round against the stops. As the speed increases the plungers fly out and clear the ring, and thus there is no friction during the higher speeds.

Vickers-Hall System.

This system depends entirely upon electrical methods of voltage regulation, and is made for single or double battery working. In the double-battery system the batteries are alternately changed each time the dynamo stops, instead of (as in the Stone's system) each time the dynamo is reversed. The voltage generated at the various speeds above the predetermined amount is regulated by using a series winding, wound inversely with the shunt winding, so that the field is weakened as the current increases. The dynamo for both systems is hung in a horizontal position on links and a tension spring keeps the belt tight, and at the same time allows for the motion of the bogie when fitted to such coaches.

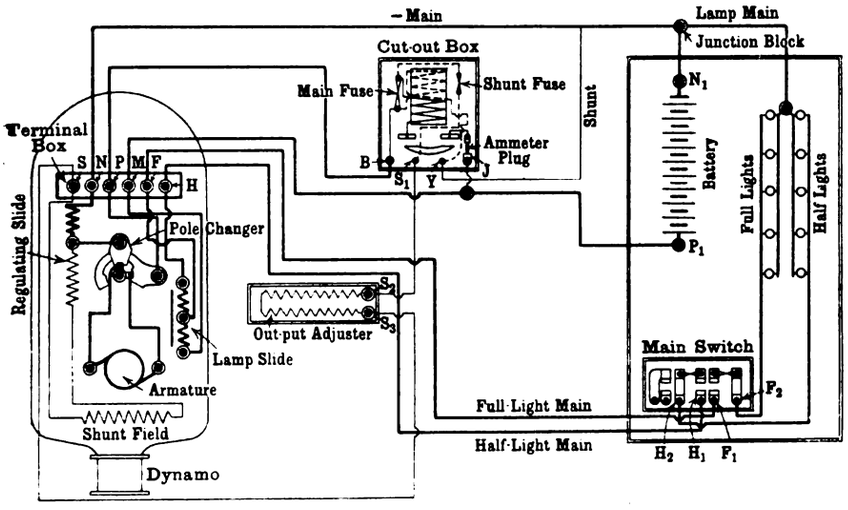

Fig. 4.—Diagram of Connections. Single Battery System.

Single-battery System.—The dynamo is four-pole compound-wound and carries at one end the automatic regulating gear, as shown on Fig. 3. The pole-changing switch is also carried at the end of this gear, and by its means current is always supplied in the same direction. The regulating mechanism is composed of the following parts: The governor consisting of a disc, 4, containing two radial slots placed diametrically opposite. In these slots slide two weights, 5, connected by chains passing over rollers to an arrangement called the spring box, 8, which slides along the shaft, and is held away from the governor disc by springs, 7. The spring box is attached to a tube, which slides with it, and forms the cone of a ball bearing, 9. The cups of the ball race are fixed in an aluminium cup, 13, having two arms, which carry the brushes, 16, of two resistances, called the lamp and regulating slides. The regulating slide, 14, consists of a number of contacts, part of which are connected to the series windng and the remainder to the shunt regulating resistances. The sliding brush moved by the governor is so designed that when the dynamo is at rest both the compound coils and the shunt resistances are short-circuited. As the speed increases, first the compound coils are thrown into circuit, and then the shunt resistance is inserted step by step. By this means the output of the dynamo is kept constant over the whole range of speeds. The lamp resistance, 15, is so connected to the main switch that when the lamps are in use current passes through all the resistance if half lights are on, and through part of it if all lights are on. The resistance is composed of similar units to the regulating slide, so that when the dynamo is at rest all the resistance is short-circuited, but as the speed increases the brush is gradually drawn out, thus cutting in the resistances until, when the full output is reached, all the resistance is in circuit. The current is kept in a constant direction in the outside circuit by a change-over switch, 19, consisting of two insulated moving blades and three fixed contacts, the two outer ones being connected together, the whole forming a reversing switch. The blades are connected to the brushes and the contacts to the external circuits. The switch is forced over one way or the other, according to the direction of rotation, by means of a pole-changer actuator, 17. This consists of a body containing two radial guides, and revolving with the shaft. In the guides slide two weights, 18, controlled by springs, and held near the shaft when at rest. When the dynamo starts they strike a trigger connected to the switch, forcing it into its proper position, and as soon as speed is reached the weights fly out by centrifugal force and clear the trigger. An automatic switch or cut-out which controls the connections outside the dynamo is fixed inside the coach. It is controlled by a compound-wound electromagnet, the fine-wire winding being directly across the dynamo terminals, and the series winding carrying the dynamo current. A controlling spring is provided, so that the switch does not close until the dynamo voltage is 6 volts above that required for the lamps. The shunt current now closes the switch, and the series winding reinforces it, and makes a firm contact. When the voltage of the dynamo falls below that of the cells, the cells send a reverse current round the series coil, and so demagnetise the core and open the switch. The main and shunt fuses are also contained in this box.

The connections for the single-battery system are shown in Fig. 4. When the dynamo is at rest the cut-out remains open cutting out the dynamo from the rest of the circuit. If lights are required, current will pass from the battery through P_1 to M, through the slide (short-circuited) to F and H, and on to the main switch, F_1 and H_1, to F_2 and H_2, through the lamps to N_1 on the battery. When the dynamo commences to run, current will pass through the reversing switch to P and on to B on the cut-out. From B current passes round the shunt winding of the cut-out and direct to N on the dynamo. It also passes through the main fuse to the shunt (dynamo) fuse to S_1, through the output adjuster to S, through the winding and regulating slide back to the reversing switch. When the voltage has risen to the required amount, as mentioned above, the cut-out closes, and current will now pass from the dynamo terminal P to B on the cut-out, through the main fuse, series winding of cut-out, through the switch to J. It then divides, part going direct to the battery and the remainder to the lamps, if in use, through M to F_1 (if full lights are on) or H_1 (if half lights are on) and then through the switch to the lamps. This time the lamp slide will not be short-circuited, and the resistance will be thrown into the lamp circuit.

(To be concluded.)

ON SOME EXPERIMENTS ON THE MAGNETIC CHARACTER OF VESSELS.*

BY CAPT. W. BARTLING, I.N.R.

I.—The Development of the Magnetic Character of a Steel Ship.

During the construction of the steamer "Thueringen" at the works of the Weser Shipbuilding Co., Bremen, the writer had the opportunity of taking a number of observations with a view to obtaining actual quantitative measurements of the effect of various influences on the standard compass. The observations were taken with three instruments: a deviation magnetometer, a specially constructed swinging system of magnets, and an instrument to measure the power of inclination. The results of the experiments show very clearly the typical development of the ship's magnetism; the writer considers this may be of some interest to shipbuilders and navigators.

As a basis, let us refer to the well-known elementary magnetic experiment. A bar of iron hanging in the magnetic N. and S. direction, and, given the proper inclination for the latitude (say about 68°), will become magnetic after a certain time; reversed it will lose the magnetic power again; but if the bar be hammered while in its first position it will retain this magnetic power even if reversed, but will lose the power on being hammered again in the reversed position. Considering a ship as a great magnet, we

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders. Slightly abbreviated.

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applied the aforesaid theory to the above-mentioned steamer, only the magnetic axis was not parallel with the keel.

The "Thueringen" is a cargo steamer of 131 metres long, 16 metres beam and 10 metres depth. The direction of the building berth whereon she was built is S. 53·3°E. The circumstances were very favourable from the experimental point of view. Owing to a strike of riveters the whole ship was completely plated and all bulkheads and decks built in, while only about 5 per cent. of the riveting was finished (exclusive of the double bottom). The first experiment was made 10 weeks after the double bottom was built and riveted.

(1, Fig. 1.) The first measurement showed 25 per cent. to be the polaric power of the ship, the direction was nearly opposite to the horizontal-magnetic power of the earth. The vertical power was increased by 33 per cent. of the vertical-magnetic power of the earth.

(2, Fig. 1.) A month later about 40 per cent. of the riveting was completed and the process of induction had considerably advanced to about 34 per cent.

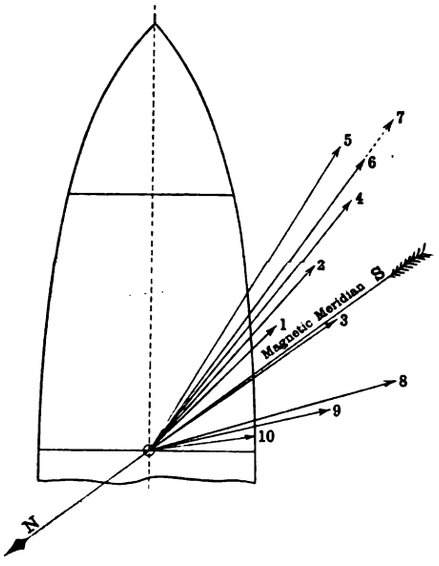

FIG. 1.

1. Ship's polaric magnetic power = 25 per cent. of earth power.
7. " " " = 57 per cent. "
10. " " " = 15 per cent. "
Deviation of standard compass after trial-trip without compensating magnets – N = +5°, E = +7°.
Steamer's head on the building berth, S. 53·3° E.
Steamer's head after launch, N. 31·3° W. (turned round).
1 shows the polaric magnetic power 75 days before launch, generally increasing till just before launch, 7.
8—10 shows the decreasing of P.M. power in 20 days.
The decrease from 2 to 3 is due to the putting on board of the flying bridge, which was built up independently alongside; evidently this structure has an opposite magnetic axis.
5—6 are taken on the same day, before and after the launch of the ship alongside. No influence P.M. power only on the deviation.

(3, Fig 1.) Again, a fortnight later, 60 per cent. of the riveting being finished, the induction was proportionally increased.

The steel structure of the flying bridge was built separately alongside of the ship, and was now lifted bodily into place by a couple of cranes; the measurements showed a decreasing influence as the result of this additional structure; a magnetic system in itself, it fortunately carried contrary poles; this is clearly shown in the figure.

(4, Fig. 1.) Again, 14 days later, 90 per cent. riveted, and induction increased to 45 per cent.

(5, Fig. 1.) Ten days later a small ship on the building berth alongside the "Thueringen" was to be launched, and to show the influence of the vessel the writer took measurements just before and just after the launch. The influence in the magnetic power was unexpectedly so small that it can be neglected, only the deviation of the magnet needle changed a few degrees, as shown in 6, Fig. 1.

Fourteen days later the "Thueringen" was ready for launching, and the ship was now a magnet of considerable power—namely, about 57 per cent. of the horizontal magnetic power of the earth. The vessel, after launching, was—please remember the first elementary magnetic experiment—swung and placed, as near as local conditions would permit, in the opposite direction—namely, N. 32° W. Before, while on the berth, it was S. 53° E. The success of this measure was perfect, the magnetic power decreasing from day to day, but considerably quicker than it had increased; after 20 days it was only 15 per cent. of the earth power. Compared with this turning of the vessel the addition of the funnel, masts, engines and boilers had only a very small influence on the ship.

The magnetic conditions proved to be very satisfactory for both the compasses on the flying bridge; the "Thueringen" went to sea without a compensating magnet for the standard compass and with only one compensating magnet for the steering compass. The deviation of the standard compass after the trial trip was N. = +5°(E.), E = +7° (E.).

A second ship, nearly a duplicate of the former, was afterwards built on the same building slip in nearly the same length of time. The magnetic conditions were found practically similar, the ship's polaric magnetic power being 59 per cent. of the earth's power on the launching day. This vessel was not swung and her head lay S. 31·3° E. during completion and outfit. The magnetic power continuously increased, a maximum value of 68 per cent. of the earth's power being reached when the ship was ready for sea. The deviation of standard compass, without any compensating magnets, was N. = +22° (E.), E. = +56° (E.). As a result of the above, seven compensating magnets had to be put in the compass, considerably lessening the most valuable quality of the compass needles—namely, the strength of the horizontal power in pointing to the magnetic north. The conditions on plain cargo boats are very simple, but become more complicated on passenger vessels with many decks and closed steel bridge houses. It may be added that the rails of the flying bridge of the "Thueringen" were of galvanised iron, except two small sections 6 ft. long, one immediately in front and the other immediately abaft of the compass. In the second ship (having the greater deviation) all the rails within a radius of 10 ft. were of brass and teak in order to improve the compass.

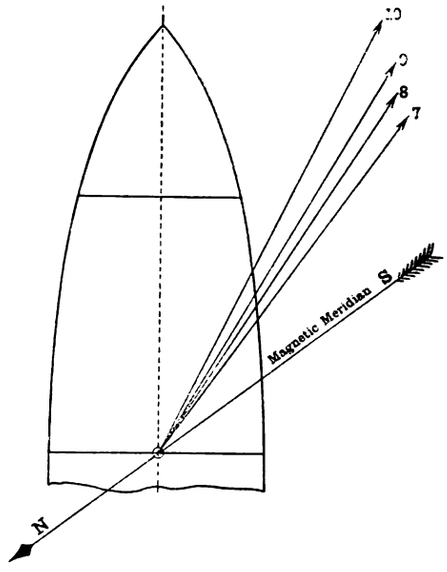

FIG. 2.

7. Ship's polaric magnetic power = 59 per cent. of earth power.
10. " " " = 68 per cent. "
Deviation of standard compass without compensating magnets—N = +22°, E = +56°.
Steamer's head on the building berth, S. 53·3° E.
Steamer's head after launch, S. 31·3° E.
7 shows the polaric magnetic power of the ship just before launch.
8, 7 days after launch.
9, 20 days after launch.
10, 40 days after launch; ship ready for trial-trip.

II.—The Improvement of the Compass Position by the Use of Non-Magnetic Material.

All horizontal bars (both longitudinal and athwartship) underneath the compass have a weakening effect on the horizontal polaric power of the instrument. In steam vessels the material near the compass to be taken into consideration consists mostly of horizontal steel bars. It is evident that the power of a compass on a steel ship is always smaller than on shore. The influence is not the same on all compass points, it is mostly stronger on E. and W., on account of the greater proximity of the induced poles in the athwartship's direction, than on the N. and S. course.

If the horizontal power on shore = H be taken as unity, the power on board will be = $\lambda \times H$, λ being a coefficient varying with the local conditions of the compass' position. On a normal merchant steamer the coefficient λ is usually about 0·8; that is, the polaric power on board is eight-tenths of the polaric power on shore. In the conning towers of some men-of war λ does not exceed 0·3; such a compass is no use at all. In general, the greater λ, the better the compass' position.

The simplest and best solution of the compass question would be to use non-magnetic material for the ship; cost price about £100 per ton. We know a number of alloys of iron which do not take up magnetism within certain limits of temperature. As a curiosity

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it may be mentioned that a strong steel magnet becomes non-magnetic in a temperature of +400°C., but this temperature is rather high for the compasses and officers. We have used non-magnetic nickel steel in our newer ships in the near vicinity of the standard compass with good results, the alloy containing 23 per cent. nickel.

In one of our large vessels now building we have interrupted all the horizontal steel in the deck under and above the compass, and replaced it with 6 ft. of nickel steel bars containing 23 per cent. nickel. From the experiments on this ship the writer hopes to arrive at a λ of from 0·9 to 0·95, an improvement of about 15 per cent.

CORRESPONDENCE.

"RECENT CONTRIBUTIONS TO ELECTRIC WAVE TELEGRAPHY."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Prof. Fleming has lately published in *The Electrician* an article entitled "Recent Contributions to Electric Wave Telegraphy," in the last part of which (p. 378) he also speaks of directed telegraphy. He quotes Marconi's researches on this subject, which are reported in the *Proc. Roy. Soc.*, May 15, 1906.

Prof. Fleming evidently ignores my researches which were undertaken in 1902 and published in 1903 (*see Physik. Zeitschrift*, May, 1903, and *The Electrician*, Vol. LVII., p. 244). They are also referred to in Zumerk's "*Electro-Magnet. Schwingungen*," 1905 (p. 904). In these articles I showed that the effect is a maximum with a wire having a slight slope to the horizon, when the vertical plane which passes through the wire lies in the direction of propagation of the waves, and that a deviation of about ± 10 deg. out of the plane can eliminate the effect of the untuned oscillations. I have further mentioned the conditions which have to be fulfilled. Marconi's results and those of Herr K. E. F. Schmidt (*Elektrotechnische Zeitschrift*, 1906, p. 853) confirm my assertions.

I cannot, therefore, agree that Marconi's receiver has introduced any new principle; those researches which Prof. Fleming describes on p. 380, and in which eight wires radiating from the receiving station are used, are especially only the application of an idea which anybody who had seen my researches could immediately originate.

The abrupt criticism with which Prof. Fleming dismisses everyone before the time of Marconi is irrelevant as regards these researches. Matters are treated in a correspondingly abrupt way when they come later, *e.g.* "Meanwhile, however, Prof. F. Braun, of Strasburg, has been engaged on a different plan for directing the radiation from antennæ."

It is a veritable fact that my patents for this arrangement date back over several years. I described the principle of the method in a lecture on November 16, 1904, in Berlin (reprinted in the *Verhandelungen der Schiffsbautechnischen Gesellschaft* and in my *Strassburger Reiteratsrede*, May, 1904, p. 44). Lastly, in the course of the same year the results and experimental arrangements were described, under my name, in *Die Woche*, August 5, 1905, in the *Wiener Neuer Freie Presse*, August 3, 1905, and thence reprinted in many other home and foreign journals. Prof. Fleming's historical statement is, accordingly, also incorrect here.—I am, &c., F. BRAUN.

Strasburg i.E.

Dr. Fleming's reply to the above letter from Prof. Braun is as follows:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Prof. Braun complains that in a recent lecture I have ignored his researches in 1902 and 1903 on directive radio-telegraphy. In a discourse which has to be comprised within the limits of 60 minutes it is not possible to describe in great detail the development of every novelty or invention mentioned. The subject of my lecture was more especially the recent work in wireless telegraphy, and, as far as possible, space was given to Prof. Braun's latest published researches on this subject. He seems, however, desirous of minimising the value of Mr. Marconi's contributions to this particular department of the subject. It is not to be denied that several observers had noticed a certain want of symmetry in the radiation from an inclined antenna, and this general fact was known also to Mr. Marconi before 1902. Prof. Braun claims priority for himself for this observation. So do several other workers whose names I have mentioned in my lecture. Mr. Marconi, however, by laborious observations proved that in the case of an antenna having a short part of its length vertical and a much longer part horizontal the radiation was a maximum in a direction opposite to that towards which the free end points, and that a similar non-symmetry held good for it when used as a receiver.

He also showed that when two such antennæ were placed back to back they formed a system of sender and receiver having very marked directive power. He did not content himself with isolated observations, but laid down in the form of polar curves a large number of metrical results furnishing the basis for an exact test of theory. He thus brought the invention to a stage at which it became practically useful on a large scale. Shortly afterwards, I myself gave the mathematical theory of the effect and showed that the results were in accordance with known facts of electric radiation. As far as I am aware, Prof. Braun did not anticipate the above practical or theoretical researches. In his letter to you he has given the titles of various Papers, but has not supported his contentions by quotations or express proofs of his statements. Hence, whilst giving to his opinions in scientific matters the respect to which they are entitled, I cannot admit that there has been any failure on my part to accord to him all that is due. In the light of Mr. Marconi's complete work, the real meaning of former isolated observations becomes clear, but, as I said in my lecture, "Previously to Marconi's experiments no definite guiding principles as to directive telegraphy had been published, but a number of unconnected observations made, not always correctly interpreted or even described, and in any case with limited application."

There is, therefore, no ground for the statement that my account of the matter is unhistorical, though from the necessities of the occasion it was extremely brief.—I am, &c.,

Poldhu, Mullion, Cornwall, Aug. 13. J. A. FLEMING.

COLOUR PHENOMENON IN PHOTOMETRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On May 25th, 1906, Mr. J. S. Dow read before the Physical Society a very instructive Paper entitled "Colour Phenomenon in Photometry." The Paper was mainly about the effect of the Purkinje phenomenon and the effect of varying the size of the field of view and its distance from the eye. It is the latter point with which I am concerned.

Mr. Dow stated that the size of field and distance from the eye had a considerable effect upon the readings obtained. This effect, however, was considerably less for the flicker photometer than for stationary screens of the Joly, Lummer or Bunsen types. As regards the effect upon these latter, I am able to confirm Mr. Dow's statements in general. I differ, however, from Mr. Dow with regard to the effect on the flicker photometer. I have not attempted to reproduce Mr. Dow's experiments with red and green glasses, but have confined my attention to the more everyday condition of a Welsbach mantle versus a pentane standard.

Mr. Dow, in comparing an incandescent gas mantle against a Methven screen, found that altering the distance of the eye from screen from 20 cm. to 60 cm. altered the reading obtained by 3 per cent. My experiments were carried out on one of my own pattern flicker photometers of the general form described by me in *The Electrician* of July 20, 1906. The photometer was arranged so that it could be used with different size diaphragms, with telescope, single eye-piece, or without any lens at all. I tried a ¼ in. diaphragm and a 1 in. diaphragm, with the eye at 6 in. and 2 ft. from the diaphragm in each case. I next added a single-lens eye-piece and repeated the experiments. Finally I substituted a telescope, and again repeated the experiments. In every case I obtained the same mean reading within ½ per cent. The conclusion I come to is that with this type of photometer the size of field of view and its distance from the eye has no effect upon the readings when the colour of the lights to be compared do not differ by more

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than the difference in colour of the pentane lamp and incandescent mantle.

Let us see in what particulars my experiments differ from those of Mr. Dow. I use a pentane lamp, Mr. Dow the Methven screen. Mr. Dow uses an Everett & Edgcumbe flicker photometer, in which the rays of light fall upon the screens obliquely, and the two screens are different distances from the eye. I use a photometer in which the rays fall upon the screen in a perpendicular direction, and in which the two surfaces to be viewed are the same distance from the eye. I cannot see that using the pentane standard in place of the Methven screen can be sufficient to turn a 3 per cent. variation into no perceptible variation at all.

I conclude, therefore, that the inclined screens or their difference in distance is the cause of the variations of readings that Mr. Dow has found. It would be interesting to see these experiments repeated with a Simmance flicker photometer, in which both surfaces viewed are the same distance from the eye but are inclined at an angle to the rays of light.—I am, &c.,

Westminster, Aug. 8. LANCELOT W. WILD.

PACIFIC CABLE BOARD.

The accounts of the Pacific Cable Board for the year ended March 31, 1907, accompanied by a report signed by the late chairman (Sir Spencer Walpole), has just been issued, and shows a total capital expenditure to March 31 last of £1,998,460. 18s. 7d., compared with £1,997,707. 18s. 6d. at the same period of 1906, or an expenditure on the year of only £753. 0s. 1d. The total revenue from traffic receipts (less £3,401. 13s. 2d. paid to the Canadian Pacific Railway and the Atlantic telegraph companies in connection with messages) was £113,000. 0s. 1d., or, with interest of £516. 7s. 1d., a total revenue of £113,516. 7s. 2d. The amount of the Parliamentary grant was £99,487. 15s. 10d., bringing the total revenue to £213,004. 3s. Working expenses, including £1,425. 14s. 9d. contribution to provident fund and £33,000 transferred to cable repair, reserve and general renewal fund, were £90,895. 1s. 4d. Adding £77,544. 18s. for the replacement of capital, the total expenses came to £168,439. 19s. 4d., leaving a balance at March 31, 1907, of £44,564. 3s. 8d.

The late chairman's report, dealing with the operations of the Board for the year, states that the cable continued in efficient working order throughout the year, the only repair effected being the replacement in February last, at Norfolk Island, of a part of the shore end of the Suva cable, which suffered from chafing. This work did not interfere with the service and was successfully carried out by the repair ship. No interruptions of any kind occurred on any section of the cable. The net message revenue was, as shown in the accounts, £113,000. 0s. 1d., against £91,814. 8s. 11d., which includes the receipts in Australia for 13 months. The actual expenditure amounted to £90,895. 1s. 4d., against £86,963. 17s. in the previous year, showing the gross surplus of £22,621. 5s. 10d. £77,544. 18s. having to be provided for interest and sinking fund, the deficiency on the year's operations was £54,923. 12s. 2d., against £72,556 1s. 9d. in the previous year. This deficiency has, of course, to be made good by the contributing Governments. Of this sum England and Canada each contributed £15,256. 11s. 2d., Australia £18,307. 17s. 5d. and New Zealand £6,102. 12s. 5d.

The forecast made by the Board of the probable revenue and expenditure for the year 1907-8 is as follows: Traffic revenue £103,000, estimated deficiency £69,368, total £172,868. Against this, working expenses are estimated at £62,823, £32,000 is set aside for renewal fund and £77,545 as the annuity for sinking fund. The report continues:—

The land-line services in Australia and New Zealand in connection with the cable have been generally well maintained by the Governments concerned. The Atlantic companies have afforded uninterrupted cable communication throughout the year, and a rapid and efficient service. In Canada the winter has been exceptionally severe, and the lines of the Canadian Pacific Railway, both in Vancouver Island and elsewhere, suffered considerable interruption. The most severe storm occurred in Vancouver Island early in December and disorganised the traffic for some days. The greater security of the lines between Vancouver City and the cable station at Bamfield is a matter of some anxiety to the Board, which is in constant communication with the railway authorities on the subject. It is hoped that the extension of railway communication to Alberni on the west coast of the island will secure a safer route for the telegraph wires across the island than by the present road.

The Board is glad to acknowledge the generally good and loyal service rendered by their staff throughout the year. In starting competition in Australia, and also on the occasion of the San Francisco earthquake and the lamented death of Mr. Seddon, a great deal of heavy work had to be dealt with, and the Board mentions the indefatigable services rendered by Mr. Milward and by the staff acting under his direction. The health of the staff has been satisfactory, and no serious illness has occurred, but the Board regrets the death suddenly, by an accident on Oct. 28, 1906, of Mr. Hugh Latham, who had been secretary for over five years, and had rendered excellent service.

In conclusion reference is made to the efficiency of the Board's repairing vessel and the success ultimately obtained by the replacement of the Chinese stokers on board with Norfolk Islanders. The employment of the latter has contributed materially to the prosperity of this small and interesting community.

LEGAL INTELLIGENCE.

Dumphy v. Montreal Light, Heat & Power Co.

The Judicial Committee of the Privy Council (the Lord Chancellor, Lords Robertson, Atkinson and Collins, S. A. Wilson and Sir A. Wills) have given judgment in this appeal by plaintiff (in formâ pauperis) from a judgment of the Court of King's Bench, Montreal, reversing a decision of the Court of Review.

In delivering judgment Lord ROBERTSON said the facts were of singular simplicity. A building contractor used a derrick in putting up a house at Montreal. His workmen brought the derrick into contact with the overhead wires of the respondent company, with the result that the current of electricity was diverted to the street and killed appellant's husband. It was manifest that the causa causans of the casualty was the action of the persons using the derrick, and the question was whether the causa sine qua non in the electric wires was there owing to the fault of respondents. The company derived its powers from an act of the Quebec Legislature, by which they were authorised to enter upon and construct under or over the streets and public highways of Montreal all such pipes, lines, conduits and other constructions as were necessary for the purposes of the company's business, all such work to be performed under the directions of the municipality in which the works are situated, provided that the company be responsible for all damages which it may occasion. The main argument for the appellant was that construction overhead, instead of underground, was of itself negligence, an alternative argument being that respondents made no attempt to insulate the wires or put guard wires round them. That, too, was the decision of the jury before whom the case originally came, and although, in the action before them, the owners of the derrick were also defendants, the jury negatived negligence on their part and found respondents alone liable on the grounds stated. The legal proposition laid down at the trial was that respondents, having alternative powers to place their wires either overhead or underground, were bound to adopt whichever method afforded the greatest protection to the public, and were guilty of negligence if they failed to do so. The Court of Review adopted this proposition, and gave judgment against respondents. On an appeal to the Court of King's Bench that judgment was reversed and appellant's action was dismissed. It seemed impossible to support the contention that, the Legislature having authorised overhead wires as well as, and just as much as, underground wires, respondents were guilty of negligence in exercising one of those alternative powers. The second ground upon which negligence had been found exhibited with singular frankness the essential defect of appellant's case on that head. The finding was, not that insulating the wires or guard wires was an efficient remedy which would have prevented the accident and which respondents were negligent in not adopting, but the verdict assumed that it was an open question whether such a provision would have done any good at all. The complaint was that respondents did not experiment to prove the efficacy of such arrangements. It was impossible to regard such a contention in the absence of substantive and affirmative evidence, and in view of the adequate support received by respondents from their witnesses, as good ground of liability for negligence. Their lordships would advise that the appeal ought to be dismissed and the judgment of the Court of King's Bench affirmed.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant is wanted in the engineering department of Darlington Technical College to teach electrical engineering and practical mathematics. Commencing salary £120 per annum. Forms of application, &c., from the director of education (Mr. A. C. Boyde), Education Offices, North Lodge, Darlington, and must be returned by Aug. 30. See advertisement.

A lecturer in applied mechanics is required at the University of Liverpool. Particulars from the Registrar. See also advertisement.

A young man is required with mechanical and theoretical knowledge of electrical instrument work. See advertisement.

An outdoor representative is required to call upon power and lighting consumers. Technical knowledge and commercial experience essential. See advertisement.

Applications are invited for the position of head of the Technical College, Huddersfield. Particulars from the Secretary.

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An assistant lecturer in engineering, to take classes in electrical engineering, is required by Swindon Education committee. Applications (on forms to be obtained from Mr. W. Seaton, Town Hall, Swindon) by Aug. 31.

Mr. J. Wyatt Papworth, assistant electrical engineer at Kilmarnock, has been appointed borough electrical engineer at Stirling at £200 per annum.

Mr. H J. Jackson has been appointed mains superintendent at Warrington at £130, rising to £150 per annum.

Mr. E. W. Dunton, late engineer and manager of the British Accumulator Co., has been appointed assistant London manager to the London office staff of the D. P. Battery Co. (Ltd.), 11, Victoria-street, Westminster, S.W.

Mr. H. Hirst, M.Sc., A.I.E.E., of the Royal Technical Institute, Salford, and Mr. J. M. Hind, B.Sc., A.R.C.Sc., have been appointed lecturers in physics and mathematics and in chemistry and mathematics respectively by the Kent Education committee.

EDUCATIONAL NOTICES.

University of Birmingham.—The engineering courses in this university extend over four years, and students who enter after matriculation and who pass successfully the examinations at the end of each year will be entitled to the degree of B.Sc. in that branch of engineering to which they devote themselves. The technical engineering classes include lectures on the strength of materials, theory of steam, gas and other heat engines, hydraulics, machine design, strength of structures, distribution of power, drawing (including the design of tools), prime motors, dynamos and other forms of machinery. The courses in civil engineering include constructional work in masonry and steel, railway work, &c., with practical surveying in the field throughout the summer term. In the engineering laboratory the work will include the determination of the strength of materials, including compressive, bending, tensile and tortion tests, experimental study of the steam engine and boiler, frictional efficiency tests, the flow of water over wires and through orifices, &c. There will be lectures and demonstrations on all branches of electrical engineering, and the work in the electrical laboratory will include testing of continuous and alternating-current machinery, electrical instruments, meters, lamps, batteries, &c. The session 1907-8 commences on Oct. 1. Full particulars can be obtained from the Secretary.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

University of Manchester.—Complete theoretical and practical training is given in this university to students preparing for the higher positions in the electrical engineering profession. The subjects may be taken as part of the courses preparing for the B.Sc. degree in both the honours school of engineering and physics. A special course has also been arranged extending over three years and preparing for certificate in electrical engineering. The John Hopkinson laboratories and dynamo house are equipped with powerful modern machinery, and excellent facilities are afforded for educational and research work. The session commences Oct. 1.

City and Guilds of London Institute.—The entrance examinations of the Institute's Colleges are held in September. Particulars of the entrance examinations, scholarships, fees and courses of study may be obtained from the respective colleges or from the head offices of the Institute, Gresham College, Basinghall-street, E.C. The City and Guilds Central Technical College, Exhibition-road, W., is a college for higher technical instruction for day students not under 16 preparing to become civil, mechanical, or electrical engineers, chemical and other manufacturers or teachers. The College is a school of the University of London in the Faculty of Engineering. The City and Guilds Technical College, Finsbury, is a college for intermediate instruction for day students preparing to enter the engineering and chemical industries, and for evening students.

Glasgow and West of Scotland Technical College.—The session begins on Monday, Sept. 23, in the new buildings. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics. The courses of study extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session at prescribed university classes. There are new and well-equipped laboratories in the departments of physics, chemistry, technical chemistry, metallurgy, mechanics, motor-power engineering, electrical engineering, &c. The preliminary examination begins Sept. 16. Calendar (price 1s. 4d.) and prospectuses (gratis) from the Secretary.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars as to fees, &c., can be obtained at the Institute, St. John's street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Argentina.—Among the important public works completed in 1906 at Rosario was the city section of the electric tramway system. The contract for the work was placed with a Belgian company. The value of the imports of electrical appliances, &c., into Rosario in 1906 was $197,894 gold.

Aston.—An inquiry was held last week into the application of the Council to borrow £17,519 for extensions of the electricity undertaking, including the laying of mains, &c., in the Erdington district and £1,650 for cables to give a supply in the Witton district for power and also to supply the Tame and Rea Drainage Board. There was no opposition.

Australasia.—The "Australian Mining Standard" states that Wangaratta (Victoria) Council are considering a scheme prepared by Mr. B. Sluyterman (on behalf of the Victorian Electric Lighting Synd., Bendigo) for electricity supply for the district. The capital cost is put at from £3,500 to £4,000 for plant and £1,200 for erection and wiring of street lamps.

Bangor.—Sanction to a loan of £1,000 for meters, mains and services has been applied for by the Council.

Bovey Tracey.—At a recent public meeting a resolution in favour of electric lighting was unanimously adopted.

Bradford.—At the meeting of the Council on Tuesday a long report from the city electrical engineer (Mr. T. Roles) on the system of charging for electric current was submitted and a revised scale of charges for large power consumers was recommended for adoption.

The chairman of the Electricity committee (Ald. Robinson) said the committee felt that they had been standing still for three years in connection with the use of electricity for power, ever since the price was put up from 1d. to 1½d. It meant that the Corporation would either have to give up supplying electricity for power or reduce the price. Unless they did that private consumers might apply for power to supply electricity in their area. Other municipalities were taking into consideration the question of lowering the cost to long-hour consumers.

The recommendation was adopted.

Bridgend.—Negotiations are proceeding for the purchase by the Council of the Bridgend generating station of the South Wales Electrical Power Distribution Co.

Burnley.—The Postmaster-General has made an arrangement for the conveyance of mails on Burnley Corporation tramways between Padiham and Burnley and Brierfield and Burnley.

Carbide of Calcium Manufacture.—We are informed that the British Carbide Factories (Ltd.) has been formed by Mr. Chas. Bingham (11, Queen Victoria-street, London, E.C.) and some friends for the purpose of building and working a carbide factory at Thornhill, Yorks. The entire plant, machinery, &c., will be of British manufacture and the raw materials will be drawn from the immediate vicinity of the factory.

It is stated that this is the first attempt on a large scale to utilise the surplus load of a large power station (that of the Yorkshire Electric Power Co.) or to fill up the valleys in the load charts of the station, this being the only means of securing, in this country, current at a low enough price to enable competition with Continental waterfalls to be met. The initial factory will be equipped with plant for about 2,500 B.H.P., and will be run on a new system (patented by Mr. Bingham) which will, it is claimed, enable the power station to supply the carbide factory with any amount of energy desired, varying between a minimum of 350 kw. and the maximum capacity of the furnaces. During the two hours of peak load, the power station will be enabled practically to cut off the supply to the carbide factory entirely, if desired, while the arrangements permit of the load being varied from minute to minute, as may be desired by the Power Co. The factory is expected to commence working in about four months.

Chichester.—The Board of Trade have approved the transfer of the Chichester electric lighting order to the Chichester & District Electric Supply Co.

China.—At Chinkiang there is an electric lighting company working on antediluvian lines and doing a very small business, chiefly amongst the Chinese shopkeepers, who have one or two lamps installed in their shops to attract the public. In a city of considerable commercial importance there are less than 3,000 16 c.p. lamps in use. Electrical appliances and fittings were imported in 1906 to the value of £1,761.

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Chobham.—The Woking Electric Supply Co. intend to apply for a provisional order.

Colne.—The Council have decided to put down additional generating plant at a cost of £5,500.

Coventry.—An unopposed inquiry was held on Wednesday into the Council's application for sanction to borrow £27,000 for extensions of the electricity undertaking.

Dundee.—On Tuesday the Electricity committee decided to make a start with the foundation work for the new main generating station, and the city electrical engineer (Mr. H. Richardson) was instructed to obtain tenders. The foundations are to be in Hennibique system of reinforced concrete and tenders will be accepted only from contractors who are licensed and qualified to carry out the work. Mr. Richardson reported that it was also urgent that the order for high and low tension cables should be placed as soon as possible and the committee gave instructions that tenders be also called for these.

Dunfermline.—The Council have declined to adopt the Electric Lighting committee's recommendation to enter into an agreement with the Fife Electric Power Co. for supply of electricity in bulk, but negotiations are to be opened with the company for the transfer of the Council's order. A new Electric Lighting committee has been constituted, with Bailie Husband as convener.

Eccles.—At a recent meeting of the Council it was decided to increase the proposed electricity supply loan by £1,200 in order to provide for the increasing power load.

Electric Signal Board at the Stock Exchange.—A new electric signal board has been erected in the Stock Exchange. The old method of manual communication is to be abolished.

Exhibition.—An electrical exhibition, remaining open a fortnight, is to be held in Montreal, beginning on Sept. 2. A meeting of the Canadian Electrical Association will also be held from Sept. 11 to 13, when the following papers, among others, will be read: "How to increase the load factor," "Some of the difficulties encountered in operating alternating current systems," "New and old type incandescent lamps," "The Nernst lamp," and "Electric heating and cooking appliances."

Falkland Islands.—In September last a new telephone exchange was established in Stanley to supplement the existing telephone service and to effect telephonic communication between the principal Government buildings and the offices of the Falkland Islands Co. An agreement has also been arrived at between the Government and the company for the erection of a line between Stanley and the company's settlement at Darwin. This work is being carried out by the company, and is nearing completion. The upland goose has proved a source of trouble in carrying out this work, as the force with which the bird in its flight strikes the wires is sufficient to break them.

Fareham.—Last week the Electric Light committee recommended the Council to put down additional plant (including a Diesel oil engine set) at £1,950, but after discussion an amendment to call in an expert to report upon the existing plant and the proposed extensions was carried.

Germany.—An interesting report has been published on the trade of the Frankfort district of Germany for 1906. In regard to electrical matters, the turnover for 1906 is stated to have constituted a record, and it is further stated that orders in hand at the beginning of the current year were sufficient in size and number to ensure another busy year. On the question of prices, however, a different tale is told. Increases in wages and salaries, the advance in price of raw materials, especially metals, had cut profits to a considerable extent. It is estimated that about 95,000 persons were employed in the electrical industry in 1906 at Frankfort, and the money-earning capacity of the leading companies, together with the evidence of public appreciation of this class of investment, are shown by the following table:—

Company.	Last dividend.	Approx. market quotation.
Akkumulatoren Fabrik	12 per cent.	.. 201
Allgemeine Electricitäts Gesellschaft	11 ,,	.. 200
Bergmann's Electricitäts Gesellschaft	18 ,,	.. 270
Berliner Electricitats Werke.....	10 ,,	.. 170
Brown, Boveri & Co.	11 ,,	.. 189
Felten & Guilleaume Lahmeyer Electricitats Werke.....	7 ,,	.. 128
Siemens-Schuckert Werke	5 ,,	.. 113
Siemens & Halske	10 ,,	.. 170
Average.....	11·6 ,,	.. 180

Glasgow.—The tramways committee have decided against the proposal to allow cycles to be conveyed on the tramcars.

Hartlepool.—The Council decided on Monday to approve the agreement to transfer the powers of the Northern Counties Electricity Supply Co. to the Cleveland & Durham Electric Power Co., but a clause has been added relieving the Corporation of the obligation to take electric current for public lighting after March, 1911, when the present agreement with the Northern Co. expires.

Harwich.—Messrs. Foote & Milne propose to apply for a provisional order.

Holland.—The British Consul at Amsterdam (Mr. W. A. Churchill) states that improvements to the North Sea Canal, necessitated by the development of the trade of the port of Amsterdam, include the building of a second and larger lock at Ymuiden, the lighting by electricity of the North Sea Canal, deepening and widening of the canal and the lighting of the interior of the harbour in the direction of the Orange locks. It is expected that these projects will be carried out during the ensuing 18 months.

Light Railways.—The Board of Trade have confirmed the Dartford and District Light Railways (Amendment and Extension of Time) Order.

Magazine Lighting.—The Naval ordnance depots and magazines at Bullpoint, Devonport, are now lighted electrically, and the War Office has approved estimates for completing similar work in connection with other buildings in the district, consisting of a range of magazines for the storage of cordite and powder, cartridges, shell and miscellaneous stores. The contract has been let to Messrs. Foote & Milne, and the work of excavating the trenches for the cables has commenced. The installation will embody all the improvements which experience has suggested, including "lighting pillars" and chambers at intervals to feed the watertight incandescent lamps to be used for illuminating the passages of the magazines and the arc lights which are to be fixed on steel standards near the entrances and at positions along the line of transporting rails and landing jetties.

Mexico.—A valuable report has recently been prepared by Mr. Consul L. J. Jerome dealing with the trade and commerce of Mexico for 1906. Mr. Jerome shows that there have been large increases in the value of both exports from and imports into Mexico in recent years, and that efforts are being continually made by American manufacturers to obtain complete control of Mexican trade. So far as the United Kingdom is concerned a considerable decrease in imports is shown for 1905-6 compared with 1904-5, but in the case of the United States the increase has been very large, and German imports also show augmentation. One of the largest items of import is "machinery and implements." In regard to the export trade of Mexico, next to the United States the United Kingdom shows by far the largest increase for 1905-6. Mr. Jerome continues:

I have often drawn attention to the development of electricity in Mexico. In my report for 1899 I indicated the demand for electrical appliances—electric lamps, incandescent or arc lights, high and low-tension cables for transmission lines, dynamos and motors, either steam or water-driven—in fact, all kinds; and I can only repeat this. Many of the tramway systems are being altered from animal power to electric power, and it should be borne in mind that there is hardly a town of any importance in the country that has not got a tramway system. Factories, too, are largely using motors with direct connection, instead of the overhead system pulleys and belting for power transmission to machine tools. I have up to the present not seen a single British-made motor or dynamo in Mexico, and only a few of German manufacture; nearly all the electrical appliances used up to the present in this country are American. The development of the mining industry, too, should offer some scope to enterprising export merchants.

Nearly all the railways are suffering from a shortage of rolling stock, both in passenger coaches and goods wagons; the same shortage exists to-day in the United States, and while railway wagon builders would have to conform to American standards, with labour and materials cheaper in the United Kingdom than in America, I believe our manufacturers should seek for an expansion of their trade by obtaining orders from the railways of Mexico.

The street railways or electric tramways of Mexico City are equipped with American passenger cars. Cars in use for over a year present a most dilapidated appearance; the flimsy material of which they are constructed, built to deceive the eye when new, rapidly take on a squalid and worn appearance when subjected to the extremes of damp and dryness, which alternate according to the season at the Mexican capital; the cars are built to be scrapped, and are hardly worth repairing after they have been run a few months. They suffer, too, from having nearly all the movable brass parts stolen at night when in the company's yards.

Contractors for the erection of factories should find Mexico a fair field for profitable action; the policy of the country is to manufacture in Mexico itself as much as possible that Mexicans require. There is a considerable amount of industrial development quietly going on.

Railway construction offers an opening for the sale of rails, bridge, and culvert material and contractors' tools, such as shovels, picks, barrows, blasting, and quarrying tools.

In fact, in a country in full process of development it is difficult to indicate lines in which there is no demand for commodities, whereas in those in which there is a demand one has to quote practically the whole list of everything that human ingenuity has conceived.

Further Mr. Jerome says that the long distance transmission of electrical high-voltage power has to a large extent solved the fuel problem in Mexico, and has permitted the erection and operation of large reduction and smelting works for the treatment of ores within the country itself.

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Not only are the precious metals being mined and treated within the country, but the iron ores are being made into pig iron, steel ingots and commercial iron. Mining methods generally are becoming more and more scientific, and the substitution of up-to-date machinery in Mexico has become more general than would be considered probable by those unacquainted with the country.

At Colima, on Dec. 1, 1906, the undertaking of the Colima Electric Light & Power Co. was formally opened by the Governor of the State. The company generates electrical energy at a water-power station at El Remate, 20 miles north of Colima, and has a distributing station at Colima. The station is designed to generate 900 H.P., and is at present generating between 300 H.P. and 400 H.P. The enterprise is owned by local capitalists, the whole of the generating plant being of German manufacture. By the end of 1907 the present horse and mule-drawn tramways will be converted to electric traction, and an extension is being built to Comala, a suburb 5 miles distant from the city.

At Monterey the local electric tramway and power company occupies an important place. This undertaking is owned by Canadian capitalists, and along with the Monterey Water Works & Sewer Co., employs 1,000 men. The establishment of these two companies has vastly increased the value of real estate in this city.

Reporting on the trade of Vera Cruz, Mr. Vice-Consul Nunn points out that, in connection with the import trade with Mexico, it is indispensable that British manufacturers should be represented by competent agents or travellers, and that catalogues, price lists and other advertising matter should be printed in Spanish. He calls particular attention to the wasted efforts in regard to translations, and states that it is notorious that not more than one advertisement in ten of those translated from English to Spanish convey the intent of the advertiser, while some are so grossly erroneous as to do more harm than good.

The report is a valuable document, and contains much matter of real interest to British manufacturers.

Motor Omnibuses —At the meeting on Tuesday of the London Road Car Co., Mr. J. H. Moore said they now had some experience of motor traction. At the outset they regarded the motor merely from the mechanical point of view, their aim being to acquire a machine capable of performing the necessary work at a profit, and they did not fully realise the large part to be played by human agency in working the machines. It had been a real difficulty to train the drivers to act in the dual capacity of driver and mechanic, but that was being gradually overcome. They had not pinned their faith to one particular type of 'bus, but had experimented with several, and they had two types which had shown good working profit from the commencement. The difficulty with the police had been overcome and had practically disappeared. They had no intention of abandoning motor 'buses and going back to horses.

Municipal Telephony.—There is now full inter-communication between National and Corporation subscribers at Swansea.

The agreement between the Corporation and the Company provides that, subject to the provision of existing contracts, the company shall continue to supply telephonic service to the existing subscribers of the Corporation in accordance with the terms of such contracts for two years from March 31, 1907, and during this period the company shall not determine any such contracts except on breach of any terms or conditions by subscribers. The terms upon which telephonic service shall be supplied to future subscribers and to the existing subscribers of the Corporation after the expiry of the two years shall be such as may be agreed upon between the Postmaster-General and the Company for general application throughout the licensed area.

Oulton Broad.—The Council have decided to apply for a provisional order.

Peterborough.—An inquiry was held here last week into the Council's application for sanction to borrow further moneys for extensions to the electricity undertaking.

Plymouth.—The Council have requested the Tramways and Electricity and Street Lighting committees to meet and confer together with a view to reporting what (if any) advantages would accrue from the management of the two undertakings by one committee.

Presentations.—The staff of the Acton electricity department have presented an address and a gold signet ring and gold mounted cigar-holder to Mr. T. H. Morris, chairman of the Electricity committee.

On leaving Wimbledon to take up an electrical appointment in India, Mr. F. Satchwell, M I E.E , has been presented by the townspeople with an illuminated address and a purse of gold in recognition of his public services.

Reduction of Prices.—The Austro-Hungarian cable manufacturers have, in consequence of the recent reduction in the price of copper, announced a reduction in the prices of their manufactures.

Russia.—The Grand Duchy of Finland is experiencing a period of great prosperity, and being only four days' journey by steamer from Hull, or three days from London by rail, offers an exceptionally good field for trading operations from the United Kingdom. It is also worthy of note that British goods are in high favour in Finland.

The Senate recently appointed a committee to inquire into the question as to the water power available for the generation of electric energy, and in a report just issued it is stated that the Government are negotiating with the owners of the Wallingkoski, Myllykoski and Kyrönkoski rapids on the river Vuoksen (Viborg) with a view to their purchase for this purpose.

There was a considerably increased import of electrical and general machinery into Finland in 1906 compared with 1905.

At Helsingfors the electric tramways are to be considerably extended and improved. A double line of track is to be laid through the principal thoroughfares of the city. The population of Helsingfors is about 140,000.

At Åbo (Finland) a contract has been placed with a German company for the electric lighting of the town, and for the construction, equipment and working of electric tramways. These undertakings have, in the terms of the contract, to be in full operation within 18 months of the signing of the agreement.

Spain.—Electric lighting continues to make rapid strides in Spain, and particularly in some districts. In that of Bilbao even the villages in the interior are supplied with electrical energy at a cheap rate, both for lighting and power, the numerous waterfalls which abound in the north of Spain being utilised for generation purposes. The Co-operative Society at Bilbao, amongst other commercial items, supplies electrical energy, and has lately considerably increased the capacity of the power station, the machinery installed being about 800 kw., chiefly of Swiss and German manufacture. La Cia Electra, in order to compete with the Co-operative Society, has recently reduced the price of current to about 4d. per unit, and has considerably extended its area of supply.

104,432 incandescent electric lamps were imported into Bilbao in 1906, of which Belgium and the Netherlands were the principal suppliers, the United Kingdom standing for 2,424 only, Belgium 59,470, Netherlands 40,338, Germany 2,200.

Mr. Consul General Smithers, reporting on the trade of the Barcelona district for 1906, refers to the importance of this district to British merchants and manufacturers. There is a population of 600,000, Barcelona being the most densely populated of all the 49 provinces of Spain and the largest capital city in the Mediterranean. Mr. Smithers claims that the electric tramway system of Barcelona is, perhaps, the most complete in Europe, German and Belgian capitalists controlling the whole of the many lines in operation in the city and district. Several small extensions to these tramways have been made during the past year. Two electric lighting and power companies, one native and the other a German company, have considerably increased the capacity of their stations, the latter having spent some £200,000 on new plant. Public lighting by electricity in the district is very complete, and private lighting by the same agent is becoming almost universal, keeping electrical engineers and installation contractors constantly employed.

A Franco-Spanish company has been formed at Irun, on the frontier, and will supply water power generated current at a low rate to districts in the south of France.

Strike of Telegraphists —A strike of telegraph operators commenced on 9th inst at Los Angeles (Cal), U S.A , and subsequently extended to other parts of the States, New York becoming involved on Monday. At the outset the Western Union Co.'s service only was affected, but the Postal Telegraph Co. has since become concerned. The strike continues, but the officers of the Western Union Co claim that their service is being maintained.

Uganda.—In the Protectorate of Uganda there are now 458 miles of overhead telegraph line and seven telegraph offices. This does not include telephone lines which have been erected at Entebbe and Kampala.

Warrington.—Sanction to a loan of £3,070. 10s. for extensions of the electricity undertaking has been applied for by the Council.

Wath.—The question of improving the public lighting was before the Council last week. Several members advocated electric lighting, and ultimately it was decided to send a deputation to other towns to collect information on the subject.

Whitby.—The salary of the electrical engineer (Mr. L. H. King) has been increased by £25 per annum, with a further increase of £25 in February next.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Broughty Ferry.—The accounts of the electricity department for the year ended May 15 show capital expenditure £18,789, increase £3,597.

Revenue was £1,824, expenses £827, leaving gross profit £997. Interest required £538 and sinking fund instalment £333, leaving £127 net profit. 124,586 units were generated, compared with 98,493 in previous year.

Bury (Lancs.)—The accounts of the tramways department for the year ended March show capital expenditure £242,466, increase £21,716.

Revenue was £50,649, and included passenger traffic receipts £50,518, parcels carriage charges £97, rent of property £26, and advertising £7. The passenger traffic receipts on the Bury sections were 10·08d. per car-

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mile (against 9·46d. in previous year), Radcliffe sections 7·50d. (7·34d.), and Heywood sections 10·08d. (10·74d.) £754 of the traffic receipts on the Radcliffe sections, being the proportion received between Goat's Gate, and Whitefield Station, has been paid to Salford Corporation, Total expenditure was £28,085 or 5·536d. (5·187d.) per car-mile, including traffic expenses £11,720 = 2·204d. (2·222d.), general expenses £3,877 = 0·729d. (0 713d), repairs and maintenance £4,018 = 0·756d. (0·418d.) and power expenses £8,471 = 1·847d. (1·834d.). Gross profit was £22,564. After meeting capital charges there was a net profit of £5,225, of which £2,500 has been placed to reserve and depreciation fund and £2,725 devoted to relief of rates. The population served by the tramways is 124,726. 9,944,897 passengers were carried and 1,276,227 car-miles run. Average total revenue per car-mile was 9·52d. and the average fare per passenger was 1·22d.

Darwen.—The Corporation electricity department accounts for the past year show a net profit of £66. 660,812 units were sold (compared with 656,918 in the previous year), of which 148,955 (141,428) were for lighting, 61,419 (51,180) for power and heating, and 391,868 (401,862) for traction.

The tramway accounts show a surplus of £478 for the Darwen section and a deficiency of £594 for the Hoddesdon section.

Ealing.—The accounts of the electricity department for the year ended March 31 show total revenue £26,055. 17s. 7d. (against £24,969 in 1905-6), including £21,524. 12s. 7d. from the sale of current by meter and £3,484. 3s. 11d. from public lighting.

Expenses came to £12,652. 8s., against £11,824. 14s. 5d., leaving a gross profit of £13,403 9s. 7d., against £13,144. 7s. Interest required £5,498. 10s. 2d.; instalments of principal borrowed came to £4,370. 17s. 6d., and contributions to loans redemption fund £1,569, and after making provision for bad and doubtful debts, audit fees, parliamentary expenses, &c., the net profit for the year is £1,768. 5s. 1d. (against £2,318. 6s.). This has been transferred to reserve. The total capital expenditure is £190,358. 1s. 9d., an increase of £5,202, 4s. 5d. on the year. 1,778,470 units were generated and 1,487,221 units were sold, including 1,151,185 to private consumers. The equivalent of 111,691 8 c.p. lamps is connected and there are 3,271 consumers. There are 73 arc lamps and the equivalent of 1,513 8 c.p. incandescent lamps for public lighting. The maximum supply demanded was 1,159 kw.

Glasgow.—The accounts to May 31 show that the capital expenditure on the electricity undertaking during the past year was £261,057, making the total £1,587,436.

Revenue was £224,845 (against £195,842 in previous year), including sale of current by meter £212,228 (£183,559), supply to public arc lamps £11,479 (£11,454) and to private street and stair lights £1,137 (£829). Expenditure, including £41,755 (£37,990) allowed for depreciation of plant, mains, &c., was £147,990 (£129,406) and comprised generation £57,046 (£45,606), of which fuel cost £26,925 (£19,732), distribution £11,548 (£11,909), maintenance of public lamps and private street and stair lights £3,760 (£3,508), management £10,626 (£9,168). Gross profit was £76,854 (£66,436). Interest on loans, &c., required £49,643 (£42,486) and sinking fund £24,142 (£20,142), leaving a net profit of £3,069 (£3,808), which has been carried to reserve. 32,052,937 (25,758,521) units of electric current were generated and 26,332,998 (21,536,425) sold, including supplies for private consumers 24,677,993 (19,921,162), public lamps 1,533,166 (1,525,505) and by contract 121,839 (89,758). The total maximum supply demanded was 42,574 kw. (37,035 kw.). There are 15,497 (13,705) private consumers and 837 (825) public lamps. Cost of fuel per unit sold was 0·245d. (0·220d.), total cost of generation 0·520d. (0·508d.), distribution 0·105d. (0·132d.), management 0·097d. (0·102d.). Total expenses 0·722d. (0·742d.). Total cost per unit sold, including capital charges, rents, feu duties, taxes and depreciation, was 2·021d. (2·140d.). Gross receipts per unit sold 2·049d. (2·182d.), net profit 0·028d. (0·042d.).

Gloucester.—On March 31, the capital expended on the electricity undertaking was £87,176, an increase of £3,093 on the year.

Revenue was £11,238 (compared with £11,832 in 1905-6), including £5,912 (£6,059) from ordinary consumers, and £2,256 (£2,616) for public lighting, &c., £2,678 (£2,888) has been charged against the Light Railways committee for current at 1d. per unit. Total expenditure was £6,549 (£5,807), including fuel £2,204 (£1,980). Gross profit was £4,689 (£6,024), and there was a net loss of £842. 1,440,897 (1,412,035) units were generated, 190,407 (195,738) supplied to public lamps, 642,692 (693,165) to light railways, 410,654 (403,706) to private consumers for lighting, and 55,876 (19,928) for power. The maximum supply demanded was 998 kw. (910 kw.). There are 535 (503) private lighting consumers, with the equivalent of 47,735 (41,344) 8 c.p. lamps connected. The number of motors connected is 60 (38) = 239 H.P. (138 H.P.) Fuel cost 0·402d. (0·35d.) per unit, and total costs were 1·080d. (0·95.d)

Govan.—During the year ended May the electricity department generated 2,327,036 units of electric current and sold 1,899,465 units, including 467,543 for street and stair lighting 487,165 for private lighting, and 944,757 for power.

The total revenue was £14,008. 19s. 7d. and the working costs £13,461. 13s. 10d., leaving a net profit of £547. 5s. 9d. There was an increase of 18·5 per cent. in the units sold, mainly owing to the increased demand for power. There was a decrease of 2 per cent. in the lighting units due to the early closing of shops under the Shop Hours Act. The price per unit sold had been reduced by 9·4 per cent.

Hove.—The accounts of the Corporation electricity department (established to supply energy in Aldrington) for the year ended March show capital expenditure £8,425, increase £1,323.

Receipts were £377, expenditure £471 (including £176 for electricity purchased in bulk), leaving a deficiency of £93. Interest required £293 and instalment of redemption of loans £206, making a net deficit of £592.

Ilford.—The capital expenditure on the Council's electricity undertaking to March last was £149,181, an increase on the year of £9,049.

Revenue was £26,586 (compared with £24,883), and gross profit £10,555 (£11,159). After meeting capital charges there was a net profit of £885 (£1,870). The total works costs came to 0·82d. (0.83d.); and total costs 1·14d. (1·17d.) 3,651,103 units were generated and 2,860,214 (2,362,341) sold, including 1,254,736 (964,493) to private consumers, 850,376 (739,322) for traction and 755,102 (658,526) for public lighting. The average price obtained for private supply was 2·80d. (3·29d.) per unit and for supplies for all purposes 1·98d. (2·24d.) The maximum demand was 1,575 kw. (1,450 kw.) and the load factor was 20·7 (18·6). There are 2,836 private consumers.

Marylebone (London).—The accounts of the electricity department for the year ended March state that the amount borrowed is £1,891,400, repaid £2,864, sanctioned but not borrowed £34,384. Capital expenditure £1,965,605, an increase of £134,005 during the year. The capital expended is made up of £1,896,765 paid to the Metropolitan Electric Supply Co. as purchase money and compensation, £3,116 consulting engineer's commission and £565,725 expended on the Council's new works.

The year's revenue was £158,460, including sale of current by meter £150,277, public lighting £716, meter rental £5,318. Total expenditure was £52,728, including generation £25,547, distribution £7,383, maintenance of public lamps £368, rents, rates and taxes £4,751, management £10,009, law and parliamentary charges £221 and special charges £4,449, the last item including £1,404 expenses incidental to change of pressure of supply and £1,000 expenses in connection with delay on mains contract. The gross profit was £105,732. Capital charges amounted to £83,670, including interest on mortgage debt £71,304, interest on bank balances £1,081, proportion of costs of obtaining 1901 order and act and 1904 act £1,043, instalments of principal repaid £2,864, and instalments of principal accrued but not due £6,672. The ultimate result is a net deficit of £22.062 on the year, making a total deficit to date of £29,360. 10,592,942 units were generated, 66,426 supplied to public lamps and 7,935,510 to private consumers. The total maximum supply demanded was 7,745 kw. There are 87 public lamps.

Portsmouth.—For the year ended March 31, 1907, the total income of the electricity department was £52,156. 10s. 5d., including £44,033. 3s. 10d. net from sale of current by meter and £5,824. 11s. 2d. from public lighting.

The total expenses were £23,444. 19s., leaving a gross profit of £28,711. 11s. 5d., against £28,630. 1s. 2d. in 1905-6. Interest required £9,043. 3s. 7d., and sinking fund £8,811. 1s. 11d., leaving a net profit of £10.853. 5s. 11d., against £11,823. 17s. 4d. The capital expenditure is £302,000. 0s. 9d., an increase of £6,963. 19s. 6d. during the year. 4,183,510 units of electrical energy were generated, and 3,338,690 units were sold (2,721,520 to private consumers by meter and 3,250 by contract, and 613,920 units were supplied to the public lamps). There are 265 arc and 442 incandescent lamps for public lighting, and the total maximum supply demanded was 2,660 kw.

The capital expenditure on the tramways is £670,157. 3s. 10d., an increase of £19,434. 4s. 3d. The traffic revenue was £98,911. 3s. 3d., including £90,063. 1s. 9d. for car receipts, and with sundry revenue, &c., the total income for the year was £102,014. 10s. 4d. The working expenses were £45,754. 17s. 4d., leaving £56,259. 13s. to meet interest (£19,697. 2s. 4d.) and sinking fund instalment (£16,216. 17s. 2d.), income tax (£1,109. 9s.) and rent of leased lines (£1,319. 17s. 10d.). The net profit was £18,269. 0s. 8d., of which £5,000 was contributed in relief of rates and £6,260. 17s. 5d. voted to renewals fund. 2,230,460 units of electric current were used by the tramcars; the generation expenses came to 0·537d. per unit, and the total expenses (including capital charges) to 8·19d. per unit. 20,668,825 passengers were carried, and 2,199,823 car-miles were run.

Salford.—The accounts of the tramways department for the year ended March show total capital expenditure £671,364.

Revenue was £237,443 (compared with £226,013 in previous year), including £4,540 interest on investments, &c. Exclusive of this item the revenue was 10·609d. per car-mile. Total working expenses were £142,193 (6·477d.) and gross profit was £95,250 (£81,819) = 4·132d. per car-mile, exclusive of interest on investments, &c. Cost of current was £45,177 (2·058d.). The net profit was £27,890 (against £22,302 last year.) £13,000 (as in the previous year) has been contributed in relief of rates, and £14,890 (£9,302) placed to depreciation and renewals fund. The population served is 350,000. 43,614,123 (41,807,539) passengers were carried, 5,268,933 (5,257,223) car-miles run and 7,983,603 units of electrical energy used = 1·53 units per car-mile. Total revenue per car-mile was 10·81d., traffic receipts being 10·56d. (10·18d.), working expenses 4·42d., or 6·47d. including power cost. Depreciation and renewals fund amounts to £46,146. No additional routes have been opened during the year, the length (single track) of the tramways being 74¾ miles.

Sutton Coldfield.—The accounts of the electricity department for the year ended March show capital expenditure £40,104, increase £950.

Revenue was £4,517. The gross profit was £2,518, excluding £75 carried forward to provide for bad debts. Capital charges and interest

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on temporary loans amounted to £2,617, making the net result a deficiency of £99.

Sydney (N.S.W.)—The accounts of the municipal electricity department for 1906 show receipts for current supplied to private consumers £25,502 and for public lighting £11,803, lighting and power supply to public buildings £2,316, and rental of motors, meters, &c., £1,359, total £40,984.

Generation cost £11,742, distribution £6,461 and management £3,232, the gross profit being £19,416. Interest required £10,916 and sinking fund £3,186. Net profit was, therefore, £5,299. £4,770 has been placed to reserve and the remaining £529 carried forward. 1,361,803 units were supplied for private lighting and 1,202,482 to private consumers for power; street, &c., lighting required 1,166,104 units and supply to public buildings for lighting 171,836 and for power 25,105. The price to private consumers for power has been reduced from 2d. to 1½d. per unit.

West Ham.—The accounts of the electricity department for the year ended March show capital expenditure £381,960, an increase of £44,605.

The year's revenue was £53,324 (compared with £51,371 in the preceding year), including receipts for current for public lighting £6,547 (£6,047), private lighting £23,337 (£26,766), power £5,766 (£3,552), traction £15,841 (£14,006), heating £64 (£25), special lighting (artizans' dwellings) £383 (£324), and hire of motors £559 (£283). Generation cost £19,795, distribution £3,541, maintenance of public lamps £1,926, rents, rates and taxes £1,046, and management and establishment charges £3,907, the total expenses being £31,954 (£27,471), leaving a gross profit of £21,370 (£23,900). After meeting capital charges there is a deficiency of £1,830 on the year, compared with a net profit of £2,523 the previous year.

In his report the engineer and manager (Mr. A. H. Seabrook) says that reductions in price of current for all classes of consumers (representing £9,500) have been made during the year. Private lighting consumers have received the largest reduction, but they have been the most difficult class to induce to increase their demands. The additional cost of generation is practically accounted for by an increase of £2,580 in the coal bill. During the past few months the generating department has been reorganised, and the cost of coal per unit shows a decrease compared with last year, although the price per ton is higher. Mr. Seabrook does not, however, consider the prices for current too low, and he has no doubt the present year's working will confirm that opinion, as the necessary increased output is now being obtained. 8,013,343 units were sold (against 6,000,616), including 2,015,884 (1,820,152) for private lighting, 800,000 (750,000) for public lighting, 1,386,117 (651,163) for power and heating and 3,811,342 (2,779,301) for traction. Average prices received were: For private lighting 2·700d. (3·31d.), power 0·950d. (1·34d.), public lighting 1·390d. (1·46d.) and traction 1d. (1·21d.). Works costs per unit sold were 0·83d. (0·94d.) and total costs, including capital charges, 1·54d. (1·79d.)

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

The Joint Committee of Management of *Clonmel* (Ireland) District Lunatic Asylum are prepared to receive tenders for the following work in connection with the lighting of the asylum: Sec. 1, suction gas plant, gas engines and electric generators; sec. 2, accumulators, switchboard, underground mains, wiring and fittings; sec. 3, powerhouse building and foundation. Plans, &c., may be inspected (by appointment) at the asylum or at the offices of the consulting engineer, Mr. Louis J. Lawless, A.I.E.E., 27, Castlewood-avenue, Rathmines, Dublin, from whom conditions, forms of tender, &c., may be obtained. Tenders, addressed to the Resident Medical Superintendent, District Asylum, Clonmel, Ireland, by Sept. 7. See also an advertisement.

Bristol Electrical committee invite applications from manufacturers for supply, delivery and erection of (*a*) one 300 kw. and two 500 kw. three phase to d.c. converters (6,000 to 500 volts), with balancers and starters; (*b*) e.h.t. a.c. and l.t. d.c. switch gear; also supply and delivery, laying and jointing of (*c*) 24 miles (approx.) of 0·05 sq. in. three-core paper-insulated B.O.T. sheathed lead-covered cable, together with the necessary troughing and filling; and (*d*) the construction of the necessary converter station, inclusive of foundations. Specifications, &c., from Mr. H. Faraday Proctor, Temple Back, Bristol.

Grimsby Corporation invite tenders for supply, delivery and erection of one 500 kw. continuous-current dynamo, direct-coupled to a triple-expansion three-crank high-speed double-acting engine. Tenders to Mr. W. A. Vignoles, electricity works, Grimsby, by first post, Aug. 19.

Oystermouth Council invite applications from firms willing to establish electricity works in the district. Information from the surveyor, Mumbles, R.S.O., Glam.

Llandudno Pier Co. want tenders by Sept. 2 for supply and erection of battery giving 420 amperes at 230 volts, for three hours. Particulars from the Secretary.

Warrington Electricity and Tramways committee want tenders by Aug. 27, for construction of coal bunkers. Specification, &c., from Borough Electrical Engineer.

Finchley Council want tenders by 5 p.m. Sept. 16 for supply of feeders, distributing mains, &c. Tender forms from the Electrical Engineer.

Manchester Electricity committee want tenders by noon Aug. 26 for foundation work for turbo-generator, filter house, &c.

Erith Council want tenders by Sept. 2 for supply and erection of electrically-driven air compressor, &c. Specification from the Clerk, Bexley-road, Erith.

TENDERS RECEIVED AND ACCEPTED.

Among contracts in hand by Richardsons, Westgarth & Co. are the following:—

The complete equipment of a power station for the Tyneside Electrical Development Co., including four Parsons turbines with Nesdrum water-tube boilers, cooling towers and condensing plant; a pumping installation at the Carville power station for the Newcastle-upon-Tyne Electric Supply Co., consisting of seven high-efficiency pumps having a combined duty of nearly 3,000,000 gallons per hour.

Stalybridge, Hyde, Mossley and Dukinfield Tramways and Electricity Board have accepted the tender of Goodbrand & Co. for economisers, and that of Thos. Beeley & Son, for three superheaters and pipework.

Dublin Corporation have accepted the tender of Ferranti Limited for sub-station switchboards at £2,668. 2s. and for feeder panels at £340. 5s. The tender of the British Electric Transformer Co. has also been accepted for transformers at £2,320. 9s. 7d.

The Société Anonyme Westinghouse of Le Havre have secured a contract for the city of Milan for a 3,500 kw. turbo-generator set running at 1,250 revs. per min. to yield three-phase current at 8,650 volts 42 periods. The turbine will operate in conjunction with a Westinghouse-Leblanc surface condenser and air pump.

The Electric Lighting & Traction Co. of Australia recently placed an order for a 1,500 kw. Brush-Parsons turbine for their station at South Yarra.

St. Helens Council have accepted the tender of the British Insulated & Helsby Cables for supply of cables.

Exmouth Council have accepted the tender of Meldrum Bros. for a refuse destructor at £2,064. 10s.

Beckenham Council have accepted the tender of the British Westinghouse Co. for 12 months' supply of meters.

The Société Anonyme d'Electricite Rag. Carlo Zanchi & Cie, of Bergamo, have placed with the Société Anonyme Westinghouse of Le Havre an order for the complete installation of a generating station.

The equipment will include a Westinghouse turbo-alternating set of 1,250 kw. at 1,500 revs. per min., yielding three-phase current at 7,500 volts 50 periods. The turbine of this set will be provided with a Westinghouse-Leblanc condenser having a capacity of 11,000 kg. steam per hour. A second generating set will consist of a Belliss & Morcom steam engine of 250 revs. per min., direct-coupled to a Westinghouse three-phase alternator of 600 kw. 7,500 volts 50 periods. This steam engine will also operate in conjunction with a Westinghouse-Leblanc condenser of 5,000 kg. capacity. The switchboard for both sets will be supplied by the Société Anonyme Westinghouse. The boilers (Babcock and Willcox) will be four in number, each of 150 sq. metres heating surface.

Cheap Steam and Smokeless Chimneys.—Messrs. Burnyeat, Brown & Co., of Nine Mile Point Colliery, Cross Keys, acting on the advice of their consulting engineer, have placed an order for a complete automatic coal and ash-handling plant for five double-

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drum water-tube boilers (at £1,645) with Ed. Bennis & Co., Little Hulton, Bolton.

After screening, the coal is brought from the bunker to the boilers. A bucket elevator, placed in position in a small coal hopper and fed from the screens, delivers the coal on a Bennis improved band conveyor (260 ft. centres) which feeds the Bennis chain conveyor of the U-link type, running along the front of the boilers and delivering either into the stoker hoppers or to the coal store, as required. By means of the ash-handling plant, the ashes are conveyed from the front of the boilers to storage bunkers, whence they are removed by an elevating chain-conveyor at the end of the range. By this conveyor they are taken over a railway and fed into an ash bunker of from 15 to 20 tons capacity. The bunker is built of reinforced brickwork.

Among the orders recently received by Ed. Bennis & Co., of Little Hulton, Bolton, for their special type of coal and ash-travelling plant are the following: Stringer & Jagger (Clayton West, near Huddersfield), 1 double stoker and self-cleaning compressed air furnace for 8 ft. diameter Lancs. boiler (repeat order); Jonas & Colver (Sheffield), 2 double stokers and self-cleaning compressed air furnaces for 8 ft. 6 in. diameter Lancs. boilers (repeat); Clayton, Son & Co. (Leeds), 2 double stokers and self-cleaning compressed air furnaces for 8 ft. diameter and 8 ft. 6 in. diameter Lancs. boilers; Greenwood & Batley (Leeds), 1 double stoker and self-cleaning compressed air furnaces for an 8 ft. 6 in. diameter Lancs. boiler; and Rochdale Corporation Electricity Works (per Messrs Yates & Thom), 2 stokers and self-cleaning compressed air furnaces for Lancs. boiler (repeat). (This is an extension to eight "Bennis" stokers and compressed air furnaces already working there.)

BUSINESS NOTICES.

Mr. F. H. Preece, A.M.I.E.E., has opened offices at 27, Clement's-lane, London, E.C., where he has started in business as an engineer and agent for mechanical, steam and electrical plant. Mr. Preece is also open to carry out inspection and testing of steam and electrical plant, a class of work in which he has had considerable experience. Already Mr. Preece has the agency for Messrs. Broom & Wade, of High Wycombe (machine tools, &c.), and the Société Suisse des Machines Lentz (steam engines), and he is also taking up agencies for superheaters, dynamos and motors, and portable steam engines. Telegrams, "Inbrake, London"; telephone, Central 5735.

Messrs. J. E. Spagnoletti & Co. have converted their business into a limited liability company, under the title of Spagnoletti (Ltd.). The directors will be Messrs J Spagnoletti, H. M. Bayly, J. Lawrence, and J. Lothian Nicholson, all of whom have been long associated with the successful management of this old-established business.

Mr. S. Irwin Crookes, A.M.I.E.E. (recently of the electrical engineering department, Battersea Polytechnic, London, S.W.), is taking up consulting work, and will be pleased to receive manufacturers' lists, at Auckland Technical College, New Zealand.

Messrs. Ed. Bennis & Co. announce that, in accordance with the arrangement made between the Employers' Federation and the various trade societies that the operatives' annual holiday should be extended to a full week in lieu of other holidays allowed during the year, their works will be closed from Aug. 17 to 24 inclusive.

BANKRUPTCIES, LIQUIDATIONS, &c

Ernest Bohm, electric lamp manufacturer, 5, Boxworth-grove, Barnsbury, London, N., has been adjudicated bankrupt.

Claims against David Roberts, electrical engineer, &c., lately trading at 3 and 5, Whiston-street, Derby, are to be sent by Aug. 28 to Mr. F. Stone, 47, Full-street, Derby.

A first and final dividend of 3d. is payable at the O.R.'s, City-chambers, Catherine-street, Salisbury, in the bankruptcy of Fras. Williams, electrician, 17, Orchard road, Bemerton, Salisbury.

The liquidator (Mr. H. de V. Brougham, 33, Carey-street, London, W.C.) in the winding-up of the Automatic Telephone Co. (1903) (Ltd.) has been released.

Deed of Assignment.—A deed of assignment has been executed by E.B. Haertel, trading as the Electromotor and Dynamo Co., 15, Gray's Inn-road, London, W.C., and 49, Deansgate, Manchester. Mr. G. E. Corfield and Mr. F. E. Wright (19, St. Dunstan's Hill, Gt. Tower-street, London, E.C.) have been appointed trustees.

Plant for Sale.—Mr. A. Underwood, 3, Queen-street, London, E.C., advertises for sale two Crossley gas engines (70 B.H.P. to 105 I.H.P.), two Crompton compound dynamos, belts, pipes, tanks, battery of 132 cells, &c.

Mr. F. Checkley, 4, Palace-street, Market street, Manchester, advertises for sale about 100 second-hand arc lamps.

Motor Wanted.—A good second-hand 100 H.P. motor (for 230 volts d.c.) is required. See advertisement.

Agents Wanted.—An old-established and well-known German firm of manufacturing electric motors and dynamos, transformers and electric cranes advertises that it is open to entertain proposals from firms with large connections throughout England and colonies with a view to representation.

Factory Site for Sale.—An advertisement contains particulars of a convenient site for engineering works, &c., which is for sale; two hours from London on G.E.R. main line.

Manufacturers' Catalogues Required.—Manufacturers of electrical supplies, plant, fittings and measuring instruments are invited (in an advertisement elsewhere) to send their latest catalogues and price lists for the use of the Government of Ceylon to the Controller of Government Stores, Colombo, Ceylon.

"The Journal."—Part 185 of the Journal of the Institution of Electrical Engineers is now ready, price 5s. Particulars of contents are given in an advertisement.

Electric Signs.—Now that the evenings are drawing in people should be attracted to shop windows by enterprising tradesmen. Messrs. O. C. Hawkes (Ltd.), Aldersgate-street, London, E.C., have handed us an advance copy of their latest publication on electric signs, and this is a well-produced and comprehensive statement of the case for the electric sign. Typical illustrations are given of the various classes of signs, facias, box signs, composite letter signs, &c., all of which are built up to any desired size or requirement. A speciality is made of a sign comprising box letters, each complete with lamp, which can be made up into words, the letters being held in an ornamental frame. Among the accessories provided for sign lighting is a neat lampholder, which slides on bare wires with which it makes contact. This lampholder is adjustable, so that it can be centred behind any letter to give an even illumination.

CATALOGUES, &c.

H.T. Switch Gear.—A handsome publication on high-tension switch gear is about to be issued by the Union Electric Co., and from the advance copy before us we should anticipate a good demand for this. The text and illustrations are well printed and tastefully and conveniently arranged. The book is the ipse dixit of the company on h.t. switch gear, and engineers and power users who are interested should make application for a copy. Some of the most interesting sections deal with iron-clad gears.

"Sunshine" Arc Lamps.—The flame arcs supplied by the Electrical Co. (yclept "The Sunshine") are described and priced in a leaflet just published.

Lifeguards.—H.B. lifeguards for tramcars form the subject of an attractive booklet issued by Messrs. Hudson & Bowring, 33, Brazennose-street, Manchester. The feature of the booklet is a coloured representation of an accident on the Keighley (Yorks.) tramways, which vividly depicts the lifeguard picking up three children who shot across the track on a toboggan from a side street during the past winter.

Simplexities.—The "Installation News" (August) official organ of Simplex Conduits (Ltd.), is as readable as ever, but more particularly so for an article on "The Continuity Problem." Not the continuity of the race, but the continuity of the conduit. Doubts are not cast on the survival of the conduit, as this title might infer. On the conduitary—that is, the contrary—the article is a serious account of the making of conduits electrically continuous, the solution of the problem being finally given as the new pin socket described in our last issue.

Meters.—A handy booklet on the subject of electricity meters is being sent out by Siemens Bros. Dynamo Works. The instruments described in detail are ampere and watt-hour meters, testing instruments, transformers, &c., the series including a number of interesting portable instruments.

Small Petrol Electric Sets.—R. J. Nicholson & Co., to whose "Ideal" petrol electric sets we referred in our last issue, now send us a copy of publication 75, describing a small 45 light unit designed for use with 25 volt Osram lamps of 16 c.p. or 10 c.p. The complete set (called the "Junior Ideal") comprises petrol engine and dynamo, storage battery and switchboard.

Fuse Boards.—Rands, Robson & Co., Dacre House, Dean Farrar-street, Victoria-street, S.W., have ready particulars of the "Victoria" fuse board.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Aug. 8 to 13, with the ports of destination:—

Africa—Alexandria, £251; Cape Town, £11; Durban, £1,115; Suakim, £194. *Australasia*—Adelaide, £94; Auckland, £1,150; Brisbane, £97; Fremantle, £293; Melbourne, £1,918 (including £33 telegraph material); Perth, £150; Sydney, £1,807 (including £112 telegraph material); Timaru £277 (telegraph material); Wellington, £423. *Belgium*—Brussels, £327. *Brazil*—Pernambuco, £2,826 (submarine cable); Rio Janeiro, £8,980 (including £7,437 telegraph material); Santos, £22. *Burma*—Rangoon, £53. *Canada*—Montreal, £62 (telegraph material); Toronto, £1,960; Vancouver, £1,934. *Cape Verde Islands*—St. Vincent, £21,000 (submarine cable). *Ceylon*—Colombo, £21. *China*—Hankow, £160; Shanghai, £93. *Fiji*, £49. *France*—Boulogne, £19 *Germany*—

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Bremen, £10; Hamburg, £15. *Holland*—Amsterdam, £138; Rotterdam, £870. *Hong Kong*, £512. *India*—Bombay, £408; Calcutta, £931; Karachi, £17; Madras, £306 (including £31 telegraph material). *Japan*—Hiogo, £244; Kobe, £175; Tokyo, £1,425; Yokohama, £671. *Mauritius*, £18 (telegraph material). *Norway*—Landscrona, £25. *Persia*—Balek Pappan, £5. *Siam*—Bangkok, £28. *Spain*—Bilbao, £11. *Straits Settlements*—Singapore, £758 (including £165 telegraph material). *Sweden*—Gothenburg, £112; Stockholm, £172. *West Indies*—Jamaica, £393. Total (for six days) £52,510, against £432,239 for 11 days last year (Aug. 4 to 14).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

May 17, 1907.

11,523 KNEEN & KING. Tramway conduit points.
11,528 GOSLING. Holders for electric lamps and shades.*
11,532 WHIDBOURNE. High-tension ignition devices.
11,541 HATFIELD. Electrically operating apparatus.
11,573 HILL & HACKING. Electrically operated gas valves.
11,580 BELLISS & MORCOM, JUDE & MORCOM. Turbines.
11,581 BODDAM. Hydraulic lifts electrically operated.
11,582 FLEMING. Wireless telegraphy.
11,594 ALLGEMEINE ELEKTRICITÄTS-GES. Electric motors. (Date applied for, 21/5/06.)*†
11,597 WARWICK MACHINERY Co. (G.E. Co., U.S.) Fluid turbines.
11,598 B.T.-H. Co. (A.E.G., Germany.) Dynamo-electric machines.
11,604 LEITNER. Contact voltmeters.
11,615 LAKE. (La Société Anonyme "Le Carbone," France.) Manufacture of carbon brushes.
11,616 FLUEGELMAN. Electromagnetic registers.
11,618 DENTAL MFG. Co. & PEARSON. Electric heat regulating apparatus.*
11,260 ANGER. Sand boxes for tramway and railway vehicles.
11,621 BROOKS & AKERS. Operating alternating-current machines in parallel. (Date applied for, 18/1/07.)*†
11,630 WALLACE & SIBTHORP. Telephones.

May 18, 1907.

11,647 LUDLOW. Telephone register for trunk calls.
11,854 KUMAI. Steam turbines.
11,667 BROOKS & ALSTON. Tremblers of induction coils.
11,670 HATFIELD & LEWIS. Arc lamps.
11,673 VON AMMON. Commutators for electrical machines.
11,695 AMALGAMATED RADIO-TELEGRAPH Co. (Seibt, Germany.) Radio-telegraphy.*
11,701 PHŒNIX DYNAMO MFG. Co. & POHL. Dynamo-electric machines.
11,706 TYLER. Reciprocating continuous-current electricity meter.*
11,713 MITCHELL. Surface-contact electric-traction systems.
11,717 SIEMENS & HALSKE A.-G. Manufacture of electric lamp filaments of tungsten or alloys thereof. (Date applied for, 19/5/06.)*†

May 21, 1907.

11,754 HEYS. (General Acoustic Co., U.S.) Telephone transmitters.*
11,769 GILLMOR. Joints in railway or tramway rails.
11,774 ROMER. Telephone exchange systems.
11,780 RICHARDS. (Electric Loop Cable Co., U.S.) Electric cable.
11,786 COOK. Electrical devices and apparatus.
11,794 LANG. Control of electric motors.
11,808 GRAHAM. Telephonic apparatus.
11,823 LAKE. (John Stone Stone, U.S.) Amplifying electrical currents.*
11,828 SIEMENS BROS. & Co. (Siemens & Halske Act.-Ges., Germany.) Transformers.*

May 22, 1907.

11,850 BOTTING & BOTTING. Rotary intermittent electric sign switch.
11,854 GIBBONS. Telemotor apparatus.
11,872 SIEMENS BROS. DYNAMO WORKS & KLOSS. Dynamo electric machines and motors.
10,873 SIEMENS BROS. DYNAMO WORKS & POYNDER. Altering the working speed of polyphase motors.*
11,874 SIEMENS BROS. DYNAMO WORKS & POYNDER. Combined electrical mechanical systems.*
11,894 PAULI. Incandescent lamps.*
11,911 HEADLAND & PLUTTE. Arc lamps.
11,926 B.T.-H. Co. (A.E.G., Germany.) Controller mechanism for electrically operated cranes, lifts.

May 23, 1907.

11,952 CHARTERS & JONES. Electrical fuse.*
11,979 DEUTSCHE BECK-BOGENLAMPEN G.m.b.H. & BECK. Supported carbon for arc lamps. (Date applied for, 29/1/07.)*†
11,984 COOPER. Electrical motor-starting and regulating switches.
12,010 ROBERTS & RIVIERE. Automatic electric boosters.
12,020 B.T.-H. Co. (G.E. Co., U.S.) Apparatus for use in space telegraphy.

May 24, 1907.

12,043 ORLING. Electro signalling by electric waves.
12,050 SIEMENS BROS. DYNAMO WORKS (LTD.) & KLOSS. Dynamo electric machines and motors.*
12,053 SIEMENS-SCHUCKERTWERKE G.m.b.H. Ventilating dynamo electric generators and motors. (Date applied for, 31/5/06.)*†
12,065 FAVERO. Holders for incandescent lamps.
12,079 CUNNINGHAM & BRACKENSIECK. Electrically heated steam radiators.
12,081 STEWART. Electrically propelled vehicles.
12,089 B.T.-H. Co. (G.E. Co., U.S.) Internal combustion engines.
12,090 ALLGEMEINE ELEKTRICITÄTS GES. Alternating-current commutating machines. (Date applied for, 25/5/06.)*†

May 25, 1907.

12,129 DRIVER. Supports for incandescent lamps.
12,135 ROOS. Magneto-electric ignition apparatus.*
12,138 KOCH. Rotary motors. (Date applied for, 1/6/06.)*†
12,152 PENNING. Electrical house terminal boards and cut-outs.

COMPLETE SPECIFICATIONS.

1906 SPECIFICATIONS.

7,248 FRANKLIN & SEYFERT. Alternating-current electric motors.
9,959 GAUNTLETT & SHERARDIZING SYND. Deposition of metals upon and their combination with metals or metallic articles.
12,333 BERRY. Electrical production of heat for cooking.
12,340 ZANI. Electromagnetic power transmission.
12,567 WILLIAMSON & WILLIAMSON. Shade devices.
12,862 MORLOCK. Electrical brake for railway trains.
12,998 FAIRWEATHER. Wireless cluster supports for electric lamps.
13,172 DRUSEIDT. Reflector mountings for incandescent lamps.
13,221 B.T.-H. Co. (G.E. Co., U.S.) Electric switches.
13,691 B.T.-H. Co. (G.E. Co., U.S.) Motor control systems and apparatus.
13,844 B.T.-H. Co. (G.E. Co., U.S.) Induction motor control.
15,704 ELECTRIC & ORDNANCE ACCESSORIES Co. & HALL. Inter-communication telephone apparatus.
15,984 B.T.-H. Co. (G.E. Co., U.S.) Systems of control of electric motor-operated devices.
16,195 B.T.-H. Co. (G.E. Co., U.S.) Overload protective devices.
16,361 B.T.-H. Co. (G.E. Co., U.S.) Electric circuit-controlling devices.
16,693 CIRI. Electrical signalling apparatus.
16,957 TAYLOR, EATON & SCHWARZ. Starting and controlling electric motors.
17,321 R. WAYGOOD & Co. & WALKER. Electrically controlled lifts or hoists.
17,564 WHITE & HOEGERSTAEDT. Electromagnetically operated valves.
17,601 FULLER, FULLER, FULLER & MOORE. Magneto-electric generating apparatus.
17,703 DAVIES. Single-phase alternating-current electric motor.
18,704 HOSCH. Sparking plugs.
18,716 SIEMENS BROS. & Co. (Siemens & Halse Akt.-Ges.) Central battery telephone systems.
19,074 POTTERAT. Electric traction systems.
20,062 WYNN. Instruments for straining telegraph wire.
21,279 WEAVER. Electric air-heaters for heating and ventilation systems.
25,509 MATZKA & TIMMERMANN. Electric fuse plugs.
26,998 MCCOLLUM. Automatic electric car brakes.
28,100 SIEMENS-SCHUCKERTWERKE GES. Single-phase commutator motors with commutation fields. (Date applied for, 11/12/05.)
29,151 SIEMENS BROS. DYNAMO WORKS & DUKE. Lighting systems for electric railway carriages and trains.

COMPANIES' MEETINGS AND REPORTS.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—At an extraordinary meeting on Monday the resolutions passed on 26th ult. approving the provisional agreement entered into with the Cie. Générale de Tramways de Buenos Ayres for the acquisition of the Buenos Ayres & Belgrano Electric Tramways Co.'s undertaking were confirmed.

CHARING CROSS, WEST END & CITY ELECTRICITY SUPPLY CO. (LTD.)—An interim dividend at the rate of 5 per cent. has been declared on the ordinary shares of the West End undertaking. The figures for the half-year ended June 30, compared with the corresponding period of last year (excluding the bulk supply from one undertaking to the other) are: *West End:* 5,098,880 units sold, against 4,720,221; revenue £63,561, against £60,554. *City:* 4,234,389 units sold, against 3,497,820; revenue £44,533, against £38,228.

CHATHAM & DISTRICT LIGHT RAILWAYS CO.—For the half-year ended June 30 the receipts were £18,273. 2s. 11d. and the expense £12,941. 3s. 7d., leaving £5,331. 19s. 4d. After writing off £222. 1s. 8d. and paying debenture interest (£1,196) and adding £578. 14s. 6d. brought forward, the available balance is £4,492. 12s. 2d. which has been carried forward. Rochester Corporation are proceeding with their extension lines to Strood Hill, Frindsbury and Borstal, and it is anticipated that these will be completed early next year and will be leased to the company.

LANARKSHIRE TRAMWAYS CO.—The receipts for the half-year onded June 30 were £29,703. 7s. 11d., and the expenses £16,051. 11s. 9d. leaving £13,651. 16s. 2d. After deducting contributions payable to local authorities (£621. 10s.) and debenture and other interest (£831. 13s. 1d.), and adding balance forward (£882. 14s. 5d.), £13,081. 7s. 6d. is available. Dividend at the rate of 5½ per cent. for the half-year is recommended, and £5,182. 11s. is carried forward.

LIVERPOOL OVERHEAD RAILWAY CO.—At the meeting on Tuesday Sir W. B. Forwood said that although the number of passengers carried during the half-year was 39,829 fewer than during the same period last year, the revenue had increased by £447, the average fare having gone up from 1·74d. to 1·78d. They had to reduce their fares to meet com-

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petition, but the low fares did not attract traffic to any great extent. They had to realise that their railway was a business line used by business men for business purposes, and those purposes would not be materially affected if the average fare was 1·75d. or 1·93d. per passenger. During the half-year they had advanced some of the fares with good results. During the past year they carried 8,636,000 passengers. He thought they might look for a gradual increase with the growth of trade, the extension of the port to the north, and the opening up of through connections. Their revenue per train mile worked out at 20·26d. against 20·09d. last year, and compared with the City and South London 33·66d., Central London 61·89d., and the Mersey Railway 27·41d. There was a slight reduction in working expenses—16·09d. per train mile against 16·28d. last year. He claimed that their running expenses were lower than on any other electric line. Another satisfactory feature was the saving they had been able to effect in their rates. They appealed against their assessment. They had already effected a saving of £600 per annum, and they expected to make a further saving of £1,500 per annum during the next year. The through traffic to Southport and Aintree, in connection with the Lancashire and Yorkshire Railway, continued to make slow but steady progress. On their tramway system they carried 1,128,074 passengers, an increase of 18,324. They hoped to minimise the higher price of coal by alterations to their condensing plant, and they had also under consideration the adoption of induced draught apparatus with a view to effecting a further economy in fuel. On July 1 an experimental system of residential contracts was introduced, and on Aug. 1 the system was further extended by including an additional station or stations for an extra payment. The contracts were only for six months, and should the system prove unremunerative it would be dropped.

METROPOLITAN DISTRICT RAILWAY CO.—The report for the half-year ended June states that capital expenditure for the half-year was £137,588. Gross receipts were £220,628, a decrease of £427 compared with the June half-year of 1906. Working expenses were £143,936, a decrease of £22,976. After providing for rent charges, interest on debenture stock, &c., there was a deficit of £18,035. To this deficit must be added £10,156, proportion of net revenue arising from the City Lines Joint Undertaking. The dividend on the 4 per cent. guaranteed stock is at rate of £1. 12s. 6d. per cent. per annum. 25,426,825 passengers were carried, a decrease of 3,846,472; receipts were £202,099, decrease of £1,929; the train mileage was 1,178,743, an increase of 20,826.

At the meeting on Wednesday the chairman (Sir Geo. S. Gibb) said he believed that they had not lost any substantial number of passengers owing to increased fares. Those fares were still very low. The average receipt per passenger had been 1·91d., the mileage being 24 miles. In 1899 the average receipt was 2·19d., so that their fares in 1899 were 14·7 per cent. higher than they were at present. The decrease was particularly due to new competition, which did not exist in the first half of 1906. The Piccadilly Tube directly competed with the District all the way from Hammersmith to Holborn. He had gone carefully into the matter and had come to the conclusion that during the half-year they lost 2,250,000 passengers by diversion to the Piccadilly Tube, which carried 12,000,000 passengers altogether. Their loss in money from the same cause had been £22,000. Car repairs showed a decrease of £2,455. He thought this expenditure would still be reduced; but in regard to both car repairs and expenditure on way and works they were quite resolved that they would not save money which ought to be spent on those items. It would be very bad policy to do so. They had not included in their car expenditure anything for depreciation. In traffic expenses there was a saving of £1,861. On train working there was the large saving of £12,934, or 14 per cent. The number of train men and the amount spent under that head had decreased by £2,987, and electric current had cost £9,000 less, £1,573 being due to a decrease in the price of current and £3,075 to a decrease in the number of car-miles run. Then they had saved £4,181 in the quantity of current used, due to the careful running of the trains and the teaching of the men so as to enable them to run the trains with a smaller expenditure of current. Omitting an increase of £419 on rates and taxes, there was a saving of £23,411 on the expenditure side, or practically 16 per cent. Of the work done by the District cars, 44 per cent. was done off the District system. The cars ran to Richmond and Wimbledon over the South-Western Railway, they ran over the Whitechapel and Bow, and over the Tilbury and Southend; they also ran over the Metropolitan, although, so far as the Inner Circle working was concerned, it was a mere exchange of running. It was due to losses incurred on the outside branches that the District's results were so disappointing. There was a loss in working the Harrow and Hounslow branches after payment of interest on the capital raised for rent charges. There was a serious loss on the City line, and at present a loss on the Whitechapel and Bow line, if they took into account the capital spent. If the District system stood by itself they would be paying a substantial dividend on their first preference stock. The losses on the outside branches came to £54,000 in the half-year. The branches would develop slowly, but on the main line he thought they might look for a steady annual increase, and that a good many of the passengers who had been lost to the company were coming back. The trains were running well and, he believed, comfortably, and he had no hesitation in expecting a steady annual increase.

Mr. R. W. Perks, M.P., has resigned his seat on the board of the District Company.

MEXICAN LIGHT & POWER CO.—At a meeting to be held on the 30th inst. the shareholders will consider a proposal to purchase the Robert Electric Co., which is stated to be the only existing competitor in the Federal District of Mexico. The board asks for authority to issue $2,400,000 gold 7 per cent. cumulative preference stock.

THOMAS PARKER (LTD.)—At the meeting last week, Mr. C. T. Mander said that the directors' predictions of last year had been fulfilled. For the greater part of the profit the shareholders must thank their managing director for his fortunate discovery of a new principle in the production of centrifugal pumps. The directors hoped that they would soon reach the dividend-paying stage, and take a place among the successful manufacturing companies. In a few months' time it was proposed to convene an extraordinary meeting, when a scheme would be submitted with regard to the issue of preference shares to wipe out the debentures and loans.

NEW COMPANIES, STATUTORY RETURNS.

NEW COMPANIES.

BRITISH AUTOMOBILE IMPROVEMENTS (LTD.) (94,477.)—Reg. Aug. 3, capital £10,000 in £1 shares (5,000 10 per cent. cumulative preference), to carry on the business indicated by the title and to adopt agreements with S. Alley and with La Société des Appareils Electriques Ignis.

J. CRAWFORD & SONS (LTD.) (94,514.)—Reg. Aug. 8, capital £2,500 in £10 shares, to acquire the business of J. Crawford & Sons, and to carry on the business of electrical, mechanical and consulting engineers, manufacturers of hauling engines, electric haulage plant, engines for dynamo driving, &c. J. Scorer is manager. Reg. office, Bonner's Field Engine Works, Monkwearmouth, Sunderland.

L'ESTRANGE & HAY (LTD.) (94,529.)—Reg. Aug. 9, capital £10,000 in £1 shares (5,000 preference), to take over the business of a consulting engineer, electrician, dealer in and repairer of and instructor in the use and management of motors and proprietor of motor garage carried on by A. H. C. L'Estrange. First directors: A. H. C. L'Estrange and Lieut. the Hon. S. M. A. J. Hay, who are permanent managing directors. Reg. office, The Clock House, Arundel-street, London, W.C.

SOCIETE ANONYME DES ACCUMULATEURS A.C.S. (SYSTEME DE SEDNEFF) (LTD.) (94,508.)—Reg. Aug. 7, capital £140,000 in £4 shares, to adopt an agreement with Cesar Trouin and Sigismond de Szepczynski, to undertake and execute contracts for works involving the use of machinery and supply thereof in connection with the use of electricity, and to carry on the business of manufacturers of electric accumulators, electrical plant and accessories, engineers, &c. Reg. office, 790—792, Salisbury-house, London, E.C.

SPAGNOLETTI (LTD.) (94,447.)—Reg. Aug. 1, capital £20,000 in £1 shares, to acquire the business of an electrical and mechanical engineer and manufacturer carried on by J. E. Spagnoletti & Co., and to carry on the business of mechanical, mining and general engineers, electricians, dealers in generators, accumulators and suppliers of electricity, &c. First directors J. E. Spagnoletti (permanent), H. M. Bayly, J. Lawrence and G. J. L. Nicholson. Reg. office, Goldhawk Works, Goldhawk-road, London, W.

STATUTORY RETURNS.

BROMPTON & KENSINGTON ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to March 31 is £300,000 in £5 shares (20,000 preference), of which 30,131 ordinary and 9,869 preference have been taken up. £5 per share has been called up on 29,131 ordinary and 9,869 preference and £195,000 has been received. £5,000 is considered as paid on 1,000 ordinary. Mortgages and charges, nil.

GORSEINON ELECTRIC LIGHT CO. (LTD.)—In return to May 20 capital is £1,000 in £1 shares, all of which have been taken up. £1 per share has been called up and £990. 10s. has been received. Mortgages and charges, £800.

ILFRACOMBE ELECTRIC LIGHT & POWER CO. (LTD.)—Return to June 24 gives capital as £15,000 in £5 shares, of which 67 have been taken up. £5 per share has been called up and £335 has been received. Mortgages and charges, nil.

CITY NOTES.

MEMORANDA (Aug. 15).—Bank rate 4½ per cent. (Aug. 15, 1907), Price of silver 31 13/16—31 15/16d. per oz. Consols 81⅝—81¾ for money, 81⅝—81¾ for account; 2½ per cent. annuities 79 1/16—80. Consols Pay Day, Sept. 2; Stocks and Shares Continuation Days, Aug. 27 and Sept. 11; Ticket Days, Aug. 28 and Sept. 12; Pay Day, Aug. 29; Mining Share Carry-over Day, Aug. 26.

PRISWELL (1906) (LTD.)—The directors recommend payment of a final dividend of 10 per cent. on the ordinary shares (making 10 per cent. for the year to June). The accounts for 1907 show a large increase in sales of motor vehicles over the year 1906.

W. T. HENLEY'S TELEGRAPH WORKS CO. (LTD.)—The directors have declared an interim dividend of 4½ per cent. on the preference shares (less tax) and at the rate of 10 per cent. on the ordinary shares (less tax) for the half-year ended June 30, both payable Sept. 2.

LIVERPOOL DISTRICT LIGHTING CO. (LTD.)—An interim dividend at the rate of 5 per cent. per annum has been declared for the half-year ended June 30.

MATHER & PLATT (LTD.)—The directors have declared an interim dividend on the ordinary shares of 3 per cent. (at the rate of 6 per cent. per annum, tax free) for the half-year ended June 30.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have been asked to appoint a special settling day in and grant a quotation to £300,000 4½ per cent. mortgage debenture stock of the *United River Plate Telephone Co. (Ltd.)*.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 7	1,561	− 31	10	15,309	− 48
Airdrie	,, 2	200	− 11	30	6,700	− 7
Anglo-Argentine	,, 12	16,386	+ 716	32	527,338	+ 54,353
Ashton-under-Lyne Corp	,, 20	429	+ 25	20	7,926	+ 783
Ayr Corporation	,, 10	447	− 47	13	5,118	− 218
Baker St. & Waterloo Ry.	,, 10	2,115	+ 824	6	14,530	+ 6,541
Barnsley	,, 2	175	+ 12	30	4,950	+ 6
Barrow	,, 2	320	− 29	30	7,547	− 81
Bath Electric Trams, Ltd.	,, 7	1,300	− 150	32	24,870	− 786
Birkenhead Corporation	,, 11	1,377	+ 167	...	...	...
Birmingham Corporation	,, 10	6,845	...	19	114,591	...
Birmingham & Mid.	July 26	829	...	29	23,151	...
Blackburn Corporation	...	...	...	...	...	...
Blackpool Corporation	Aug 8	3,359	− 95	18	23,341	− 1,714
Blackpool and Fleetwood	,, 10	2,478	− 250	6	8,280	− 2,114
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 11	2,660	+ 516	19	44,359	+ 2,597
Bournemouth Corporation	,, 7	2,758	+ 15	¶18	32,726	+ 551
Bradford Corporation	,, 10	5,385	− 44	19	89,957	+ 234
Brighton Corporation	,, 11	1,814	− 319	19	18,427	− 2,059
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 9	6,875	− 84	5	23,362	− 743
Burnley Corporation	,, 10	1,355	+ 38	19	22,398	+ 241
Burton Corporation	,, 11	366	− 21	19	5,697	− 302
Bury Corporation	,, 4	1,148	...	18	19,924	...
Calcutta Tramways Co.	,, 10	R47,474	+ R3,579	5	R237,052	+ R20,112
Camborne-Redruth	,, 10	147	+ 17	32	3,805	+ 52
Cardiff Corporation	,, 10	2,677	− 240	19	43,023	+ 2,046
Cavehill	,, 2	101	− 31	30	2,588	+ 66
Central London Railway	,, 10	4,267	− 610	6	30,886	− 2,555
Charing C., Euston & H'stead	,, 10	2,955	...	6	15,775	...
Chatham & Dist. Lt. Rys.	,, 8	1,120	+ 153	‡32	22,701	+ 1,954
City & South London Rly.	,, 11	3,106	+ 840	6	18,757	+ 4,072
City of Birmingham	,, 2	2,775	...	30	84,108	...
Colchester Corporation	,, 7	350	− 24	...	...	...
Cork Electric Trams Co.	,, 8	537	− 77	32	14,690	− 549
Croydon Corporation	,, 9	1,879	− 111	19	27,803	− 1,749
Devonport & Dist. Trams.	,, 2	455	− 51	30	13,699	− 68
Dover Corporation	,, 10	353	− 86	19	4,575	− 698
Dublin & Lucan Railway	,, 9	206	+ 19	6	908	+ 37
Dublin United	,, 9	8,494	+ 1,889	‡6	43,081	+ 10,137
Dudley Stourbridge	,, 2	843	− 159	30	25,159	− 767
Dundee Corporation	,, 7	1,094	− 22	12	13,795	+ 289
East Ham Council	,, 10	1,164	− 24	19	17,765	− 416
Exeter Corporation	,, 9	446	+ 8	19	6,291	+ 551
Falkirk and District	,, 7	298	...	...	...	...
Gateshead & Dist. Trams.	,, 2	1,042	+ 10	30	30,236	+ 600
Glasgow Corporation	,, 10	17,249	+ 122	10	175,031	+ 2,014
Glossop	,, 10	143	− 2	32	4,345	+ 47
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	,, 2	268	− 11	30	7,189	− 15
Great Northern & City Rly.	,, 10	1,440	+ 21	6	9,758	+ 176
Gt. Northern, Piccadilly, &c.	,, 10	3,590	...	6	24,560	...
Greenock & Port Glasgow	,, 2	693	− 67	30	20,069	− 118
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 2	353	− 43	30	8,487	− 516
Hastings Elec. Trams Co.	,, 8	2,066	+ 272	6	7,211	+ 2,287
Hong Kong	,, 10	$7,312	− $34	18	$245,935	+ $34,486
Huddersfield	,, 10	1,842	+ 125	19	30,583	+ 1,209
Hull Corporation	,, 10	2,685	+ 132	19	45,610	+ 2,138
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 7	197	...	19	2,765	+ 158
Ipswich Corporation	,, 10	652	− 43	19	8,102	− 681
Isle of Thanet Co.	,, 10	2,064	− 147	45	21,491	− 680
Jarrow	,, 2	140	...	30	3,639	...
Keighley Corporation	,, 8	178	+ 15	6	964	+ 39
Kidderminster & District	,, 2	136	− 8	30	3,413	− 161
Kilmarnock Corporation	,, 10	145	− 7	12	2,137	− 32
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 8	1,232	+ 304	32	36,476	+ 8,803
Lancashire United	,, 7	1,811	+ 417	32	39,462	+ 10,229
Leamington	,, 2	183	− 4	30	4,640	− 739
Leeds Corporation	,, 10	8,149	+ 654	19	126,501	+ 4,982
Leicester Corporation	,, 10	2,805	− 84	6	14,297	− 344
Leith Corporation	,, 10	551	+ 6	†13	7,037	+ 70
Lincoln Corporation	,, 10	143	+ 10	19	2,352	+ 56
Liverpool Overhead Rly.	,, 11	2,168	+ 360	6	10,650	+ 1,009
Liverpool Corporation	,, 3	11,771	+ 505	31	333,844	+ 4,650
*London County Council	,, 3	31,259	+ 5,750	18	591,389	+ 86,580
London United	,, 9	10,547	+ 478	‡32	203,850	+ 5,387
Lowestoft	,, 10	439	− 10	45	8,160	+ 902
Maidstone Corporation	,, 10	147	− 19	19	2,163	− 107
Manchester Corporation	,, 10	16,287	+ 574	19	282,348	+ 21,411
Mersey Railway	,, 10	1,883	+ 104	6	11,106	+ 966
Merthyr	,, 2	206	+ 2	30	6,251	+ 309
Metropolitan Dist. Railway	,, 11	6,846	+ 157	6	45,645	+ 281
Metropolitan Elec. Trams.	,, 2	5,147	+ 1,429	30	134,599	+ 29,125
Middleton	,, 2	399	− 14	30	10,559	− 196
Nelson Corporation	,, 10	158	+ 3	20	2,938	+ 42
Newcastle-on-Tyne Corp.	,, 10	4,260	+ 123	19	79,530	+ 448
Newport (Mon.)	,, 10	891	+ 7	19	13,966	+ 1,575
Northampton Corporation	,, 9	661	− 36	‡19	8,498	− 429
Oldham, Ashton & Hyde	,, 2	623	+ 1	30	18,082	+ 226
Oldham Corporation	,, 11	2,022	+ 162	20	38,974	+ 2,530
Perth (N.B.) Corporation	July 31 / Aug. 7	191 / 178	+ 3 / − 8	12	2,097	+ 27
Perth (W.A.) Elec. Trams.	,, 9	1,346	− 18	32	45,609	− 1,515
Peterborough	,, 2	145	− 17	30	3,676	− 168
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 10	3,193	− 190	19	39,526	− 2,010
Potteries	,, 2	1,906	− 25	30	56,489	+ 1,414
Preston Corporation	July 31 / Aug. 7	780 / 816	− 39 / − 10	19	14,571	+ 136
Rotherham Corporation	,, 8	748	+ 105	†19	11,196	+ 1,633
Rothesay	,, 2	406	− 47	30	6,151	− 337
Salford Corporation	,, 12	4,688	+ 295	19	90,512	+ 1,812
Sheerness	July 31	67	− 8	30	1,672	− 50
Sheffield Corporation	Aug. 11	6,051	+ 340	20	111,291	+ 4,794
Singapore Trams.	,, 10	$9,550	+ $1,425	19	$181,440	+ $5,310

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days. * Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	Aug. 7	1,421	+ 94	...	...	...
Southend Corporation	,, 7	898	− 1	19	7,815	− 363
South Metropolitan	,, 2	895	+ 408	30	23,028	+ 3,319
Southport Tramways	,, 2	397	+ 12	30	8,651	− 533
South Staffs	,, 2	869	+ 23	20	26,733	+ 1,819
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	...	...	...	...	...	...
Sunderland and District	,, 7	650	− 7	32	14,316	+ 1,744
Swansea Trams	,, 2	1,007	+ 23	30	25,889	+ 917
Swindon Corporation	...	...	...	...	...	...
Taunton	,, 2	53	...	30	1,272	− 87
Tynemouth and District	,, 2	389	− 50	30	6,935	− 737
Tyneside Trams Co.	,, 7	598	− 27	32	14,804	+ 617
Victoria, Elec. Supply Co. of	July 7	665	+ 18	15	12,585	+ 102
Wallasey District Council	Aug. 10	1,315	+ 84	19	16,718	+ 394
Walsall Corporation	,, 10	708	+ 9	32	16,021	− 471
Warrington Corporation	,, 8	436	+ 20	19	7,210	+ 263
West Ham Corporation	,, 8	2,795	+ 86	19	45,675	+ 1,246
Weston-super-Mare	July 31	281	− 43	30	3,287	− 425
Wolverhampton Co.	Aug. 2	462	+ 21	30	13,479	+ 707
Wolverhampton Corpn.	,, 7	1,122	+ 18	3	2,828	+ 42
*Worcester	,, 2	347	+ 7	30	8,225	− 247
Wrexham	,, 2	107	+ 1	30	3,030	− 35
Yorkshire W.R. Trams	,, 11	1,691	+ 369	32	36,528	...
Yorkshire Woollen District	,, 2	936	− 15	30	28,894	+ 1,338

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., Aug. 14.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to Aug 14. High-est.	Business Week to Aug 14. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	Anglo-Argentine Ord. Shares	8½–8⅝	4 7 0	Ap, Oct	8 7/16	8¼
5	2/9	Do. 5% per Cent. Cum Pref.	6 –6¼	4 8 0	Ja, Jul	6 5/16	..
St.	6%	Do. Permanent 6% Deb. Stock	131 –134	4 9 9	Ju, Dec	131	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 –105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3⅜–3⅝	2 19 6	May ..	3½	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅛–5 1/16	4 14 0	My, Nv	4 3/16	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 –100	4 10 0	Ja, Jul	98	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 –132	4 3 6	Mr, Spt	129	..
St.	5%	Do. Pref. Ord. Stock	110 –114	4 7 6	My, Nv	112½	112
St.	5%	Do. 5% Cum. Perp. Pref. Stock	103 –106	4 14 6	Ja, Jul	101½	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 –103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 –102	4 8 0	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4½–4⅝	8 11 9	Ap, Oct	4½	4⅜
5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4⅝–5	5 14 0	Ap, Oct	..	..
5	3/0	Do. "B"	4⅝–5	5 14 0	April ..	4⅝	..
St.	5%	Do. 5 per Cent. Debs.	105 –115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 –103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 –97	5 3 0	Ja, Jul	96	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 –103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds.	101 –103	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7⅛–8	5 0 0	Mr, Spt	7⅞	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5⅝–5⅞	4 13 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 –106	4 5 0	Ja, Jul	102¾	..
St.	..	Cape Electric Tram Shares	5/16–7/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 –98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	83 –88	5 14 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 –93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 –82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛–1⅛	3 15 0	July ..	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅛	4 10 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs.	95 –98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 –99	5 1 0	Ja, Jul	..	..
St.	4½%	†Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 –103	4 7 6	Fb, Aug	..	..
St.	5%	Perth E. Trams. 1st Mt. Db. Stock	100 –104	4 16 0	Ja, Jul	..	..
..	5%	Sao Paulo Tramway, Light & Power Co. $100 Stock	105 –110	7 5 6	..	108	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	93⅝–95⅞	5 5 0	Ju, Dec	94	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅜–5⅛	5 14 0	Mr, Spt	..	..
10	4/6‡	†Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅜–8⅛	5 16 6	..	95½	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 –96	4 13 9	Ja, Jul	..	..
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅜ 7⅜	5 3 3	Ap, Oct	7⅛	..
5	2/3	Do. (80,001 to 160,000)	6⅛–7⅛	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 –53	4 14 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2⅛–2⅜	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	85½–89⅛	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½–96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 –106	5 13 0	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 –97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	3/16–¼	3 6 9	April ..	7/32	..
1	1 2/3	Do. 6 per Cent. non-Cum. Pref.	5/8–1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 –98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 –5½	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 –101¼	4 19 0	Ja, Jul	100¼	100

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

Shrs.	Last Dividend	Name.	Price Wed., Aug. 14.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to Aug. 14. High-est.	Low-est.
		ELECTRICITY SUPPLY.					
10	9/0	Bournemouth & Poole Elec. Sup. Ord...	10 —11	6 6 0	Mar, Sept,	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	10 —10⅝	4 5 6	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10⅛ - 10⅜	5 11 6	Feb, Aug	10⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	99 —102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜-5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 —100	4 10 0	May, Nov	..	..
5	5/6	Brompton & Kensington Elec. Sup. Ord.	7⅞-8⅜	5 14 6	March.....	..	..
5	3/6	Do. 7 per Cent. Pref.....	7⅞-8⅛	4 6 0	Mar, Sept	7⅛	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜- 4	5 11 0	Feb, Aug	3⅞	..
5	2/3	Do 4½ per Cent. Pref.	3⅜-4⅛	5 8 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 - 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜-4⅛	6 0 0	Jan, July	3⅛	..
5	2/3	Chelsea Electric Supply Ord.	3⅜-4⅛	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 —104	4 6 6	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 - 9½	6 6 0	Feb, Aug	9⅜	9½
10	6/0	Do. 6 per Cent. Cum. Pref.	11 —12	5 0 0	Jan, July	11⅛	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	121 —124	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 —99	4 11 0	Jan, July	97½	..
5	5%	County of Durham Elec. P.D. Ord.....	3⅜-4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜-4⅞	5 4 11	April, Oct	..	..
10	4/0	†County of London Elec. Supply Ord.....	7 —8	6 5 0	Feb, Aug	7¼	..
10	6 0	† Do. 6 per Cent. Cum. Pref.....	10½-11½	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 —109	4 2 9	Jan, July	107½	107⅝
St.	4½%	Do. Second Deb. Stock Prov. Certs...	94 - 97	4 12 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜-5⅜	5 2 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	Mar, Sept	..	..
St.	4½%	† Do. 4½ 1st Deb. Stock (red).....	96 —99	4 11 0	Feb, Aug	..	..
5	5 0	Hove Electric Lighting Ord.	6⅜-7⅛	6 4 0	April, Oct	..	..
5	5/0	†Kensington & Knightsbridge Ord.....	8⅛-9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜- 7	4 5 9	Jan, July	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Knghtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 - 101	3 19 0	April, Oct	..	..
3	2 4⅜	London Electric Supply Ord.	1⅜- 2	6 0 0	Mar, Sept	..	..
5	3.0	Do. 6 per Cent. Pref.....	4⅜-5½	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	88 - 96	4 3 8	Jan, July	..	..
5	3/0	†Metropolitan Electric Sup. Ord.	5⅛-6¼	6 9 0	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅛-5⅜	4 9 0	Jan, July	4⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	88 - 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	96 —98⅞	4 11 9	June, Dec	97	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9⅜—9⅝	4 15 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	98 - 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅜—7	5 16 4	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜-5½	4 16 0	Feb, Aug	..	..
100	4%	† Do. 4 per Cent. Mort. Deb. red. 1907.	97 —98	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	—	..
100	4½%	† Do. 4½ per Cent. Deb.	97 —99	4 11 10	Jan, July	..	..
10	6 0	Notting Hill Electric Ord.....	11 —12	7 10 0	March ..	..	..
5	4,6	Oxford Electric Ord.	5⅜—6⅛	5 12 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 - 97	4 2 6	Jan, July	..	..
5	5 0	†St. James' & Pall Mall Elec. Ord.....	7⅜—8⅛	5 14 0	Feb, Aug	..	..
5	3/6	† Do. 7 per Cent. Pref.	6⅞—7⅝	4 10 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86—91	3 17 0	Jan, July	86½	86
5	..	Smithfield Markets Electric Sup. Ord...	⅛-1⅛	..	Feb	..	..
St.	4%	† Do. 4 per Cent. Deb. Stock.....	71 —75	5 6 0	Feb, Aug	..	..
5	3.0	South London Electric Supply Ord.....	2 - 2⅛	6 0 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜—⅝	3 6 9	..	..	..
1	0/8⅜	Do. 7 per Cent. Cum. Pref.....	1⅛—1⅜	4 15 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	109 —103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅜—2¼	8 18 0	April, Oct	..	..
5	2 6	Do. 5 per Cent. Cum. Pref.	2 — 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 - 97	4 12 9	April, Oct	..	..
5	6 6	Westminster Elec. Sup. Ord.	9⅛ - 9⅜	6 8 0	Mar, Sept	9⅜	9⅛
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 —5½	4 2 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	88 —93	4 6 0	Jan, July	89½	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜—⅝	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅝—1⅛	4 17 6	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	92 —97	4 13 0	April, Oct	95	93
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 - 97	4 13 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14 —14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8½—9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 - 99	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅛—2⅜	..	June, Dec	2⅛	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6⅞—7⅛	8 6 0	Feb, Aug	7⅛	6⅞
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 - 103	4 17 0	April, Oct	101½	100
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 —81	5 11 0	May, Nov	..	..
St.	4%	Central London Ordinary Stock.....	78 —75	5 6 9	Feb, Aug	74½	..
St.	4%	Do. 4 per Cent. Pref. Stock	91 - 93	4 6 0	Feb, Aug	..	..
St.	4%	Do. Deferred Stock	53 - 56	7 2 8	Feb	53½	..
100	4%	Do. 4 per Cent. Debs.	102 - 105	3 16 0	Jan, July	104	..
St.	4%	Charing X. Euston & Hmpstd Per. Db. Stk.	81 —84	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½— 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 —101	3 19 0	April, Oct	..	..
St.	2%	City & South London Rly. Con. Ord. ...	45 —47	4 5 0	Feb, Aug	46⅝	46⅜
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	117 —121	4 2 9	Feb, Aug	..	..
St.	5%	Do. (1896)	115 —118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1901)	115 —118	4 4 9	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 - 105	3 16 0	May, Nov	..	..
10	6/0	†Dublin United Trams. (1896) Ltd. Ord...	13½-14½	4 4 0	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Pref.....	12⅝-13¾	4 7 0	Feb, Aug	..	..
10	4/0	Gt. Northern & City Rly. Pref. Ord. (4%)	1⅜-2½	..	Feb, Aug	..	..
10	4/0	†G. Northern, Piccadilly & Brompton Ord.	6 —7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 —85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Lb. St.	98 —101	4 9 0	April, Oct	99⅜	..
10	9%	‡ Imperial Tramways Ord.....	11 - 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10½—11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 - 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 —1⅛	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 - 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5 Prior Lien Db. St.	94 —97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅛—1⅜	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6⅛ - 7⅛	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 - 86	4 13 0	Jan, July	..	..
10	5 0	London United Trams. 5% Cum. Pref. ...	7⅜—7⅞	5 14 8	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 - 88	4 11 0	Jan, July	89½	..
St.	..	Mersey Con. Ord. Stock	2 —4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp Pref.	3 — 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅜—⅝	..	April...	..	..
1	0/6	† Do. 5 per Cent. Cum. Pref.	⅝—¾	5 3 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 - 97	4 13 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	⅜—1⅜	..	May	..	..
1	0/8	Potteries Electric Traction Ord.	⅝—⅞	7 3 0	April, Oct	..	..
1	5%	Do. 5 per Cent. Cum. Pref.	⅝—⅞	6 8 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 - 98	4 11 9	May, Nov	96½	..
1	0/8	†S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅝—1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 —84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	84 —88	5 18 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	64 - 67	7 9 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 —1⅛	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅛—3⅜	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 —10	5 0 0	Jan, July	..	..

Shrs.	Last Dividend	Name.	Price Wed., Aug. 14.	Rate % Yield. £ s. d.	Dividend Due.	Business Week to Aug. 14. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅝—¾	..	..	..	..
1	0.7½	Do. 6% Cum. Pf.	⅞—1⅛	8 16 0	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.....	3⅜—4	5 0 0	April, Oct	3½	3⅜
1	0/7½	Do. Pref.....	1⅜—1⅝	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅜—7½	6 18 0	July, Feb	7⅛	6⅝
5	3/0	† Do. 6 per Cent. Pref.	5⅜- 6⅝	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	102½	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt. Db.	87 —91	4 19 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 —1⅛	..	Feb, Aug	1⅛	1⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	59 —64	6 5 0	Jan, July	61	..
2	..	Brush Electrical Engineering	⅞—1	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅞—1⅛	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	89 - 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 —74	6 0 9	Jan, July	..	..
5	10 0	Callender's Cable Con. Ord.....	9⅜—10⅜	6 19 0	Jan, July	10⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅜—5⅝	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105¼—106⅞	4 3 6	Nov, May	106⅜	106⅛
1	0/9⅜	Castner-Kellner Alkali Co.	1⅛—1⅜	5 12 6	May, Nov	..	..
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb. (red.).	95 —100	4 10 0	Feb, Aug	..	..
1	1 2⅝	Chadburn's (Ship) Telegraph Ord.	1⅛ - 1⅜	8 0 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	5 7 0	April, Oct	..	..
3	3/-	*†Crompton & Co. (Nos. 1 to 54,000)	1⅜—2⅛	7 1 0	Jan, July	2⅛	2
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	94 —97	5 3 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅜—1⅝	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 - 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1⅛—1⅜	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛—2⅜	4 11 6	Feb, Aug	..	..
St	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 - 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 —92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½—1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1½ 2	..	May, Nov	1⅜	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 —81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜—⅞	..	Jan, July	..	..
2	2/9⅜	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	8 12 0	July	..	..
St.	..	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 —81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref....	8 - 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 —96	4 4 0	Mar, Sept	..	..
5	10/0	Henley's Telegraph Works Ord.....	11⅞—12⅜	6 0 0	Feb, Aug	11⅞	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5½	4 2 0	Feb, Aug	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14⅜—15½	6 9 0	Feb, Aug	15½	14⅛
100	4%	Do. 4 per Cent. Debs. (red.).....	97 —99	4 1 0	April. Oct	..	..
1	1/2⅝	Richardsons, Westgarth & Co., Ltd. Ord.	⅝—⅝	7 14 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅛—1	6 0 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 —96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	12/0	†Telegraph Construction & Maintenance	31 —33	5 9 0	Mar, July	32½	31
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	99 —102	3 18 3	Jan, July	..	..
1	1/0	†Vickers, Sons & Maxim, Ltd., Ord.	2⅜—2⅞	5 16 0	..	2⅝	2⅜
1	0/6	† Do. 5 per Cent. non-Cum. Preference	1⅜—1⅝	4 4 6	..	1⅝	..
St.	5%	† Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red.)	102 —104	3 17 0	June, Dec	102½	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 —103	4 5 3	June, Dec	..	..
10	8 0	J. G. White & Co. 6 per Cent. Cum. Prf.	9½—9⅝	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1⅜—1⅝	..	Apr, Oct	1⅜	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅝—4⅛	..	Apr, Oct	4⅛	4
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 —80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 —3½	—	June, Dec	..	—
100	5%	Do. 5 per Cent. Debs. (red.)	85 —88	5 2 0	June, Dec	—	—
St.	15/0	†Anglo-American	60 —68	6 2 0	F,My,Ag,N	62	60
St.	30,0	‡ Do. Preferred	105½—106½	5 12 6	F,My,Ag,N	107½	106½
St.	15%	Do. Deferred	16½—17½	9 6 0	F,My,Ag,N	17⅜	16½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 —94	4 4 6	Jn,Ap,Jy,O	93½	..
10	5 0	Cuba Submarine Ord.....	7⅛—8½	6 1 9	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15½—16½	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜—3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 - 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅞-103⅞	4 7 3	Jan, July	..	..
20	6/6	†Direct United States Cable xd & bonus	15 —15½	6 0 0	Ja,Ap,Jy,O	15⅞	15⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99 —101	4 9 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	134 —139	5 0 0	Ja,Ap,Jy,O	136½	134½
St.	17,6	Do. 3½ per Cent. Pref. Stock	88 —90	3 17 9	Ja.Ap,Jy.O	89½	88½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 16 6	May, Nov	104½	..
10	2/6	Eastern Extension	13 —13½	5 8 6	Ja,Ap,Jy,O	13⅝	13½
St.	4%	† Do. 4 per Cent. Deb. Stock	102 —104	3 17 0	Feb, Aug	..	..
100	4%	†Eastern & S. African 4% Mort. Deb. 1909	98 —100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	9 ½-100½	4 1 0	May, Nov	..	..
10	5 0	G.N. (of Copenhagen), with Coupon 71...	84 —86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99⅜—101⅛	4 8 6	June, Dec	..	..
25	52,6	Indo-European.....	56 —58	5 12 0	May, Nov	55½	..
100	£1	Mackay Companies Common	64 —68	5 18 6	Jan, July	..	..
100	£1	Do. Preference	67 —69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞—1	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	100 —101	3 19 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 —10½	8 16 0	June, Dec	..	..
2½	1/8	West Coast of America	1⅛—1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 —101	3 19 0	Jan, July	..	..
10	..	West India & Panama	⅛—⅜	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛—7⅞	7 15 0	May, Nov	7⅛	..
10	..	Do. 6 per Cent. 2nd Pref.....	6⅞—7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 —102	4 18 0	Jan, July	..	..
10	3.0	Western Telegraph	13 —13½	5 8 0	Mr,Jn,O.D	13⅝	13⅜
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 —92	4 7 0	Jan. July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —104	4 16 0	Mar, Sept	..	..
5	5 0	†Chili Telephone	6⅞—7½	5 10 6	August ..	..	..
1	0/4⅜	Monte Video Telephone Ord.	⅜—1⅛	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅝—1	5 0 0	May, Nov	..	..
St.	6%	†National Co. Pref. Stock	105 —108	5 11 0	Feb, Aug	107	106
St.	6%	† Do. Def. Stock.....	105 —107	5 12 0	Feb. Aug	106⅛	105
10	6.0	† Do. 6 per Cent. Cum. 1st Pref.	11 —13	4 12 0	Feb, Aug	11⅛	..
10	6.0	† Do. 6 per Cent. Cum. 2nd Pref.	9½—11½	5 4 0	Feb, Aug	10⅛	..
5	2/6	† Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛—6¼	4 11 0	Feb. Aug	5⅛	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	95½ - 97½	3 12 0	June, Dec	96½	96
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100½ - 102½	3 18 0	Jan, July	102	101½
1	0/8	Oriental	1⅛—1⅜	6 2 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	4 10 0	April. Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 —94	4 5 0	Jan. July	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	98 —101	4 9 0	Jan. July	..	..
5	5.0	†United River Plate.....	6⅞—7½	6 18 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜—4⅜	6 6 3	Jan, July	..	..
10	6 2	Globe Telegraph & Trust.....	10⅜—10⅝	5 2 6	Ja,Ap,Jy,O	10⅝	10⅜
10	4/0	Do. 6 per Cent. Pref.....	13⅜—13⅝	4 8 0	Ja,Ap,Jy,O	13⅝	13½
10	6%	Submarine Cables Trust (Cert.).....	127 —130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but not for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

Use of Electricity in Factories and Workshops.

THE Home Office have just issued a new draft of the Regulations for the Use of Electricity in Factories and Workshops, but they will not come into force until January 1st next; in the meantime any suggestions regarding their modification will be carefully considered by the Secretary of State. The present draft is of a very much more comprehensive nature than that issued in 1904, which was withdrawn owing to serious opposition. A point worthy of notice is that the new regulations are to apply to all systems in which the normal working pressure exceeds 130 volts (continuous current) or 65 volts (alternating current). As most of the rules may be considered essential for systems of lower voltage, it might, perhaps, have been advisable to fix the limit at 100 volts, so as to embrace practically all installations. The reason given for not doing so is ingenious, but it displays a want of that paternal care with which Government departments have regarded things electrical. Undoubtedly, any pressure below 130 volts is commonly regarded as harmless, and yet fatal accidents may occur and have occurred with only 100 volts. The conditions must be exceptional, but they are by no means impossible where lack of care is displayed. For this reason it is an open point whether a 130 volt system installed in accordance with the Home Office Regulations, and under the supervision of that department, is not less dangerous than a 100 volt system installed without any such safeguards.

The Canadian Government and the Marconi Co.

AN interesting situation has arisen in Canada by reason of the Canadian Marconi Wireless Telegraph Co.'s objection to their stations being used for the reception and transmission of messages from or to stations belonging to other systems. Indeed, it is reported that the Company is bringing an action against the Federal Government, the object of which is to relieve them from this alleged obligation. The Acting Minister of Marine, Mr. TEMPLEMAN, has issued a lengthy statement dealing with the situation. Apparently the Company was offered licences for three Canadian Pacific steamers in British Columbia, but these licences were not accepted because they stipulated that the licensees should make the new stations available for other systems. The condition was made in view of Great Britain's anticipated adherence to the Berlin Convention, and was accepted without question by the De Forest Company when the latter accepted a licence which had previously been refused by the Marconi Company.

OBJECTION was also taken by the Marconi Company to the installation of Government wireless stations on the Pacific Coast, but in view of the very great number of vessels equipped with wireless apparatus manufactured by other companies it was decided that it would not be proper to confine the coast stations to one system. Hence, since the Marconi Company refused to communicate with any but their own installations, the Government took the matter over and employed a different system. This at once brought forth a complaint to the effect that the Government was depriving the Marconi Company of its livelihood for the benefit of foreign manufacturers; but Mr. TEMPLEMAN affirms that the engines, wires and everything else, excepting the wireless apparatus, required for the Pacific Coast stations were made in Canada. Moreover, he alleges that the wireless apparatus installed by the Marconi Company in the 15 stations which they built for the Government was itself imported from England or

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the United States. In concluding his statement, which has appeared in *The Times*, the Acting Minister says: "The policy of the Government is that it will control wireless telegraphy in Canada. The policy of the Marconi people is that the Marconi Wireless Telegraph Co. will be masters of the situation." This has elicited a vigorous protest from the Canadian Marconi Co., whose manager denies that the Company refused to interchange messages on the Pacific Coast with other makes of apparatus, and maintains that the Government's action is part of a despotic policy of confiscation. It certainly would appear that both parties are inclined to despotism, and the struggle, if it may be so called, will be watched with considerable interest.

The Peak Load in Electricity Works.

In our leading article last week we drew attention to the possibility of the electrolytic industry providing a means whereby the load factor on central stations might be brought very near to the ideal, and we pointed out that one of the greatest difficulties might be in arranging for a cessation of supply during the time of the ordinary peak load. As stated in our last issue the British Carbide Factories (Ltd.) intend to erect a calcium carbide factory close to the Yorkshire Electric Power Co.'s generating station at Thornhill. The arrangement which, it is stated, has been arrived at between the two companies provides that only the surplus power of the Power Company is to be utilised, so that the energy employed for electrolytic purposes will fluctuate according to the load on the power station.

Function of the Earth in Wireless Telegraphy.

For years it has been assumed that connection to earth was essential for the efficient transmission of signals by Hertzian oscillations, and for long-distance work the earth connection is still used. For purposes of syntony, however, it appears that the earth connection is by no means advantageous, whether the arc or the spark method of sending be employed, and it will have been noticed in the descriptions of the Lodge-Muirhead system which have appeared in *The Electrician* that the aerial wire has always been insulated from the earth. Sir Oliver Lodge emphasised this point in a Paper which he read before the British Association, an abstract of which appears in this issue. Prof. Fleming, on the other hand, has hitherto maintained that connection to earth is essential, and it will be interesting to know what is his opinion of Sir Oliver Lodge's statement. The latter suggests that an earth connection may be suitable for untuned long-distance work, but having confined his attention to distances not exceeding 300 miles, and having always endeavoured to work with tuned oscillations, he does not commit himself on this point.

Explosions in Electric Main Culverts.

On another page we give an abstract of a report presented to the Gas and Electric Lighting committee of Aberdeen by Mr. J. A. Bell, city electrical engineer. This report embodies some interesting details regarding efforts which have been made during the past 12 years to deal with explosions in the culverts used for the copper strip system of mains. At the present time there are about 3½ route miles of these mains in Aberdeen, but in consequence of the trouble experienced it has been decided to replace them by cables laid on the solid system. Although leaky gas mains were, in nearly all cases, responsible for the explosions whereby manhole covers were raised, yet experiments carried out by the electricity department indicated that even in the absence of coal-gas it was possible for manhole covers to be lifted in the event of a heavy short-circuit on a cable. Moreover, the provision of very ample ventilation in the covers apparently did not suffice entirely to overcome the trouble. The effect is far less marked with covered cables owing to the excessively low thermal conductivity of the insulation, which thus prevents the air from becoming heated so rapidly as it would if in contact with bare copper.

Breakdowns of Machinery.

A section of the last annual report of the chief engineer to the British Engine, Boiler and Electrical Insurance Company is of particular interest to electrical engineers, inasmuch as the information contained therein relating to typical breakdowns experienced during the year is of a very valuable character. Moreover, it is gratifying to learn that the percentage of breakdowns is decreasing, and in this respect we hope that the figure for motors, which in 1906 was 1 in every 8·2 of the motors insured, will be considerably improved in the course of the next few years. This is, of course, likely to be the case as motor users become better educated in the care of their machines. In a large number of cases the report shows that the motors are allowed to run without any attention whatever for long periods at a stretch, and this is certainly a merit which the best and most efficient gas engine on the market does not possess. Where breakdowns occurred the design was often at fault, and in this respect it is interesting to learn that such machines were usually of foreign manufacture.

Memorial to the late M. Berthelot.—The Paris Municipal Council have decided to perpetuate the memory of the late Prof. Berthelot by re-naming La Place du Collége de France La Place Marcelin Berthelot.

Wireless Telegraph Notes.—A wireless telegraphy station has been established on high ground to the west of the town of Dieppe (France). At this station experiments are being made with the Artom system between Dieppe, Harve and Barfleur.

Manchester Steam Users' Association.—We have received the memorandum of the chief engineer (Mr. C. E. Stromeyer) of this association, which contains several points of interest to steam users. There is a report on the work done by the National Physical Laboratory on the specific heat of steam, and also a report by the same institution on pressure gauges. This latter contains the results of tests made on the pressure gauges of 10 well-known British manufactures and is considered to be highly satisfactory. The only point criticised by the National Physical Laboratory is that no attempts have been made to reduce the effect of changes of temperature. A historical note on the development of the pressure gauge is added by the chief engineer.

Cable Interruptions.	Date of Interruption.
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Grand Canary—Lanzarote	Sept. 18, 1906
Brest—Dakar	July 22, 1907
Kotonou—Libreville	July 18, 1907
Accra—Lagos	Aug. 11, 1907
Para—Pernambuco	Aug. 21, 1907
Maranham—Ceara.....	Aug. 21, 1907

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Personal.—It is announced that the Franklin Institute have awarded the "John Scott Legacy Medal and Premium" to Mr. L. H. Walter and Prof. J. A. Ewing for their method of detecting electrical oscillations.

It is announced that Prof. H. Le Chatelier has been appointed Professor of Chemistry at the Paris Faculty of Sciences as successor to the late Prof. Henri Moissan.

Submarine Cables for the Transmission of Energy at High Pressures.—With reference to the note regarding the submarine cables connecting Venice with Lido, which appeared in our issue of August 2nd, we are informed by the Societa Anonima Ing. V. Tedeschi & Ci. that in the submarine cables referred to, which are of their manufacture, no gutta-percha is used, but an insulating material of very high dielectric strength, and the base of which is indiarubber, is employed.

Prevention of Electrolysis in Pipe Lines.—An insulating joint to prevent electrolysis has been used in the 6 in. water pipe which enters the power station of the Cleveland Electric Railway. According to the *Engineering Record*, it consists of a large wooden washer bolted between special castings forming adjoining ends of the service. Each casting has an 11 in. flange with eight $\frac{3}{4}$ in. holes by which it is attached to the service pipe, and a $13\frac{1}{2}$ in. flange with a dished face and eight $1\frac{1}{8}$ in. holes to form the insulating joint. The wooden washer is a piece of hard maple boiled in paraffin, and having on each side a $\frac{1}{4}$ in. boss which fits into the recess in the face of the flange of the casting. The bolts at the joint pass through rubber hose, and their nuts press on large fibre washers.

Obituary.—We regret to record the death of the Rev. John Kerr, F.R.S., which occurred last week at Glasgow. Dr. Kerr was lecturer on mathematics at the Glasgow Training College of the United Free Church. He was well known as a devoted student in electro-optics and magneto-optics. In 1898 Dr. Kerr received the gold medal of the Royal Society for important experimental researches on the optical relations of electricity and magnetism.

We also regret to record the death on the 20th inst. of Mr. Joseph Kincaid, senior partner of Messrs. Kincaid, Waller, Manville & Dawson. Mr. Kincaid was chairman of the City of York Tramways Co. and a director of the Primitiva Gas & Electric Lighting Co. of Buenos Ayres.

The death is also announced of Prof. Karl Vogel, Director of the Astrophysical Observatory at Potsdam, which occurred on August 13th.

Motor Ambulances.—A short time ago (*The Electrician*, Vol. LIX., p. 178) we gave an account of the equipment of an electric ambulance, and of the system of calling connected therewith, which had been adopted by the Corporation of the City of London. It is interesting to note that since its inauguration on May 15th the total number of calls answered up to August 13th was 239. As it was impossible for one ambulance to serve the whole of the City, an area of about two-thirds only has been covered by the new service. Experiments carried out in June showed that in five cases out of six the time occupied from the arrival of a constable on the scene of an accident to the arrival of the patient at the hospital was, when the motor was employed, just half that taken when the hand ambulance was used. A satisfactory feature of the three months' work is that on no occasion has the ambulance broken down or been in an accident itself. The record of this ambulance's work not only fully justifies its institution, but accentuates the need there is for another vehicle of the same type.

Electricity in Mining.—The *Engineering and Mining Journal* gives a description of the electrical plant which has lately been installed by the Calumet & Hecla Mining Co. at their mills at Lake Linden to replace the worn-out steam engines which were formerly used. Three-phase current is generated at 13,200 volts, and a frequency of 25 ~ per sec., and is transmitted 5 miles by overhead lines to a sub-station, where it is stepped-down to 2,300 volts for distribution. This sub-station also contains two 350 kw. motor-generators, which convert the 2,300 volt 25 cycle current into current at 2,200 volts, with a frequency of 60 for lighting purposes. In the stamp mills the motors are supplied with current at 440 volts. They are 40 in number, and vary in size from 20 H.P. to 50 H.P. There is also a 700 H.P. induction motor geared to a 60 ft. sand wheel. This wheel is used to elevate water and sand as it passes out of the mills. At the mine itself 2,300 volt motors are used instead of the small steam engines previously installed. There are one 27 H.P. and three 100 H.P. motors. The underground pumping is done electrically, four 110 H.P. motors being provided for this purpose. Current is transmitted underground at 2,300 volts, but is transformed to 440 volts by static transformers for use at the motors.

Electric Drive in Rolling Mills.—The *Elektrische Kraftbetriebe und Bahnen* gives some data of the electrical drive in the Peiner rolling mills, which obtain 4,000 kw. from the Hüttenwerk Gr. Ilsede, $4\frac{1}{2}$ miles away. This is partly generated in an old three-phase steam station at 500 volts, and is stepped-up to 10,000 volts for transmission. In parallel with this is a second station, in which three phase current is generated at 10,000 volts by blast-furnace gas. The transmission lines are in duplicate, and consist of six silicon-bronze wires 0·075 sq. in. in section. At full load the voltage drop is 6 per cent. and the total loss 4 per cent. In the rolling mills there are three synchronous motor-generators each of 800 kw. capacity, which convert the three-phase current into continuous at 500 volts. There are also three 500 kw. static transformers, which step down to 500 volts. This alternating current is further reduced to 110 volts for lighting purposes. There is a 289 cell battery with a capacity of 2,000 ampere-hours. The mean load in the rolling mills is 1,540 kw. and varies between 600 kw. and 1,800 kw. The transmission line also feeds a phosphorus factory, and an induction motor-converter supplies direct current to the slack conveyor. The total horse-power of the motors installed is 5,772.

The Distribution of Current in Electrodes.—A study of the electrolysis of various saline mixtures has shown the importance of current density and E.M.F. on the nature of the deposits obtained and consequently on the ionic reactions taking place. As a result, many hitherto unsuspected allotropic modifications of such metals as lead, copper and zinc have made their appearance, together with a general method of separating the various modifications. The problem is one of extreme importance, and it was decided by M. G. Rosset to make a systematic study, one at a time, of the influences bearing on this subject. To this end the distribution of the current in electrodes was investigated. The results are given in a recent issue of *L'Eclairage Electrique*. To avoid complications as far as possible, these electrodes were rectangular in shape and varnished on the back and sides, thus presenting only one conducting surface to the action of the electrolyte. In the first place the subject was treated mathematically by simply elaborating Ohm's law and following it up by a few simple applications. Treated in this manner it follows as a natural consequence that a regular metallic deposit can be obtained by a low-current density only from a stationary kathode, a fact well supported by experience. For each allotropic state of a metal there is apparently a well-defined maximum current density required for its separation, and it is there that many irregularities of deposition are obtained. The action of points such as those appearing on badly-cut electrodes has also received attention and the results of experiment are in agreement with theory. It must be constantly kept in mind that the E.M.F. in any electrode varies from point to point, and that this is quite unavoidable. On the other hand, it is possible to deduce conditions suitable for obtaining a constant current density. This was treated in a manner similar to the above, and it was deduced that the required condition would be realised with parabolic electrodes.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, August 24th.

ASSOCIATION OF ENGINEERS-IN-CHARGE.

1:25 p.m. **Visit to the Works of the Associated Portland Cement Manufacturers (1900), Ltd., at Northfleet. Meet at Charing Cross Station.**

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USE OF ELECTRICITY IN FACTORIES AND WORKSHOPS.

We have received a draft of the Regulations proposed to be made by the Home Secretary for the generation, transformation, distribution and use of electrical energy in premises under the Factory and Workshop Act, 1901.

In October, 1904, the Home Office issued, in draft, certain Regulations* for the use of electricity in workshops and factories. These, however, only covered part of the ground, and owing to the opposition offered to them, were not proceeded with. As a consequence a more complete code has now been prepared. In the circular sent out by the Home Office it is stated that:—

The present draft applies to the generation and transformation, as well as the distribution and use, of electrical energy on all premises under the Factory Act, and at all pressures above 130 volts continuous and 65 volts alternating. In adopting the above limitations on the basis of pressure, the Secretary of State, while realising that there may be danger at still lower pressures, has been guided by the fact that the serious accidents from shock which have come to his notice have been at pressures exceeding those named. Special consideration has been given to the conditions under which preventable accidents have arisen. The Secretary of State regrets to learn that, while in many electrical installations the utmost care has been taken to prevent unnecessary danger, there are striking exceptions to this rule, even in work recently carried out. In drafting the Regulations, the Home Office Rules for the Use of Electricity in Mines, the various Board of Trade rules, including those already in force for the use of electrical energy at medium pressures, the Rules of the Institution of Electrical Engineers and of fire insurance offices have been consulted. Some of these prescribe details to a greater extent than would be possible in regulations applicable to such a wide field as is now in question; and in many points it has been thought to be more expedient, in view of the rapid development of electrical engineering, to indicate broadly the dangers to be avoided and the nature of the precautions required than to define particular means of securing the necessary safety. It appears often to be thought that where the supply of electrical energy is at low pressure there is no danger of shock, or rather that there is no danger to life from a shock at such pressure. It has, however, been abundantly proved that this is not the case. Fatal cases of shock at low pressures are by no means of rare occurrence. Accidents from shock may occur by a person making contact simultaneously with two live conductors at different pressures, but more usually by merely touching one conductor whilst being in contact with the ground. A mere momentary contact with a conductor at low pressure, even when standing on damp ground, may not produce a serious shock; but a person who happens to grasp the conductor may be quite unable to release his hold, and the shock is prolonged until assistance comes. In such circumstances it may take only a few seconds for the shock to prove fatal. The dividing line between the conditions which will render the shock merely trifling and those which will render it fatal is so narrow that it becomes necessary to provide, so far as is practicable, that no shock shall be received at all.

In accordance with the requirements of the Factory Act, the Regulations are now published in draft and are subject to further consideration. Any objections of substance, made by employers, workpeople or other persons affected, will be carefully considered by the Secretary of State, and will, if necessary, be the subject of full inquiry made by a competent person appointed by him. In that event the owners, occupiers, employers, workpeople and all others concerned will be entitled to a full hearing at the inquiry, and the report of the person holding it will be considered by the Secretary of State before the Regulations are made.

If, therefore, any person desires the Regulations to be further considered, he should lodge objections in accordance with sec. 8 of the Factory Act, and in pursuance of that section the Secretary of State gives the following notice:—

That he proposes to make Regulations dealing with the generation, transformation, distribution and use of electrical energy in factories and other places to which the Factory Act applies, in accordance with the enclosed draft, copies of which may be obtained on application to the Factory Department, Home Office, London, and that any objections with respect to the draft regulations by or on behalf of any person affected thereby must be sent to the Secretary of State within 40 days from this date (Aug. 14). Every objection must be in writing and must state (*a*) the Regulations or portions of regulations objected to; (*b*) the specific grounds of objection; and (*c*) the omissions, additions or modifications asked for.

DRAFT REGULATIONS FOR THE GENERATION, TRANSFORMATION, DISTRIBUTION AND USE OF ELECTRICAL ENERGY IN PREMISES UNDER THE FACTORY AND WORKSHOP ACT, 1901.

Whereas the generation, transformation, distribution and use of electrical energy in any factory or workshop, or any place to which the provisions of sec. 79 of the Factory and Workshop Act, 1901, are applied by that act, has been certified in pursuance of the said section to be dangerous:—

I hereby in pursuance of the powers conferred upon me by that act make the following regulations, and direct that they shall apply in all places before mentioned. These regulations shall come into force on January 1, 1908, except as regards such parts of electrical stations as were constructed before January 1, 1907, in respect of which they shall come into force on July 1, 1908.

Duties.—It shall be the duty of the occupier to comply with these regulations. And it shall be the duty of all agents, workmen and persons employed to conduct their work in accordance with these regulations.

Definitions.—In these regulations *pressure* means the difference of electrical potential between any two conductors, or between a conductor and earth, as read by a hot wire or electrostatic volt-meter; *low pressure* means a pressure normally not exceeding 250 volts; *medium pressure* means a pressure normally above 250 volts, but not exceeding 650 volts; *high pressure* means a pressure normally above 650 volts, but not exceeding 3,000 volts; *extra-high pressure* means a pressure normally exceeding 3,000 volts; *system* means an electrical system in which all the conductors and apparatus are electrically connected to a common source of E.M.F.; *conductor* means an electrical conductor arranged to be electrically connected to a system; *apparatus* means electrical apparatus, and includes all apparatus, machines and fittings in which conductors are used, or of which they form a part; *cable* means a cable, wire, rod, strip or other form of conductor used for conveying electrical energy; *circuit* means an electrical circuit forming a branch of a system; *insulating stand* means a floor, platform, stand or mat, *insulating screen* means a screen, *insulating boots* means boots, *insulating gloves* means gloves of such size, quality and construction according to the circumstances of the use thereof, that a person is thereby adequately protected from danger; *covered with insulating material* means adequately covered with insulating material of such quality and thickness that there is no danger; *bare* means not covered with insulating material; *live* means electrically charged; *dead* means at, or about, zero potential, and disconnected from any live system; *earthed* means connected to the general mass of earth in such manner as will ensure at all times an immediate discharge of electrical energy without danger; *sub-station* means any premises, or that part of any premises, in which electrical energy is transformed or converted, and which are large enough for a person to enter after the apparatus is in position; *switchboard* means a collection of conductors and apparatus for the purpose of controlling the current or pressure in any circuit or circuits; *switchboard passage-way* means any passage-way or compartment used in connection with a switchboard and large enough for a person to enter; *authorised person* means a person appointed by the occupier to carry out certain duties incidental to the generation, transformation, distribution or use of electrical energy, and competent to carry out those duties; *Danger* means danger of shock, burn, or of other injury to persons employed, or of fire, attendant upon the generation, transformation, distribution or use of electrical energy.

Exemptions.—Nothing in these Regulations shall apply to any system the normal working pressure of which does not exceed 130 volts continuous or 65 volts alternating. Nothing in Regulations 7, 8, 9 and 10 shall apply in electrical stations to any circuit, conductor or cable used for conveying electrical energy for public supply. Nothing in Regulation 12 shall apply to any motor of a motor-generator or to any motor forming a part of any electrical converter, regulator or similar apparatus.

If the occupier can show with regard to any requirement of these regulations that the special conditions in his premises are such as to prevent danger not less adequately than if the said requirement were observed, that requirement shall be deemed to be satisfied.

Regulations.—1. All apparatus and conductors shall be sufficient in size and power for the work they may be called upon to do, and so constructed, installed, protected, worked, and maintained as to prevent danger.

2. All cables shall be covered with insulating material, and further efficiently protected where necessary to prevent danger; or they shall be so placed and safeguarded as to prevent danger.

3. Every switch, circuit-breaker, and isolating link shall be: (*a*) so constructed, placed, or protected as to prevent danger, (*b*) so constructed and adjusted as accurately to make and to maintain good contact, (*c*) provided with an efficient handle or other means of working, insulated from the system, (*d*) so constructed or arranged that it cannot accidently fall or move into contact when left out of contact.

4. Every switch and circuit-breaker shall be so constructed as to be incapable of remaining in partial contact, or of maintaining an arc on breaking circuit.

5. Every fuse, and automatic circuit-breaker used instead thereof, shall be so constructed and arranged as effectively to interrupt the current before it so exceeds the working rate as to involve danger. It shall be of such construction or be so guarded or placed as to prevent danger from overheating, or from arcing or the scattering of hot metal or other substance when it comes into operation. Every fuse shall be of such construction or be so protected by a switch that the fusible metal may be readily renewed without danger.

6. Every electrical joint and connection shall be of proper construction as regards conductivity, insulation, mechanical strength, and protection.

7. Efficient means, suitably located, shall be provided for cutting off all pressure from every circuit.

8. Every circuit shall be efficiently protected from excess of current, and every circuit arranged to carry more than 750 watts shall be separately so protected.

9. Where one point of a system is connected to earth no single pole switch other than a link for testing purposes shall be placed in any cable connected thereto.

10. Where one of the main conductors of a system is uninsulated and bare, such as a bare return of a concentric system, no switch, fuse or

* See *The Electrician*, Oct. 21, 1904, p. 18.

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circuit-breaker shall be placed in that conductor, or in any conductor connected thereto, and the said conductor shall be earthed.

11. Every motor, converter and transformer shall be protected by a switch or switches, suitably placed, and so connected that all pressure may thereby be cut off therefrom and from any apparatus in connection therewith.

12. Every electrical motor shall be controlled by an efficient switch or switches for starting and stopping, so placed as to be easily worked by the person in charge of the motor. Every electrical motor rated at more than one-third of a horse-power shall be further protected by a release that will automatically break the circuit if the current is interrupted, unless the motor is incapable of re-starting automatically on the current being restored. In every place in which machinery is being driven by any electrical motor, there shall be means at hand for quickly stopping the motor.

13. Every flexible cable for portable apparatus shall be connected to the system either by efficient permanent joints or connections or by a properly constructed connector. Every portable apparatus and its flexible cable shall be independently controlled by a switch conveniently placed. Adequate precautions shall be taken against shock, due to leakage or other cause, in all places where the persons handling the portable apparatus is not insulated from earth. In such places, and in any place where the pressure exceeds low pressure, the switch shall be so constructed as to break the circuit on each pole.

14. The general arrangement of switchboards shall, so far as reasonably practicable, be such that: (*a*) all parts which may have to be adjusted or handled are readily accessible; (*b*) the course of every cable may be readily traced; (*c*) conductors connected to different systems are kept apart and can be readily distinguished; (*d*) all bare conductors are so placed or protected as to prevent danger from accidental short-circuit.

15. Every switchboard having conductors normally so exposed that they may be touched shall be located in an area or areas set apart for the purposes thereof and suitably fenced or enclosed. No person except an authorised person or a person acting under his immediate supervision shall have access to any part of such area.

16. All apparatus appertaining to a switchboard and requiring handling shall, so far as practicable, be so placed or arranged as to be operated from the working platform of the switchboard, and all measuring instruments and indicators connected therewith shall, so far as practicable, be so placed as to be observed from the working platform. If such apparatus be worked or observed from any other place, adequate precautions shall be taken to prevent danger.

17. At the working platform of every switchboard and in every switchboard passage-way, if there be bare conductors exposed or arranged to be exposed when live so that they may be touched, there shall be a clear and unobstructed passage of ample width and height with a firm and even floor. For low-pressure and medium pressure the clear height shall not be less than 7 ft. and the clear width not less than 3 ft., and for high-pressure and extra-high pressure 8 ft. and 4 ft. respectively. Bare conductors shall not be exposed on both sides of a switchboard passage-way unless either the clear width of the passage is double that otherwise required, or the conductors on one side are so guarded that they cannot be accidentally touched. Adequate means of access, free from danger, shall be provided for every switchboard passage-way.

18. In every switchboard for high-pressure or extra-high pressure:—(*a*) Every conductor within reach from the working platform, or in any switchboard passage-way, shall be so placed or protected as to prevent danger; (*b*) the metal cases of all instruments shall be either earthed or completely enclosed with insulating covers; (*c*) All metal switch handles and all metal rods connnecting them with the switches, shall be earthed; (*d*) every switchboard in continuous use shall be so arranged that the conductors thereof can be made dead in sections, and no work shall be done at any section unless that section be (*a*) made dead, and (*b*) so separated by permanent or removable divisions or screens, from all adjoining sections of which the conductors are live, that the work may be carried out without danger.

19. All fixed coils, conductors or terminals of generators, motors, transformers or other apparatus, at high pressure or extra-high pressure, and within reach from any position in which any person employed may require to be, shall be so protected as to prevent danger.

20. Where a high-pressure or extra-high pressure supply is transformed for use at a lower pressure, adequate means shall be provided to prevent the lower-pressure system from being accidentally charged above its normal pressure by leakage or contact from the higher-pressure system.

21. Adequate precautions shall be taken to prevent any metal other than the conductors from becoming electrically charged, and such metal shall be earthed where necessary to prevent danger.

22. Adequate means shall be provided and used for preventing any conductor or apparatus from being accidentally or inadvertently electrically charged when persons are working thereon.

23. Where necessary to prevent danger, insulating stands or screens shall be provided and kept permanently in position and shall be maintained in sound condition.

24. Portable insulating stands and screens, boots and gloves shall be provided and used when necessary to prevent danger, and shall be periodically examined by an authorised person.

25. Adequate working space and means of access, free from danger, shall be provided for all apparatus that has to be worked or attended to by any person.

26. All those parts of premises in which apparatus is placed shall be adequately lighted to prevent danger.

27. All conductors and apparatus exposed to the weather, wet, corrosion, or to inflammable surroundings or explosive atmosphere, or used in any process or for any special purpose other than for lighting or power, shall be so constructed or protected, and such special precautions shall be taken, as may be necessary to prevent danger in view of that exposure or use.

28. Adequate periodical tests shall be made by an authorised person to ensure (*a*) that the insulation of all conductors and apparatus is duly maintained: (*b*) that no metal part of any apparatus, other than the conductors thereof, is electrically charged so that there is danger; and (*c*) that all earth connections are in order. Adequate periodical examinations shall also be made by an authorised person to detect any other defects from which danger may arise.

29. No person except an authorised person, or a person acting under his immediate supervision, shall undertake any work where technical knowledge or experience is required in order to avoid danger.

30. Instructions as to the treatment of persons suffering from electric shock shall be affixed in all premises where electrical energy is used, other than for incandescent lighting at low pressure, and in all premises in which electrical energy is generated or transformed.

31. Every sub-station shall be of ample dimensions and substantially constructed of fire-resisting material; and shall be so arranged that no person can obtain access thereto otherwise than by the proper entrance, or can interfere with the apparatus or conductors therein from outside; and shall be provided with efficient means of ventilation and be kept dry.

32. Every sub-station shall be under the control of an authorised person, and none but an authorised person or a person acting under his immediate supervision shall enter any part thereof where there may be danger.

33. Every underground sub-station shall be provided with adequate means of access by a door or trap-door, with a staircase or ladder securely fixed, and so placed that no switchboard or bare conductor shall be within reach of a person thereon:

Provided, however, that the means of access shall be by a doorway and staircase if (*a*) any person is regularly employed therein, other than for inspection and cleaning; or if (*b*) there is moving machinery therein, other than ventilating fans; or if (*c*) there is extra-high pressure therein.

Home Office, Whitehall, 1907.

LIVERPOOL CORPORATION TRAMWAYS.

We give below an abstract of some of the principal points dealt with in the annual report of the traffic manager of the Liverpool Corporation tramways for the year ending December 31, 1906. The number of cars in use was 475. The plough guard pushed 44 people, who had fallen in front of the cars, or had been knocked down, clear of the metals without any serious injury. The ratio of fatalities to passengers carried decreased from 1 in 6,000,000 in 1897 to 1 in 30,523,632 last year. There were four fatal accidents caused by the cars, as against 29 caused by other vehicles. The number of articles left in the cars was 22,254, as against 22,891 the year before. The staff numbered 1,955, as against 1,901 the previous year.

1d. fares were 89·197 per cent. of the whole, or 108,905,274 out of 122,094,528. Passes issued to servants, police and members of the Tramways committee numbered 94,307, an increase of 10,168. The average fare per passenger was the same as in 1905—*i.e.*, 1·108d. The average length of the penny stage was 2 miles 699 yds., and the total length of track 104 miles.

The total electrical energy used during the year 1906 for tramway purposes was 20,871,002 units. These units were purchased from the electricity department at a cost of 1·11d. each, a slight increase on last year's price. The price charged for energy included all capital charges and delivery of the current at the section boxes.

The average number of units used per car-mile has been as follows:—

	Units used per car-mile.	Percentage increase over preceding year.
1903.....	1·448	 6
1904.....	1·566	 8
1905.....	1·677	 6
1906.....	1·730	 3

A comparative table of passengers carried, car-mileage and receipts is given for each year since 1898.

The increase for the year 1906 over 1905 is as follows: Passengers 2,970,884, *i.e.*, 2·5 per cent.; receipts £13,693, *i.e.*, 2·5 per cent.; mileage 48,901, *i.e.*, 0·4 per cent.

The total cost for electric haulage and lighting of cars was £99,918. 10s. 1d., as compared with £96,596. 6s. 8d., an increase of 3·1 per cent.

The following table gives a few of the most interesting

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figures in connection with the expenditure during the years 1905 and 1906 :—

Traffic Expenses.	Expenditure. 1905.	1906.	Cost per car-mile. 1905.	1906.
Superintendence.. .... Wages of traffic employés	£121,121 ..	£118,631 ..	2·409d. ..	2·350d.
Cleaning cars	10,932 ..	13,168 ..	0·217d. ..	0·261d.
Cleaning and sanding tracks	1,034 ..	1,649 ..	0·022d. ..	0·033d.
Fuel, light and water	2,472 ..	2,093 ..	0·049d. ..	0·041d.
Ticket checking	3,183 ..	6,375 ..	0·063d. ..	0·126d.
Uniforms, badges, &c.	2,489 ..	3,933 ..	0·049d. ..	0·078d.
Lighting routes	147 ..	150 ..	0·003d. ..	0·003d.
Miscellaneous	2,718 ..	2,668 ..	0·054d. ..	0·053d.
Total	£144,096	£148,667	2·866d.	2·945d.
General Repairs and Maintenance.				
Permanent way	£32,338 ..	£32,130 ..	0·643d. ..	0·636d.
Electrical equipment	5,671 ..	6,225 ..	0·113d. ..	0·123d.
Buildings and fixtures	1,909 ..	2,523 ..	0·038d. ..	0·050d.
Workshop tools and sundry plant	987 ..	640 ..	0·020d. ..	0·013d.
Cars	43,252 ..	40,838 ..	0·860d. ..	0·809d.
Miscellaneous equipment ..	922 ..	10 ..	0·019d. ..	—
	£85,079	£82,366	1·693d.	1·631d.
Power Expenses.				
Cost of current	£96,596 ..	£99,920 ..	1·921d. ..	1·980d.
General Expenses.				
Rates, taxes, management expenses, compensation and law charges	£55,607 ..	£54,452 ..	1·105d. ..	1·079d.
TOTAL EXPENSES (excluding Capital Charges)	£381,378	£385,405	7·585d.	7·635d.

Capital Charges, &c.				
Interest and sinking fund..	£99,718 ..	£112,452 ..	1·983d. ..	2·226d.
Reserve, renewals and Depreciation Account	50,639 ..	58,176 ..	1·010d. ..	1·150d.
Total Capital Charges	£150,357	£170,628	2·993d.	3·376d.
TOTAL EXPENSES (including Capital Charges)	£531,735	£556,033	10·578d.	11·011d.
INCOME (from all sources)	£558,844	£583,619	11·111d.	11·557d.
BALANCE (applied in aid of General Rate)	£27,109	£27,586	0·533d.	0·546d.

The total capital expenditure up to December 31st, 1906, was £1,901,997. 8s. 10d., and was allocated under the following headings :—

CAPITAL ACCOUNT.

	£ s. d.	Per cent.
Purchase money paid to Liverpool United Tramways and Omnibus Co.	484,162 5 11 ..	25·40
Tramway lines	758,530 4 3 ..	39·97
Electrical equipment	110,996 12 1 ..	5·82
Land, buildings, &c.	134,974 15 8 ..	7·09
Workshop tools	8,913 16 7 ..	0·46
Cars	292,230 8 11 ..	15·41
Other rolling stock	4,679 19 0 ..	0·24
Horses	480 0 0 ..	0·02
Miscellaneous equipment	1,394 18 4 ..	0·07
Office furniture	162 5 8 ..	0·01
Parliamentary and law expenses	72,890 5 0 ..	3·80
Engineer's fees	2,967 6 0 ..	0·15
Widening streets	9,856 19 2 ..	0·51
Purchase of Garston & District Tramways Co.	20,257 7 3 ..	1·05
TOTAL CAPITAL EXPENDITURE	£1,901,997 3 10 ..	100·00

Passengers, Mileage and Receipts.

		1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
Passengers	Electric cars	785,064	15,853,160	58,068,531	100,076,789	108,906,472	113,015,728	116,642,663	119,123,644	122,094,528
	Horse cars..	31,985,158	39,321,946	19,051,875	218,166	74,685	41,506	..	..	..
	Omnibuses..	9,001,812	8,596,344	5,247,552	813,825	354,428	..	..	..	..
Total		41,772,034	63,771,450	82,367,958	101,108,780	109,335,585	113,057,234	116,642,663	119,123,644	122,094,528
Mileage	Electric cars	53,197	1,478,750	5,584,357	10,771,461	11,705,425	11,724,097	12,166,419	12,067,033	12,115,934
	Horse cars..	4,736,103	4,758,652	2,571,163	46,247	16,534	10,741	..	..	..
	Omnibuses..	1,490,458	1,368,144	945,346	152,355	68,856	..	..	..	..
Total		6,279,758	7,600,546	9,100,866	10,970,063	11,790,815	11,734,838	12,166,419	12,067,033	12,115,934
Receipts	Electric cars	£4,087	£77,515	£284,759	£463,164	£504,304	£524,321	£540,850	£550,084	£563,777
	Horse cars..	250,975	234,756	105,212	717	278	147	..	..	..
	Omnibuses..	59,145	47,658	27,603	4,502	2,146	..	..	..	..
Total		£314,207	£359,929	£417,574	£468,383	£506,728	£524,468	£540,850	£550,084	£563,777

THREE-PHASE POWER SUPPLY OF THE MANCHESTER CORPORATION.

In the early eighties, when the battle of the systems—continuous and alternating current—was at its height, Manchester was looked upon as the most powerful stronghold of the former, and was regarded as an efficient example of what could be done with multi-wire distribution. In spite of this experience the Manchester Corporation, with commendable enterprise and foresight, within the past six years, or thirteen years from the inception of its electricity department has established one of the largest municipal alternate-current stations in the country, and is now supplying polyphase power direct to consumers' premises. The Stuart-street station was primarily laid down to furnish a large number of sub-stations with three phase power, and this was converted to continuous current and distributed to the tramway feeders and the lighting and power three-wire network. During the last 18 months, however, a large number of power consumers have been connected up direct to the three-phase mains and energy is supplied without any other change than the reduction of the transmission voltage.

At the present time the large Stuart-street station (see *The Electrician*, Vol. LVI., p. 1040), contains 27,000 H.P. of plant, comprising slow-speed vertical engines and flywheel alternators, but a 6,000 kw. steam turbine is being added and will shortly be put on load. Approximately 10,000 H.P. of this plant is at the disposal of the power supply, the remaining and greater portion taking the traction and lighting loads. The extra high-tension feeders from Stuart-street are run in a cable tunnel. In each case the feeder is three-core, paper insulated, and armoured with steel wires. Beyond the tunnel the cables are laid in the ground in iron troughs filled with bitumen compound. 32 feeders are run from the works at present, as indicated in Fig. 1, and it is interesting to note the methods adopted for the supply of power consumers, with a view to economy of main feeders.

Where consumers lie on the route of extra high-tension feeders from Stuart-street to the sub-stations, one cable is looped into the consumer's sub-station, as shown digrammatically in Fig. 2. Duplicate cables for lighting and traction are always run between the main and sub-stations to distinct sets of 'bus bars for each section. At the sub-station, as is shown in Fig. 2, selector switches are provided, by which the duplicate cables can be coupled to either the traction or lighting bars, and as the same bars are also fitted with coupling switches a number of changes can be rung on the supply to the con-

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sumer through the looped feeder. For instance, if the cable length CD is disconnected or faulty, a supply can be given through AB. If this latter is out of service the duplicate feeder EF can supply back through CD from the sub-station. Again, if EF and AB are at fault the other feeders can give a supply through the 'bus-bar coupling switches. Consequently, the consumer's supply is well safeguarded against interruption.

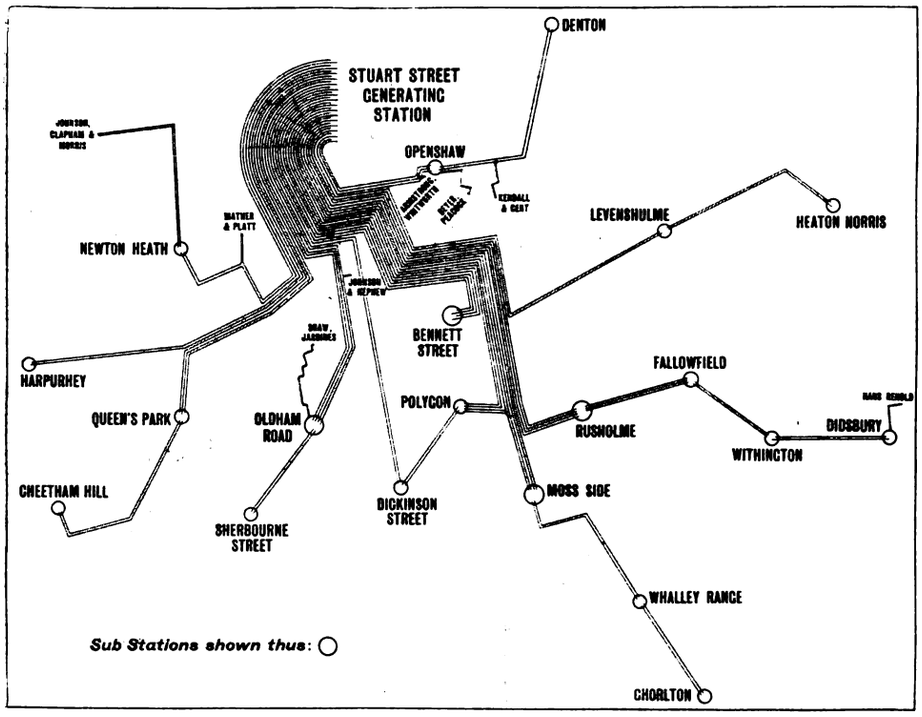
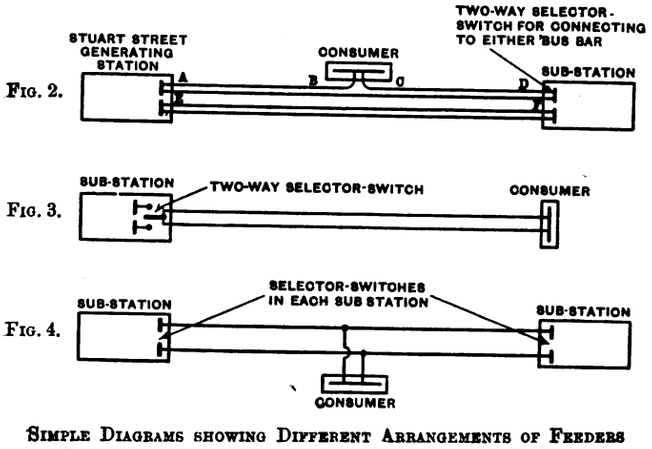


FIG. 1.—DIAGRAM OF HIGH-TENSION THREE-PHASE NETWORK.

In Fig. 3 the method of supply direct from a sub-station is shown diagrammatically. In this case duplicate cables are laid, and a selector switch at the sub-station admits of the supply being given from either traction or lighting 'bus bars. Fig. 4 shows in diagram the cable connections when consumers are on the line of a feeder route between two sub-stations. In this instance the duplicate feeders are both tapped and brought into the consumer's sub-station. As the



SIMPLE DIAGRAMS SHOWING DIFFERENT ARRANGEMENTS OF FEEDERS ADOPTED FOR POWER SUPPLY.

supply to the two sub-stations is in duplicate from Stuart-street, and as selector switches are fitted at the ends of the sub-station interconnecting cables, it will be evident that many changes of the supply can be made to customers connected in this particular way.

The consumer's sub-station equipment is, in the case of new installations, arranged for polyphase supply entirely. When private plants have already continuous current in use, and the motors are too numerous to replace with alternating-current machines, provision is made in the sub-station for suitable converting plant to transform the transmitted alternating current into continuous.

A plan and elevation of a typical sub-station for alternate-current supply only is shown in Fig. 6, and an interior view of the same is depicted in Fig. 8.

The ultimate capacity of the installation determines approximately the size of the sub-station. The building, which may be any dry disused premises, or be specially built for the purpose, is required to contain high and low-tension switch gear and groups of static transformers. The disposition of these latter is shown in the plan on Fig. 6. The transformers and high-tension switch gear are divided from the low-tension board by an iron grating with padlocked gate. The high-tension switch gear is of the iron-frame type with marble panels for the instruments and porcelain insulators for the current-carrying parts. Each transformer panel controls a maximum of 600 kw. and measures 2 ft. 8 in. wide by 3 ft. deep by 8 ft. 6 in. high. The high-tension connections are carefully shielded and the 'bus bars are fixed out of reach at the top of the panels. The instruments are placed in the low-voltage circuits of current and potential transformers. The feeder panels, of which there are two, one incoming and one outgoing, are each fitted with three-pole oil-break hand switch, and ammeter and voltmeter. The switch is of the tank type with handle projecting through a slot in the marble panel. Each switch has a lock-on-and-off bolt. In the connecting 'bus bars are the watt-

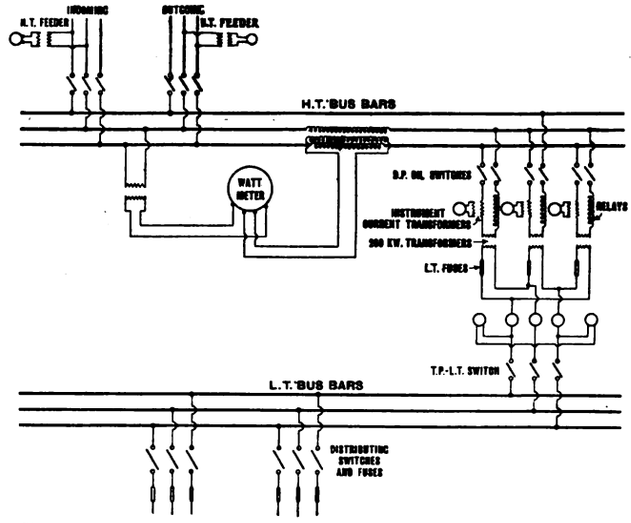


FIG. 5.—DIAGRAM OF CONNECTIONS AT SUB-STATION FOR MESSRS R. JOHNSON & NEPHEW.

meter transformers, and the main indicating instrument measuring the entire consumption of the station is placed on the feeder panels. The supply from the feeders is carried through 'bus bars to the transformer panels, each of which has mounted on it three double-pole oil circuit-breakers controlling the circuits to the three separate transformers, forming a complete three-phase unit. Each circuit-breaker has an overload

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relay and a time-limit device, these being fixed in separate covers on the panel. Finally, there is an ammeter fed from its own current transformer in each transformer circuit. The oil circuit-breakers have tripping coils mounted below the operating handles and in each case the handle is free of the switch release, so that the circuit-breaker cannot be held closed on an overload or a short circuit; the time limits can be set for intervals varying between instantaneous and 1 to 5 seconds.

The transformers used are the Berry air-cooled radiating single-phase type, the 200 kw. size being 3 ft. in diameter by 3ft. 4 in. high, as shown in Fig. 9. The extreme height over the high-tension terminals is 4 ft. 2 in. These make very compact converting units, and being free from oil insulation they require no attention. Each transformer is mounted on four wheels, which facilitate transport, and also keep the core clear of the ground. The windings are not exposed at any point, and the high-tension terminals, which are on the transformer top, are recessed deeply into porcelain hoods. A porcelain cap is cemented on as a cover to the incoming high-tension cable

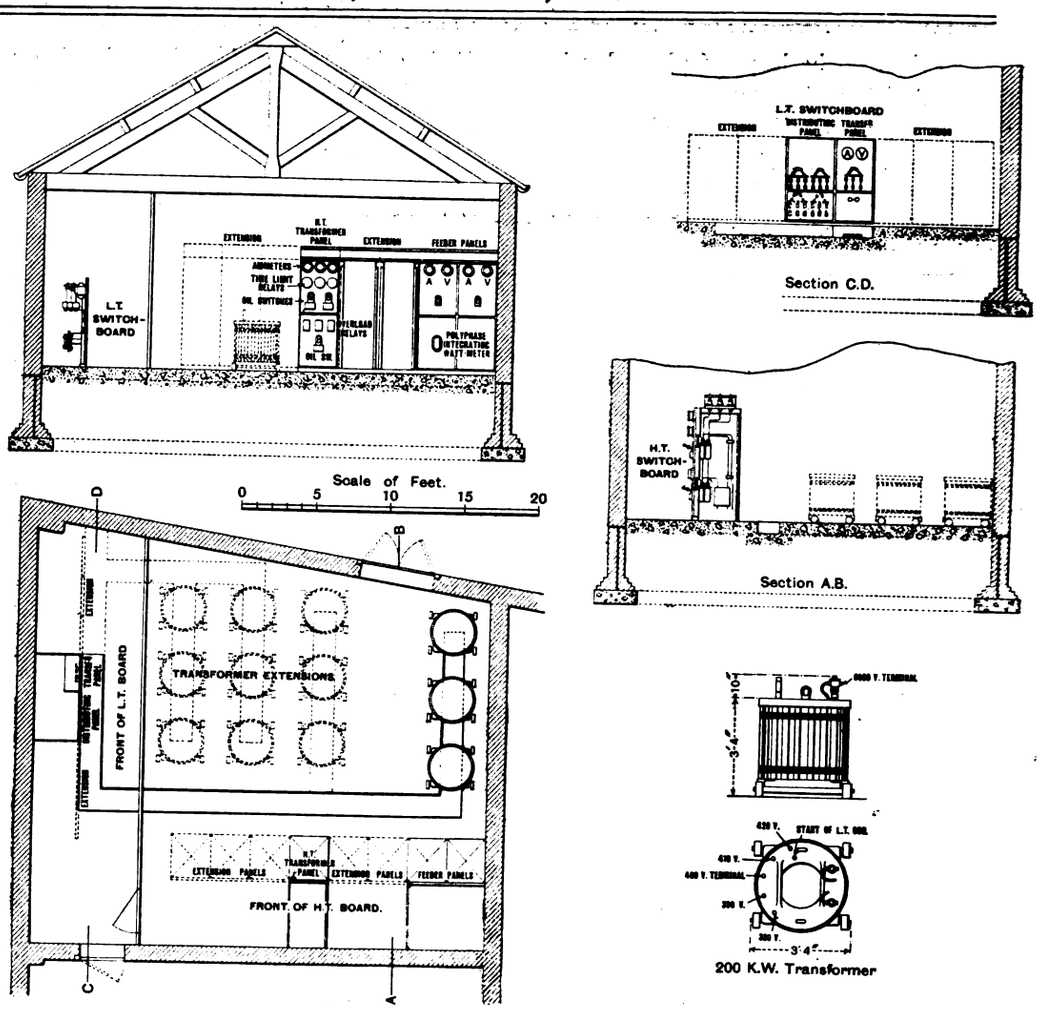
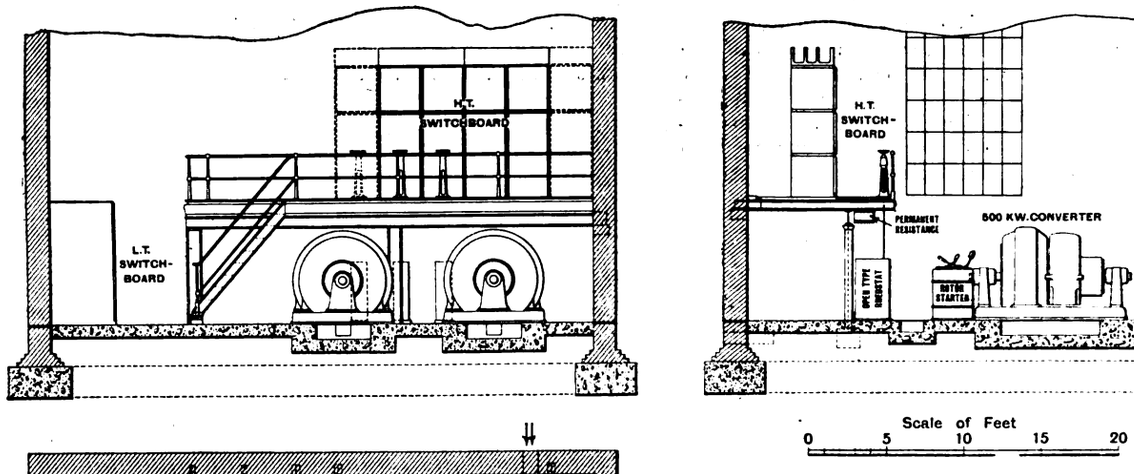


FIG. 6.—SUB-STATION AT THE WORKS OF MESSRS. R. JOHNSON & NEPHEW.



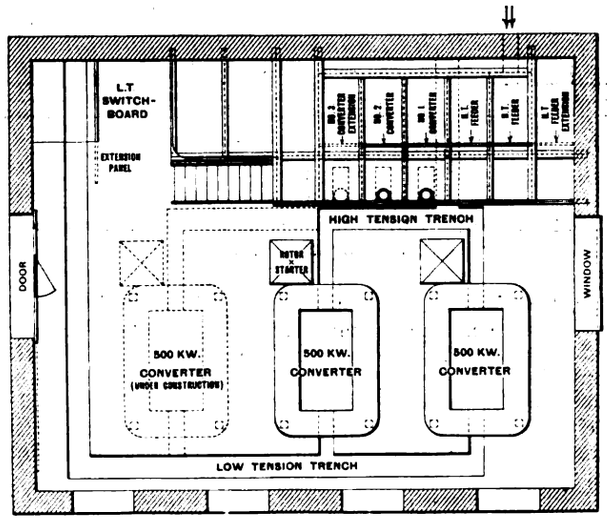


FIG. 7.—SUB-STATION FOR MESSRS. ARMSTRONG, WHITWORTH & CO.

terminal, so that there are no loose insulating parts to be dropped or incautiously removed. The high-tension connecting cables from the transformer switch gear are run overhead on suitable insulated supports. Five tappings are brought out on the low-tension side giving voltages of 380, 390, 400, 410 and 420 respectively. The low-tension cables are taken underground in trenches in the floor from the transformers to the switchboard outside the high-tension enclosure. These trenches are covered with chequer plates and are clearly shown in the plan of the station. During the building of the sub-station trenches were also made in the floor to take the extension cables. The sub-station illustrated has a total capacity of 2,400 kw. or 3,000 H.P. approximately. The floor area is approximately 900 sq. ft., and taking this as a basis for a sub-

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station with static transformers the area required is 0·3 sq. ft. per horse-power installed.

The low-tension switchboard, which occupies but little space, is fixed in a narrow portion of the sub-station outside the high-tension enclosure. Iron framework supports the marble panels, and on the face of these the necessary switches and instruments are mounted. The cables from the secondaries of the transformer feed on to the low-tension 'bus bars through a triple-pole switch, and three ammeters and the distributing feeders leave the board by way of three-pole switches and fuses. The transformer panel is 2 ft. 8 in. wide and the distributing panel 3 ft. 4 in. wide, the height of the board being 6 ft.

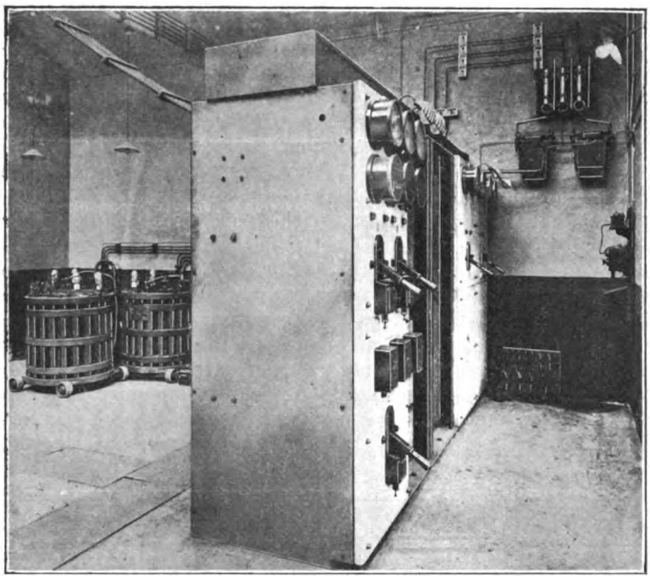

FIG. 8.—INTERIOR OF SUB-STATION AT THE WORKS OF MESSRS. R. JOHNSON & NEPHEW.

A diagram showing the transformer connections of this sub-station is given in Fig. 5. The transformers are connected up in delta on both high and low tension sides, and it is possible with these connections to continue a three-phase supply with any two transformers out of one set, but only up to two-thirds of the capacity of the three transformers. The phase supplied by any one transformer would in the event of breakdown be supplied by the remaining two transformers, as will be seen in the diagram. The wattmeter transformers and connections are arranged to give a true reading on an unbalanced load.

Where continuous current is to be supplied from the polyphase mains some form of rotary transformer must be used. The plan and elevations in Fig. 7 show a typical installation of motor converters and high and low tension switch gear.

The building in this case was specially erected and its capacity is three 500 kw. motor converters, a total of 1,800 kw. The floor area is approximately 870 sq. ft., and taking the capacity at 2,000 H.P., the station space required is about 1·2 ft. per H.P. This is a comparatively small amount of space considering that the floor area required by the motor converters is 165 sq. ft. The general arrangement of the plant and switchgear can be gathered from Fig. 10, which is an interior view of the sub-station.

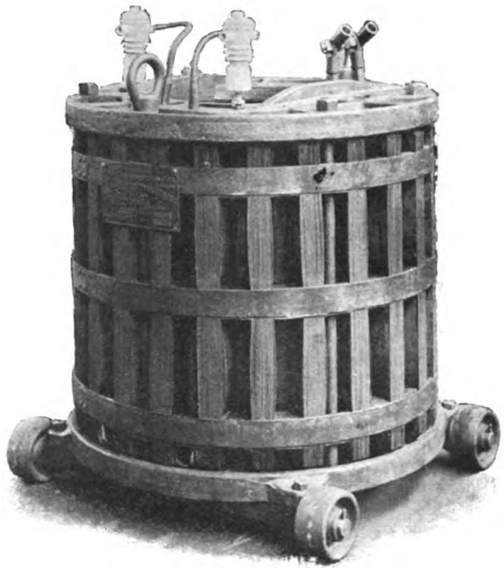

FIG. 9.—200KW. BERRY SINGLE-PHASE TRANSFORMER.

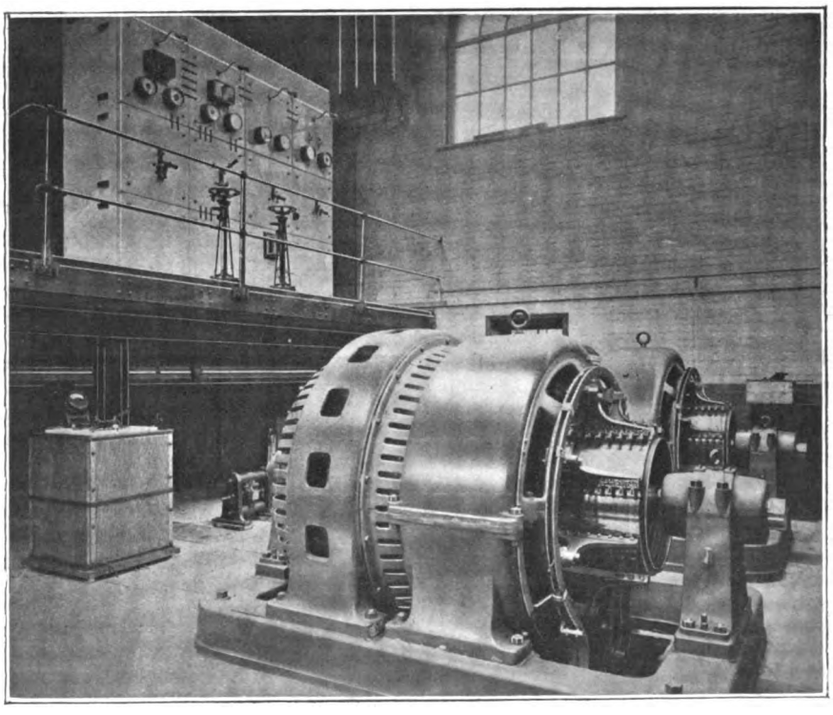

FIG. 10.—INTERIOR OF SUB-STATION AT THE WORKS OF MESSRS. ARMSTRONG, WHITWORTH & CO.

The motor converters are bolted down on to concrete foundations, the centre of which is recessed for air circulation to the converter windings and for the cable connections. Trenches are cut into these recesses, at each end of the machine, and the high and low tension cables are laid in these from their respective switchboards. The use of motor converters dispenses with the necessity for reducing transformers, as the transmission voltage can be supplied direct to the stator windings of the machine. Where space is valuable this arrangement tends to economise it considerably. The converters in this particular station are run in parallel with a large private plant installed in the same works.

The starting resistances for the converter are placed under the switchboard gallery facing their respective machines and

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the synchronising voltmeter is placed on a bracket facing the machine, so that the attendant can watch its movements when he short-circuits the alternating-current ends of the rotor windings with the switch provided for the purpose on the machine. The general details of the high-tension switchgear are practically identical with those of the gear depicted in Fig. 3 as far as the feeders are concerned. The field rheostats are fixed over the low-tension panels, which are erected in a corner of the sub-station. The gear is of the iron-frame type with slate bases for the current-carrying parts. Overload circuit-breakers are fitted to the continuous-current sides of the machines and the necessary instruments complete the gear. Heavy cables connect this board with the 'bus bars of the private plant.

This type of sub-station may be frequently required in industrial districts because many large manufacturers have had continuous-current plants in operation for several years. It is to be expected that where favourable terms for power supply can be arranged with the Corporation they should avail themselves of it instead of extending the existing installation. The efficiency of the motor converter, which is a speciality of Messrs. Bruce Peebles, is very high, so that from

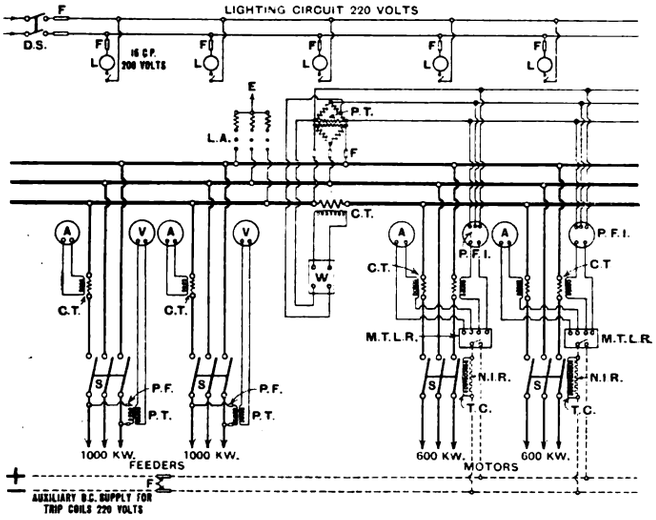

FIG. 11.—DIAGRAM OF CONNECTIONS AT MESSRS. ARMSTRONG & WHITWORTH'S SUB-STATION.

A, Ammeter. V, Voltmeter. W, Wattmeter. M.T.L.R., Max. time limit relay. P.F.I., Power factor indicator. S, Three-phase oil switch. C.T., Current transformer. P.T., Potential transformer. T.C., Trip coil. P.F., Potential transformer fuse. L.A., Lightning arrester with resistance. F, Fuse. D.S., Double-pole switch. N.I.R., Non-inductive resistance. L, Lamp.

the consumer's standpoint the use of such plant will be attended with losses much lower in comparison than those with a steam or gas driven installation.

In Fig. 11 a diagram of connections of the above-mentioned motor converter installation is shown. The high-tension feeders, it will be noticed, are in duplicate, and they supply one set of three-phase 'bus bars. Between the feeder and converter panels is the main wattmeter, the potential transformer for which also supplies the power factor indicators. These instruments are advisable where rotary converting plant is used. The converter panels have circuit-breakers, with maximum time-limit relays, and the pattern adopted by Messrs. Ferranti, who supplied the gear, requires a separate continuous-current circuit for the tripping coils. This also necessitates a non-inductive resistance across the coil when the circuit is broken to keep down sparking at the relay contacts.

(To be concluded.)

Electric Traction on the Canadian Pacific Railway.—Sir Thomas Shaughnessy, president of the Canadian Pacific Railway Co., is reported to have stated that his company is considering the substitution of electric for steam locomotives for use on heavy gradients in British Columbia. Several tests that have been made of late have proved entirely successful, and the company's engineers are satisfied with the designs.

RADIO-TELEPHONY.

[COMMUNICATED.]

The first actual application of radio-telephony to practical work anywhere in the worldw as made at Put-in Bay, on Lake Erie, during the week July 15th to 20th, 1907, in reporting the regatta of the Interlake Association. The Radio Telephone Company installed the De Forest wireless telephone apparatus on board the cruiser yacht "Thelma," owned by Commodore W. R. Huntington, of Elyria, Ohio, and also equipped a shore station at the Fox Dock at Put-in Bay. The "Thelma" (Fig. 1) is thus the first craft in the world to be fully equipped with the wireless telephone.

Although not well suited to the task, on account of her short spars and wooden hull, the "Thelma" gave an excellent account of herself and of the radio-telephone throughout the regatta. The distances which were attained exceeded the hopes of Dr. Lee de Forest, the inventor, who was in charge of the apparatus. The "Thelma" followed the competing yachts, or motor boats, round the course through most of the races, and full and graphic accounts were telephoned into the shore station exactly as the events occurred. Speech was not alone transmitted during these demonstrations, but singing,

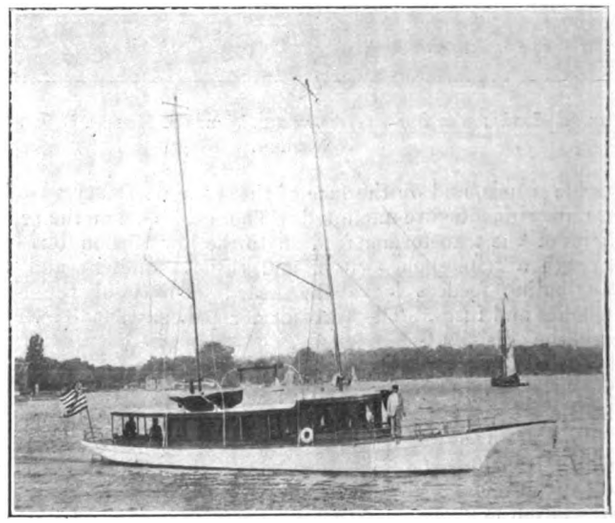

FIG. 1.—THE "THELMA" WITH WIRELESS EQUIPMENT.

whistling and gramophone music or dialogues were interpolated with the news reports. It was astonishing to note the clearness and fidelity of the reproduction. Friends recognised one another's voices without difficulty. The scratching of the gramophone needle over the disc after the record had been played through, even the tapping on the mouthpiece of the microphone transmitter with a pencil, was distinctly heard at a distance of three miles from shore.

The greatest distance at which the reports from the yachts were heard and recorded was four miles, which was considered remarkable in view of the height of the "Thelma's" spars, and the power of the transmitter on board. Her equipment comprised a 220 volt generator of 1 kw. capacity, the De Forest oscillator and transmitter, and for the receiving apparatus an audion detector and "pancake" form of syntoniser or tuner. Her aerial wires led through the roof of the wheel house to a small cross-arm on top of the foremast, thence to a similar arm on the mainmast. Earth connection was at first made to the propeller shafts of her twin screws, but, as this was found insufficient, more area was added by fastening two sheets of zinc to the yacht's hull at the bow.

The "Thelma" is a cruiser yacht of 17·82 tons net, length over all 72 ft., width 10 ft. 8 in. beam and 5 ft. draught. She carries two 20 H.P. Lacy engines and is schooner rigged. The telephone dynamo was belted direct to the flywheel of her starboard engine, aft, and the rest of the radio apparatus

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was mounted on a small table in her main cabin convenient to all (*see* Fig. 2).

On shore 110 volt direct current was available, and this was transformed to 220 volts by a motor-generator. This current was led through a rheostat and choke coils to the oscillator. Connected to this oscillator was a shunt circuit consisting of a condenser of peculiar construction and a primary coil, the exact number of turns of which could be varied at will to alter the tune or wave-length of the electrical waves which were generated. A second coil within this primary had its upper end connected directly to the antenna, or aerial wire, while its lower end led first through the microphone transmitter and thence to the earth plate. In this way the changes in resistance in the microphone produced by the modulations of the human voice directly affected the intensity of the high-frequency currents, which were continually passing from the air wire to the ground plate. Inasmuch as the receiver instrument is affected exactly in proportion to the strength of the received electric waves, it is evident that every variation in the microphone resistance by the voice will be reproduced to the listening ear at the distant station by the vibration of the telephone diaphragm there. In other words, in the De Forest radio-telephone the high-frequency currents, or electric waves, play the part of the direct current in

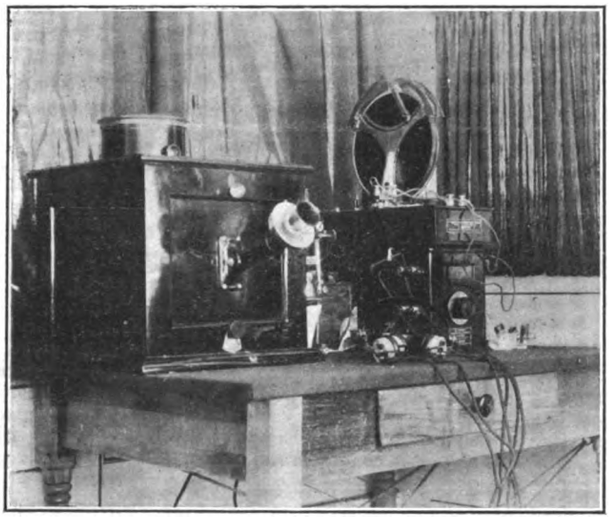

Fig. 2.—General View of Transmitting Apparatus.

the ordinary telephone: the ether transmits these waves in place of the old-fashioned telephone wire, and the responder, or "audion," at the receiver translates these received oscillations into ordinary telephonic currents, which can affect the diaphragm to reproduce speech to the human ear. The microphone transmitter and the telephone receiver are exactly the same as used in the wire telephone. The "oscillator" and the "responder" are the only new and additional features, and the ether takes the place of the connecting wire. As illustrating the advantage in point of expedition of business of the radio-telephone over the wireless telegraph, it was found that from three to four times the number of words could be transmitted in a given period of time. The following is a fair sample of the service rendered by the installation on the "Thelma":—

9:57½ a.m. I will tell you when the first boat crosses the line.——First boat is about crossing the line.——9:59. "Spray" crossed the line at 9:59.——"Spray" crossed about 25 second after 9:59.——9:59 and 5 seconds is the exact time.——(This was followed by gramophone music played on the "Thelma.").——Later: Second boat just crossed 10:07½. ——First in the cat boat race crossed at 10:01½.——"Cleveland" finished second, time 10:03½. "Borealis" 10:04½. "Cleveland "finished second. ——What shall I put down for you in the second race?——St. Clair just crossed 10:07½ (repeated often).——Hello, Frank! We will be back in about two hours. "Osekita" just crossed the line; you spell it, I can't. Time 10:08½.

And so on until the races were finished and the "Thelma" started back for Put-in Bay dock. At the finish of the regatta the telephone apparatus from the "Thelma" and the Put-in Bay shore station was shipped to Toledo, where it is the intention of the Radio-Telephone Co. to instal it permanently. Here it can be in communication with other wireless telephone sets to be installed on vessels sailing Lake Erie. The Great Lakes, it is considered, offer the most promising field for the first general application of this new invention to the needs of a merchant marine, and it is the intention of the company to at once enter this promising field.

GREAT WESTERN RAILWAY.—ELECTRIC POWER AND LIGHTING AND THE ELECTRIFICATION OF THE HAMMERSMITH & CITY RAILWAY.

(*Concluded from page 714.*)

Track Work.

As has been explained above, the system adopted for supplying current to the train-collecting shoes is the same as that already in use on the Metropolitan and District Railways. There are two insulated conductor rails, the positive being 3 in. above rail level and 16 in. outside the running rail, and the negative conductor being 1⅛ in. above rail level and in the centre of the track (*see* Fig. 19). The two conductor rails are of an inverted channel section, resting at intervals not exceeding 10 ft. on iron-capped porcelain insulators, as shown in Figs. 20 and 21. The insulator is fixed to the sleeper by small clamps and coach screws. This design leaves the conductor rail and insulator free to move up and down relatively to each other when trains are passing, owing to the spring in the sleepers and in the road bed. The guards fixed to the positive conductor rail are shown in Fig. 24.

The rails, which are 44 ft. 6 in long, weigh 102·8 lb. per yard, and have a cross-sectional area of 10 sq. in. They are made of a special quality of steel having a conductivity equal to 15 per cent. of that of copper. The conductor rails are fished by a joint plate bolted on the underside, and are bonded by four laminated copper strip bonds (Fig. 25) which are practically protected by the sides of the conductor rails and the joint plate. At intervals of about 130 ft. the conductor rails are anchored by means of special insulators having a groove in the iron cap in which a bolt engages which passes through the flanges of the conductor rail, the anchor insulator being secured to the sleeper by semicircular clips. The bond terminals were expanded into the conductor rails by means of hydraulic presses which were of two types. One type consisted of a combined press and pump, shown in Figs. 22 and 23, which was used when the trains were not running, and which could be readily moved by means of runners along the surface of the rail and have the centres of the rams quickly adjusted to the bond terminals. The other type consisted of a specially designed press worked by a separate pump, and so arranged that it could be used on the positive conductor rail without removing it when trains passed.

Steel ramps 13 ft. long (1 in 50), made from a bent section of the ordinary conductor rail, are normally used at facing ends, and steel ramps, 4 ft. 6 in. long (1 in 9), at trailing ends. At sidings and points where the collecting shoes may pass over the rails in either direction at a medium speed, steel ramps, 8 ft. long (1 in 25), are fitted to each end of all rails. At cross-overs, where the speed is less, cast-iron ramps (1 in 8) are fitted.

At points and crossings the different lengths of conductor rail are connected together by rubber-insulated, lead-sheathed and armoured cables buried direct in the ground, each end of the cable being sealed in a specially designed porcelain terminal cap from which a solid copper rod projects. To this projection two flexible copper bonds are clamped, the other ends of the bonds being expanded into the conductor rail. Any jumper cable can in this way be at once disconnected by the removal of two bolts in the clamp. Fig. 26 shows the general arrangement of one of the terminal insulators. The concentric feeder cables from the sub-stations end in terminal boxes where they are connected to four jumper cables, two positive and two negative, which, in turn, are connected to the conductor rails in the same way as the other jumper cables.

Both positive and negative conductor rails are insulated from earth throughout their whole length, but at each sub-station the negative is connected to earth through a resistance. On the occurrence of an earth on the positive the potential of the negative conductor rail may drop to about 600 volts below earth when a current of about 100 amperes passes through the earthing resistance.

The conductor rails on the "up" line can be connected electrically from one end of the line to the other, and those on the "down" line can be similarly connected from one end to the other. Cross-bond pillars are placed at various points on the line, usually near a station, for the purpose of connecting the conductor rails of the "up" line with those of the "down" line. Each cross-bond pillar

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contains a double-pole switch worked by rodding from a lever placed in the nearest signal cabin, the signalman being in telephonic communication with one of the sub-stations. The switch, when closed, connects the two positive conductor rails together and the two negative conductor rails together, so that the "up" and "down" lines are worked in parallel.

the train on to a dead section insulator or on to the faulty section of the line. The section insulator consists of a 315 ft. length of conductor rail (in the positive and in the negative) which is separated from the conductor rails on the same line at each end by a 3 in. gap, which is filled in with a hard-wood block. Under normal working conditions both ends of the section insulator on the nega-

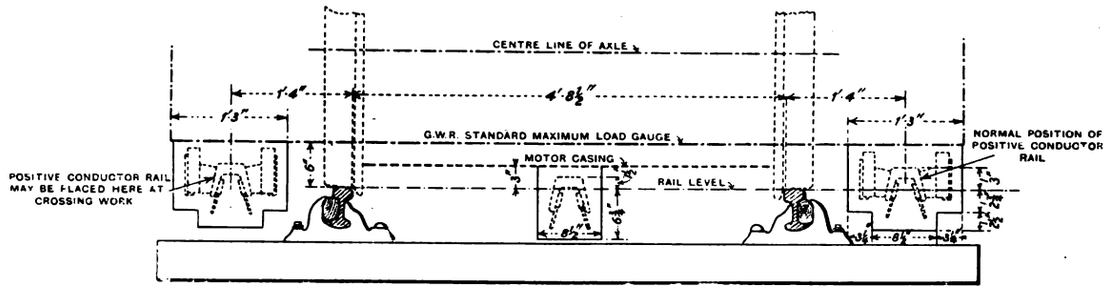
CENTRE LINE OF AXLE
G.W.R. STANDARD MAXIMUM LOAD GAUGE
MOTOR CASING
RAIL LEVEL
POSITIVE CONDUCTOR RAIL MAY BE PLACED HERE AT CROSSING WORK
NORMAL POSITION OF POSITIVE CONDUCTOR RAIL

FIG. 19.—CONDUCTOR RAIL CLEARANCES. Scale ½ in. to 1 ft.

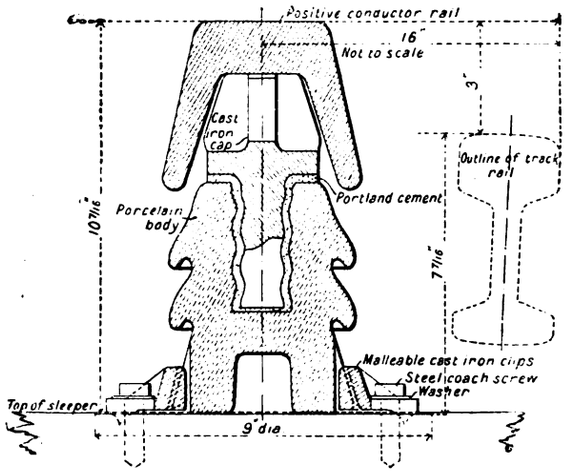

FIG. 20.—INSULATOR AND POSITIVE CONDUCTOR RAIL.

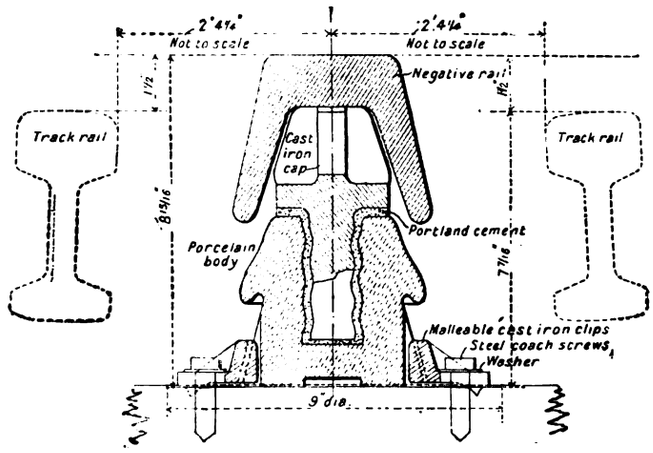

FIG. 21.—INSULATOR AND NEGATIVE RAIL.

Section insulators are placed at certain points in the conductor rails on each line for the purpose of disconnecting any section of the conductor rails when a fault occurs or repairs are necessary. The section insulators on the "up" and "down" lines are placed opposite each other in all cases. The section insulator is placed beyond

tive and one end on the positive are connected to the conductor rails by heavy copper straps which bridge the hard-wood insulating block and which are easily removable. A section pillar is placed opposite the insulating wood blocks at the other end of the section insulator in the positive conductor rail, and contains two single-pole

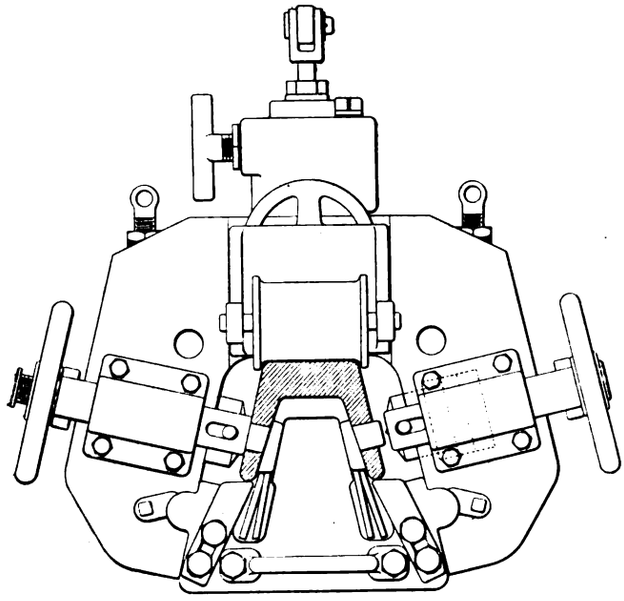

FIG. 22.—RAIL BOND COMPRESSOR. One-eighth full size.

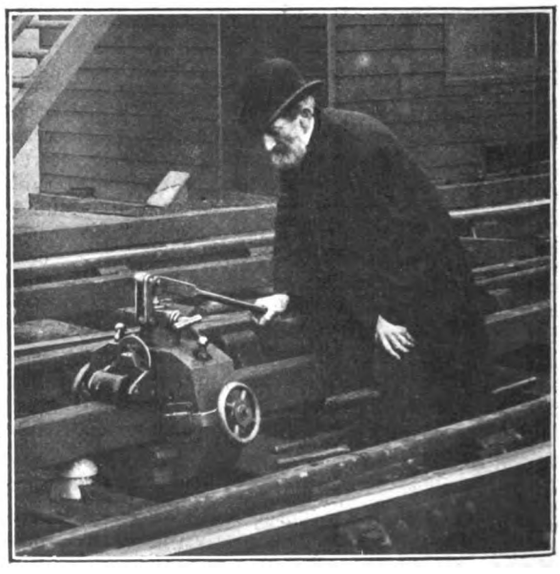

FIG. 23.—VIEW OF RAIL BOND COMPRESSOR IN USE.

the cross-over between the "up" and "down" lines at a railway station, so as to leave rather more than a train's length between the end of the cross-over and the end of the section insulator. This allows trains to be shunted from one line to the other without taking

switches, one switch for the "up" line and the other for the "down" line. Each switch is so connected to the conductor rails that, when closed, it bridges the insulating wood block at the end of the section insulator in the positive conductor rail.

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The cross-bond and section pillars are of cast-iron with locked doors. The switches in the section pillars are worked by hand. Interlocking tablets are provided in the signal cabin in the case of a cross-bond pillar, and in the pillar in the case of a section pillar, so arranged that when a key is withdrawn the switch is left locked in the open position and cannot be again closed until the key is inserted. When the switches are in the closed position the keys cannot be withdrawn.

At the electrical boundary at Bishop's-road two disconnecting pillars are provided, one for the "up" line and the other for the "down" line. Each pillar has two switches, one for connecting the positive, and the other the negative conductor rail to the corresponding rails on the Metropolitan Company's system. These switches are kept open at all times except when it is arranged that, under emergency, the two systems can be connected together. The opposite end of each section insulator at the boundary has the positive and negative conductor rail connected up through a resistance instead of by the copper straps used at other section insulators. The resistance is only in circuit as a train passes from the Hammersmith and City line to the Metropolitan lines, or vice versa, and is required to prevent an excessive rush of current from the one system to the other. Under the emergency referred to above, the resistances can be short-circuited by copper straps.

Short lengths of conductor rail, similar to the section insulators, but only 40 ft. long, are provided on the "up" and "down" lines opposite Shepherd's Bush and Royal Oak sub-stations so as to separate the sections fed by the different feeders. Straps are also provided for bridging the insulating wood blocks at the ends of these short sections if required.

Normally, the lines are supplied from the two sub-stations at Shepherd's Bush and Royal Oak in parallel. When the two sections are worked separately they are divided by means of a section insulator between Westbourne Park and Notting Hill stations.

Electric Trains.

For the service between Hammersmith, Kensington (Addison-road), Aldgate and Whitechapel 20 electric trains have been provided by the Great Western and Metropolitan Railways. The cars are of the closed vestibule type, with doors only at the ends and sides of the vestibules, the car frame being stiffened by a partition half-way along its length. Each train is composed of six cars, approximately 52 ft. long by 8 ft. 9 in. extreme width. Each car is carried on two four-wheel bogies, those of the front and rear cars each being equipped with two motors. The train has a total seating capacity of 320 passengers, with additional room for about 160 passengers standing, making a total passenger load of 30 tons, while the train itself unloaded weighs about 174 tons with electrical equipment complete. The two centre cars are divided into two portions, one portion of each being reserved for first-class non-smoking and smoking passengers; the rest of the train is divided equally between third-class smoking and non-smoking passengers. The driver's compartment is at the front end of each motor car, and immediately behind this is a luggage compartment 8 ft. 4 in. long. The side frames and roof of the cars are made of wood, built on steel underframe, while the seats and other interior fittings are made as nearly fireproof as possible, the floors being of Paris patent plastic cement. The cars are fitted with central buffers and automatic couplers.

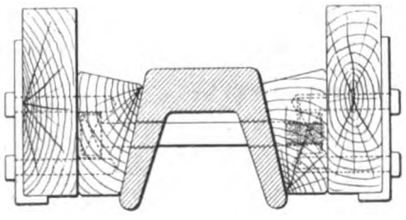

Fig. 24.—Positive Rail Guards. Scale, one-sixth full size.

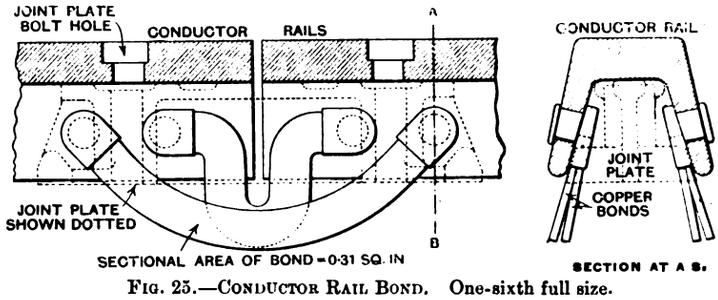

Fig. 25.—Conductor Rail Bond. One-sixth full size.

The motors are of the G.E. 76 type with two bearings on the main axle and supported from the outside of the fixed bolster of the bogie frame by a special nose cast on the motor frame. The contactors for operating the various motor circuits are placed in boxes bolted to the underframes of the cars and readily accessible by anyone standing at the side of the cars. The resistances are also hung from the underframe under the centre of the car, where they are suitably protected from accidental injury, but get sufficient ventilation to keep them quite cool in ordinary working. Each pair of motors when starting the train is connected in series with suitable resistances which are cut out in four steps until each pair of motors is connected direct in series across the full voltage supply. By an ingenious method of arranging the switches each motor is then separately connected with a suitable resistance across the full voltage without any interruption to the supply occurring. The resistances are then cut out in four steps until the full parallel position is obtained. To effect this result 14 contactors with suitable interlocking contacts are required for each pair of motors. The controller is fitted with the "deadman's" handle so arranged that, should the driver release his hold, once the reverser handle has been put to the forward or reverse position, the controller current is cut off and all contactors open, cutting off current to the motors, and the brakes are applied throughout the train. The circuit-breaker switch is so arranged that the circuit-breakers can be tripped with the controller in any position, but they cannot be set again until the controller handle is in the "off" position. The main controller handle can be locked in the "off" position by setting the reverser handle in a position midway between forward and reverse, but it is not possible to move the reverser handle into this position unless the main controller is in the "off" position. When in this mid-position the reverser handle can be removed from the controller, but not otherwise. The eight motors are capable of accelerating a fully loaded train at the rate of 1·6 ft. per second with a track voltage of 600, the momentary maximum current per motor not exceeding 320 amperes, while the average maximum is about 280. The motors are capable of attaining a train speed of 40 ft. per second within 40 seconds of the start, and the energy consumed on the trip from Hammersmith to Aldgate and back does not exceed 75 watt-hours per ton-mile. Westinghouse air brakes are fitted throughout the train, as well as hand brakes in the motor cars. An electrically driven air compressor is provided under each motor car with an automatic governor which switches on the current when the pressure falls below 70 lb. per square inch, and opens circuit when the pressure has risen to 90 lb.

The trains are lighted and heated throughout by electricity, and by means of a change-over switch each car can be lighted separately by flexible cables from the trolley wires in the shed, without making the shoes or other main circuits alive.

Train Sheds.

The 20 electric trains are accommodated in new sheds built by the Great Western Railway Co. at Hammersmith. The large shed takes 15 trains and the small shed 5 trains. At the side of the small shed two roads run into a repair shed, particulars of which are given below. Inspection pits are provided under all the motor cars in the large shed and throughout the small shed and repair shed. The buildings are of red brick, the roof, which is partly glazed, being supported by steel principals. Roller doors are fitted to the entrance of every bay. Offices and stores are being provided at the south end of the repair shed, and mess rooms, &c., for the staff in the grounds outside. Electric current is supplied to the trains throughout the large and small sheds by means of positive and negative overhead trolley wires, which are supported by wooden battens and bridge hangers from lines of "H" joists placed above, and slightly to the side of, each track and bolted to the underside of the roof principals. Current is collected from these trolley wires by means of small trolleys on four wheels which run on the bottom flange of the joists and to which are attached grooved rubbing contacts or collectors mounted on springs and insulators. From these collectors the current is conveyed to the trains by

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means of two flexible cables bound together with leather braiding and reinforced by a stranded steel wire. To the bottom ends of the cables are attached the standard train cable plugs which allow a connection to be made to either end, or either side, of any car, and by means of a special attachment it is impossible to insert the plug in the train in such a manner as to reverse the polarity of the circuits. As the sockets on the trains are not arranged to allow the plugs to pull out in an upward direction, a safety coupling has been inserted in each pair of cables which breaks the circuit and releases the trolley from the train should the latter run right out of the shed without detaching the trolley. The overhead trolley wires receive current from distributing bars running across the north end of the large and small sheds, each pair of wires being fed through a D.P. isolating switch so that the supply to any line can be cut off, or any necessary repairs can be carried out without interrupting the supply to the other lines. Along the south end of the large and small sheds are equalising bars to which each pair of trolley wires are connected, also through isolating switches. These equalising bars are brought down to the south-east corners of the large and small sheds to double-pole switches, the lower terminals of which are connected by armoured cables to the positive and negative conductor rails in the yards outside the sheds. These rails are normally disconnected from the conductor rails on the

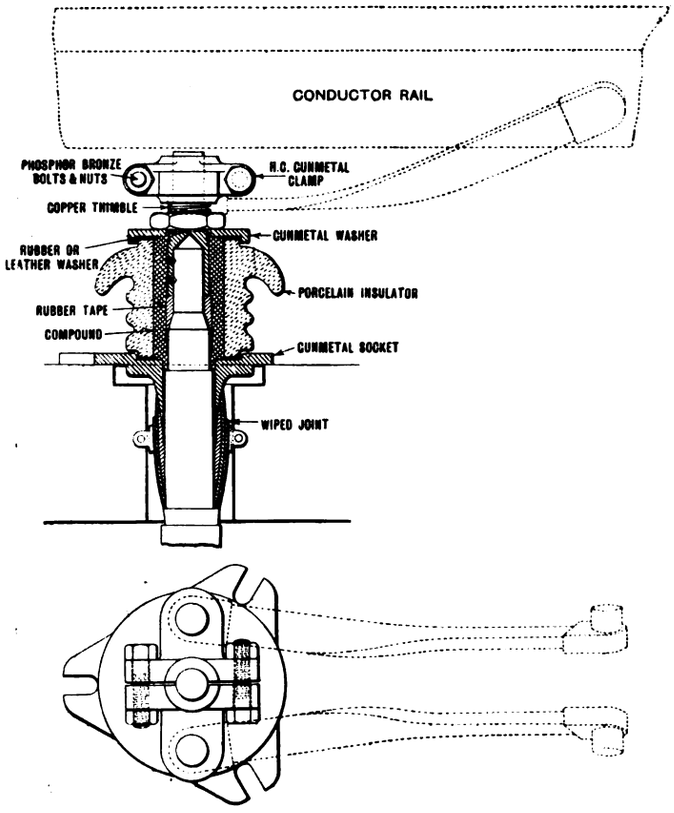

FIG. 26.—CABLE TERMINAL.—One-sixth full size.

main lines so that all current used for shunting, as well as in the sheds, is measured by a special wattmeter fixed on a switchboard in the north-west corner of the large shed. On this switchboard are also fixed circuit-breakers connecting the two concentric feeders from the sub-station to the distributing bars in the sheds, and two double-pole quick-break switches connecting the same feeders to the conductor rails on the main lines just outside the sheds.

The repair shop is fitted with a 15 ton electric crane running the whole of its length. The three motions of the crane are worked by three separate series-wound motors, supplied with current at 600 volts from the distributing bars in the small shed. The controllers, which are of the tramway type, are placed in a horizontal position at one end of the crane girders and are operated by ropes from the floor level, springs being fitted to return each controller to its "off" position as soon as the ropes are released. The crane is fitted with a mechanical and an automatic electric brake, either of which will hold the full load on the hook. A special cradle has been provided with the crane for lifting one end of a car off its bogie, so that the latter may be changed or other repairs executed.

Wheel and axle turning lathes have been installed as well as smaller lathes, drilling and shaping machines and other tools required for carrying out all ordinary running repairs. A wheel press is not provided, as it is intended that work of this description should be done elsewhere. The two large lathes are each driven by separate motors of the three-phase squirrel-cage type, the motors being rated at 11 H.P. and 7½ H.P. The smaller tools are worked in groups from overhead shafting driven by similar motors of various sizes. The three-phase supply for these motors is obtained from a distributing centre situated at the side of the large shed. From there also current is supplied for lighting the sheds. Arc lamps are suspended with lowering mechanism from the roof principals throughout the sheds, and plugs are provided in all the inspection pits to enable hand lamps to be used under the cars.

TELEPHONE SYSTEM.

A very complete system of telephonic communication has, of course, had to be provided throughout the whole system of electrical supply. At the generating station and at each of the three sub-stations an exchange switchboard is installed, and each of the distributing centres, railway stations, signal cabins and section switch pillars can communicate direct with one or other of the four exchange switchboards, and can thence be plugged through to any of the remaining switchboards. In addition to the exchange switchboards, three telephone instruments are installed at the generating station and at each of the three sub-stations for direct communication between the main H.T. switchboards.

The buildings for the generating station, sub-stations, distributing centres and inspection chambers have been provided under the supervision of the Great Western Railway Co.'s engineers, who were also responsible for the trench work in connection with the system of cables. The whole of the rest of the work in connection with the generating station, sub-stations, distributing centres and cable work was carried out to specifications prepared by Messrs. Kennedy & Jenkin, acting as consulting engineers to the Great Western Railway Co., and under their supervision.

The rolling stock was constructed to a specification prepared by the locomotive department of the Great Western Railway and the carriage and waggon department of the Metropolitan Railway Co. The electrical equipment of the trains was carried out to a specification prepared by Messrs. Kennedy & Jenkin, acting as consulting engineers to the Great Western Railway Co., and Mr. Thomas Parker acting as consulting engineer to the Metropolitan Railway Co.

The car shed has been provided and the permanent way equipped under the supervision of the Great Western Railway Co.'s engineers. The electrical equipment of the line and of the train sheds was carried out to specifications prepared by Messrs. Kennedy & Jenkin, acting as consulting engineers to the Great Western Railway Co., the laying, bonding and jointing of conductor rails being done by the Great Western Railway Co.

Among the main contractors we may mention the following: Babcock & Wilcox (Ltd.) for boilers and pipe work; Spencer & Co. (Ltd.) for conveyors; Aiton & Co., pipework and water softening plant; Belliss & Morcom (Ltd.) for main and auxiliary engines and condensing plant, the Electric Construction Co. (Ltd.) for engines, generators and condensing plant, L.T. switchboards at sub-stations and static transformers; the British Thomson-Houston Co. (Ltd.) for switchboards at Park Royal and sub-stations and electrical train equipment; the Klein Engineering Co. (Ltd.) for cooling towers, Marshal, Fleming & Jack for overhead travellers; Siemens Bros. & Co. (Ltd.) for cables; Bruce Peebles & Co. (Ltd.) for motor converters; the Tudor Accumulator Co. (Ltd.) for storage batteries; the Metropolitan Amalgamated Railway Carriage & Wagon Co. (Ltd.) for rolling stock; and the Westminster Engineering Co. (Ltd.) for lighting, telephone and bell circuits. Switchboard instruments were supplied by Chamberlain & Hookham, Elliott Bros., Everett, Edgcumbe & Co. (Ltd.), Evershed & Vignoles, Ferranti Limited, Nalder Bros. & Thompson (Ltd.), and the British Thomson-Houston Co. (Ltd.).

We are indebted to Messrs. Kennedy & Jenkin for the particulars here given, and for placing drawings and photographs at our disposal.

NOTE ON TUNING IN WIRELESS TELEGRAPHY.*

BY SIR OLIVER LODGE, D.SC., F.R.S.

Summary.—In these notes the author deals with the characteristics of a "tuned arc" station as distinct from a "spark" station.

The principles of tuning were clearly explained at Mr. Duddell's lecture†, and I shall assume them known; but it is not to be supposed that the application of these principles requires the arc. Sufficient tuning for all practical purposes can be obtained by using the right kind of spark. It is possible to use too long a train of waves, in which case the latter half of the train will undo what the former half has begun, in analogy with beats. Thirty or forty swings can be easily got by a spark, and that is enough for practical requirements

* Abstract of a Paper read before Section G of the British Association at Leicester, August 6, 1907.

† *The Electrician*, Aug. 9th, p. 684.

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Kind of Spark.—A non-tuned station puts all the energy into a single snap, so as to produce a single discontinuous pulse calculated to affect every kind of station within the range of its power. For a tuned station this sudden snappy spark is to be avoided. The ideal arrangement is a spark of a sufficient number of alternations, of approximately equal strength, no one of which is sufficient to operate, but such that the accumulated influence of all of them is powerful. Instead, therefore, of the clean polished metal knobs in fresh or compressed air, which are suitable for a snappy spark, a tuned station may employ a series of points enclosed in ionised air so as to maintain conduction as long as possible. The maintenance is also assisted by using an alternator with a curve of the right shape—not a sine curve, but a high-shouldered curve—so as to keep up the stimulating potential for a sufficient time. It is this kind of spark which, at the Lodge-Muirhead station at Elmer's End, was photographed by Mr. Duddell in a revolving mirror, and exhibited in his lecture.

Effect of the Earth.—But attention to the spark alone is not sufficient; it is necessary to eliminate the influence of the earth. For the snappy or non-tuned emission, such as was employed by Mr. Marconi for great distances, it is convenient to use an elevated wire on the one hand and the earth on the other, but for a tuned station this is not appropriate. A tuned station requires two capacity areas, both elevated above the earth, as published by me in 1897. These capacity areas are usually horizontal frames, of shapes devised by my friend and partner, Dr. Alexander Muirhead, who has found that there is a best position for the lower aerial, such that the capacity is a minimum. It was under these circumstances that the photograph above spoken of was taken, and the sending efficiency is most marked.

If the lower aerial be too much raised, the radiating power diminishes; if it be lowered, the train of waves is shortened until, when it is allowed to touch the earth—still more, if it is connected with the earth—there is hardly any train of waves at all, and the discharge is almost dead-beat. There is a great advantage in thus getting rid of earth contacts, inasmuch as variations of moisture and uncertainties of the soil do not enter in to confuse the problem and throw the tuning out. But even if the earth remained constant it would be deleterious; it seems by its resistance to damp out the vibrations and shorten the train of waves, in so far as it is allowed to exert any influence.

Method of Receiving from a Distant Tuned Station.—The first thing is to tune up the receiver accurately. This can be done by a Duddell radio-micrometer, which measures the received energy satisfactorily, although it is very small. Tuning is altered until the reading on this micrometer rises to a high value; then the receiving apparatus is purposely made insensitive, so that the coherer will only respond to this high value: in other words, to the top of the curve. The message can then be received from the desired station. If the receiving apparatus were left sensitive it would be affected violently by the desired station, but it would pick up a number of disturbances from other stations. By working at the top of the curve it feels the desired station alone.

Perfection of Tuning.—In this way it was possible to receive at Hythe from Elmer's End, while a much more powerful and nearer station at Dover was making a disturbance which was entirely eliminated. It is easy to hear the ships in the Channel, but it was also easy to tune everything out and listen to the desired station alone. A 5 per cent. change could be made to throw this out and throw a neighbouring one in; but in practice it would be undesirable to try to work quite so close as that. With changes of that order of magnitude, however, several neighbouring sending stations can be made to send to several neighbouring receiving stations without interference. That is to say, diplex telegraphy is possible, though not duplex.

Tuning at the Sending End.—In order to economise power, it is desirable to have every part tuned. The aerials connected through the secondary of a peculiarly-made Ruhmkorff coil constitute one oscillating system of a low frequency, to correspond with an ordinary commercial alternator which excites them. When the swing is worked up they burst through the spark gap, short-circuiting out the Ruhmkorff and giving excessively rapid oscillations, which are the ones transmitted. These are picked up by the receiving station and transferred at constant frequency into a closed air-condenser circuit, which, when its swings reach a maximum, overflows into the coherer. This is called the "overflow method," and was described by me in 1889 and 1891.

Ratio of Received to Emitted Energy.—Theoretical calculation shows that the energy received, compared with energy radiated, depends on the cube of the linear dimensions of emitter and receiver, if they are alike, and likewise on the cube of the distance between them. Measurements made with the radio-micrometer confirm this estimate approximately, the value in one series of experiments being 10^{-9}. Although this is a small fraction, the accuracy of tuning is such that messages are sent between Burma and the Andaman Islands—a distance of about 800 miles—with less than a horse-power.

Other Precautions.—To get such a result, precautions must be taken to avoid damping out the oscillations, not only by elevation even of the lower aerial above the earth, but by using appropriate conductors for these excessively high frequencies. To this end the wires are finely subdivided into insulated strands and consist of a great cable or bundle of thinly-insulated No. 40 wires, and the various self-inductions and other arrangements for effecting tuning are similarly wound. The tuning capacities are also arranged so as to be continuously adjustable, without pegs or discontinuities; and every kind of broken or uncertain contact is scrupulously avoided.

EXPERIMENTAL DETERMINATION OF RESISTANCE TO ALTERNATING-CURRENTS AND OF EQUIVALENT PERMEABILITY OF RAILS.*

BY L. LICHTENSTEIN.

In the spring of 1905 the author was commissioned by the Siemens-Schuckert Works to carry out on the Marienfelde-Zossen military line a number of measurements, having for their primary object the determination of the resistance of the rails to alternating currents of various strengths and frequencies. The continuous-current resistance of the rails was also measured for the sake of comparison. The importance of being able to predetermine the drop along the overhead line and rails need hardly be pointed out, and the experiments in question were undertaken with the desire to obtain sufficient experimental data to render an approximate calculation of this kind possible.

Maxwell has given the following formula for the self-inductance L, in absolute electromagnetic units, per unit length of a circuit, consisting of two straight parallel cylindrical conductors, having permeabilities μ_1 and μ_2, radii R and r, and placed a distance ρ apart in a medium of permeability μ_0:—

$$L=\frac{1}{2}\left(\mu_1+\mu_2+4\mu_0 \log_e\frac{(\rho-R)(\rho-r)}{Rr}\right). \quad . \quad . \quad . \quad (1)$$

If the conductor of radius r be of copper, that of radius R of iron, and if the medium surrounding the conductors be air, the above formula becomes

$$L=\frac{1}{2}\left(1+\mu+4\log_e\frac{(\rho-R)(\rho-r)}{Rr}\right). \quad . \quad . \quad . \quad . \quad (2)$$

This formula is based on the assumptions that both conductors are cylindrical, that the current is uniformly distributed over their cross-sections, and that the permeability μ of the iron conductor is constant. These assumptions do not hold good in the case of a circuit consisting of an overhead copper wire and rails used as return conductors. Hence if (2) is to be used for the purpose of calculating the inductive drop, μ must be given a value which is conveniently termed the *equivalent permeability* of the rails, and which it was one of the objects of the present investigation to determine. In using formula (2), R and r would be taken to denote the radii of circles whose areas are equal to the areas of the conductors.

Some preliminary experiments, in which a cylindrical copper rod was used as one conductor and a cylindrical rod of steel as the other, yielded values of the equivalent permeability ranging from about 30 to about 70, the value decreasing with increase of frequency or current. The frequencies employed were 25 and 50. The ratio of the alternating current resistance r_a of the steel conductor to its continuous current resistance r_c varied from about 7 to about 25, increasing with increase of frequency and decreasing with increase of current.

The following table contains a brief summary of the results obtained on the Marienfelde-Zossen line under various conditions:—

Frequency.	Current, amps.	r_a/r_c	Equivalent permeability μ.	
58·5	49	4·34	8·0	Rails bonded with copper bonds.
48·7	153·8	5·55	7·2	
28·2	62·5	2·85	14·8	
25·4	108·4	3·76	15·0	
19·4	36·4	2·5	16·0	
17·3	123·2	2·93	19·3	
58·6	35	2·68	9·6	Rails not bonded.
48·6	152	3·42	8·6	
28·4	46.2	1·94	11·0	
25·7	169	2·2	14·4	

The rails on the Marienfelde-Zossen line have a cross-section of about 5,160 sq. m.m.

* Abstracted from the *Elektrotechnische Zeitschrift.*

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JOINT ELECTRICITY AND TRAMWAY COMMITTEES.

Probably one of the weakest points in municipal undertakings is the fact that a municipality so often deals in paper figures. A municipality, in fact, is apt to be one of its own largest consumers, and for that reason it is often difficult to determine whether the financial results are satisfactory or not. The problem which is most generally under consideration is: What is the cost per unit under certain given conditions? And closely connected with this is the further question: What should be the profit to the municipality? and, possibly, Should there be any profit at all?

The consumers of a municipal electricity works may generally be divided into three classes—the general public, municipal tramways, and public lighting departments. The first class causes no difficulty, since it is composed of consumers who are handled in the same way as they would be by any trading concern. When, however, we consider municipal tramways and public lighting the case is different. The undertaking may be regarded as a whole (and, in fact, it must necessarily be regarded from this point of view eventually), or it may be regarded as split up into sections, each of which should work on a paying basis apart from the others. Thus the revenue obtained from municipal tramways should more than defray all costs incurred by giving

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a supply to the tramways alone, after taking account of any benefits resulting from combined working with other departments. In taking such a view of a municipal undertaking it is, of course, necessary to allocate various capital costs and running charges before it is possible to arrive at a true result.

Although specialisation in departments may be desirable to some extent, it is undoubtedly a mistake to carry such specialisation too far. The effect of doing so has recently become evident in rather an unfortunate way at Leeds, where specialisation is carried so far that the Council have one electricity works for supplying light and another electricity works for supplying municipal tramways, and there appears to be very little harmonious working between the Electricity department and the Tramways department. So much is this the case that when the Electricity committee desired to extend the mains to an outlying district at a cost of about £15,000, the Tramways committee contended that the supply to this district could very well be given by a tramway feeder already in existence; that any possible variation in pressure could be overcome; and that a supply could, therefore, be given very much more cheaply by the Tramways department than it was possible for the Electricity department to give it. The Electricity committee were, however, unwilling to accept the offer.

That it should be possible for a situation of this kind to arise shows how absurd the duplication of municipal trading departments can become. The fact that one committee gets very good or very bad terms out of another does not in any sense make a municipal undertaking a financial success or otherwise. If prices are too high, a certain section of the ratepayers may suffer; if, on the other hand, prices are too low, there may be an absolute loss which must be met out of the rates. It is, therefore, better that competition of this kind should be avoided altogether, and that the whole question of electrical generation, at least, should be in the hands of a single committee. Whether there should be a Public Lighting committee and a Tramways committee in addition to look after points which are essentially concerned with public lighting and with tramways respectively is a subsidiary question; but, in any case, the Electricity department should be managed by a committee capable of taking a broad view of all the circumstances upon which the success of electricity supply for all purposes depends.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Wireless Telegraphy for Amateurs. By R. P. Howgrave-Graham. (London: Percival Marshall.) 160 pp. Price 2s. nett.

To the amateur who has had some experience in the construction of electrical apparatus Mr. Howgrave-Graham's book opens up a field of great possibilities, for it gives directions which should enable him to erect a complete wireless telegraph installation which will maintain communications over a distance of several miles. The only instruments described in a practical manner are modified forms of the Lodge-Muirhead and of the Marconi apparatus. In adhering to two simple types the author shows his wisdom, as an attempt to go into the constructional details of a greater number would have resulted either in too much condensation or in a book of far larger dimensions. Even as it is the amateur who works conscientiously through chapters III. and IV. will find that he has undertaken a considerable task, though it is one which will amply repay him both by its great intrinsic interest and from the excellent training it will give him in accurate workmanship and patient experiment. The book is well written, giving, as it does, clear and concise remarks on theories coupled with thorough and extended descriptions of practical details; the scale drawings and photographic reproduction of the actual apparatus used by the author are also good.

Drahtlose Telephonie. By Ernst Ruhmer. (Berlin: Ernst Ruhmer.) Pp. 144.

Mr. Ruhmer's most interesting book is divided into two sections, the first dealing with methods of wireless telephony based on Graham Bell's photophone, in which the transmission is by means of light or heat energy, and the second describing more recent systems in which electrical waves of greater length are used.

The construction of the photophonic apparatus and the results obtained with it are carefully gone into, and descriptions of many experiments are given, in the more recent of which the range was greatly increased by the use of a sensitive arc as transmitter. In fine weather speech was audible at a distance of from 15 to 20 km. These systems suffer, however, from their inability to communicate round corners, which limits their application to so small a field that they can hardly be looked upon as practical means of communication unless in very exceptional cases.

The modern electrical methods, which are described in the second part of the book, stand on quite a different plane. They are as powerful as wireless telegraphy, and it would be rash to suggest a limit beyond which wireless telephony will not be possible, even in the next few years, by their means.

The author's treatment is at once scientific and popular. Very little mathematical work is included, and, though the theory of the sensitive arc is carefully explained, it is by graphical rather than algebraical methods that the relations of the various factors concerned are obtained. Commencing with the closed-circuit systems used by Gavey and others, the author passes to the open-circuit arrangement described by Dolbear, and then through the various modifications of the spark method to the utilisation of the unstable arc as transmitter. It is obvious that, as the frequencies of the sound vibrations which constitute the upper harmonics of ordinary speech and give their special characters to the various vowel and consonant sounds range as high as ten or twenty thousand per second, it is quite useless to attempt telephony with a coil which gives only a few hundred sparks in that time. The methods by which this difficulty have been overcome are described in detail. The first is that of increasing the rate of sparking by the use of an alternator and large inductances. By this means as many as 20,000 sparks per second have been obtained. This stream of sparks is then broken up into groups, through the action of a telephonic transmitter. In the receiver any type of self-acting detector may be used. Many photographic records, taken with a revolving mirror, are given, which show the groups of sparks corresponding to various tones. Next come the methods in which the interrupter is an arc rendered unstable by proper adjustment of the voltage and series resistance, and by the employment of a magnetic "blow-out." Finally, the most modern and most promising system, in which the arc itself is employed, without a secondary spark, is treated in a thorough and workmanlike manner. All the known methods are discussed, and the theory of the unstable arc is explained and illustrated in a simple but satisfactory manner. The line diagrams and photographic reproductions, with which the book is lavishly illustrated, are on the whole very good, though some of the latter are rather worn, or badly printed, while some of the cuts in the earlier part of the book are obviously contemporaneous with the subjects which they illustrate.

Mr. Ruhmer must be congratulated on being the first to produce a connected and systematic work on this latest electrical advance, of which he is himself one of the pioneers, and for the care which he has taken in giving references to some hundreds of original Papers and patent specifications dealing with the subject.

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INSURANCE AND INSPECTION OF ELECTRICAL MACHINERY.

We have received a copy of the report for the year 1906 of Mr. M. Longridge, chief engineer to the British Engine, Boiler & Electrical Insurance Co. The report is divided into the usual sections: (1) Insurance and inspection of steam, gas and oil engines. (2) Insurance and inspection of electrical machinery. (3) Insurance and inspection of boilers. (4) Boiler explosions, collapses and mishaps, and abstracts of Board of Trade reports. It concludes with an account of the trial of a 500 B.H.P. Diesel oil engine at the works of the makers. It is noteworthy that in section (1) the rate of breakdown among steam engines is as high as 1 in 8·1 of the engines insured, whilst among gas and oil engines it is only 1 in 12·4. Mr. Longridge's explanations of this are as follows: (1) Gas engines have fewer parts than steam engines; (2) these parts are, on the average, much smaller than the parts of steam engines of the class which are insured; and (3) gas engines cannot be habitually subjected to stresses much heavier than the parts are designed to bear. A considerable increase is recorded in the electrical branch of the business, the number of dynamos and motors insured having increased by 15 per cent. It is pleasing to note that the percentage of breakdowns has decreased, and the average cost of same is also lower. A large number of motor-starting switches are being insured, and it is only recently that the advantages of doing so have been realised by the owners. The breakdowns of these switches have increased quite out of proportion to the number of insurances, but it is hoped that a more satisfactory result will be obtained after a year or two of regular inspection.

The rate of breakdowns during 1906 was for dynamos 1 in 16 and for motors 1 in 8·2. The rate of breakdowns was twice as high for continuous-current machines as for alternating-current machines, but the cost of repair per breakdown was only about one-half in the former case. This is considered to be due to the relatively large sizes of the alternators. The company's experience leads to the belief that a considerable number of commutators not of British manufacture are sold in the British Isles, and that a number of them are of very stinted dimensions, so that there is little margin for wear. The proportions in which the various parts of the machines are thought to have given way are set out in the following tables:—

Part which is believed to have failed first.	Dynamos. 1905.	Dynamos. 1906.	Motors. 1905.	Motors. 1906.
Armatures and rotors .....per cent.	53	50	48	44
Magnet coils and stators.... ,,	6	11	13	14
Commutators and brush gear ,,	25	20	28	28
Miscellaneous ..... ,,	16	19	11	14
	100	100	100	100

Starting switches and controllers.	1905.	1906.
Resistance coils .....per cent.	48	48
Contacts and switch arms..... ,,	15	10
Automatic apparatus ..... ,,	13	17
Miscellaneous ..... ,,	24	25
	100	100

The causes of these breakdowns were probably as follows:—

	Dynamos.	Motors.	Starters.
Accidental .....per cent.	15	9	22
Dirt and neglect ..... ,,	14	19	11
Age and deterioration .... ,,	21	25	23
Bad workmanship and design ,,	23	18	9
Overloading ..... ,,	0	2	7
Unascertained ..... ,,	27	27	28
	100	100	100

The following typical examples have been selected by way of illustration from among the breakdowns of the year:—

1. Two-pole compound-wound dynamo, giving 55 amperes at 230 volts when running at 1,070 revs. per min. The dynamo was driven by countershafting and belting from a steam engine. While cleaning the engine the attendant disturbed the governor and pulled it to its lowest position, where it stuck. The engine began to race, and before it could be stopped the dynamo attained sufficient speed to cause sparking severe enough to fuse the copper gauze brushes and the surface of the commutator. Many of the lamps in connection with the dynamo were destroyed by the high voltage resulting from the increased speed, but the armature was not damaged.

2. Four-pole shunt-wound open-type dynamo, five years old, giving 65 amperes at 275 volts when running at 700 revs. per min. The magnets were placed, as it were, at the ends of the arms of a St. Andrew's cross. The ends of consecutive coils were permanently soldered together, forming loops from coil to coil.

While the dynamo was running in parallel with a battery the connection between the two lower magnet coils was broken, probably by a blow from a broken armature binder (for one of the binders was afterwards found broken). The magnetic field thus being destroyed, the dynamo ceased to generate, and short-circuited the battery. Fortunately, the attendant switched off the dynamo before the armature was burnt out, and the only damage done was to some of the connections between the battery cells. There was a reverse-current cut-out switch in connection with the dynamo, but for some reason or other it failed to act before the attendant pulled out the dynamo switch.

The case is described not because it is at all unusual, but to draw attention to the necessity of carefully protecting the connections between the magnet coils of shunt-wound machines. The wires in the coils are necessarily fine and easily broken, therefore the loops linking coil to coil should be formed of substantial strips of copper, or should be carried in or attached to some substantial structure which cannot be broken by a light blow or dragged down by a duster.

3. Four-pole enclosed compound-wound motor-generator, forming what is known in the printing trade as the "teaser" of the Bullock equipment of a printing machine.

The machine is driven by a 30 H.P. motor, which, under the ordinary working conditions, receives current direct from a 400 volt supply. When threading the paper through the rolls, or "inching in," as it is called, a dead-slow speed is required. The motor then gets its current from the "teaser," which generates at 100 volts only. Supplied at this voltage, the main motor can, by means of a controller, start the printing machine quite slowly, and gradually increase its speed as required. When sufficient speed is attained, the "teaser" is thrown out, and the motor switched direct on to the 400 volt supply, after which the full speed is got up by varying resistance in the armature and shunt circuits.

One day the "teaser" suddenly gained sufficient speed to burst the binding wires and throw off the conductors.

The cause could not be ascertained. When the inspector arrived he found the shunt was connected and in order, and a spare armature put in as soon as the damaged one was taken out, ran satisfactorily.

4. Semi-enclosed 3 B.H.P. shunt-wound motor, taking current at 400 volts. A coating of oil and fluff inside the motor caught fire, and burnt the insulation of one of the magnet coils. The girls who were working in the room extinguished the fire by pouring a bucket of water into the motor casing. The cause of the fire was accumulation of inflammable dirt, owing to neglect of cleaning.

5. Three-phase protected motor of 20 B.H.P., taking current at 440 volts. Periodicity, 40 per second; speed, 770 revs. per min.

Owing to neglect of lubrication, the bearing at the pulley end of the rotor shaft got hot, and the white-metal lining was melted, and ran out. The end of the shaft dropped sufficiently to bring the rotor into contact with the core of the stator, and both rotor and stator windings were damaged, and had to be re-wound. There was no oil gauge upon the bearing.

6. Four-pole semi-enclosed shunt-wound 5 H.P. continuous-current motor, one year old, receiving current at 230 volts, and running at 1,300 revs. per min.

Owing to wear of the shaft bearings, the armature came into contact with the pole faces, rubbing the insulation off the conductors and short-circuiting them. The wear was very rapid, for one of the company's inspectors examined the machine a fortnight before the breakdown, and found the armature central, with $\frac{1}{32}$ in. clearance all round. The bearings were of gunmetal without white-metal linings and must have been full of grit or left without oil to wear so rapidly.

7. Semi-enclosed continuous-current shunt-wound motor, 2·5 H.P., connected across the outer and middle wires of a three-wire system having a difference of potential of 460 volts between the outer wires. The middle wire and the frame of the motor were earthed. Owing to a deposit of oil, carbon dust and soot upon the insulating washer separating the commutator segments from the clamping ring, a path for the current was established between the armature and the earthed frame, thus short-circuiting the armature and the supply. Before the fuse melted, three of the commutator segments were burnt beyond repair, and several of the armature conductors separated from the commutator spokes by the melting of the solder.

These insulating washers quickly become greasy, and gather dust from the brushes or surrounding atmosphere. They are also so narrow that they are very easily bridged, and therefore must be kept scrupulously clean if they are to fulfil their function as insulators. This is specially important when, as in the present case, the frame of the machine and one pole of the supply are earthed, as there is then the full difference of potential of the supply between the copper and the iron tending to break down the insulation.

8. Enclosed shunt-wound motor, six years old, 15 H.P., taking current at 400 volts; speed, 640 revs. per min.

The mica-insulating ring between the commutator segments and the clamping ring was burnt. Three of the segments were short-circuited, and one of the armature coils burnt. The replacement of this coil necessitated the entire re-winding of the armature, for the insulation of the conductors was so deteriorated by overheating and frequent repair that it was impossible to lift the burnt coil without damaging the rest. The cause of the short-circuit was probably accumulation of carbon dust upon the insulating washer. The motor was usually found in a dirty and oily state when inspected. Also there was nearly always an "earth" on some part or other of the system.

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9. Four-pole compound-wound protected motor, made in 1903, running at 945 revs. per min., and taking 15 amperes at 250 volts.

The four magnets, which were placed at the ends of the vertical and horizontal diameters of the casing, were held by set-screws—one to each magnet, with heads outside the casing. The head on the top of the casing carried a ring, which was used for lifting the machine. The screw in connection with it was lossened either by vibration caused by the running of the motor or by having been twisted by the hook of the crane, and had slackened back until the shoe of the magnet came into contact with the armature, and cut up the insulation of the conductors.

The armature of a six-pole machine was damaged in the same way by the dropping of a magnet core held by a set-screw carrying a lifting ring.

In last year's report attention was drawn to the frequent short-circuiting of commutator bars insulated from each other and from the binding washers or nuts by "made-up" mica—*i.e.*, small flakes of mica bound together by shellac, fish glue, or other cementing materials, and compressed into sheets by hydraulic pressure. Breakdowns of this class have again been numerous, particularly among machines of certain makers.

The following is a typical case:—

10. A six-pole shunt-wound 15 B.H.P. motor, taking current at 200 volts, broke down by fusion of several of the armature coils. The armature had to be entirely re-wound.

The inspector who examined it came to the conclusion that the damage was caused by short-circuits in the commutator, for the bars, especially those connected to the damaged coils, were burnt, and the insulating material between them carbonised. This material was found to be "made-up" mica. The carbonisation had probably been caused by ignition of the binding material used for cementing the flakes of mica, or of carbon or copper dust collected in the interstice between the flakes. As far as the writer knows, much of the "made-up" mica used is made by girls, who work rapidly and without much care. Under such circumstances it seems probably that the flakes of mica are not always of equal thickness or laid close together, and that interstices are left from which the cement is not entirely expressed by the hydraulic pressure. If this cement be combustible, it is easy to understand how it becomes carbonised by sparking, and how the material becomes perforated like the leaves of a worm-eaten book.

For insulating the segments of large commutators "made-up" mica must be used, and is used successfully, but the company's experience leads them to think that for small motors soft green mica is a better material than some of the "made-up" stuff sent out.

11. Four-pole semi-enclosed shunt-wound 10 H.P. motor, taking current at 460 volts.

The brushes, eight in number, were of carbon, ⅜ in. wide by ½ in. broad, fixed in brass holders, which were connected by hinged levers to the spindles and constrained by springs.

Three of the brush-holders were burnt by coming in contact with the commutator through the carbon block having worn away. It may be asked why, in such cases, does the inspector not see that the brushes are getting worn, and advise the owner of the motor to replace the carbons? The answer is that in many cases the motors visited are running and cannot conveniently be stopped when the inspector calls, and in others the wear of the carbons is very rapid, and a brush which is nearly new at one visit may be worn out at the next. It is curious how differently carbon brushes behave on different commutators; a brush which will run perfectly on one will wear rapidly on another. The moral of this story is that hinged brush-holders should be fitted with stops of some kind, to prevent contact with the commutator if the carbon wear or drop out.

Another type of holder, which is held at a fixed distance from the commutator and carries a movable carbon pressed radially inwards by a spring, also causes frequent stoppages when neglected owing to the carbon sticking and ceasing to follow up the wear. This type of holder should be frequently examined and cleaned to keep the carbon free to move forward under the action of the spring.

PROF. SMITHELLS' ADDRESS TO SECTION B OF THE BRITISH ASSOCIATION.*

After referring to the great loss suffered by chemistry through the death of Mendeléef, Menschutkin, Beilstein, Berthelot, Moissan and Bakhuis-Roozeboom on the Continent, and Sir W. H. Perkin in this country, the author passes to the consideration of flame, the ideas on which have been modified largely during recent years. The old idea that there existed a fixed temperature at which inflammation suddenly took place cannot now be maintained, and the term "ignition temperature" has acquired a different meaning. It is now known that in a very great number of cases a mixture of two flame-forming gases, when gradually raised in temperature, will develop luminosity quite gradually, *pari passu*, with the chemical combination that is being induced. Phosphorus is not a unique example; in fact, phosphorescent combustion is the normal phenomenon antecedent to what we ordinarily call flame.

This is, after all, only in harmony with the general truth that chemical combination between two gases does not set in suddenly, but comes into evidence quite gradually as the temperature is raised from a point at which the action, if it occurs at all, is so slow as to be negligible. The increase in the rate of combination is, of course, very rapid as compared with the increase of temperature, a difference of about 10°C. serving to double it. The interval between the beginning of phosphorescence and the production of vigorous flames may, therefore, be very short. In the case of phosphorus this interval, being from 7°C. to 60°C., includes ordinary atmospheric temperatures; hence the phosphorescence of phosphorus is a phenomenon that could not well be overlooked. To make phosphorescence apparent in other cases it is necessary to take special care to heat up a mixture of the combustible gas and air gently, and to maintain it at a temperature approaching, but not quite reaching, that of ignition.

The change from phosphorescence to ordinary flame is not sudden, but the appearance of ordinary flame is the end point of a continuous, though rapid, development. This end point is the temperature of ignition. What, then, determines the temperature of ignition? The answer to this question has been given with characteristic conciseness by Van't Hoff as "the temperature at which the initial loss of heat due to conduction, &c., is equal to the heat evolved in the same time by the chemical reaction."

We may obtain a clear idea of the meaning of temperature of ignition by supposing a combustible mixture of gases such as that of air and the vapour of carbon disulphide to issue through an orifice into an indifferent atmosphere. If we surround the orifice by a ring of platinum wire, which is gradually heated up by a current of electricity, a flame will gradually make its appearance. If, as soon as this is observed, the heating of the wire by the current be discontinued, the flame will disappear; it is, in fact, not self-supporting, but depends on the accessory supply of heat through the electrically-heated wire. If now we raise the ring to a higher temperature we shall get a brighter flame, owing to an increased rate of chemical action, and at last we shall reach a point where it is possible to cut off the electric current without causing at the same time the extinction of the flame. This is the true temperature of ignition, the temperature at which the reaction proceeds at a rate just sufficient to overbalance the loss of heat by radiation, conduction and convection from the burning layer of gases, so that the next layer is put in the same state, and steady combustion proceeds.

Phosphorescence has been spoken of as degraded combustion, and, though literally the appellation is correct, I think it is liable to be misunderstood. Again, it is often supposed that phosphorescence is necessarily associated with the formation of incompletely oxidised products. This may be the case in a chemical system which is capable of affording different products at different temperatures, but it is not an essential feature; the phosphorescent combustion of sulphur, for example, affords nothing but sulphur dioxide.

Temperature of ignition is, then, neither a temperature at which combination suddenly begins nor one dependent solely on the nature of the combining gases. It will vary with the proportion in which the gases are mixed and with their pressure and other circumstances. Notwithstanding the simplicity of this conception, it must be admitted that there are many obscure facts connected with the ignition of gases. The inflammability of gaseous mixtures is not necessarily greatest when they are mixed in the proportions theoretically required for complete combination; the influence of foreign gases does not appear to follow any simple law; the presence of a very small quantity of a foreign gas may exercise a profound influence on the ignition temperature, as in the case of the addition of ethylene to hydrogen.

The structure of flames has always been regarded as dependent upon the chemical changes taking place in the differentiated regions, but until recent times little attention has been given to any question beyond the cause of the bright luminosity of hydrocarbon flames. Erroneous ideas have gained currency from the use of impure gases, and hydrogen is still described as burning with a pale blue flame. The fringe of a flame in air may be often tinged by the presence of oxides of nitrogen.

The flames of hydrocarbons have naturally been the subject of most frequent investigation. The use of single hydrocarbons instead of the mixtures present in coal gas and other common combustibles has simplified the study considerably. Two problems stand out prominently: one is to trace the steps in the oxidation of the hydrocarbon, the other to account for the bright patch of yellow luminosity. With regard to the question of the luminosity, I do not think there is any longer doubt about its being due essentially to the separation within the flame of minute solid particles of what is practically carbon.

The mode in which a hydrocarbon yields carbon by the application of a high temperature has been the subject of experiment and of hypothesis; but neither the view of Berthelot, that the carbon results from a continuous coalescence of hydrocarbon molecules with elimination of hydrogen, nor that of Lewes, according to which the formation and sudden decomposition of acetylene is the essence of the phenomenon, appears to me to be in harmony with the experimental facts; and I am not aware that either view has secured any support from other workers in this field.

* Abstract of the presidential address delivered at Leicester on August 1st by Prof. A. Smithells, B.Sc., F.R.S.

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The course of oxidation of hydrocarbons has been the subject of very careful and fruitful study. The old view that a selective or preferential oxidation of the hydrogen always took place, that with a restricted supply of oxygen the hydrogen was oxidised and the carbon set free, is, I think, no longer maintained by anyone who has studied the question. The explosion of ethylene with its own volume of oxygen, which leaves us with practically all the carbon oxidised and all the hydrogen free, is fatal to this view.

According to Prof. Bone, the oxidation of a hydrocarbon involves nothing in the nature of a selective or preferential oxidation of the carbon or the hydrogen; but it occurs in several well-defined stages, during which oxygen enters into and is incorporated with the hydrocarbon molecule, forming oxygenated intermediate products, among which are alcohols and aldehydes.

It is a great aid to the study of chemical changes, when we can resolve them into stages, whether or not these stages be realisable under certain experimental conditions. In this way we can get a clear view of the relationship between the action under one set of circumstances to the action under another set.

I am far from wishing to disparage these practices, but I think it important that we should realise how far we are dealing with convenient devices and how far with ascertained facts. The isolation of an intermediate product under one set of circumstances is in itself no proof that this product is transitorily formed when the reaction is proceeding under another set of circumstances.

The mode of burning of carbon, whether in the free state or as a constituent of a compound, is not at all easy to determine; and notwithstanding many investigations, among which must be specially mentioned those of Prof. H. B. Dixon and his collaborators, so simple-looking a question as whether carbon forms carbon monoxide by directly uniting with oxygen, or only by reducing carbon dioxide, is still a matter of uncertainty.

The question of calculating the temperature attained during combustion by reference to calorimetric values, specific heat dissociation, and other considerations is to form the subject of a joint discussion with section G during the present meeting, so that I shall not here enlarge upon it.

With regard to the use of thermo-couples, I may remark that the practical difficulties have been successfully met. The chief difficulty is, of course, to secure that the thermo-junction attains as nearly as possible the temperature of the region in which it is immersed. As ordinary flames consist of thin shells of burning gases, on either side of which there is a very rapid fall of temperature, it is necessary to use thin wires, and to dispose them so that there is no appreciable drain of heat from the junction. By using wires of different gauge for the couples it is possible by extrapolation to arrive at a temperature for a couple of infinitely small cross-section, and it is also possible to make a correction for the superior radiating power of the couple as compared with the flame gases. Without this last correction a maximum temperature of 1,770 deg. was obtained for the Bunsen flame by Waggener in Germany, and 1,780 deg. by White and Traver in America. Correcting for radiation, Berkenbusch found 1,830 deg. as the maximum temperature.

M. Féry, by an ingenious application of his beautiful optical pyrometer to a flame containing sodium, gives 1,871 deg. as the highest temperature of the flame of a Bunsen burner burning coal-gas.

The acetylene-oxygen flame in which a temperature of about 3,500 deg. prevails, not very different from that of the electric arc, is the hottest of the hydrocarbon flames, and finds some important practical uses.

I have already said something about the luminosity of flames so far as relates to the separation and glow of solid carbon. But there remains the more general question of the luminosity of flames containing nothing but gases. The older explanation of the emission of light from combining gases said no more than that the energy liberated during the reaction and appearing as heat raised the product to incandescence—that is to say, so increased the velocity of its molecules and the violence of their collisions that vibrations were set up whose wave-lengths lay within the limits of visible radiation. This explanation has long been questioned, and there is now, I think, a very general agreement that it will not suffice. Certain considerations point to the high temperature of a flame being a consequence rather than a cause of its light.

This subject of the mechanism of luminosity, however, like so many others, has now become involved with the theory of electrons, and a chemist may be excused if he hesitates to pursue the subject further. Some years ago I called attention to the scantiness of our knowledge of the chemical changes that take place when metallic salts are used in flames for the production of spectra. Though there was general agreement that, for example, the yellow flame produced by common salt was due to the liberation and glow of metallic sodium, there was no agreement as to how the sodium was set free.

Arrhenius, pursuing the analogy which exists between the laws governing matter in the gaseous state and in the state of dilute solution, had previously been led to the view that the electrical conductivity of flames containing salt-vapours was due to ionisation of the salt throughout the volume of the flame. It appeared possible therefore that the luminosity might be ascribed likewise to the metal separated in the ionic state. Experimental investigation undertaken with a view to elicit information on this subject seemed to favour the view that the metal was reduced by chemical processes and that it glowed in the un-ionised condition. Evidence seemed to point to the conclusion that, for example, when common salt is introduced into the flame of coal-gas the sodium chloride yields sodium by the conjoint action of steam and reducing gases; when liberation of the metal was prevented by adding a large quantity of hydrochloric acid to the flame the glow disappeared, but the conductivity was not always diminished. The fact that sodium salts, including the chloride, impart their characteristic glow to the flame of cyanogen and to other flames in which water is absent leads to some difficulty in finding a chemical explanation, and it must be admitted that a direct thermal dissociation of an alkaline haloid or oxide is not out of the question. The interval of detachment of the metallic atom may be exceedingly brief, but it must be remembered that even so short a time as the interval between the molecular encounters in a gas at a high temperature is still sufficient for the emission of thousands of undisturbed characteristic vibrations. The experiments to which I have alluded have been followed up with great industry and success by Prof. H. A. Wilson, who has added much to our knowledge of the electrical condition of the flames containing vaporised salts; but the question of the condition of the luminous gas is still far from being settled. Very interesting and important investigations have been carried out by Lenard, who has shown that the stream of luminous vapour produced from a sodium salt in a Bunsen flame is deflected in an electric field in such a way as to indicate that the vapour is positively charged; but he gives reason for believing that the charged condition is intermittent with the neutral condition. The lines in the spectrum of an alkali metal are divisible, as is well known, into distinct groups or series, in each of which the oscillation frequencies corresponding with the lines are in a definite mathematical relationship. The principal series, which include the lines seen individually as such in ordinary flame spectra, are, according to Lenard, due to the electrically neutral atoms. In a salted spirit flame, and in other flames of low temperature where only lines of the principal series are represented, the stream of luminous gas does not behave in an electric field as if it were charged. In the flame of coal-gas burnt in a Bunsen burner the salt vapour gives in addition to the distinct lines of the principal series, diffuse bands of luminosity on the dark background, which, according to Lenard, represent the undeveloped subordinate series; and it is the atoms emitting these series that are deflected in the electric field. It is inferred, therefore, that the light in a salted Bunsen flame comes from different groups of centres of emission—the principal series from the neutral atom, and the lines of the first, second and third subordinate series from atoms which have lost respectively one, two and three electrons. Lenard goes further, and shows that the salt vapour in a Bunsen flame, as in the flame of the electric arc, emits these different kinds of radiation from different structural regions; thus the vapour at the edge of the flame is electrically neutral and gives only the lines of a principal series.

The negative electricity in a salted flame would, according to Lenard, be disembodied, and recent experiments by Gold confirm the view that the negative carrier in flames is a free electron. In connection with this subject I ought to allude to an investigation by Tufts, which seems to throw some doubt on the conclusions which were drawn from the experiments made by Prof. Wilson, Dr. Dawson, and myself; and I must also mention an important contribution to the subject recently made by Prof. Hartley, in which considerable light is thrown upon the chemical changes undergone by compounds of the alkaline earth metals when they are introduced into flames, and upon the relation of these changes to the various special features. I am afraid, however, that it would be wearisome if I were to prolong this summary, and I must be content to leave it without doing justice to those who are engaged upon the work. The subject is obviously one of fundamental importance in relation to spectrum analysis, and my own slight connection with it has only strengthened my opinion that there is still a great deal connected with the genesis of spectra that requires the attention of the chemist even more than that of the physicist. Spectrum analysis arose under the joint influence of Bunsen and Kirchhoff, and I think its problems still call for more combined work on the part of chemist and physicist than has latterly been the custom.

In passing to a general review of chemical science, it must be felt that we live in a time of rapid development and of some embarrassment. The perplexities of chemists at the present day do not come, I think, from the novelty of the ideas that are being presented to them, but from the great rapidity with which the whole science is growing, from the invasion of chemistry by mathematics, and, in particular, from the sudden appearance of the subject of radio-activity with its new methods, new instruments, and especially with its accompaniment of speculative philosophy. There is an

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uneasy feeling that developments of great importance to the chemist are being made by experiments on quantities of matter of almost inconceivable minuteness. Spectrum analysis, of course, took chemistry beyond the limits of the balance, but the new materials which it disclosed could at least be accumulated in palpable quantity. With radio-activity we seem, in relation to the ponderable, almost to be creating a chemistry of phantoms.

I should, however, gravely abuse the position in which I am allowed to speak for the moment as a representative of chemists if I failed to express profound admiration for the masterly work which has been accomplished by the pioneers of the science of radio-activity.

The most conspicuous development of the science during the past 20 years has been, of course, on the physical side, and abundant have been its fruits; but it has seemed to demand from chemists habits and endowments which they did not normally possess, and which they could not easily acquire. I was much struck by a remark made to me a few years ago by a distinguished chemist, who is, I think, the most perfect manipulator I have ever seen at work, to the effect that he felt himself submerged and perishing in the great tide of physical chemistry which was rolling up into our laboratories. Now, it is precisely such men that must be preserved to chemistry. Though chemistry and physics meet and blend, there is, I believe, an essential difference between the genius of the chemist and the genius of the physicist, and I venture to think that some insistence on the primary functions of a chemist is not untimely. The chemist's first qualification is that he shall be master of a peculiar craft; his greatest merit that he is a consummate workman; his distinctive power a nicety of discrimination in questions affecting the composition and quantity of materials. He is not given to elaborate theories and is usually averse to speculation; nor has he usually an aptitude for mathematics. Such the normal chemist is, or was, and such I hope he always may be—naked, perhaps, in some respects, but unashamed.

There seems to be a solicitude in some quarters to make a chemist something more than a chemist, a solicitude which, if gratified, will, I believe, make him something less than one. We are told, for example, that a chemist should be a mathematician. I do not admit it for a moment. Some mathematics he must of necessity have—that has always been admitted—but in proportion as chemistry develops on the mathematical side does it become important, not that our chemists should be trained in mathematics, but that they should be more than ever carefully trained in the art of exact experiment; that their methods of work, their powers of observation, and, if possible, their experimental conscience, if I may use the expression, should acquire a finer edge. There is never more cause for anxiety than when we see a mathematical theory awaiting the delivery of the confirmatory facts, and there is nothing more important for chemistry than the continual recruiting of that old guard which will be ever ready to stand to arms on the appearance of an eager theorist.

I do not for a moment wish to disparage the adventurous spirits within or outside our science, still less do I wish to range myself with those who meet new ideas with mere objurgation or raillery. We must be content to see new alliances and new activities on the frontiers that separate us from other sciences; content to see many new kinds of chemistry arise in which we cannot all effectually participate. Chemistry is becoming bewildering in its extent, and it would be a great misfortune if this led to the notion that every chemist must try to enlarge his ambit to its confines and fit himself for every variety of work. Those of us who have responsibilities as teachers cannot, I think, be too careful. It is not easy to meet all requirements, but I think we shall all agree that, whatever is left undone, we must make a chemist a good craftsman.

Another perturbation within the chemical camp in recent times has come from the region of philosophy. Even before the days of radium we have been accused of clinging too fondly to our atomic theory and of stating our knowledge too exclusively in terms of that theory. We are said to have drifted into a dogmatism as real as any we ourselves have had to attack, and to shut our eyes to the light which will enable us to orient ourselves truly in the wide realm of thought.

If, as I have ventured to hint, mathematics brings with it an element of danger into chemistry, I think that the intrusion of metaphysics would give far greater cause for apprehension. Philosophy always stands with open arms desiring a closer embrace of all the sciences, of which she declares herself to be the fond mother, whilst science, as we understand the term, has stood reluctant, suggesting, as someone has wittily remarked, that she regards philosophy rather as a mother-in-law. It may perhaps be desirable, especially in the present state of things, that scientific men should allow themselves to become a little more interested in deep questions affecting all knowledge, and should at least examine with some care the gifts that philosophy is so anxious to bestow upon us. I have a fear that otherwise in the elaboration of scientific theory we may find ourselves embroiled in an unequal contest with what I cannot but regard as the traditional enemy—I mean the unmitigated metaphysician—and the suggestion that I make is, to tell the truth, not so much from the hope of gain as from the desire for self-defence and the safe preservation of the methods that have served us so well in the past.

I think the accusation that we delude ourselves into the belief that our hypotheses are final truth is not true of any thoughtful chemist; the great men of science have surely possessed that quality of mind which philosophy would most approve. If, as has often been remarked, Faraday was mathematically-minded, though untrained in mathematics, it seems not less true that he stood in the same relation to philosophy.

Few, I think, will deny that the atomic theory stands to-day as an indispensable instrument for productive chemical work; it has neither had its day nor ceased to be. Physicists have never been quite satisfied with the hard, indivisible ball of specific substance and definite mass which has served chemistry so well. They have given it bells, have made a vortex ring of it, and have indeed done much that few chemists can understand to make it meet the exacting requirements of their science. But to us it has always been the same; what we have done to it has been external; we have given it, vaguely perhaps, a charge of electricity, a store of energy; we have attached the hooks or rods of valency, but we have not meddled with its interior. We are now called upon by chemical considerations of change of composition, as well as by other considerations more recondite, to subdivide our atom, to credit it with an unsuspected store of energy, to consider it a congeries of unsubstantial electrons. We should wish, of course, to know that the evidence is good enough, but otherwise there can be no possible objection from our side; it will undo nothing that has been done, and we may have good hopes that it will lead to the doing of many new things in chemistry. The newer theories are in consonance with the old in one most vital point: they afford those mental pictures of phenomena which most of us find indispensable for fruitful work. They do not belong to what Prof. Schuster has characterised as "the evasive school of philosophy." "Those," he says, "who believe in the possibility of a mechanical conception of the universe, and are not willing to abandon the methods which from the time of Galileo and Newton have uniformly and exclusively led to success, must look with the gravest concern on a growing school of scientific thought which rests content with equations correctly representing numerical relationships between different phenomena, even though no precise meaning can be attached to the symbols used." Most of us, I think, will take comfort in this pronouncement and rejoice that if our conception of the atom is to be transformed, it may still be represented as having some kinship with what Sir Henry Roscoe's famous examinee described as the "square blocks of wood invented by Dr. Dalton."

TRAIN LIGHTING.*

BY H. HENDERSON.

(*Concluded from page 727.*)

Summary.—In this Paper the author deals with the important question of the lighting of railway carriages by electricity. After giving particulars as to the cost of equipment and maintenance he proceeds to describe the various systems which have been proposed and, in a few cases, adopted.

VICKERS-HALL SYSTEM. (*Continued.*)

Double Battery System.—The connections for the double-battery system are shown in Fig. 5. The principal difference lies in the automatic cut-out, which in this system consists of two electromagnetic switches, and each switch has four contacts, contacts being also made when the switches are down. It will be seen by following the connections that each cut-out connects its own battery when up to the dynamo, and when down to the lamps, and although both can be down at the same time both cannot be up together. This is prevented by a small change-over switch, fixed at the top of the cut-outs into the shunt windings of the coils, so as to excite these windings alternately. This switch is actuated by means of two ratchet wheels mounted on its axle, the wheels being turned by a pawl mounted on each plunger of the cut-out coils. By this means the switch is moved one step each time the dynamo stops. The main switch consists of five contacts—three for the lamps and two for connecting the batteries directly in parallel when the lamps are not in use, the switch bridging the lamp resistance. The conditions of working are as follows: When the dynamo is at rest both automatic switches are down. If the lights are on, current will pass from P_1 to B_3, and also from P_2 to B_2 through the lamp slide (short-circuited) to B_1 and B_3 and also to B_4. From these points the combined currents pass through the switches to L_1 and L_2, and to the lamps through F and H. If the dynamo is running and the lights off, B_5 and B_6 will be connected on the main switch. When the voltage of the dynamo rises, one of the automatic switches will be drawn up, say the left one. Current will now pass from P

* Abstract of a Paper read before the Newcastle Local Section of the Institution of Electrical Engineers.

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to P_3, round the coil through the top contacts of the switch to B_3, from B_3 to P_1, and also through B_5 and B_6 on the main switch to P_2, thus charging both batteries in parallel and cutting out the lamp resistance. If, now, the lamps are put on whilst the dynamo is running, the main switch will connect L_2 to F and H as required. Current now passes from P to P_3 through the coils and switch to B_3. Part will go to P_1, and the remainder will pass to B_1, through

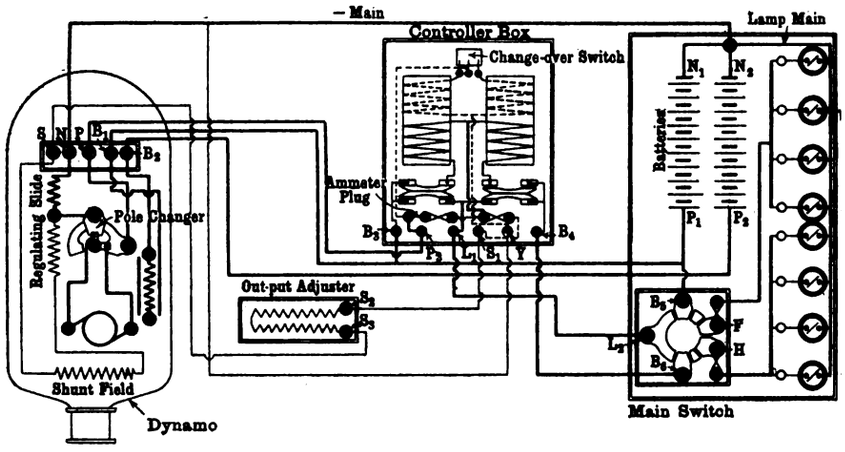

FIG. 5.—DIAGRAM OF CONNECTIONS. DOUBLE BATTERY SYSTEM.

the lamp resistance to B_2 and P_2. Also, it will pass to B_4 through bottom contacts of the second switch to L_1, L_2, F and H to lamps, thus putting the lamps and No. 2 battery in parallel and the lamp resistance in the main circuit. The author then describes the Verity-Dalziel system,* which has not yet had an extensive trial.

MOSKOWITZ SYSTEM.

The method of regulation is electrical, and is entirely carried out by using a variable carbon resistance in parallel with the shunt winding on the dynamo. The dynamo is a shunt-wound machine, with no special arrangements beyond a reversing switch on the end of the shaft for maintaining a constant direction of the current in the external circuits. Fig. 6 shows the complete switching arrangements and connections. The regulating apparatus mentioned above consists of a variable carbon plate resistance, VCR, the pressure on the plates being varied by the pull of an electromagnet, M, on a lever, L, and a spring, I, acting against M. This spring can be ad- adjusted to suit any load required. The variable carbon resistance and the shunt winding, which are in parallel, are both in series with a fixed resistance, R, without which the regulation of the field current would be impossible. There is also an automatic cut-out for operating the battery, the coils being in series with the field circuit and also having additional coils in series with the main circuit. This is marked C, and operates a lever switch, N, which closes contacts Q and Q_1, and in the off position makes a contact, Q_2. This lever is controlled by an adjustable weight for controlling the voltage at which the dynamo cuts in. There is also a lamp resistance needed, which is in circuit when the dynamo supplies the lamps direct. Following out the connections as in previous cases described, taking the dynamo at rest, and the lamps in use, current will pass from B+ to Q_2, through the lever N to terminal L+ to a terminal on the lamp resistance, and straight to the lamps, returning to L– direct to the battery. Next, if the dynamo is running and the lamps are in use, as soon as the cut-out closes current will pass from G+, through M, through series coils of C, through switch and fuse to A+. From this point three circuits leave—viz., the shunt, the carbon resistance and the main current. Following the shunt current, this passes through C to F+, through the winding to F–. The carbon resistance circuit passes direct from A+ through the plates also to F–. where it joins the shunt current, and both pass through the resistance R to the negative of the dynamo. Following the main current from A+ it passes through the ammeter to A–, to Q and Q_1, thence through lamp resistance to lamps, and back to L– and G– to the dynamo. Also from Q_1 it will pass to B+ through the battery to G–. If the lamps are not in use the battery will receive a charge, as shown above. This system of regulation works exceedingly well, and is very simple.

Fig. 7 shows the principle upon which the regulation is so simply carried out.

VICARINO SYSTEM.

This system, which is largely in use on the Continent, depends upon inverse compound winding for the voltage regulation. The dynamo is two-pole, fixed in a similar manner to other electrically-controlled machines. Instead of using a reversing switch for maintaining a constant direction of current, the brushes are revolved through 180 deg. upon each change of motion. Fig. 8 shows the complete switching arrangements and connections. The principal part of this is the automatic switch, which is compound wound and performs two operations—viz., that of connecting the dynamo to the batteries and also cutting in a lamp resistance in the lighting circuit. The core of the solenoid carries on the bottom a contact which connects the series coil of the switch to the negative, when the switch closes. The top of the core carries a similar contact, which when down connects the lamp negative to the battery negative, but when the switch closes this contact is broken, inserting in the circuit a lamp resistance which had previously been short-circuited. Following out the connections as in previous cases, taking the dynamo at rest and the lamps in use, current will pass from B+ to switch and L+, through lamps to terminals L–, through contact T (closed) to B–. If the dynamo is running and the lamps are in use current will now pass from G+ through ammeter and divide to four circuits —viz., (1) to lamp switch and lamps, (2) to B+ and battery, (3) to lamp switch and shunt coil of automatic switch S, (4) to lamp switch and shunt field circuit. There is also a connection from B+ through a switch to the field circuit, so that if the lamp switch is off, and it is desirable to charge the batteries, or have the dynamo running not excited, the second switch can be operated independently of the lamp switch. Following these currents, the first passes from the switch directly to the lamps through L+, back to L–, through the resistance (T being up and open), through the series coil on S, through D to M, G–, and dynamo series coils to brush. Following the battery current, this will pass from

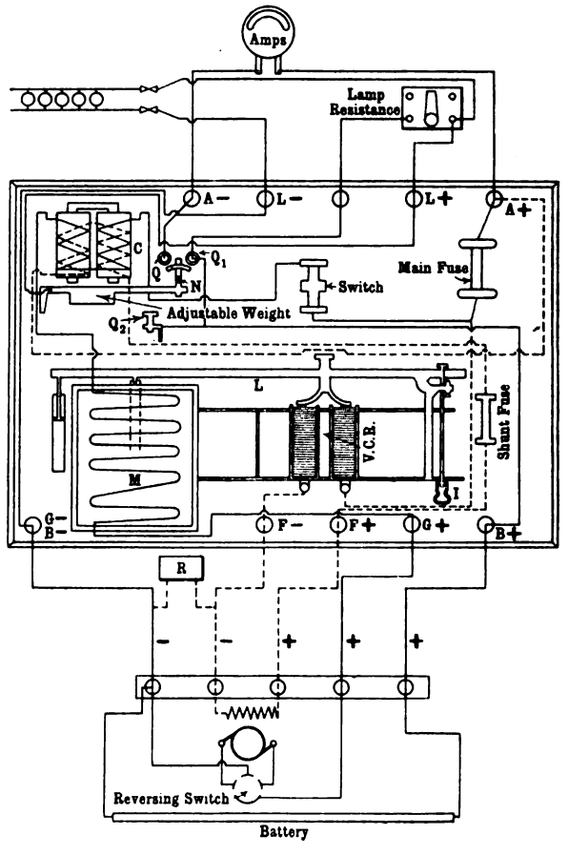

FIG. 6.—DIAGRAM OF CONNECTIONS. MOSKOWITZ SYSTEM.

the ammeter to B+, through the battery to B– series coil on S, M, G– as before. Of the shunt currents, that round S is directly across the lamp switch and M, whilst the field circuit is connected from the lamp switch to F+, or from B+ through field switch to F+, and round the field coils. If the lamps are not in use the coil S is still excited by the fine-wire winding if the shunt switch is closed, and therefore the cut-out will operate and the negative

*This system was described in *The Electrician* August 17, 1906, and May 24, 1907.

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charging current will pass through the automatic switch back to the dynamo. If the shunt switch is open both shunt circuits are broken, and therefore no voltage will be generated, and the automatic switch will remain open at the bottom, leaving the battery to run the lamps if required. This arrangement would be very useful in summer, and save overcharging the batteries. The system is used principally in France. It seems very simple, and, provided the dynamo is well designed to run with weak fields, there should be little trouble.

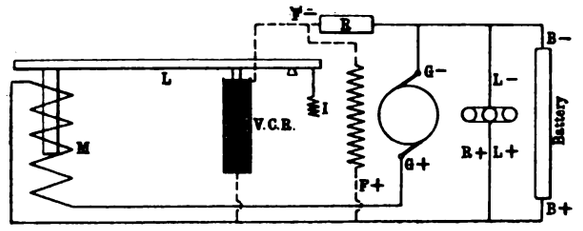

FIG. 7.—DIAGRAM SHOWING THE METHOD OF REGULATION. MOSKOWITZ SYSTEM.

The author finally describes the Leitner-Lucas* and the Mather and Platt† systems, the latter of which was the invention of Dr. Rosenberg, and is sometimes known by his name.

CONCLUSIONS.

After considering the various systems just described, the conclusions arrived at for successful train lighting are:—

1. Moving parts must be confined to the armature of the dynamo, one commutator being sufficient to have to keep in order. The addition of motors or motor-driven regulators adds chances of breakdown and increases cost of maintenance, at the same time adding complicated connections which would easily baffle an ordinary electrical workman.

2. Pole-changing devices should be in the form of a reversing switch, and not obtained by revolving the brushes.

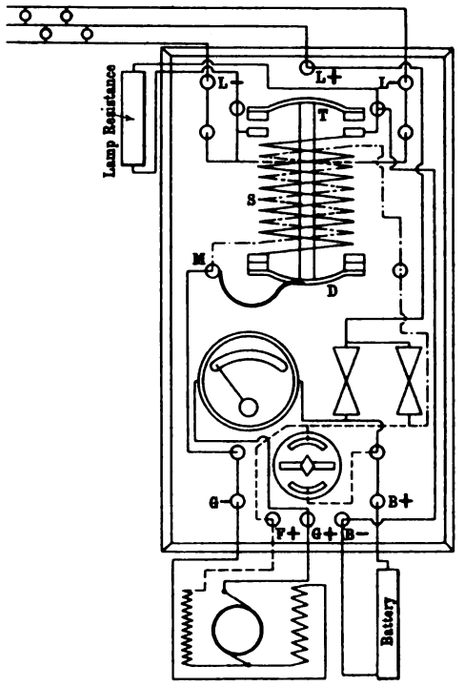

FIG. 8.—DIAGRAM OF CONNECTIONS. VICARINO SYSTEM.

3. Electrical switching is the safest from the point of view of preventing the batteries sending a reverse current through the armature should the dynamo fail to excite. The switch should be first operated by a shunt coil connected across the dynamo or in series with the field magnet circuit, as is done in the Vickers-Hall, Moskowitz, Vicarino, and Leitner-Lucas systems. On the other hand, mechanical switching has been found reliable, and the number of cases of failure of the dynamo to excite is very small.

4. The voltage should be regulated electrically, thus giving a more efficient working of the dynamo.

5. The use of high-efficiency lamps with metallic filaments would be a great saving in power and first costs of all parts, and this part of the business should be looked into if successful competition is to be carried out against incandescent gas.

6. In bogie coaches, wherever possible, the dynamo should be attached to the bogie, this methed of fixing being better whilst running round curves.

* Described in *The Electrician*, July 7, 1905.

† Described in *The Electrician*, June 9, 1905.

DISCUSSION.

Mr. J. HOLMES said that the Holmes machine mentioned in the Paper was made to give constant volts at any speed and when running in either direction. At the present day designers seemed to aim at giving constant current, which, with the same conditions, was a much easier problem.

Mr. PIGG said that the author had dealt very fully with a subject which was rapidly assuming considerable importance, and one which in the near future would, it was to be hoped, lead to a considerable extension of electrical business. He could not agree altogether with some of the deductions drawn by the author, but in many cases they were very valuable. Careful examination of the financial statements showed the large amount allotted to the cost of electric lighting for capital charges, and from this the deduction was obvious that the cost of installation was high. Taking the author's figures it seemed that the cost per coach for electric equipment was about £150, and the charge for interest on capital was 55 per cent. of the annual cost of operation. The cost of the installation of gas with flat-flame burners was apparently about £48, and the charge for interest on capital was 12 per cent. of the annual cost of operation. The cost of the installation of gas using incandescent burners was apparently about £70, and the charge for interest on capital was 32 per cent. of the annual cost of operation. Analysing the figures further, it would be found that the large proportion which the capital charge bore in the annual cost of the use of incandescent gas compared with flat-flame burners was due not entirely to the greater cost of installation, but in a great degree to a tremendous decrease in the consumption of gas. These figures pointed conclusively to the necessity for a reduction in the cost of electric installations if it was desired to bring them into line with the cost of gas lighting. He was not sure that the estimates as they stood were such as would be accepted commercially. There did not appear to be any provision for depreciation or a sinking fund. If such an account was included for both gas and electric lighting it was probable that some difference would be made in the comparative estimates. There was no means of getting at this from the accounts referring to gas as given in the Paper, as the capital charges on the cost of the gas works were not separately shown. As far as could be ascertained, however, the capital charge referred to was only a charge for interest. There was another charge that some railway companies would be inclined to impose on any electric lighting scheme put forward to displace existing gas lighting. Such displacement would result, in all probability, in a loss being incurred in disposing of the displaced plant, and one had often, in similar circumstances, to arrange for a payment for interest on unrealisable capital, before any advantage could be claimed for a proposed scheme. There was a good deal to be said for this way of looking at competitive schemes. There was one point in connection with the comparative costs which should not be lost sight of, and that was that an electric installation on a coach was a complete manufacturing, distributing and utilising installation. This was not the case with a gas installation. Mr. Henderson's estimates afforded no information on this question in connection with gas, and his installation costs were obviously not a complete comparison. No reliable comparison, he thought, could be made on estimates of the cost per coach. The only real comparison was the relative total cost in each case. In this respect the experience of the L. & N.W. Ry. Co. with Messrs. Stone's system of lighting was interesting. Some 1,138 coaches, already fitted with gas, were stripped and lighted electrically at a cost of £88,345, or an average of £77. 13s. per coach, which was little more than 50 per cent. of the figure taken by Mr. Henderson. The cost of the lighting by oil gas, including interest on capital, was £15,150 per annum. The cost of the electric lighting which displaced the oil gas, including interest on capital, was £9,792 per annum. Thus it showed a saving of about £6,246 per annum, or about 41 per cent. of the cost of the previous gas installation. These figures represented interest £3. 2s. per coach, maintenance £5. 10s. per coach. If to this was added the author's estimate of the cost of coal, there was a total of £9. 12s. 6d. per coach per annum, which was only about 10 per cent. higher than the author's figures for incandescent gas. If the item for maintenance given in the Paper (£3. 19s. 6d.) was taken instead of £5. 10s. as above, the results would be in favour of the electric light. There was no doubt that the figure of £5. 10s. per coach per annum for maintenance was very high. Other statistics covering eight half-years gave figures varying from £5. 5s. to £4. 8s. per coach per annum. The organisation of the arrangements for the effective maintenance of train lighting was not an easy matter, and the number of vehicles in use had a considerable effect upon the cost of maintenance. The results obtained by the London, Brighton & South Coast Railway Co. with the Stroudley-Houghton and the Stone system were interesting. When the former system, fitted on 380 coaches, was in use alone, the average annual cost for maintenance was £5. 19s. 1½d. per coach. Later, when Stone's system had been applied to 293 coaches, and the Stroudley-Houghton system was used on 271 other coaches, the annual cost for maintenance was £4. 17s. 1¾d. per coach, a decrease of 19 per cent. Railway companies, like other industrial concerns, found in many cases that there were some things they must have irrespective of cost, and the electric lighting of steam-driven trains was likely, in view of the recent remarks of the inspectors of the Board of Trade, to be one of those. It was not, however, by any means established that gas lighting, even with

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the reduced consumption claimed for the incandescent burner, was cheaper than the electric light. The cost of gas lighting on one railway was over 14 per cent. higher than the figures given by the author. On the South-Eastern & Chatham Railway the locomotive engineer stated that electric light had been found to be not only more satisfactory than gas, but more economical.

Mr. REID gave some figures which he had just obtained with regard to the cost for maintaining incandescent gas lighting. These were as follows:—

Gas, including capital charge	£8	3	0	
Cost for mantles	1	16	0	
Interest on capital expended	1	12	2	
Depreciation and renewals	1	4	0	
Maintenance of apparatus	1	18	0	
Cost of gas in cylinders	0	9	7	
				£10 2 9

The candle-power of the incandescent light was 30 compared with the flat flame of 13. This made the price of electric light compare very favourably with incandescent gas lighting.

Mr. HENDERSON, in reply, said that he was of opinion that the incandescent gas light could be improved, as there was not yet a reliable mantle on the market. The chief point which had to be considered by those in favour of electric light was the reduction in capital expenditure. Unless this could be reduced there was not much chance of railway companies adopting electric lighting universally. He thought that from the point of view of safety the electric lighting of carriages was undoubtedly the best. The Board of Trade should insist upon it, and thus obviate the dangers which arose from fire caused by gas in railway collisions.

DEVELOPMENTS IN ELECTRIC INCANDESCENT LAMPS.*

BY LEON GASTER.

Summary.—In this Paper the Author gives a description of the numerous improved forms of incandescent lamps which have been experimented with during the last few years.

It is my object in this Paper to give a short review of some of the most important improvements which have come before my notice during this year, and to exhibit the lamps mentioned in actual operation. I will start with the improvements of the carbon filament, and bring before your notice the metallised or, as it is also called, the graphitised carbon filament, by the aid of which lamps are made consuming on an average 2·5 watts per candle, with a useful life of about 600 hours. The lamps are manufactured for voltages varying between 100 and 130. I should also like to mention the use of the double carbon filament lamps, the two filaments being comprised in the same bulb, one large and one smaller filament, by the aid of which either the full candle-power or only a very small candle-power can be used, and the expenditure in lighting thereby reduced.

I will now pass on to the Nernst lamp. A recent improvement consists in fitting the lamps with a newly designed cut-out coil of high resistance, and it is claimed that by the use of this coil a great reduction of the premature failures of filaments will be secured. As regards the efficiency of the lamp, no very great further improvement has yet been secured.

Coming now to the metal filament lamps proper, the osmium lamp, as produced by Dr. Auer von Welsbach, owing to the expensive nature of the metal used, and partly to the difficulty in manufacture, and bearing in mind the improvements which have since been made by the same inventor by the use of tungsten, is now likely to be restricted to comparatively low voltages.

Tantalum is certainly the only metal filament lamp which has proved to be successful commercially. There has not been, as far as I know, any particular developments made during this year which require to be recorded, except those in the direction of lengthening the life of the lamps when used on alternating-current circuits. It is as yet only made for voltages up to 125.

The next most important metal used in the manufacture of filaments, and with which much is expected to be accomplished, is certainly tungsten (wolfram). Several methods have been devised for preparing filaments by the use of this metal. One of the first methods was worked out by Dr. H. Kuzel, of Vienna. By his process the metal is obtained in the colloidal state by means of an arc under water. The resulting paste of extremely fine metal is squirted into filaments, and afterwards heated in order to make them better conductors. The lamps are manufactured in Vienna by Kremenetsky. From such tests as have been made it is ascertained that the lamps consume a little over 1 watt per candle-power, with a useful life of about 1,000 hours, with a loss of only 10 to 15 per cent. of the initial candle-power. Another method of manufacturing tungsten filament is the joint invention of Dr. Alexander Yust and Franz Hannaman, of Vienna. According to their process the carbon filament is electrically raised to a high temperature in an atmosphere of gaseous tungsten or molybdenum compounds. The carbon then becomes coated with metal, and after burning out the carbon the filament appears quite homogeneous, even under the microscope. By another method the metallic powder is prepared by chemical means mixed with an agglutinant, and squirted into the form of filaments, which are then freed from carbon as before. Messrs. Siemens & Halske have devised a process of stamping tungsten powder, sometimes mixed with another metallic powder, but without an agglutinant, in a tube of some metal, which is easily drawn or rolled, such as tantalum or iron. Then, after electrically sealing the ends, they subject the tube to drawing or rolling processes. After the completion of the drawing process the outer skin can, if desired, be removed. This method obviates the necessity for the great care and treatment involved in the ordinary fusing process, but I have not heard whether the method is actually in use.

The next lamp using tungsten, and which is already used commercially, is the "Osram" lamp, which is at present manufactured by the Deutsche Gasglühlicht Gesellschaft. The lamps burn with an efficiency of 1·2 watts per candle power, having a useful life on an average of over 600 hours. The lamps are recommended to be burnt for the present with the filament in a vertical plane, and can be equally well used on direct or alternating-current circuits. The Berlin A.E.G. Co. are also manufacturing some type of tungsten lamps, the process for the manufacture of which has not been divulged.

Turning now to the zircon wolfram lamp, I should like to draw attention to some of the improvements which have been made during the last few months. You will have an opportunity to see, for the first time, I believe, metal filament lamps of voltages above 100 which burn satisfactorily in any position. The filaments are mounted on spring hooks made out of tungstenised carbon, the hooks having the effect of maintaining the filament rigid and in shape whilst in service, and of preventing the loops from touching, also of allowing of a greater number of filaments in the bulb, and, consequently, of reducing their length and that of the lamp. The lamps can be burned in any position, and the breakage of filaments is considerably reduced. On account of the elasticity of the spring hooks the breakages of filaments have been reduced in transit and in service. Another improvement over the old type of lamp is the adoption of electrical soldering of the filament to the leading-in wires, thus doing away with the inconveniences caused by the use of graphite paste, which was a partial cause of the blackening, the giving off gases and the defective contacts met with in the previous lamps. The improvement also avoids much extra labour, and also the danger of oxidation of the filament, if the paste is not very carefully burned away. The electrical soldering process takes place in the open, and an experienced operator can carry out the soldering of about 500 lamps daily. The firm of La Carriere in Paris are the inventors of this spring hook, and I understand that the filaments can now be mechanically mounted in such a manner that the operators do not have to touch them with their fingers, thus reducing thereby the number of breakages in mounting the filaments. The latest type of 110 volt lamp contains only four filaments, of 0·025 mm. diameter, giving out 24 hefner candles, or for 220 volt 48 hefner candles, necessitating only the use of eight filaments.

The author then showed a helion lamp, of which very little information is as yet available. The lamp looks like an ordinary carbon incandescent lamp, mounted in the same-sized bulb, and consumed 35 watts, giving out 30 c.p. In the manufacture of the filament, silicon is reduced from a gaseous form in combination with carbonaceous gases on the surface of a high resistance carbon core. The inventors claim that this lamp operates at a high temperature without the carbon and silicon uniting to form carborundum as might be supposed. The silicon shows no tendency to become molten or fluid at the temperature attained. The filament starts with a negative temperature co-efficient less than carbon, but at about a red heat the co-efficient changes distinctly to positive, and remains so as the temperature is further increased. The efficiency of the lamp is claimed to be 1·2 to 1 watt per candle, or it can run even at less. Although a useful life between 600 and 1,000 hours is claimed, a proper series of life tests could not be made, as there seems to be a difficulty in keeping the joints between the filament and the leading-in wires in good condition. For the proper working of the lamp, it is essential that mercury pumps be used for obtaining the vacuum, and great care must be taken in selecting the carbon core, so as to obtain homogeneity and purity, otherwise the results are considerably affected. Experiments are now being conducted by the inventors, using as a core the graphitised (metallised) carbon filament, and also with a special cement for the use of making the joints. One of the characteristic features of the lamp is that the length of the filament need not be increased over the ordinary carbon lamp. The filament is very pliable, and there will be no difficulty (if the present defects, which are chiefly of a mechanical character, have been overcome) in making lamps of low and high voltages and of reasonable candle-power. The lamp easily stands transport, and will be just as safe to handle as the ordinary carbon filament lamp of to-day.

*Abstract of a Paper read before Section G of the British Association at Leicester, August, 1907.

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Iridium has also been used for the manufacture of lamp filaments. According to Gulcher's process, amorphous iridium is made up into a paste by the aid of an organic binding material. The filaments are squeezed from this paste, and are made to glow in the air, and not in a receiver containing air in the diminished pressure or in-different gases. The lamp is only produced for low voltages up to 24, and consumes between 1 and 1·5 watts per candle. Other metals, like vanadium, niobium, molybdenum, &c., may also be used in the future, but not much has been made public as yet regarding their use for filaments.

During a visit which I paid to Mr. W. T. Hammer, of New York, I saw a few sample lamps of Mr. Heany's invention, some using, I was given to understand, titanium for the filament, and others using a metallic alloy of tungsten and titanium in a dense, shining, coherent state.

Although we have seen that the metal filament lamps can be made of relatively small candle-power at voltages above 100, and of high voltage up to 240, I am given to understand that it is not the intention of most of the manufacturers to sell for the present other lamps than those of high candle-power above 80 c.p., and intended for voltages varying between 100 and 130. This decision has a distinct commercial value, making the change from the carbon filament to the use of metal filaments gradual, so as to be properly appreciated and beneficial to the consumer, manufacturers, and energy suppliers alike. It is well known that the carbon incandescent lamps are at present in many cases fixed at a low position, often situated in the direct angle of vision, and, therefore, detrimental to sight. The reason may be that, on account of the expense at which energy is supplied to the consumer, he could not well afford to enclose the lamps in properly diffusing globes, or to remove them a good distance away from the objects he wishes to be illuminated. With the advent of the new metal filament lamps of relatively high candle-power, the lamp could easily be removed to above the level of the eyes, or enclosed in properly diffusing globes. We should thus obtain good illumination without additional increase of expenditure.

For those circuits where high voltage is used, and where it is advisable to introduce the metal filament, resort must be had to series wiring, which, as a whole, is not quite satisfactory, because as soon as one of the lamps breaks, all the lamps in the circuit go out, and it is not so easy for the ordinary consumer to detect the broken lamp. Several devices have now been introduced to mitigate this drawback.

Speaking generally of the impressions which I received during my recent visit to America, I should like to inform the meeting that very great progress has been made in the recognition of illuminating engineering as a distinct branch of specialisation in the engineering profession. I observed an extensive use of successful combinations of shades, lamps and lamp-holders, by the aid of which combination the best and most efficient illumination is obtained. The Holophane shades and reflectors seemed to be very much used, enabling us to direct the light where it is mostly wanted, and produce any desired effect of illumination. I think that this combination of lamp, lamp-holder and reflector, forming one suitable unit, is worthy of the careful consideration of the lamp-makers in this country.

I should like to draw attention to the progress made in the use of vacuum tubes, and in particular wish to refer to the Moore vacuum-tube method of illumination. Two installations have already been erected in London, one outside the Savoy Hotel, and another at Salisbury House. The Savoy installation consists of a tube 176 ft. in length, consuming 2,950 watts, using nitrogen gas for producing yellow light; power factor 70 per cent. The Salisbury House installation consists of a tube 85 ft. in length, consuming 2,200 watts, with a power factor of 60 per cent. A white colour is obtained by using CO_2. The use of CO_2 has enabled Mr. Moore to obtain with his tube the nearest approach to daylight yet attained, and I am given to understand that colour can be matched in such a light with extreme accuracy. This is certainly a severe test for any method of lighting.

I should also like to draw attention to one fact in connection with illumination which seems to deserve greater consideration at the hands of manufacturers and large consumers of light, and that is the great value which ought to be attached to the adopting of proper methods of illumination. The advantages to be derived are: Firstly, the sight of the workpeople will be improved and prolonged; secondly, the output will be quite appreciably increased; and, thirdly, which is very important, the quality of the work under proper illumination will be of the same high standard as when done in the daytime.

Before closing I should like to refer to the work of the engineering department of the National Electric Lamp Association. Fifteen lamp-makers in the United States have combined for the purpose, not of forming a trust, but with a determined object of improving the quality of the lamps they are manufacturing, and thereby maintaining a proper and high standard. Instead of each factory employing imperfectly trained chemists to analyse the chemicals which enter into the manufacture of lamp filaments, a well-paid and highly skilled chemist is employed in a thoroughly equipped laboratory to perform this work, and sufficient resources are put at his disposal to keep on making proper researches, and keep abreast with the latest discoveries. I may also mention in connection with the necessity of testing incandescent lamps the beautifully equipped electric testing laboratory which I visited in New York, which is so ably conducted by Dr. C. Sharp. In view of the fact that in this country a standard specification for carbon lamps has been framed, and has come into force on this July 1st, I hope before long that such a testing laboratory will also be established in this country, and will receive the proper support of the municipal authorities and companies supplying current for lighting purposes, enabling the consumers to get lamps of really good quality.

In bringing this Paper to a close, I should like to venture in indicating the lines upon which further researches might be conducted, and for that purpose I will refer once more to Mr. Hammer and his publications, and say with him that the ultimate solution of the problem of securing a satisfactory and efficient illumination may be obtained by means of the stimulation of phosphorescent and fluorescent substances in various ways, thus producing a cold light, a light, as he calls it, without flame and without heat. We must soon stop producing long and useless heat waves, and also, as far as possible, all radiation outside the visible spectrum, in the utilisation of our illuminants.

MANCHESTER AND SALFORD ELECTRICAL EXHIBITION, 1908.

We have received from Mr. W. Davenport, secretary of the National Electrical Manufacturers' Association, the following communication regarding the arrangements at present made in connection with the holding of an electrical exhibition in the Manchester and Salford district in or about October, 1908:—

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Manchester and Salford Corporations have decided to hold an electrical exhibition in their district, under their direct patronage and substantial support, in or about October, 1908, and arrangements are being made to call a meeting, at an early date, of Corporation officials and supply companies' representatives in the north of England who are interested. A general advisory committee will be appointed, as also an executive committee, to assist in the carrying out of the scheme in detail.

The executive committee will consist of representatives from Corporations supporting the scheme, supply companies, representatives of the Municipal Electrical Association, the National Electrical Manufacturers' Association, the Electrical Contractors' Association and representatives of the exhibitors.

Profits arising out of the Exhibition will be allocated to exhibitors and donators, grants will be made to benevolent funds connected with the electrical industry and an institution nominated by the Manchester and Salford Corporations, and situated in their respective districts.

Mr. S. L. Pearce, A.M.I.C.E., M.I.E.E., and Mr. V. A. H. McCowen, M.I.E.E., M.I.M.E., Corporation engineers of Manchester and Salford respectively, have kindly consented, with the approval of their chairmen, to act as consulting engineers to the scheme.

Mr. C. S. Northcote, M.I.E.E., late deputy chairman of the recently highly successful Electrical Trades' Exhibition held at Olympia, will act as general manager to the Executive committee, and Mr. W. Davenport will act as organising secretary.

As soon as the final details of the scheme are a little more advanced, the electrical trade will be asked to attend a meeting to appoint their representatives and to approve of the preliminary arrangements.

Negotiations are at present proceeding for a suitable site, of which full particulars and plans will in due course be published.

Re Franco-British Exhibition, Electrical Section.—The Institution of Electrical Engineers have appointed a committee under the chairmanship of their president, Dr. R. T. Glazebrook, F.R.S., to supervise the interests of the electrical trade at the forthcoming International Exhibition to be held at Shepherd's Bush. The exhibits, however, will probably be of a general character, represented by the biggest and more important manufacturing firms of the country, with a view to showing the progress of the industry and the friendly rivalry which exists between France and the British Empire, but, broadly speaking, it will not be a trade exhibition in the true sense of the word, as was the late Electrical Exhibition at Olympia, and the forthcoming Manchester and Salford Exhibition will be.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Elements of Mechanics." By W. S. Franklin and Barry Macnutt. (London: Macmillan & Co.) 6s. 6d. net.

"Socialism: Its Fallacies and Dangers." A collection of Papers. Edited by F. Millar. (London: Watts & Co.) 6d.

"Wärmelehre." By Dr. Johs. J. C. Müller. (Leipzig: Johann Ambrosius Barth.) M. 4.

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CORRESPONDENCE.

COLOUR PHENOMENON IN PHOTOMETRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While it is impossible to maintain that flicker photometers are entirely independent of all colour effects (such as, for instance, colour blindness on the part of the observer), I agree with Mr. Wild that the influence of the size of the retinal image is much less evident in instruments of this class. This, I believe, is connected with a difference in the limiting frequency at which the sensation of flicker disappears in the case of the rods and cones respectively. Yet, in my own case, I still find that a small difference in the results can be produced by alteration of the retinal image, even in the case of a flicker instrument.

I hardly think that the use of inclined screens in the Everett Edgcumbe photometer, or a difference in their distance from the eye, could explain the result to which Mr. Wild refers. The two portions of the surfaces which are utilised in the field of view of this instrument are practically equidistant from the eye, and I do not think that my result could be explained by "angle-errors," as Mr. Wild seems to hint.

There are other possible explanations of the small difference between Mr. Wild's result and my own.

A grease-spot photometer, for instance, tends to tone down the apparent difference in colour between two sources, for the greased portion is viewed both by transmitted and reflected light.

Again, the magnitude of the influence of the size of the retinal image depends very greatly on the order of illumination of the photometrical surfaces.

Moreover, while I am reluctant to press the conventional explanation of all photometrical differences—the personal element—yet considerable differences in the distribution of rods and cones on the retina of different individuals are known to occur, and might perhaps explain why such a comparatively small difference as 3 per cent. should occur in the case of some eyes and not in the case of others.

If only on this account, I am glad that Mr. Wild is repeating my experiments on this subject.—I am, &c.,

Malvern, Aug. 16. J. S. DOW.

"SYNCHRONMASCHINEN FUR WECHSEL- UND DREHSTROM."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you please allow me space for the following note in connection with Herr Winkelmann's letter appearing in your issue of the 9th inst.

The skin effect in a conductor such as a simple transmission cable is to be distinguished from that in conductors embedded in armature slots. In the latter case the self induction per unit length of conductor is greater than in the former, and moreover the distribution of flux due to a current flowing in the conductors is quite different in the two cases. On account of these considerations, although in a simple isolated conductor the skin effect may be very often neglected, it must be taken into account when dealing with armature conductors.

Further, the eddy currents produced in solid pole shoes, end plates, bolts, &c., by the pulsating current in the conductors all have the effect of increasing the apparent resistance of the armature winding; or, in other words, the effective resistance is greater than the resistance as measured by direct-current to the extent of from 30 to 100 per cent. (See Arnold and La Cour, "Die Wechselstromtechnik," Vol. IV.)—I am, &c.,

Liverpool, Aug. 19. THOS. F. WALL.

BRITISH ASSOCIATION REPORT ON ELECTRICAL STANDARDS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Appendix I. to the above report published in your last number (p. 717), I am credited with having submitted for testing at the National Physical Laboratory, some Weston cadmium cells made according to the provisional specification issued by that institution two years ago. The report should have stated that these cells were sent from the Central Technical College, and were set up by Mr. J. A. Sadd, A.C.G.I., Honorary Demonstrator in the Electrical Engineering Department.—I am, &c.,

London, Aug. 21. T. MATHER.

RESTRICTED-HOUR SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your leading article of to-day's date you refer to the possibility of a tempting offer for current being sufficient to induce manufacturers to waive the interruption to supply as a thing to be thus pecuniarily compensated for.

In my 1904 Paper (p. 236 of I.E.E. *Journal*, No. 174) I raised this very question, and the reply I got, from one manufacturer at least (Mr. Morcom, see p. 262 of *Journal*), was very disappointing, though I suggested power at the then-considered ridiculously low rate of ½d. per unit.

The result was that I set about providing, by means of cells, a stand-by to that gap; and I am sufficiently optimistic to think that we shall hear more of this method during the next year. When certain aspects of the case are properly understood, there is much more to be said for the use of cells on consumers' premises in the manner I propose than, I venture to think, many people are yet aware of, who might be supposed to know.—I am, &c.,

King's Heath, Aug. 16. A. M. TAYLOR.

PARLIAMENTARY INTELLIGENCE.

Pacific Cable.—In the House of Commons on 15th inst. Mr. Runciman stated that the accounts of the Pacific cable for 1906-7, recently published, showed a deficiency for the year of £54,923. 12s. 2d., of which the portion payable by the taxpayers of the United Kingdom was £15,256. 11s. 2d. If the cable were charged merely with the interest payable on borrowed capital (£60,000 a year), instead of being charged also with the annuity for repayment, the total deficiency would be £37,378. 14s. 2d., and the British share would be reduced in proportion. The working expenses also included £33,000 carried to renewal account.

Electric Railway Accidents.—On the motion of Viscount Galway, a return was ordered by the House of Lords on Wednesday of the total number of persons injured by contact with "live rails" on electric railways in 1904, 1905, 1906 and the first eight months of 1907.

Patents and Designs Bill.—This bill was read a second time in the House of Lords on Tuesday.

London Traffic Board.—In the House of Commons on Wednesday the President of the Board of Trade (Mr. Lloyd-George) stated, in reply to a question, that the new Traffic Department of the Board would have no power to compel promoters of locomotion schemes in London to submit their schemes for preliminary examination before the deposit of bills, unless such submission should be required hereafter by the standing orders of Parliament.

SALFORD AND ECCLES ARBITRATION AWARD.

The arbitrator appointed by the Board of Trade (Major P. Cardew) to ascertain the price to be paid by Salford Corporation to Eccles Corporation for the electrical energy required for working the tramways in Eccles has now issued his award. The arbitrator sat at Westminster in May to hear evidence, and the proceedings were reported in *The Electrician* for May 31. At the arbitration proceedings Eccles Corporation succeeded in obtaining the following guarantees, which enabled them to reduce the amount asked for from Salford Corporation:—

(1) That Salford Corporation should pay for a minimum quantity of 500,000 units per annum; (2) that not more than 11 four-motor equipment bogie cars should be on the Eccles lines at any one time; (3) that the pressure of 500 volts required by the agreement in question should only be required at the nearest feeding point to the Eccles station; (4) that Salford Corporation should lay the necessary cables for the supply at a cost of £1,828.

The last two clauses reduced the capital outlay by nearly £2,000, and the amount for loan charges by over £100. The price asked for at the inquiry by Eccles was 1·5d. per unit for a supply of 500,000 units and 1d. per unit for all above that quantity, and the amount offered by Salford, which they stated would allow a profit to Eccles of 2 per cent., was 1·048d. for 500,000 units, and ¼d. per unit for all above that amount. Before the arbitration the only amount which Salford would agree to pay Eccles was a sum not greater than that at which they could obtain a supply from their own Electricity committee. Last year the amount was 1·35d. which has now been reduced to 1·3d., and no guarantee would be

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given that the amount would remain at either of these figures, nor that a minimum quantity would be taken. This basis was admitted by the Salford engineers, on cross-examination, to be an unreasonable one, seeing that it might be a "domestic" arrangement, and it did not matter to Salford which department (the electricity or the tramways) made a profit. At the arbitration Salford contended that a fair price to charge for an output of 500,000 units was actually a ½d. less than the price which they were charging themselves on an output of 7,000,000 from an up-to-date station recently constructed in the same neighbourhood, under similar working conditions.

Major P. Cardew, in his award, sets out that by agreement dated April 11, 1902, between Salford and Eccles Corporations, it was provided that Salford Corporation should construct tramways in Eccles at the expense of the Eccles Corporation and fix the electrical equipment concurrently with the construction of the tramways, and supply electrical energy for the purpose of working the said tramways or any part or parts thereof; but Eccles Corporation might, upon giving certain notice of their intention to supply electrical energy from their own stations for the purpose of working the said tramways, require Salford, upon the expiration of a certain time thereafter, to purchase electrical energy from Eccles, and by sec. 13 of the said agreement it was provided that Salford should pay to Eccles for all electrical energy supplied by Eccles at the following rates and charges: For a consumption not exceeding 150,000 units per annum 1½d. per unit, for every unit exceeding 150,000 and not exceeding 250,000 per annum 1¼d. per unit, provided always that on the application of either Corporation such rates and charges should be subject to revision every five years after the date of the said agreement, and failing agreement on any such revision the matter should be referred to a referee appointed by the Board of Trade. As Eccles were to supply and Salford to take on and from Sept. 1, 1907, electrical energy for working the tramways, and as the Corporations failed to come to an agreement on the revision of the rates, on the application of Salford Corporation the Board of Trade appointed Major Cardew as referee. During the hearing of evidence it was agreed to between counsel for both Corporations that the agreement of April 11, 1902, should be amended, and that so amended the same should be binding and of full effect as precedent to and should be taken into consideration in making the referee's award. By agreement of July 31, 1907, between Salford and Eccles Corporation (supplemental to the agreement of April 11, 1902) the principal agreement was amended accordingly.

The award proceeds: Now I, the said Philip Cardew, having heard and duly weighed and considered the several allegations of the said Corporations and their evidence, and having cognisance of and having taken into consideration the said supplemental agreement of July 31, 1907, I award and determine that the rates and charges to be paid by Salford Corporation to Eccles Corporation for electrical energy supplied by Eccles for a service on the said tramways at any one time of not more than 11 four-motor equipment bogie cars shall be (1) for a consumption not exceeding 500,000 units per annum 1½d. per unit. (2) For every unit exceeding 500,000 per annum 1d. per unit.

LEGAL INTELLIGENCE.

National Telephone Co. v. Hemmings & Carruthers.

In the City of London Court on Tuesday, plaintiff company sued Mrs. H. C. Hemmings and Mr. J. Carruthers, representatives of the Threo Syndicate, for £6. 19s. 8d., for the use of a telephone for a second year.

For the defence, it was said defendants took the telephone for three months, paid for it 12 months in advance, and that it was taken away at the end of about the first six months. Therefore plaintiffs had no claim for a second year's subscription.

Mr. STROUD, for the company, said that they had received no notice to discontinue, such as they were entitled to under the contract. After defendants had had the telephone for about six months the company found their premises vacated, and plaintiffs removed the instrument. They were justified in doing that under their bye-laws and regulations, and without notice. They still held the instrument at defendants' disposition, and as no notice to discontinue had been given, defendants were liable for a second year's subscription.

Mr. HEMMINGS (for defendants) said plaintiffs had taken two guineas from Carruthers in discharge of his obligation *without prejudice*. He urged that that discharged the other defendant.

Judge LUMLEY SMITH, K.C., held that the discharge of one of two joint debtors was a discharge of both, and gave judgment for the other defendant, with costs.

Carbide Manufacture in Norway.—The report of the Alby United Carbide Factories (Ltd.) for 1906 states that the new Odda factory on the Hardanger Fjord, Norway (a port which is ice free throughout the year) was being equipped under the supervision of the company's general manager and chief engineer, Dr. Albert Petersson. The installation would be completed by the end of 1907. The harnessing up by the Tyssefaldene Co. of the first unit of water power (20,000 E.H.P.) was well advanced, and was being carried out in such a manner that an additional 20,000 E.H.P. could be connected up and delivered within a year from the date of starting.

HOUSE LIGHTING CONTROL.

The very nature of electric lighting, among other advantages, gives its user greater ease of control than either gas or oil lamps. Many makers of electrical apparatus have thus been encouraged to evolve arrangements of wiring, allowing one or more lights to be switched on or off from any convenient position or positions.

One of the best-known workers in this field is Mr. A. P. Lundberg (of Messrs. A. P. Lundberg & Sons), who has just placed on the market a new "Marvel" switch which, it is claimed, will still further develop the possibilities of convenient control from two

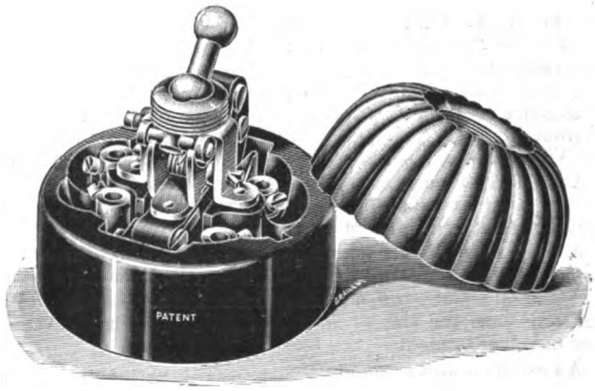

FIG. 1.—GENERAL VIEW OF "MARVEL" SWITCH.

positions. The "Marvel" switch, a general view of which is given in Fig. 1, has three definite positions for the lever knob, and as there is only one controlling spring a uniform tension is obtained. The rocking contact arm consists of a piece of insulating material, on each side of which are arranged contact studs, suitably interconnected, which become current carrying or not according to the positions of the knob and the circuit connections. The rocking contact arm is locked in each of the inclined positions of the knob and cannot be released by vibration. It is therefore very suitable

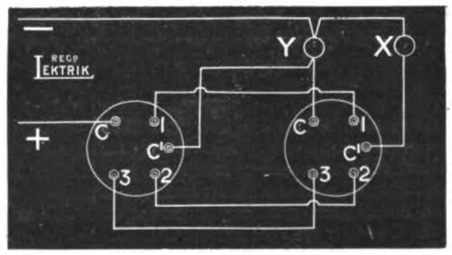

FIG. 2.—METHOD OF USING "MARVEL" SWITCH IN BEDROOMS.

for use on board ship or in railway trains, where a total extinction of the lights would be especially annoying. The "Marvel" switch is of strong construction, and is so designed that its parts are interchangeable, and it can also be fitted with any of the standard covers manufactured by this firm.

In Figs. 2 and 3 we give two examples of the use for which this switch is primarily designed. Fig. 2 shows an arrangement of wiring, whereby either (*a*) lamp X can be used alone, or (*b*) lamp Y can be used alone or (*c*) both lamps can be switched off. In Fig. 3

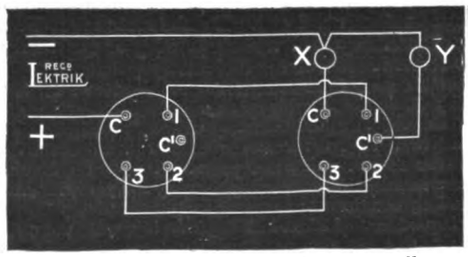

FIG. 3.—METHOD OF USING "MARVEL" SWITCH ON ELECTROLIERS.

a system of wiring suitable for use on electroliers is given. With the help of two of these switches either part or the whole of the lamps can be switched on or off from two different positions.

It is claimed that the wiring under this system is no more difficult than that employed in two-way wiring, the only difference being that an extra wire is run. Except in one particular arrangement this extra wire is always on the same pole as the other two. A leaflet which we have received from Messrs. Lundberg gives seven different applications of the use of this switch, and no doubt there are others waiting to be thought out.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A test-room assistant is required, with experience in adjusting, calibrating, and scaling Wright's demand indicators. Applications to the Engineer and Manager, Stepney Electricity Works, 27, Osborn-street, Whitechapel, E., by Aug. 28. See an advertisement.

A demonstrator is required in the department of electrical engineering at the Heriot Watt College, Edinburgh. Salary £130 per annum. A lecturer and laboratory assistant is also required at 21s. per week. Further particulars from Prof. F. G. Baily. Applications to the Principal by the 28th inst. See an advertisement.

A chief clerk is required by the British Continental Electricity Co. (San Remo, Italy) to take charge of consumers' department. Preference to applicants having knowledge of French or Italian. Commencing salary £9 per month. Applications to the Company, 82, Victoria-street, Westminster, S.W. See also an advertisement.

A general foreman is required by Scarborough Tramways Co. Salary £120 per annum. Applications to the Manager, Scalby-road, Scarborough. See an advertisement.

A lecturer in applied mechanics is required at the University of Liverpool. Particulars from the Registrar. See also advertisement.

A selling representative is wanted for a first-class firm, to energetically push the sale of rheostats, starters, circuit-breakers, &c. See an advertisement.

An assistant lecturer and demonstrator in mechanical engineering is wanted at the University of Leeds. Salary £200. Particulars from the Registrar. Applications by Aug. 26.

Two demonstrators in physics are also required at Leeds University. Salary £100 each.

Ilford Council require a second engineer-in-charge at their electricity works. Salary £120 rising to £150. Applications by Aug. 27.

An assistant is wanted in the engineering department of Darlington Technical College to teach electrical engineering and practical mathematics. Commencing salary £120 per annum. Applications to the director of education (Mr. A. C. Boyde), Education Offices, North Lodge, Darlington, by Aug. 30.

An assistant lecturer in engineering, to take classes in electrical engineering, is required by Swindon Education committee. Applications (on forms to be obtained from Mr. W. Seaton, Town Hall, Swindon) by Aug. 31.

Mr. Hugh Edmiston has been appointed city electrical engineer of Perth, Western Australia. Mr. Edmiston has had long experience of electrical engineering work as a partner in Edmiston & O'Neill (Melbourne) and earlier in Palmer, Struthers & Edmiston, and also as Australian advisory engineer of W. T. Henley's Telegraph Works Co. and the Australian Otis Engineering Co. He has also been in the service of Crompton & Co. and the Brush Co., his first connection with electrical engineering work being with the Anglo-American Brush Electric Light Corpn. in London in 1885.

Mr. Alex. Wyllie, borough electrical engineer, Walsall, has been appointed chief electrical engineer at Auckland, New Zealand.

Major W. Montgomery, R.E., has been appointed officer-in-charge of the Forth Defence electric lights.

EDUCATIONAL NOTICES.

University College, London.—When the new session opens on Oct. 1 the extensions to each of the engineering departments at this college will be completed. By the removal of University College School to Hampstead the south wing of the College buildings in Gower-street is set free for University purposes.

The chief features of the extensions are as follow: In the *Mechanical Engineering Department*, which is under the direction of Prof. J. D. Cormack, a new hydraulic laboratory will be provided in the basement, and also additional space for experimental work in mechanical engineering during the second and third years. A separate laboratory will be set aside for research work, thereby leaving the main laboratory entirely free for undergraduate work.

In the *Department of Electrical Engineering*, which is under the direction of Prof. J. A. Fleming, the present lecture room (which faces on Gower-street) will be replaced by a large new lecture room with a small demonstration class-room adjoining which will face south, and be entirely removed from the noise of traffic. The old lecture room will be fitted up as an experimental room for advanced students. The electrical engineering department will also obtain a fine research laboratory with apparatus and preparation rooms adjoining.

The *Department of Applied Mathematics*, under Prof. Karl Pearson, which is immediately above the electrical engineering department, will also receive considerable extensions, thereby setting free the existing accommodation for the work of engineering students, and providing new accommodation for those taking civil and municipal engineering. The extensions to the Department of Applied Mathematics will also provide two special research laboratories.

On the second floor extensions will be made to the drawing office, which will make it possible to reserve benches for the entire use of each of the students working therein. Adjoining the drawing office will be a large museum of apparatus and diagrams. Many of the leading engineering firms have already presented apparatus for exhibition in this museum. Hardly less important to the student of engineering is the provision of entirely new accommodation for the *Department of Geology*, under the direction of Prof. E. J. Garwood. This department will now be provided with a handsome museum, a research room, and a lecture room suitably equipped with lantern apparatus. In addition to these improvements a large room (50 ft. × 20 ft.) has been set aside for the use of the Students' Engineering Society, of which Sir Alexander Kennedy was the founder.

The fees have been re-arranged under a scheme which provides a composition fee of 120 guineas for the complete three years' course in any one of the branches of mechanical, electrical, municipal, or civil engineering, this fee being payable in three instalments of 45, 40, and 35 guineas.

University of Glasgow.—The new session commences on Oct. 17 and ends on March 16, 1908. The students usually spend the summer months in practical work, thus receiving their training on the "sandwich" system. Prospectuses of the courses for the degrees of B.Sc. and D.Sc. in engineering, mining and architecture and syllabuses of all classes, &c., can be obtained from the Assistant Clerk, matriculation offices, the University, Glasgow.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

Glasgow and West of Scotland Technical College.—The session begins on Monday, Sept. 23, in the new buildings. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics. The courses of study extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session at prescribed university classes. There are new and well-equipped laboratories in the departments of physics, chemistry, technical chemistry, metallurgy, mechanics, motor-power engineering, electrical engineering, &c. The preliminary examination begins Sept. 16. Calendar (price 1s. 4d.) and prospectuses (gratis) from the Secretary.

Merchant Venturers' Technical College (Bristol).—The calendar for the 52nd session (1907-8) contains full particulars of the courses of instruction in electrical and mechanical engineering, applied physics and mathematics, chemistry, &c. There are day and evening classes, and the courses prepare for the degrees of the University of London. Copies of the calendar may be obtained, price 6d.

South-Western Polytechnic (London).—At this polytechnic a complete three years' course is given in electrical engineering during the day and a four years' course in the evening. There are courses of lectures and practical work in elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, electrical wiring and fitting and the calculus for engineers.

Hackney (London) Technical Institute.—The next session commences on Sept. 23. Evening lectures and laboratory courses are held in electrical engineering subjects, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses, &c., from the Principal, Dalston-lane, London, N.E.

Alleged Noisy Tramcars.—At West Hartlepool Police Court on Monday the General Electric Tramway Co. were summoned for causing annoyance by the machinery of four of their tramcars.

Mr. M. Harrison (for the company) said his clients approached the Corporation some time ago when complaints were made, and the cars were then put right to the satisfaction of the Corporation, with the exception of four. He now asked Mr. Simpson (the town clerk) to allow an adjournment for one month, and they undertook to put the cars right or to take them off the track.

Mr. Simpson thought the proposal not unreasonable. Under the regulations the company were required to run these cars without a clattering of machinery. He was informed that in the early morning, when the cars were freshly lubricated, there was not the same noise as later in the day. That would suggest additional lubrication.

The case was adjourned for a month.

Ashton-under-Lyne.—The Council have applied for sanction to a loan of £11,673 for extensions of the electricity undertaking.

Australasia.—Fremantle Electric Tramways Board have entered into an agreement for the extension of the tramways into North Fremantle.

Austria-Hungary.—The value of electrical machinery and apparatus exported from Austria-Hungary to the United Kingdom in 1906 represented a value of £70,261, compared with nil in 1905.

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Ayrshire.—The Ayr County Road Board have referred to a committee a project for the construction of electric tramways in Largs and district.

Bradford.—The Watch and Tramway committees have been considering the possibility of ameliorating the obstruction of the streets caused by passenger crowds at the tramway termini, and will submit to the Council a proposal to construct, on the site of the present Forster-square garden, an island platform, round which the cars will travel to pick up passengers.

Brazil.—In connection with the general trade of Brazil for 1906 there was a considerable falling off in the imports of machinery and accessories for electric light and power, equal to 230 tons of £42,156 value. Imports of this character from the United Kingdom in 1906 were valued at £30,779, from Germany £77,770, from the United States £159,075, France £10,000.

At Rio de Janeiro there has been considerable progress made by the Electric Tramway, Light & Power Co., who now supply electric energy from their generating station at Ribeirão das Lages, situate 50 miles distant from Rio. Work is actively progressing at the principal generating station of the company on the Parahyba river, situate 80 miles distant from Rio, and the company anticipate that by next year they will have command of some 60,000 H.P. at this station, and so be in a position to supply all requirements of the Federal district and of Nitheroy. The Villa Isabel tramway service is now worked electrically, and the conversion of other mule-drawn lines to electricity is being proceeded with. The unification of the entire system to one gauge and to electric traction is well advanced. Electric lighting both for public and private uses has greatly increased and the demand is still growing.

Bremen.—Two new harbours were built in the fall of 1905 at Bremen, and a dam is now under construction above the city, at a cost of £400,000, in order to raise the level of the water port of the river. The fall of this water will be utilised for the water-power generation of electric energy to supply Bremen with electricity for lighting and power.

China.—The value of electrical apparatus and materials imported into Canton in 1906 was £8,584, compared with £9,519 in 1905.

Colne.—An unopposed inquiry was held here last week into the application of the Council to borrow £5,550 for extensions of the electricity works.

Columbia.—Mr. Consul Gillies, reporting upon the trade of Barranquilla and Cartagena in 1906, states that the telegraph service of the country has been recently greatly improved and new branch lines established connecting the main system with a number of outlying districts. The submarine cable service has also been improved, but there is said to be great need for the establishment of a cable station on the Atlantic coast, as messages coming from abroad for Barranquilla have to travel across the Continent from Buenaventura on the Pacific coast. The weight of telegraph and telephone wire imports is given as 222,130 lb., of which the United Kingdom supplied 53,250 lb. weight, the greater portion of the remainder coming from Germany.

Corea.—Recent imports into Corea show a large increase in telegraph and telephone material. The imports into Corea, except for metals, show very little of British origin. Telegraph and telephone materials are described as of Japanese origin.

At Chemulpo (which, by the way, it is suggested should be made a free port) the local electric light and power company commenced operations in April, 1906.

Customs Duties.—Sir William Lyne has submitted to the Australian Federal Parliament proposals for revised import duties on various articles and materials of which the following affect the British exports of electrical goods, apparatus, &c. :—

	Proposed general tariff. Per cent. ad val.	Proposed duty on British goods. Per cent.	Present rate for British goods. Per cent.
Lampware	25	15	15
Lamp (gas and electrical) stoves	30	20	
Miners' safety lamps	10	nil	nil
Engines, turbines, boilers, pumps, &c	30	25	12½
Machinery (and parts)	10	nil	12½
Machine tools for metal working, &c	25	20	nil
Manufactures of metal (n.e.i.)	30	25	nil
Electric generators and motors not over 500 H.P., fans and rheostats.	30	25	12½
Ditto over 500 H.P.	17½	12½	
Electrical appliances, electroliers, pendants, brackets, switches, controlling devices, radiators, &c.	25	20	nil
Electrical materials	5	nil	nil
Motor cars (and parts)	35	25	—
Electric fuses	5	nil	nil

According to a recent decision, pocket electric lamps (with or without battery) are subject, under the Swiss tariff, to a duty of 25fr. per 100 kilogs (10s. 2d. per cwt.).

"Economy" in the Use of Electrical Energy.—The "Daily Mail" states that Mr. H. Lacy, of Birmingham, has perfected an invention for abolishing resistances. The invention is designed to save "waste" of current and applies equally to motors for every class of work. Satisfactory tests are said to have led to its adoption throughout the Carlton and Ritz Hotels.

Electric Light and Power Plants in the Far East.—We have received from the Engineering Society of Siam a copy of a list of electric light and power plants in the East in 1907, which gives some details of electricity supply works in China, Japan, Siam, Straits Settlements, &c.

Electricity in Mining.—Messrs. Bolckow, Vaughan & Co. have recently had electric lighting and power plants installed at their collieries in South Durham.

At the Binchester, Auckland Park and Newfield collieries three power stations have been equipped by the Electrical Co. Each group of pits has its own generating station, at which steam at 150 lb. pressure is obtained from boilers fired with coke oven gas. The three stations contain seven 200 kw. Willans-A.E.G. generating sets. The three-phase generators are for an output of 200 kw. at 2,400 volts at 60 cycles. Three sets have been installed at Auckland Park, two at Newfield and two at Binchester.

Exhibition.—A municipal electrical exhibition will be held at Colchester Skating Rink during the week commencing Oct. 20. Further particulars from the Borough Electrical Engineer.

Explosions in Electricity Culverts —As stated in our issue of the 2nd inst., the city electrical engineer of Aberdeen (Mr. J. Alex. Bell) has prepared a report for the Gas and Electric Lighting committee of the Corporation on the recent explosions in electricity culverts which occurred in that city.

The report states that on May 21 last an explosion occurred in the copper strip culverts in the east end of Union-street. Two manhole lids were blown up, and 8 yds. of pavement between the two manholes were lifted, the flagstones being raised from 5 in. to 6 in. on one side; the two manhole covers were thrown up into the air and both broken, and a section of one, falling on the copper strip, caused four or five short-circuits, resulting in some minor explosions. The main explosion, in Mr. Bell's opinion, was due to a service cable falling in on an end box and igniting the coal gas in the culvert. There was gas present in the culverts, and the gas department found a leak. The electricity department keep four men constantly at work examining culverts and manholes, and the section in which the explosion occurred was inspected on April 20, and the opposite culvert on May 2. No traces of gas were found on either of those dates. Since Jan. 1, 1905, 51 cases of gas leaks were reported by the Electricity department to the gas department. The section damaged had pipes leading in at either end, it being an isolated section of culvert, and on carrying out repairs Mr. Bell took the opportunity of laying cable and filling in the culvert solid. As far back as 1895, in view of some explosions which occurred in other towns in connection with their electric-lighting installations, the Aberdeen Council consulted Sir Alex. Kennedy, who advised that efficient provision should be made to prevent escape of gas from the gas mains. The first explosion in culverts in Aberdeen of which they had any record was on Feb. 15, 1897, which was admitted to be caused by gas. Explosions occurred at various intervals up to the autumn of 1903. In many cases after these explosions there were distinct traces of coal gas in the culverts, and that was most marked when the effects of the explosion were of a severe nature. The remedies taken at that time were to advise the gas department where gas was traceable and the periodical examination of the culverts. In short, up to that period the opinion was held that a fault in the cable or the blowing of a fuse was the cause of a spark, and that, owing to the presence of coal or sewer gas in the culverts, explosions resulted.

In the autumn of 1903 explosions occurred at much shorter intervals, and in fact were of such a nature as to necessitate immediate investigation with a view to their prevention. With those latter explosions it was found that a portion of the electric mains or service cable in the manhole concerned was burned out at the time of the explosion, and the presence of coal gas was not traceable in every case. To investigate the matter thoroughly a culvert with boxes similar to those used in the streets was built in the electricity works yard and a series of tests carried out. The convener and the gas engineer were present at most of these tests, and Dr. Matthew Hay interested himself in the matter. In carrying out these tests in the first place a service cable was built into the manhole and intentionally short-circuited—that is to say, a fault was put on it similar to what might occur in practice, and then the full-pressure current applied, the result being that the cable was immediately burned out and the manhole cover lifted. This at once showed that it was possible for an explosion to occur without the presence of coal or other explosive gas. The next step taken was to prove whether any explosive gas was generated from the insulating material by the intense heat of the fault, and it was found on experiment that a piece of bare copper wire—if short-circuited in the culvert—would create the same explosion, provided electrical energy sufficiently powerful were applied. Those experiments tended to show that the explosions were in many cases brought about by the sudden heating and consequent expansion of the air in the manhole or culvert.

Experiments were next carried out with ventilated covers, but it was found that a 6 in. square hole cut in a manhole cover 26 in. by 24 in. was not sufficient to make any appreciable difference in the height to which

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the cover was lifted. Culverts similar to those in use in Aberdeen have in some towns been ventilated by means of fans, and where a continuous line of culvert is available this method is in some respects satisfactory. Union-street culverts, however, were divided up into 24 different sections, having pipes, more or less filled with cables, connecting same. That method of ventilation was therefore impracticable. Experiments were made also with covers bolted down, but that was not found to be satisfactory.

As most of the explosions in 1903 were caused by the failure of a certain type of end connection on service cables—the failure being found to be due to moisture in the culverts attacking the insulation of the cables—a new form of end box was designed to minimise that trouble as far as possible, and some 509 service cables laid into consumers' premises from culverts were altered at considerable expense. There could be no doubt that that alteration had the desired effect, as for well over 12 months after that improvement was made there was not a single case of a manhole explosion brought about by a cable fault.

To sum up the results of the experiments made and the experience gained by the explosions investigated it was demonstrated first that if a cable failure occurred in a manhole, and sufficiently heavy current were available behind it, the box lid would be lifted by the sudden heating and expansion of the air; secondly, if there were any sewer or coal gas present in the box, the explosion would be very much more serious. The system of laying electricity supply mains in the city from 1894 to 1896 was that known as bare copper strip drawn into concrete culverts. At present those culverts were laid in 13 streets, and four had culverts under both foot pavements. In all there were 3¼ miles of culverts. Radical alterations in supporting and insulating the copper strip and cables in those culverts had been made three times in the last eight years at considerable expense, and he (Mr. Bell) was unable to suggest anything that would remove the chances of explosion, short of doing away entirely with that type of distribution. It did not appear practicable to prevent coal gas leaking into the culverts from time to time. An interesting fact, Dr. Hay advised them, was that coal gas might, by filtering through a sufficient thickness of earth, lose its odorous constituents and become quite odourless, but would continue to retain its explosive elements. Even if it were possible to exclude gas from the culverts, there was still the danger of a box lid being lifted by the sudden expansion of air caused by the heat from a cable fault.

Mr. BELL therefore recommended that the committee authorise him to replace the existing copper strip culverts by cables laid on the solid system, and that all important manholes on cable work be replaced by section boxes placed above ground. In carrying out the work he proposed to lay a distributing cable on the inside of the existing culverts, tapping on consumers as the work proceeded, then to lift the pavement over the culverts and remove road boxes and lay the feeder cables on the solid system inside the concrete culverts, filling in solid with earth before replacing the foot pavement. In the estimate of net cost of the work (£8,910), Mr. Bell allows for increasing the capacity of distributors and feeders to meet future requirements. Due allowance is made in the estimate for metal, &c., recoverable.

As stated in our issue of the 9th inst. the Council have adopted Mr. Bell's recommendations.

Gold Coast.—The number of subscribers connected with the telephone exchanges at Accra, Cape Coast, Sekondi and Tarkwa total 104, of which 59 are Government offices.

Government Contracts and Fair Wages.—The Treasury have appointed a committee to consider the working of the Fair Wages Resolution of the House of Commons of 1891, as embodied in Government contracts, and to report whether any administrative changes are desirable.

The members of the committee are Sir G. H. Murray, K.C.B. (chairman), Mr. H. D. de la Bere, C.B., Mr. A. Wilson Fox, C.B., Mr. A. F. King, Mr. F. W. Black, Mr. R. Bailey, M.V.O., and Mr. J. B. Westcott, M.V.O. Mr. J. J. Wills, of the Labour Department of the Board of Trade, will act as secretary.

Havre.—A considerable extension and improvement of the docks at Havre is under construction, and is expected to be completed in 1909. On the south bank of the Canal de Tankarville a new quay will be available for shipping. The mechanical equipment to be provided includes 18 electric cranes. Further extensions, with additional cranes, will have to be made later to provide suitable loading and unloading facilities for the huge vessels which use the docks at Havre.

Last year a special electric tramway service was established at Havre to substitute the old horse omnibus service between the L. & S. W. Co.'s quay and the railway station for Paris. The new service is very popular and is well patronised.

Hetton (Durham).—The Council have decided to make an experiment in street electric lighting and two thoroughfares are to be lighted by incandescent electric lamps at 27s. per lamp per annum.

Hornchurch (Essex).—A committee is considering an electric lighting scheme submitted by Mr. G. A. Browning.

Inquest.—An inquest was held last week into the death of a chargeman, named Allan, in the Bothal Yard Seam at Ashington (co. Durham).

While tending an electric pump deceased found a cable hanging from the roof. He lifted the cable and immediately shouted. A fellow workman went to his assistance, and when Allan was loosed from the cable he fell. Mr. Thomas McKie, electrical engineer at Ashington Colliery, said the cable had been examined by eye. Since the accident he had examined it, and found the insulation damaged. He thought it could only have occurred by the electric current leaking from one core of the three-core cable. The indicator in the power station showed no signs of leakage at the time. The outside covering of the cable was burnt for 1½ in. The jury returned a verdict that deceased was accidentally electrocuted.

Japan.—An instructive report on the trade of Japan in 1906 has been prepared by Mr. Harrington, Acting Commercial Attaché to the British Embassy at Tokio.

Under the heading of Instruments, Tools, Machinery, &c., it appears that there was a decrease of £107,000 in the value of imported electric motors, and of a considerable amount in regard to electric lighting apparatus. The total value of telegraph and telephone apparatus imported in 1906 was £11,713. It is estimated that about 25 per cent. of the electric motors imported into Japan, representing a total value of £143,765. came from the United Kingdom, more than half the supply being of United States manufacture. Telegraph wire stands for £116,170; £86,290 came from Germany, £22,550 from the United States and only £2,790 from Great Britain.

The paid-up capital of joint-stock companies in Japan represents a total of £84,608,000, and companies engaged in electric lamp making stand for £1,410,000. Electric lighting apparatus imports were valued at £50,610, a falling off of about £14,000 compared with 1905. About 25 per cent. also of this trade is British. The imports of electric vehicles and parts thereof stand for £31,212, a falling off of £23,000 compared with 1905. Nearly the whole of these imports are American. Electric light wires and cables represent a total of £84,969, an increase of £7,240 over the previous year, these supplies coming from Great Britain and America, the former being accredited with £46,798. Electric lamps, of German and American manufacture, stand for £24,247, an increase of nearly £10,000 over 1905.

In a report on the trade of Nagasaki for 1906 Mr. Consul Playfair gives particulars of extensions to the shipbuilding works and yards of the Mitsu Bishi Dockyard Co. Two turbine shops have been erected in these works and have been equipped with one 50 and one 30 ton electric overhead travelling cranes, and the erecting and fitting shops have been provided with electric overhead travelling cranes of 5, 10, 20 and 50 ton capacity. In the old boiler shop a 40 ton electric crane is erected, this being an addition to a similar crane previously in use, and in two new boiler shops a 7 and a 40 ton crane electrically driven have been put in. The company's electric power station at Akunoura has been enlarged and provided with two 500 kw. alternators, direct-coupled to Parsons turbines, and one 300 kw. d.c. dynamo coupled to a three-phase induction motor. Seven Babcock & Wilcox boilers have been added to the boiler shed, and a quantity of electrically driven tools are included in the general equipment of the works, which, at Dec. 31 last, employed nearly 9,000 workmen. The plant and tools for the turbine shops are stated to have been supplied from Great Britain, the source of supply of the remaining machines, &c., not being stated.

The imports into Nagasaki for 1906 included electric light wires and cables to the value of £9,054, compared with nil in 1905.

Municipal Telephony.—The annual accounts of Portsmouth municipal telephone department were approved by the Council last week.

The chairman of the Telephone committee (Councillor DITTMAN) moved the approval of the accounts and said that the average cost of a telephone (limited and unlimited) was about £4. 10s. 6d.

Councillor BOLITHO said he looked upon the balance sheet with misgivings. The profit was £1,800 last year, but it was reduced to £225 this. Other municipal undertakings had considered that it was necessary that a reserve should be created. At the end of last year the Telephone committee's reserve was £1,900, but the fund had been reduced to £1,557. He believed that the cables would not last 30 years, as they had been laid in a cheap and nasty fashion. The switchboard would also have to be renewed in about six years, and there would be no money for the work. The rate fixed for subscribers was far too low. At the end of 10 years their system would be half worn out. He proposed that the accounts and balance sheet be referred to the Finance committee for consideration and report. He denied that the profits stated had been earned.

The amendment having been negatived the accounts were approved.

Personal.—Mr. T. W. Stratford-Andrews, managing director of the Indo-European Telegraph Co. (Ltd.) has been presented by the Czar with a gold cigarette case, with the Imperial initials set in jewels, in recognition of the services rendered to the Russian Government in connection with the telegraph service between this country and South Russia.

Presentations.—Nottingham tramway employés have presented a gold watch, and the inspectors and office staff a gold chain, to chief motor inspector Griffiths, who is leaving for the Isle of Man. Mrs. Griffiths received a gold and diamond brooch.

Mr. J. A. Crowther, engineer and manager of the Wallasey electricity works, has been presented by the employés with a photograph of himself and the staff and a gold and pearl breast pin, as a token of esteem.

Provisional Order Transfer.—Ossett Corporation give notice of intention to transfer their powers, obligations, &c, under their 1898 electric lighting order to the Electrical Distribution of Yorkshire (Ltd.) for £600, plus 5 per cent. on amount annually received

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for current for tramways in the borough. The Corporation may purchase the undertaking at the end of 21, 35 or 42 years.

Radcliffe (Lancs.)—Application has been made for sanction to borrow £13,000 for extensions of the electricity undertaking.

Railway Signalling in India.—Mr. J. E. Neale, chief telegraph superintendent to the G.I.P. Railway Co., is to receive a bonus of R4,500 (£300) in recognition of the value of his voucher block instrument which is in use at 65 of the company's 264 stations. There are also 76 stations on the East Indian Railway fitted with the instrument.

The South Indian Railway Co. have given their resident engineer (Mr. R. H. Martin) permission to apply for patents in respect of an electric interlocking system and an electric bell for use in locomotives.

Rawtenstall.—The Council have decided to increase the amount to be spent on electricity supply from £29,000 to £39,000.

Recent Wills.—The will of the late Mr. W. P. Page, a director of the Brompton & Kensington and the Chelsea Electricity Supply and the Urban Electric Supply Companies, has been proved. The gross value of the estate is returned at £59,506, and the net at £56,357.

Sir Spencer Walpole, K.C.B., formerly Secretary to the Post Office, and subsequently chairman of the Pacific Cable Board, left £16,906.

Sierra Leone.—A scheme is under consideration for the establishment of a telephone exchange at Freetown.

Spain.—The "Madrid Gazette" for Aug. 15 contains copy of a decree granting a concession for the construction of an electric tramway in San Sebastián to the Compañia del Tranvía de San Sebastian. The "Gazette" may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

Swinton and Pendlebury.—The Lancashire Electric Power Co., who are supplying electricity in bulk to the Council, are issuing circulars in the district drawing attention to the many advantages of electricity for power and lighting.

The arrangements of the Council for giving a supply of electricity are making rapid progress. The sub-station has been equipped and a portion of the distributing network has been laid, and it is expected that supply will be available in a few days. Tenders are being invited for wiring the public buildings.

Telegraph Strike in America.—The strike of telegraph operators in the United States, referred to in our last issue, continues, and there does not at present seem to be a prospect of settlement.

Wakefield.—An unopposed inquiry has been held into the application of the Corporation for sanction to a loan of £7,250 for extensions of the electricity works.

Workhouse Lighting.—Stepney (London) Guardians have received a report from Mr. W. H. Trentham on the electric lighting of the workhouse, and the Council have submitted terms for the supply of current for lighting and power for the workhouse. The subject will be dealt with by a special committee.

Municipal Tramways Amateur Football League.—A meeting of the committee of this League was held at the Manchester Tramway Offices on 15th inst., Mr. C. W. Mallins, A.I.E.E., hon. president, in the chair. There were also present representatives of the following municipal tramways football clubs: Manchester, Sheffield, Oldham, Liverpool, Leeds, Birmingham, Salford, Bradford and Wallasey.

The application of the last five clubs to join the competition was unanimously agreed to. The committee decided to run the competition on Association Cup lines during the forthcoming season, and adopted new rules. The draw resulted as follows: Bradford v. Oldham, Birmingham v. Liverpool, Manchester v. Wallasey, Leeds v. Bradford or Oldham, and Sheffield v. Salford. The matches are to be played on the ground of the first-named club. Bradford and Oldham are to play their tie during September; the first round is to be completed by Oct. 31, the second by Dec. 25, and the final is to be played about March next. The trophy, which was won the first year by the Sheffield club, the second year by Manchester, and last season by Liverpool, consists of a shield 4 ft. high, mounted on a solid oak base.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Batley.—The electricity department accounts for the past year show capital expenditure £42,077, increase £1,128.

Revenue was £5,711. Total expenditure was £2,968 and gross profit £2,742. Interest required £1,398, and sinking fund £850, leaving a net profit of £494. 882,252 units were generated (compared with 730,773 in the previous year). 44,500 units as (in 1905-6) were supplied to public lamps, 174,082 (154,810) to private consumers by meter and 514,854 (393,589) by contract. The total maximum demand was 350 kw. (as in previous year) for traction and the equivalent of 15,725 (13,680) 8 c.p. lamps for lighting and power.

Glasgow.—On Thursday last the Corporation approved the past year's accounts of the electricity department.

The convener (Coun. Stewart) said the year had been one of steady progress. The revenue had increased by £29,000 and the expenses by £14,819, the latter being due in part to increased outlay on fuel and wages, rates and taxes, &c. The capital expenditure was increasing and was bound to increase, because it was necessary they should provide for the growing demands for light and power. There were 3,302 motors (of 8,000 H.P.) connected, an increase of 707 motors. There were 15,497 customers for light and power, an increase of 1,792. The committee were unable to offer any reduction in the charges.

Gravesend.—The gross profit on the past year's working of the electricity works was £4,030, and the net profit £245. The capital expenditure is £66,000.

Morecambe.—The accounts of the electricity department for the past year show a deficit of £1,784.

Portsmouth.—The accounts of the electricity department (abstracted in our last issue) were approved by the Council last week.

The chairman of the Electric Lighting committee (Coun. F. G. Foster) said that it was proposed to appropriate the profit (£10,853. 5s. 11d.) as follows: Insurance fund £1,000, reserve £5,991. 5s. 11d., urban sanitary authority (in aid of the general district rate) £3,500, revenue contribution to capital outlay £362. He also moved the adoption of the revised scale of charges for electric current, and said there were a number of large firms and institutions where it might pay to put down private plants for electric lighting, and it was to keep these as customers that the revised charges were made. While, however, the big consumers were given the benefit of the years of prosperity of the undertaking, it had been decided that all consumers should benefit, and therefore meter rents would be abolished. That would entail a loss of revenue of £981. 12s. 6d. In future a minimum charge of 7s. 6d. per quarter is to be made instead of 5s. for any amount of energy supplied up to 20 units.

TRADE NOTES AND NOTICES.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

TENDERS INVITED.

The *Metropolitan Asylums Board* invite tenders for alterations and additions to the fire alarm and telephone system at the Gore Farm Hospitals (near Dartford, Kent), in accordance with drawings and specifications prepared by the engineer-in-chief (Mr. W. T. Hatch, M.Inst.C.E.). Drawings, specifications and forms of tender may be inspected and obtained at the offices of the Board, Embankment, London, E.C., where tenders must be delivered by 10 a.m. Sept. 4. See also an advertisement.

Torquay Electric Lighting committee invite tenders for the supply of 1,500 to 2,500 tons of smokeless thro' steam coal. Specifications, &c., from the town clerk (Mr. Frederick S. Hex), Town Hall, Torquay, to whom tenders by noon Sept. 3. See also an advertisement.

Dublin Lighting committee invite tenders for the supply of extra-high-pressure and low-pressure cables (*a*) delivered at their Fleet-street stores and (*b*) laid complete on site in Dublin. Specifications, &c., from the city electrical engineer (Mr. Mark Ruddle), Fleet-street, Dublin. Tenders to the chairman of the Lighting committee, 8, Cork-hill, Dublin, by Sept. 9. See also an advertisement.

The Joint Committee of Management of *Clonmel* (Ireland) District Lunatic Asylum are prepared to receive tenders for the following

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work in connection with the lighting of the asylum: Sec. 1, suction gas plant, gas engines and electric generators; sec. 2, accumulators, switchboard, underground mains, wiring and fittings; sec. 3, power-house building and foundation. Plans, &c., may be inspected (by appointment) at the asylum or at the offices of the consulting engineer, Mr. Louis J. Lawless, A.I.E.E., 27, Castlewood-avenue, Rathmines, Dublin, from whom conditions, forms of tender, &c., may be obtained. Tenders, addressed to the Resident Medical Superintendent, District Asylum, Clonmel, Ireland, by Sept. 7.

The *Postmaster-General* requires tenders by Sept. 9 for creosoting Norwegian, Swedish, Finland or Russian red fir telegraph poles. Forms from Mr. S. E. Hooley, Stores Department, G.P.O., 17-19, Bedford-street, London, W.C.

Swinton and Pendlebury Council want tenders by noon Sept. 5 for wiring the town hall (Pendlebury) and the Council offices and public baths (Swinton). Specifications from the clerk.

Hastings Corporation want tenders by noon Sept 17 for six months' supply of best Welsh smokeless coal for the electricity works. Forms from the Borough Electrical Engineer.

Finchley Council want tenders by noon Aug. 31, for supply and erection of surface condensing plant.

Specifications may be obtained at the Australian Commonwealth offices, 72, Victoria-street, London, S.W., for contracts for the supply of 11 sections of branching system metallic switchboard (tenders by Oct. 8), and 11 sections of common battery switchboard and 3,000 subscribers' telephones and other apparatus (tenders by Jan. 7) for the *Victorian Government*.

The Dirección General de Obras Publicas, *Madrid*, want tenders before Sept. 14, for the Oeste de Barcelona electric tramway concession, on terms more favourable to the Government than those presented by Don Manuel Crusat Decrey.

The Camara Municipal do Concelho de *Ovar* (Portugal) require tenders by Sept. 4 for supplying electricity for public and private lighting.

TENDERS RECEIVED AND ACCEPTED.

Salford Council have accepted the following tenders: W. H. Keys, Trinidad bitumen and bitumen compound; Baxendale & Co., arc lamp globes; British Insulated & Helsby Cables, house fuse boxes; British Westinghouse Co., special car accessories; Edison & Swan Co., gravity type ammeters.

Southend Corporation have placed a contract with Wm. Boby for one of his "Simplex" water softeners to deal with the feed water for the boilers at the electricity station, the water possessing troublesome impurities (principally of an alkaline nature) which caused scaling and corrosion.

Portsmouth Electric Lighting committee have accepted the tender of Aiton & Co. for steam, exhaust and water pipes, &c., at £3,004; that of the British Thomson-Houston Co. for a h.-t. switchboard at £850. 8s.; and that of the British Electric Transformer Co. for six transformers at £66 each.

The Mirrlees-Watson Co. have secured an order from Nobel's Explosives Co. (Stevenston) for a complete installation for the utilisation of exhaust steam from high-speed reciprocating engines. The installation will consist of a Rateau-Brown-Boveri turbo-generator with a barometric counter current jet condensing plant and cooling tower, with accessories.

Manchester Infirmary committee have accepted the tender of Higginbottom & Mannock for the supply of eight electric passenger elevators, six electric goods lifts and four hand hoists for the new infirmary.

Glasgow Corporation have accepted the tender of Richardsons, Westgarth & Co. for a 3,000 kw. steam turbine for the Pinkston power station.

Melbourne (Derbyshire) Council have accepted the tender of Mr. Underwood for supplying current to incandescent lamps for public lighting at 15s. per lamp per season, and £5 each for arc lamps.

Hampton Council have accepted the tender of the Horsfall Destructor Co. for a refuse destructor.

Bolton Electricity committee have accepted the tender of the British Westinghouse Co. for transformers and switchboards.

Maidstone Council have accepted the tender of Jones & Co. for the electric bell fitting work at the hospital.

Huddersfield Corporation have accepted the tender of E. Bould & Son for wiring the new schools at Greenhead Hall.

Condensing Plant.—The Mirrlees-Watson Co. has recently received the following orders: From the Lancashire Dynamo & Motor Co., one low level counter current jet condensing plant (duty 10,000 lb. steam per hour) for Huelva, Spain; from Fraser & Chalmers, for one surface condenser, duty 6,000 lb. steam per hour; and from Coatbridge & Airdrie Electric Supply Co., air and circulating pumps.

BUSINESS NOTICES.

The partnership between Messrs. Thos. L. Miller and Adrian Collins (practising in London at 61, Old Broad-street, E.C., under the style of Miller & Collins) has been terminated by mutual consent as from July 31. Messrs. T. L. Miller & Wilson, consulting engineers, 18, Westminster-chambers, 1, Crosshall-street, Liverpool, and 19, Brazennose-street, Manchester, have taken into partnership Mr. Henry Villiers Pegg, A.M.Inst.C.E., and have opened an office at 47-48, Scottish Temperance Insurance-buildings, Donegal-square, Belfast, where they will in future practise under the style of T. L. Miller, Wilson & Pegg.

The works and offices of Ferranti (Ltd.) will be closed from Friday evening, Aug. 30, to Monday morning, Sept. 9, a small staff being in attendance to deal with urgent correspondence.

BANKRUPTCIES, LIQUIDATIONS, &c

A receiving order has been made against C. M. Vere & Co., electrical engineers, 5, Park-parade, North Finchley, Middlesex.

W. A. Roderick, electrical engineer, 12, Penmaen-street, Swansea, (late of 25, Adare-street, Bridgend) has been adjudicated bankrupt.

A first and final dividend of 3s. is payable at Bankruptcy-buildings, London, W.C., in the bankruptcy of Geo. M. Sellick, electrical accessories manufacturer, 464, Romford-road, London, E.

The trustee (Mr. E. W. J. Savill, 4, Pavilion-buildings, Brighton) in the bankruptcy of R. O. Thompson, electrical engineer, 30A, Dorset-gardens, Brighton, has been released.

The York Electrical Co. (Ltd.) is being wound up voluntarily. Mr. C. A. Rymer, Yorkshire Bank-chambers, York, is liquidator.

A meeting will be held at 9, Charles-street, Bradford, on Sept. 25 to receive an account of the winding-up of the Dewsbury Electric Mfg. Co. (Ltd.).

Sale by Auction.—Messrs. Fuller, Horsey, Sons & Cassell have been instructed to sell by auction in lots (unless previously sold privately as a whole) at the Paragon Motor Works (Ltd.), London-road, King's Lynn, on Tuesday, Aug. 27, at 11 a.m., the entire contents of the works, comprising nearly new machine tools by best American and English makers, four electric motors and dynamos, electrical installation, shafting and belting, motor components and finished parts, a general assortment of stock, stores, &c. Catalogues at the works; of Mr. Johnson M. Woodman, C.A., 95, Gresham-street, E.C.; Messrs. Ford, Lloyd & Co., solicitors, 38, Bloomsbury-square, W.C., and of the auctioneers, 11, Billiter-square, London, E.C. Further particulars are given in an advertisement.

Plant for Sale.—Mr. A. Underwood, 3, Queen-street, London, E.C., advertises for sale two Crossley gas engines (70 B.H.P. to 105 I.H.P.), two Crompton compound dynamos, belts, pipes, tanks, battery of 132 cells, &c.

Messrs. Mottershead & Co, 7, Exchange-street, Manchester, advertise for sale an E.C.C. booster.

Agents Wanted.—The directors of the Bastian Meter Co. (Ltd.), invite applications from responsible firms willing to act as agents in defined districts throughout the United Kingdom. Communications to the chairman of the company, Bartholomew Works, Kentish Town, London, N.W. See an advertisement.

An old-established and well-known German firm of manufacturing electric motors and dynamos, transformers and electric cranes advertises that it is open to entertain proposals from firms with large connections throughout England and colonies with a view to representation.

Factory Site for Sale.—An advertisement contains particulars of a convenient site for engineering works, &c., which is for sale; two hours from London on G.E.R. main line.

Motor Wanted.—A good second-hand 100 H.P. motor (for 460 volts d.c.) is required. See advertisement.

Prevention of Corruption Act.—We have received from Messrs. Stevens & Sons a pamphlet entitled "An Exposition of the Prevention of Corruption Act, 1906," by Mr. C. E. Brackenbury. The author gives some particulars of the legal position prior to the passing of the Act and deals briefly with the attempts made to influence public opinion against certain corrupt commissions and payments. The text of the act, which is next given, is accompanied by some explanatory notes by the author. The pamphlet should prove useful to business and commercial men. Price 1s.

Patents and Designs Bill.—We have received from Messrs. Stevens & Sons a copy of a pamphlet written by Messrs. E. Lunge and Bernhard Dukes on this bill. The authors display a close acquaintance not only with the law relating to patents in this country, but also with the law and practice of the United States and Germany. We have ourselves freely criticised Mr. Lloyd-George's measure and we consider that many of the objections of Messrs. Lunge and Dukes to the provisions of the new bill are fully justified. It is true that since the present pamphlet was printed some

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of the objections have been met by amendments introduced in the report stage, but the whole bill displays hasty draftsmanship, and certainly some of the amendments introduced in the House of Commons do not improve it. We hope, therefore, that when it reaches the Committee stage in the House of Lords the whole of the clauses will be carefully considered and revised. Messrs. Lunge and Duke's pamphlet is published at 1s.

CATALOGUES, &c.

Wooden Poles.—A handsome and instructive publication on the subject of creosoted wood poles for electric power transmission and telegraph and telephone work has been prepared by Richard Wade, Sons & Co., of Hull, and is now obtainable. Our readers will recall the interesting paper on this subject recently read by Mr. C. Wade before the Institution of Electrical Engineers, and the catalogue now available will serve to make the subject even more interesting. The photo illustrations are upon a large scale, clearly bringing up the particular subject depicted, and the line drawings are clearly reproduced. Messrs. Wade have specialised for so many years in this class of work that this publication will doubtless be regarded by electrical engineers, and particularly by those engaged with high voltage overhead transmission lines, as an authoritative statement of the problems involved in supporting these lines and the most efficient methods to be adopted for solving such problems.

Oils for Electrical Uses.—A pamphlet is issued by the Silvertown Oil-Storage Co. setting out the advantages of their insulating oils for transformers, switches, &c., in rather a novel manner. A curve is given which shows the relation between the spark gap and the breaking down voltage. The company manufactures oils for all lubricating purposes and refine all their oils in London. The selling agents are Messrs. H. R. Witting and W. W. White, Temple Bar House, Fleet-street, E.C.

Resistance Units.—Two leaflets (27 and 28) published by Kramos Limited give particulars and prices of steel tube resistance units and small enclosed reversible controllers. A pamphlet also to hand describes electric pulley block specialities of the same firm.

Motors.—A mammoth card, holed for hanging, is sent out by Wright & Wood, of Halifax, dealing with their special slow-speed continuous-current protected-type motors. Prices and particulars are given of machines from ½ to 30 B.H.P.

Aluminium.—A budget of pamphlets and other literature reaches us from the British Aluminium Co., 108, Queen Victoria-street, London, E.C. One of these (Pamphlet L) shows specimen joints in aluminium conductors, these being made without solder or flux. Another list contains particulars of aluminium conductors, and a table is supplied of a number of users of aluminium wires for electric-power transmission in America The information supplied is generally of an interesting character.

Wires and Cables.—There is ample scope for an effective and attractive display on the front cover of a catalogue, and the Armorduct Mfg. Co. utilises this to the full in its latest list of "Armorduct" wires and cables.

House Switches.—The "Vee" type house-service switch and "Fin-Grip" and "Plume" fuses are described in publication No. 564, now being distributed by Verity's Limited.

Plummer Blocks.—The Sheffield Engineers (Ltd.). Cambridge-street, Sheffield, publish a leaflet describing "Sheffield" plummer blocks with cast-iron swivel bearings for shafting.

Electric Fans.—Although the season is well advanced publications on electric fans continue to come in. The latest is from Baxendale & Co., Miller-street, Manchester. This list is accompanied by some loose leaflets on bell wires and accessories.

Photometers.—A circular price list issued by Mr. Lancelot W. Wild, of York-mansions, York-street, Westminster, S.W., deals with the Wild flicker photometer, for which many advantages are claimed and described. There are many readers of *The Electrician* who will be particularly interested in this circular, which can be obtained on application.

Aluminium Solder.— Messrs. T. W. Young, 220, Old-street, London, E.C., are introducing an aluminium solder, the chief claim for which is that it is effective. There are only two agents needed for making repairs—viz., flux and solder—the soldering bit being such as is used by tinsmiths. Messrs. Young will supply all necessary particulars on application.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Aug. 14 to 20, with the ports of destination:—

Aden, £20. *Africa*—Alexandria, £57; Beira, £62; Cape Town, £1,707 (including £1,376 telegraph material); Durban, £939 (including £114 telegraph material); East London, £26; Kilindini, £33; Port Elizabeth, £648 (including £23 telegraph material); Port Said, £18; Suez, £40 (telegraph material). *Argentina*—Buenos Ayres, £650. *Australasia*—Auckland, £454; Invercargill, £10; Launceston, £100; Lyttelton, £454; Melbourne, £3,537; Otago, £486; Perth, £177; Sydney, £769; Wellington, £45 (including £16 telegraph material). *Austria*—Trieste, £25. *Belgium*—Antwerp, £10; Ostend, £109. *Brazil*—Rio Janeiro, £77. *British Guiana*—Demerara, £46. *Burma*—Rangoon, £126. *Canada*—Halifax, £48; Toronto, £788. *Ceylon*—Colombo, £220. *China*—Foochow, £134; Hankow, £173; Shanghai, £1,389 (including £157 telegraph material); Tientsin, £44. *Germany*—Bremen, £1,191; Cologne, £359; Hamburg, £644. *Gibraltar*, £46 (telegraph material). *Holland*—Amsterdam, £296; Rotterdam, £1,240. *Hong Kong*, £628. *India*—Bombay, £1,006; Calcutta, £2,538; Madras. £115. *Japan*—Kobe, £721; Yokohama, £667 (telegraph material); *Malta*, £325. *Norway*—Christiania, £426 *Portugal*—Oporto, £58. *Russia*—St. Petersburg, £22. *Siam*—Bangkok, £796. *Spain*—Bilbao, £45; Grenada, £14. *Straits Settlements*—Penang, £273 (including £12 telegraph material); Singapore, £240. *Sweden*—Stockholm, £11. *Uruguay*—Monte Video, £1,903; (including £18 telegraph material). *U.S.A.*—Boston, £22. *West Indies*—Barbadoes, £174; Dominica, £10; Zanzibar, £17 (telegraph material). Total £24,223, against £47,130 in the corresponding week last year (Aug. 15 to 21).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are now open to public inspection until after acceptance of Complete Specifications Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

May 27, 1907.

12,177 KÖNIG. Telemeters with separating prism system.
12,188 LISTER, LEATH, MORGAN & HARRIS. Obtaining, collecting and indexing electrical energy supplies from continuous-current dynamos and motors at various voltages.
12,198 WIESENGRUND. Electric switches.
12,217 MARCONI'S WIRELESS TELEGRAPH CO. & PRENTICE. Measuring the logarithmic decrement of high-frequency electric circuits.
12,220 JOHNSON. (Badische Anilin & Soda Fabrik, Germany.) Production and employment of electric currents.
12,223 GIRDLESTONE & THORKELIN. Electric arc lamps.*
12,238 B.T.-H. Co. (Allgemeine Elektricitäts-Ges., Germany.) Systems for electrically operating signals and points.
12,243 LEITNER. Dynamo electric machines.
12,244 & 12,245 LEITNER. Electric train lighting.
12,250 BUTLER. Connection with electric switches.
12,253 BECK & DEUTSCHE BECK-BOGENLAMPEN-G.M.B.H. Alternating-current electromagnet.*
12,260 RHODE. Lamp for electric or gas light or both together. (Date applied for, 25/5/06.)*†

May 28, 1907.

12,315 MUSGER. Electric wall lamp.
12,321 KELLY. Electric locomotives.
12,322 BOULT. (Rolfe, N.S.W.) Automatic thermo-mercury switch for making and breaking electric circuits.
12,324 HOOKER & NORTHY. Starting or stopping electric motors.
12,336 ACKROYD & BEST. Miners' safety lamps.
12,342 BURRY. Printing telegraph receivers.*
12,353 AUSTIN. Receivers for wireless telegraphy. (Date applied for, 29/5/06.)*†
12,356 STEPANOW. Signalling by means of electric lights and apparatus therefor.*
12,368 LEHMANN. Electric amperemeters and voltmeters.
12,369 BRZISKI & STRAUSS-COLLIN. Arc lamps.
12,374 LAKE. (Hallock, U.S.) Electric generators.*
12,386 MAVOR, MAVOR & COULSON & BILES. Electrical propulsion of marine vessels.
12,389 YARNELL. Wireless transmission.*

May 29, 1907.

12,402 GRIFFIN. Mechanism for operating magneto machines.
12,407 GRANT. (Haggarty.) Ships' telegraphic and analogous apparatus.
12,411 ROUND & GILMAN. Joints of railway and tramway rails.
12,420 LANCASHIRE DYNAMO & MOTOR CO. & STANSFIELD. Dynamo-electric machinery.
12,430 STERN. Holders or sockets for incandescent lamps.
12,436 SCIPLE. Crossarms for carrying telegraph, telephone wires or ropes.*
12,443 RAWORTH & RAWORTH. Control of electric motors.*
12,458 VARNEY. Electric trolley line construction. (Date applied for, 4/6/06.)*†
12,462 PINCHING & WALTON. Sockets for electrical purposes.
12,484 B.T.-H. Co. (G.E. Co., U.S.) Electric transformers.

May 30, 1907.

12,489 CRAMP. Armature winding machine.
12,529 MAICHE. Telegraphic and telephonic communication. (Date applied for, 30/5/06.)*†
12,531 TURNER. Electric connectors or couplings.*
12,532 DEUTSCHE TELEPHONWERKE G.M.B.H. Contact spring for electrical apparatus. (Date applied for, 31/5/06.)*†
12,552 CONRAD & BRADSHAW. Measurement of electrical energy. (Date applied for, 4/6/06.)*†

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12,563 La Société Julien & Dessolle. Rendering electrolytic copper homogeneous. (Date applied for, 31/5/06.)*†
12,578 Heyland. Self-regulating electrical machines for alternating or direct current. (Date applied for, 30/5/06.)*†
12,581 Trillon & Société Electro-Chimique du Giffre. Electric furnaces. (Date applied for, 26/9/06.)*†
12,584 Bleichert & Bleichert. Trolley cars for wire rope or suspension railway.*
12,588 Stave. Armatures.
12,593 B.T.-H. Co. (G.E. Co., U.S.) Electric transformers.

May 31, 1907.

10,091a Sutcliffe. Electric telegraph apparatus. (Date applied for, 1/5/07.)
12,632 Stewart. Switches for preventing excessive current on circuits in which a variable current flows.
12,633 and 12,634 Galletti. Producing electric oscillations. (Dates applied for, 29/1/07 and 9/3/07.)*†
12,635 and 12,636 Galletti. Wireless telegraphy. (Dates applied for, 29/12/06 and 24/1/07.)*†
12,659 Rivals. Electrically-controlled systems. (Date applied for, 1/6/06.)*†
12,664 Banks. Multiple switches.

June 1, 1907.

12,702 Rokes. Construction of containing cases for secondary cells.
12,709 Hirst & Gullette. Inter-communication telephone systems.
12,711 Davis. Electric conductors for use in connection with installations of electric light.*
12,712 Miller. Unidirectional current from spark coils.
12,747 Cowper-Coles. Electro-deposition of iron.

June 3, 1907.

12,761 Jankelowitz. Telephone transmitters and receivers.*
12,765 Soddy. Electric resistances and heaters.
12,788 Humphreys. Trolley poles of electric tramcars.
12,807 & 12,808 Oxley & Such ostawer. Electric traction on surface-contact system.
12,810 Tompkins. Trolleys or collectors for electric railways and tramways.
12,857 Tonry. Ball and socket joints for gas and electric light.

June 4, 1907.

13,782b/06 Leitner. Motor-generators. (Date applied for, 15/6/06.)
12,860 Rivers-Moore & Donald. Contactor commutator.
12,871 Gornall. Electrically heated vulcaniser.
12,902 Quint. Enclosed arc lamps.
12,907 Newitt. Electrical counter and indicating gear.
12,912 Winby. Means for securing rails and rail joints on railways or tramways.
12,913 Irving. Reciprocating electric motors.*
12,930 Russell & Jung. Automatic or self-acting fire alarms.
12,932 British Westinghouse Electric & Mfg. Co. (Westinghouse Electric & Mfg. Co., U.S.) Electrical transmission circuits.*
12,937 Felten & Guilleaume-Lahmeyerwerke Act.-Ges. Compensated alternate-current series motors. (Date applied for, 12/7/06.)*†
12,960 Marconi's Wireless Telegraph Co. & Franklin. Receiving apparatus for wireless telegraphy.
12,967 Robke & Robke. Switch for controlling electrical circuits.
12,968 Marconi's Wireless Telegraph Co. & Bangay. Holding electrical condensers and the like.*
12,973 B.T.-H. Co. (G.E. Co., U.S.) Brake leverage systems.

June 5, 1907.

12,993 Cooper. Steam turbines.
13,021 Woodhouse. Brush-holders and carriers for generators and motors.*
13,022 Mantell & Wolf. Induction coils.
13,028 Dibbin. Tramway points.
13,032 Eastwood. Systems for electric railways.*
13,035 Wolhaupter. Rail joints. (Date applied for, 12/7/06.)*†
13,044 Webb. Insulators for telegraph and telephone wires.

COMPLETE SPECIFICATIONS.

1907 Specifications

2,049 König. Electrical hair-curlers.
3,803 Féry & Langlet. Electric resistance furnaces. (Date applied for, 17/2/06.)
4,576 Rawson & Buchholtz Reversible Turbine Synd. Turbines.
6,515 Kronheim. Electric vehicle wheel.
7,011 Carter & Fletcher. Lifeguards for tramcars.
8,231 Kelley. Electro-thermostatic switches. (Date applied for, 19/4/06.)
9,355 Allgemeine Elektricitäts-Ges. Bearing for the upper end of the shaft of an electric motor meter. (Date applied for, 14/9/06.)

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

DUBLIN & CENTRAL IRELAND POWER SYND. (LTD.) (3,228)—Reg. in Dublin on Aug. 16, capital £10,000 in £1 shares, to carry on in the counties of Dublin and Kildare, in King's and Queen's counties and elsewhere, the business of an electric power and power-gas supply company in all its branches. First directors, E. J. Duff, A. E. Mills and J. Sturgeon. Reg. office, 7, Westmoreland-street, Dublin.

S. H HEYWOOD & CO. (LTD.) (94,580.)—Registered Aug. 13, capital £12,000 in £1 shares, to acquire the business of electrical, mechanical and hydraulic engineers carried on by S. H. Heywood & H. W. Heywood at Manchester and Reddish, and to carry on the same and the business of electricians, suppliers of electricity, manufacturers of electrical apparatus, &c. First directors, S. H. Heywood and H. W. Heywood Reg. office, Standard Works, Reddish, Lancashire.

PENMAN & CO. (LTD.)—Reg. in Edinburgh, capital £70,000 in £1 shares (35,000 preference), to acquire and carry on the business of boiler-makers, engineers, &c., carried on as Penman & Co. Reg. office, 64, Strathclyde-street, Dalmarnock-road, Glasgow.

G. A. STEINTHAL & BOYDELL (LTD.) (94,610.)—Registered Aug. 16, capital £5,000 in £1 shares (2,000 6 per cent. cumulative preference), to acquire the business of electrical engineers and contractors carried on by W. P. Steinthal at Bradford and Manchester as G. A. Steinthal, and to carry on same and the business of suppliers of electricity and electric installations, manufacturers of and dealers in electrical apparatus, &c. First directors: W. P. Steinthal and H. M. Boydell (man.) and J. H. Boydell. W. P. Steinthal is chairman.

STATUTORY RETURNS.

COUNTY OF NORTHAMPTON ELECTRIC POWER & TRACTION CO. (LTD.)—The capital in return to July 2 is £25,000 in 2,500 shares of £10 each, all of which have been taken up. £9. 12s. per share has been called up and £24,000 has been received. Mortgages and charges, nil.

LEWES & DISTRICT ELECTRIC SUPPLY CO. (LTD.)—In return to June 10 capital is £50,000 in 2,500 ordinary and 2,500 preference shares of £10 each, of which 2,327 ordinary have been taken up. £23,270 has been received. Mortgages and charges, nil.

LOUGHBOROUGH & DISTRICT ELECTRIC TRACTION SYND. (LTD.)—Return to June 5 gives capital as £1,000 in 100 shares of £10 each, all of which have been taken up and paid for in full. Mortgages and charges, nil.

TYER & CO. (LTD.)—Return to June 12 gives capital as £25,000 in £1 shares, of which 22,007 have been taken up. £1 per share has been called up on 2,007 and £2,000 has been received, leaving £7 in arrears. £20,000 is considered as paid on the remainder. Mortgages and charges, nil.

MORTGAGES AND CHARGES.

WALTER'S ELECTRICAL MFG. CO. (LTD.)—£2,000 5 per cent. debentures, created and dated July 31, 1907, charged on the company's property, present and future, except uncalled capital, have been registered. No trustees.

CITY NOTES.

MEMORANDA (Aug. 22).—Bank rate 4½ per cent. (since Aug. 15, 1907). Price of silver 31 $\frac{5}{16}$—31 $\frac{3}{8}$d. per oz. Consols 82—82⅛ for money, 82—82⅛ for account; 2½ per cent. annuities 80⅛—80⅜. Consols Pay Day, Sept. 2; Stocks and Shares Continuation Days, Aug. 27 and Sept. 11; Ticket Days, Aug. 28 and Sept. 12; Pay Days, Aug. 29 and Sept. 13; Mining Share Carry-over Day, Aug. 26.

BROWN, BOVERI & CO. (A. G., BADEN, SWITZERLAND).—The report for the year ended March states that the works have been fully occupied, but owing to increased cost of manufacture the ratio of profit has not been maintained. The report gives details of the working of the various subsidiary companies. The manufacture of steam turbine generating sets formed the most important branch of the company's output during the year. There was an increase in the number of dynamos, motors and transformers manufactured, and also in the aggregate value of foreign orders. The electrical working of the Simplon Tunnel has fully realised expectations. It is proposed to increase the company's capital from 16,000,000 fr. to 20,000,000 fr., to provide for extensions of the works and of the branches. A dividend of 11 per cent. has been declared, the same as in the previous year.

COMPANIES TO BE STRUCK OFF THE REGISTER.—The following will be removed from the Register of Joint Stock Companies unless cause is shown to the contrary before Nov. 20: Auto Steam Generator Synd., Bridge Accumulator Synd., Burnand Transformer Co., Crown Electric Heating Synd., Dudley Art Metal Co., Finchley Electric Light Co., Folkestone District Electric Light & Power Co., Medical Electro-Vibration Institute, Paddington Electric Supply Co., Rand Electric Synd., Thames Electric and Motor Boats, Vaughan, Brown & Co.

ELECTRIC LANDAULET CO. (LTD.)—The directors have declared an interim dividend for the first half of 1907 at the rate of 5 per cent.

HADFIELD'S STEEL FOUNDRY CO. (LTD.)—The directors have declared an interim dividend of 1s. per share.

HARDY PATENT PICK CO. (LTD.)—For the year ended June 30 the net profit was £16,258. After paying debenture interest and the 7 per cent. preference dividend, the directors have declared a dividend of 10 per cent. on the ordinary shares.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have appointed Sept. 5 a special settling day in a further issue of £616,425 deferred stock of the National Telephone Co. (Ltd.)

TYNESIDE TRAMWAYS AND TRAMROADS CO.—The report for the half-year ended June 30 shows a surplus of receipts over expenses of £4,476. The directors recommend a dividend at the rate of 2 per cent.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 14	1,661	+ 92	11	16,970	+ 44
Airdrie	,, 9	211	- 9	31	6,911	- 16
Anglo-Argentine	,, 19	16,078	+ 249	33	543,316	+ 54,602
Ashton-under-Lyne Corp	...	...	...	...	...	...
Ayr Corporation	,, 17	524	+ 31	14	5,639	- 190
Baker St. & Waterloo Ry.	,, 17	2,010	+ 727	7	16,540	+ 7,268
Barnsley	,, 9	201	+ 25	31	5,151	+ 31
Barrow	,, 9	418	- 21	31	7,964	- 102
Bath Electric Trams, Ltd.	,, 14	946	- 71	33	25,816	- 858
Birkenhead Corporation	,, 18	1,088	- 12	...	...	...
Birmingham Corporation	,, 17	5,928	...	20	120,519	...
Birmingham & Mid.	,, 2	817	...	30	...	...
Blackburn Corporation	,, 14	1,196	+ 168	¶20	25,854	+ 966
Blackpool Corporation	,, 15	3,318	+ 30	19	26,659	- 1,662
Blackpool and Fleetwood	,, 17	2,052	- 245	7	10,332	- 2,363
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 18	2,351	+ 88	20	46,711	+ 2,686
Bournemouth Corporation	,, 14	2,349	- 135	¶19	35,075	+ 416
Bradford Corporation	,, 17	4,837	+ 61	20	91,794	+ 295
Brighton Corporation	,, 18	1,155	- 195	20	19,582	- 2,254
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 16	5,154	+ 178	6	28,516	- 921
Burnley Corporation	,, 17	1,318	+ 51	20	23,716	+ 292
Burton Corporation	,, 18	318	- 34	20	6,015	- 337
Bury Corporation	,, 11	1,229	...	20	22,421	...
	,, 18	1,263	...			
Calcutta Tramways Co.	,, 17	R48,570	+ R3,842	6	R285,622	+ R23,954
Camborne-Redruth	,, 17	131	- 4	33	3,936	+ 47
Cardiff Corporation	,, 17	2,179	+ 25	20	45,202	+ 2,067
Cavehill	,, 9	104	- 30	31	2,693	+ 36
Central London Railway	,, 17	4,265	- 711	7	35,151	- 3,266
Charing C., Euston & H'stead	,, 17	2,320	...	7	18,095	...
Chatham & Dist. Lt. Rys.	,, 15	846	+ 118	‡33	23,518	+ 2,073
City & South London Rly.	,, 18	2,810	+ 410	7	21,566	† 4,481
City of Birmingham	,, 9	3,136	...	31	87,243	...
Colchester Corporation	,, 14	262	...	...	...	...
Cork Electric Trams Co.	,, 15	536	- 26	33	15,326	- 575
Croydon Corporation	,, 16	1,458	+ 11	20	29,261	- 1,738
Devonport & Dist. Trams	,, 9	568	- 65	31	14,267	- 133
Dover Corporation	,, 17	328	- 26	20	4,903	- 724
Dublin & Lucan Railway	,, 16	166	+ 19	7	1,074	+ 56
Dublin United	,, 16	7,605	+ 2,145	‡7	50,685	+ 12,233
Dudley Stourbridge	,, 9	1,653	+ 7	31	26,811	- 760
Dundee Corporation	,, 14	1,142	+ 65	13	14,938	+ 355
East Ham Council	,, 17	1,028	+ 151	20	18,793	- 265
Exeter Corporation	,, 16	371	+ 31	20	6,651	+ 582
Falkirk and District	,, 14	310	...	...	...	...
Gateshead & Dist. Trams	,, 9	1,163	+ 52	31	31,399	+ 732
Glasgow Corporation	,, 17	17,466	+ 692	11	192,497	+ 2,706
Glossop	,, 17	147	+ 2	33	4,492	+ 49
Gravesend—Northfleet	,, 9	394	- 21	31	7,584	- 36
Great Northern & City Rly.	,, 17	1,457	- 38	7	11,215	+ 138
Gt. Northern, Piccadilly, &c.	,, 17	3,405	...	7	27,905	...
Greenock & Port Glasgow	,, 9	676	- 118	31	20,745	- 236
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 9	469	- 7	31	8,956	- 533
Hastings Elec. Trams Co.	,, 15	1,783	+ 388	7	8,974	+ 2,675
Hong Kong	,, 17	$7,859	+ $426	19	$253,794	+ $34,946
Huddersfield	,, 17	1,839	+ 120	20	32,423	+ 1,329
Hull Corporation	,, 17	2,525	+ 240	20	48,136	+ 2,378
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 14	147	+ 8	20	2,913	+ 166
Ipswich Corporation	,, 17	535	- 4	20	8,637	- 777
Isle of Thanet Co.	,, 17	1,931	+ 112	46	23,422	- 568
Jarrow	,, 9	172	...	31	3,811	...
Keighley Corporation	,, 15	173	+ 21	7	1,135	+ 60
Kidderminster & District	,, 9	323	- 4	31	3,735	- 165
Kilmarnock Corporation	,, 17	155	+ 1	13	2,291	- 31
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 15	1,315	+ 417	33	37,791	+ 9,220
Lancashire United	,, 14	1,341	+ 316	33	40,803	+ 10,530
Leamington	,, 9	296	+ 2	31	4,937	- 737
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	,, 17	2,148	+ 79	7	16,445	- 265
Leith Corporation	,, 17	597	+ 15	‡14	7,634	+ 85
Lincoln Corporation	,, 17	122	+ 6	20	2,474	+ 63
Liverpool Overhead Rly.	,, 18	1,610	- 38	7	12,260	+ 971
Liverpool Corporation	,, 10	14,802	+ 2,392	32	348,646	+ 7,042
*London County Council	,, 10	34,259	+ 5,271	19	595,647	+ 91,850
London United	,, 16	7,834	+ 1,031	‡33	211,685	+ 6,419
Lowestoft	,, 17	484	+ 24	46	8,644	+ 932
Maidstone Corporation	,, 17	112	- 16	20	2,275	- 123
Manchester Corporation	,, 17	15,489	+ 1,809	20	297,837	+ 23,537
Mersey Railway	,, 17	1,783	+ 110	7	12,869	+ 1,076
Merthyr	,, 9	282	+ 14	31	6,533	+ 323
Metropolitan Dist. Railway	,, 18	6,564	+ 46	7	52,209	+ 327
Metropolitan Elec. Trams	,, 9	6,781	+ 1,730	31	141,380	+ 30,855
Middleton	,, 9	427	- 56	31	10,186	- 252
Nelson Corporation	,, 17	168	+ 14	21	3,106	+ 56
Newcastle-on-Tyne Corp.	,, 17	3,909	+ 88	20	83,439	+ 537
Newport (Mon.)	,, 17	686	+ 38	20	14,653	+ 1,614
Northampton Corporation	,, 16	455	+ 2	‡20	8,953	- 427
Oldham, Ashton & Hyde	,, 9	667	+ 29	31	18,749	+ 255
Oldham Corporation	,, 18	2,074	+ 163	21	41,048	+ 2,693
Perth (N.B.) Corporation	,, 14	178	+ 5	13	2,275	+ 32
Perth (W.A.) Elec. Trams	,, 16	1,293	- 22	33	46,902	- 1,565
Peterborough	,, 9	237	- 35	31	3,913	- 203
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 17	2,659	- 48	20	42,186	- 2,057
Potteries	,, 9	2,265	+ 93	31	58,754	+ 1,507
Preston Corporation	,, 14	946	+ 13	20	15,517	+ 149
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 15	639	+ 134	‡20	11,835	+ 1,767
Rothesay	,, 9	557	- 131	31	6,708	- 468
Salford Corporation	,, 19	4,900	+ 358	20	95,412	+ 2,170
Sheerness	,, 7	99	- 20	31	1,771	- 70
Sheffield Corporation	,, 18	5,615	+ 451	21	116,936	+ 5,245
Singapore Trams	,, 17	$9,593	+ $2,055	20	$191,033	+ $7,365
Southampton	...	...	...	...	...	...

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southend Corporation	Aug. 14	759	+ 2	20	8,574	- 362
South Metropolitan	,, 9	1,254	+ 458	31	24,282	+ 3,777
Southport Tramways	,, 9	556	- 22	31	9,206	- 555
South Staffs	,, 9	1,283	+ 89	31	28,016	+ 1,908
Stalyb'dge, Hyde, &c., Jt. Bd	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	...	...	...	...	...	...
Sunderland and District	,, 14	484	+ 62	33	14,800	+ 1,806
Swansea Trams	,, 9	1,493	+ 42	31	27,382	+ 959
Swindon Corporation	July 31	173	...	...	...	...
	Aug. 7	222	...			
Taunton	,, 9	65	- 3	31	1,337	- 90
Tynemouth and District	,, 9	617	- 2	31	7,552	- 739
Tyneside Trams Co.	,, 14	482	+ 55	33	15,286	+ 672
Victoria, Elec. Supply Co. of	...	...	...	...	...	...
Wallasey District Council	,, 17	983	+ 39	19	17,701	+ 423
Walsall Corporation	,, 17	552	+ 56	33	16,573	- 415
Warrington Corporation	,, 15	386	+ 22	20	7,596	+ 285
West Ham Corporation	,, 15	2,218	+ 73	20	47,893	+ 1,319
Weston-super-Mare	,, 7	619	- 63	31	3,906	- 488
Wolverhampton Co.	,, 9	741	+ 62	31	14,221	+ 769
Wolverhampton Corpn	,, 14	827	+ 12	4	3,655	+ 54
*Worcester	,, 9	503	- 20	31	8,729	- 267
Wrexham	,, 9	148	- 19	31	3,175	- 54
Yorkshire W.R. Trams	,, 18	1,331	+ 472	33	37,860	...
Yorkshire Woollen District	,, 9	1,081	+ 33	31	29,975	+ 1,371

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., Aug. 21.	Rate % Yielded.	Dividend Due.	Business Week to Aug 21. High-est.	Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8¼—8⅜	4 15 6	Ap, Oct	8⅜	8⅛
5	2/9	Do. 5% per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	6⅜	6
St.	6%	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	131¼	131
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3⅛—3⅛	3 2 0	May	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅛—5⅛	4 14 0	My, Nv	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	97	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 —132	4 8 6	Mr, Spt	129	..
St.	5%	Do. Pref. Ord. Stock	110 —114	4 7 6	My, Nv	111½	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	103 —106	4 14 6	Ja, Jul	104	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 —102	4 8 0	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4⅛—4⅜	8 11 9	Ap, Oct	4⅜	4⅛
5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4⅜—5⅛	5 14 0	Ap, Oct	4⅛	..
5	3/0	Do. "B"	4⅜—5⅛	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 —97	5 8 0	Ja, Jul	..	..
10	5½%	Buenos Ayres Grand National 5% per Cent. Pref. Debs.	99 —103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	101 —105	5 14 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7⅛—8	5 0 0	Mr, Spt	7⅜	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 13 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —105	4 5 0	Ja, Jul	..	..
S	..	Cape Electric Tram Shares	5/16—7/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 —87	5 15 0	Fb, Aug	..	..
10	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
		Do. 6 per Cent. "B" Ditto	78 —82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1⅛—1⅛	3 15 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅛	4 10 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb.	95 — 98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 —103	4 7 6	Fb, Aug	..	..
St.	1%	Perth E. Trams. 1st Mt. Db. Stock	100 —104	4 16 0	Ja, Jul	..	..
..	8%	Sao Paulo Tramway, Light & Power Co. $100 Stock	111 —115	6 19 0	..	113	107
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92½—94½	5 6 8	Ju, Dec	93½	92⅝
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½ - 5½	5 14 0	Mr, Spt	4⅝	..
10	4/8	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅛—8⅛	5 16 6	..	7⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 —95	4 13 9	Ja, Jul	95¼	94⅛
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅞ - 7⅜	5 3 3	Ap, Oct	6⅞	..
		Do. (80,001 to 160,000)	6½ - 7⅛	..	..	6⅝	..
5	2/3	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 —53	4 14 3	Ja, Jul	..	..
50	5%	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½—2⅝	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	8½—9½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ - 96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —106	5 13 0	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Consln. Deb. St.	91 —97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	⅝—¾	3 6 9	April ..	..	..
1	1/2½	Do. 6 per Cent. non-Cum. Pref.	⅞—1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 —98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101¾	4 19 0	Ja, Jul	100	99¾

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., Aug. 21.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO AUG. 21. High- est.	Low- est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	†Bournemouth & Poole Elec. Sup. Ord...	9⅜ – 10⅜	6 10 0	Mar, Sept,	10¼	..
10	4/6	† Do. 4½ per Cent. Cum. Pref.	9⅞ – 10¼	4 8 0	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Cum. Second Pref. ...	10 – 10⅜	5 14 9	Feb, Aug	..	..
St.	4¼%	Do. 4½ per Cent. Cum. Pref. (red.) ...	99 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5⅛	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	£8 —100	4 10 0	May, Nov	..	..
5	4/6	†Brompton & Kensington Elec. Sup. Ord.	7⅞ – 8⅛	5 17 6	March....	..	..
5	3/6	† Do. 7 per Cent. Pref.....	7⅛ – 7⅜	4 3 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar,Db.Stock	£9 – 10 2	3 18 0	June, Dec	..	..
5	2/6	†Charing Cross (W.End & City)El.Sup.Co.	3⅜ – 3⅞	6 9 0	Feb, Aug	3¾	3⅝
5	2/3	† Do. 4½ per Cent. Pref.	3⅜ – 4⅛	5 9 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 - 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3½ – 3⅝	6 0 0	Jan, July	3⅛	3⅛
5	2/3	Chelsea Electric Supply Ord.	3¼ – 4¼	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 104	4 6 6	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 – 9⅛	6 6 0	Feb, Aug	9⅛	9⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	11 – 12	5 0 0	Jan, July	10⅞	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	121 —124	4 1 0	June, Dec	121⅛	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 – 99	4 11 0	Jan, July	99	..
5	5%	County of Durham Elec. P.D. Ord.....	£3–4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	£3 – £3	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	7⅛	7⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	10½ – 11¾	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ Deb. Stock (all paid) (red.)....	106 – 109	4 2 9	Jan, July	107	..
St.	4½%	Do. Second Deb. Stock Prov. Certs...	£4 – £7	4 12 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅞ – 5⅛	5 2 0	April, Oct	4⅜	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅜	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	£6 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ - 7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ – 9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜ - 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Knghtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	93 – 101	3 19 0	April, Oct	..	..
3	2/4⅓	London Electric Supply Ord.	1⅛ - 2	6 0 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4⅞–5⅛	5 14 0	Mar, Sept	4⅞	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	£2 –95	4 4 0	Jan, July	93	..
5	3/0	Metropolitan Electric Sup. Ord.	5⅝–6⅛	6 8 0	April, Oct	5⅝	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ - 5⅛	4 9 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 –107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	£8 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp.for P.D.1stMort.Db.	95 –£8%	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist.Elec.Ltg.Ord.(£9 paid)	9⅝—9⅞	4 15 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	93 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅞–6⅞	5 18 6	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛–5⅛	4 15 3	Feb, Aug	..	..
100	4%	Do. 4 per Cent, Mort. Deb. red. 1907.	97 - £8	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	† Do. 4½ per Cent. Deb.	97 —99	4 11 10	Jan, July	..	..
10	£/0	Notting Hill Electric Ord.....	11 –12	7 10 0	March ..	..	..
5	4/6	Oxford Electric Ord.	£3 - 6¼	5 12 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 - 97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord	7⅞–8⅛	6 1 4	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref, ...	6 –7	5 0 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	£6–£1	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	½–1½	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord,.....	2 – 2½	6 0 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝–¾	3 6 9	..	..	..
1	0/8⅔	Do. 7 per Cent. Cum. Pref.....	1⅝–1⅞	4 15 0	Feb, Aug	⅞	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 —103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1½–2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	2⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
5	5/0	†Westminster Elec. Sup. Ord.	8½ 9¼	6 1 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 2 0	Jan, July	5⅛	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	£8 – £3	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅞–1	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	1⅛–1⅜	5 7 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	92 – 97	4 13 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 – 97	4 13 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14 –14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8¾–9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	97 – 99	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2¼–2⅝	..	June, Dec	2⅜	2⅜
10	6/0	† Do. 6 per Cent. Cum. Pref.....	6⅜–7⅛	8 8 0	Feb, Aug	6⅝	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 103	4 17 0	April, Oct	101⅛	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	£8 –81	5 11 0	May, Nov	£0	..
St.	3%	‡Central London Ordinary Stock..	71 – 73	4 18 0	Feb, Aug	72⅛	71⅛
St.	4%	† Do. 4 per Cent. Pref. Stock	£8 – 91	4 8 0	Feb, Aug	£9⅛	£9
St.	4%	Do. Deferred Stock	£3 - 56	7 2 8	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	102 – 105	3 16 0	Jan, July	..	..
St.	4%	Charing X Euston&Hmpstd Per.Db Stk.	£1 –£4	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm.Pref.	4½– 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	£8 – 101	3 19 0	April, Oct	..	..
St.	3%	†City & South London Rly. Con. Ord. ..	44 – 46	4 13 0	Feb, Aug	£5⅛	£4⅝
St.	5%	† Do. 5 per Cent. Perp. Pref. (1891) ..	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	† Do. (1896).....	113 – 116	4 6 0	Feb, Aug	113½	..
St.	5%	† Do. (1901).....	113 – 116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent, Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	104	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13¼ – 14¼	4 4 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	12⅜ – 13⅜	4 7 0	Feb, Aug	..	..
10	0/11½	‡Gt. Northern & City Rly. Pref. Ord. (4%)	1½ - 2	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£3 – 85	4 14 6	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec.Trams.Co.4½ b.St	£8 –101	4 9 0	April, Oct	91¾	..
10	9%	‡ Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10¼–11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 - 99	4 19 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 –1½	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	£6 –71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	94 –97	5 3 0	Jan, July	9⅝	..
10	..	Liverpool Overhead Railway Ord.	1¼ - 1⅝	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6½ - 7⅛	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 - 86	4 13 0	Jan, July	..	..
10	5/0	London United Trams. 5% Cum. Pref. ...	7⅜–7⅝	5 14 3	Jan, July	8¼	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	84 - 88	4 11 0	Jan, July	..	..
St.	..	Mersey Cor. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 - 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅝–¾	..	April....	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¾–⅞	5 3 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	£4 - 97	4 13 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾– 1⅜	..	May	..	..
1	0/9⅜	Potteries Electric Traction Ord.	⅞–1	7 3 9	April, Oct	..	..
1	0/6	‡ Do. 5 per Cent. Cum. Pref.	½–¾	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 – £8	4 11 9	May, Nov	..	..
1	0/6	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	½–1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£0 — 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec.Trms.5% 1st Mt.Db	£4 – £8	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	£1 – £4	7 16 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2¾–3⅜	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	£7 –£0	5 0 0	Jan, July	..	..
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅝–⅞	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅝–1	8 16 0	April, Oct	..	..
1	2/4⅔	Babcock & Wilcox Ord.....	3⅞–4	5 0 0	April, Oct	3¾	3⅝
1	0/7⅝	Do. Pref.....	1⅛–1⅜	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅝–7⅛	4 18 0	July, Feb	..	..
5	3/0	Do. 6 per Cent. Pref.	5⅝ - 6⅛	4 18 0	Jan, July	6⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	104	..
St.	4½%	British Thoms'n-Houst'n 4½% 1st Mt.Db.	£7 - 91	4 19 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1½	..	Feb, Aug	1⅝	1⅝
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£9 – 64	6 5 0	Jan, July	..	..
		Brush Electrical Engineering	⅛–⅜	..	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜–1⅜	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	£5 – 91	4 19 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 —74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9⅜ – 10⅜	6 19 0	Jan, July	10⅜	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼–5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105½–107⅛	4 3 6	Nov, May	107⅛	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅝–1⅞	5 12 6	May, Nov	1⅝	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	95 – 100	4 10 0	Feb, Aug	..	..
1	1/2⅝	Chadburn's (Ship) Telegraph Ord.	1⅛ - 1⅜	8 0 0	March ..	1⅝	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 –1⅛	5 7 0	April, Oct	..	..
3	2/-	* Crompton & Co. (Nos. 1 to 54,000)	1⅞– 2⅛	7 1 0	Jan, July	2⅛	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	£4 – 97	5 3 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝–1⅞	6 3 0	Sept	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 –1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1⅛–1⅜	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼–2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 –92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½–1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1½ - 2	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜ – ⅞	..	Jan, July	..	..
2	2/9⅔	Do. 7 per Cent. Cum. Pref.	1⅛ - 1⅜	8 12 0	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	£/0	General Electric (1900) 5% Cum. Pref...	8 – 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
£	10/0	Henley's Telegraph Works Ord.....	11⅛ - 12⅛	6 0 0	Feb, Aug	12⅛	11⅝
5	2/3	Do. 4½ per Cent. Pref.	5 – 5⅛	4 2 0	Feb, Aug	5⅛	5⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½–107½	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14½–15½	6 9 0	Feb, Aug	15⅞	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 –99	4 1 0	April. Oct	97	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	⅞–⅞	7 14 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞–1	6 0 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 –£6	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	31 —33	5 9 0	Mar, July	31½	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	£9½–102½	3 18 0	Jan, July	99⅝	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2¼–2⅝	5 16 0	..	2⅝	2⅛
1	0/6	Do. 5 per Cent. non-Cum. Preference	1½–1⅝	4 4 6	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 6	..	111	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	104	103½
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 –103	4 3 3	June, Dec	106½	106½
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9¼–9⅝	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1¼–1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅜–4¼	..	Apr, Oct	4¼	4⅛
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	—	June, Dec	..	..
10	5%	Do. 5 per Cent. Debs. (red.)	£5 –88	5 2 0	June, Dec	£7⅞	..
St.	15/0	Anglo-American	61 – 63	6 2 0	F,My,Ag,N	..	..
St.	20/0	Do. Preferred	105½–106⅞	5 12 6	F,My,Ag,N	106⅝	106⅛
St.	12½%	Do. Deferred	16⅜–16⅞	8 6 0	F,My,Ag,N	16⅞	16⅛
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 –94	4 4 6	Jn,Ap,Jy,O	92⅛	93
10	5/0	Cuba Submarine Ord.....	7 – 8	6 5 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞–16⅞	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅝–3⅞	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 – 9½	5 5 6	April, Oct	9⅜	..
50	4½%	Do. 4½ per Cent. Deb.....	100%–103⅜	4 7 3	Jan, July	..	..
20	6/6	Direct United States Cable	14⅜–15	6 4 0	Ja,Ap,Jy,O	15⅛	14⅝
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99½–101⅝	4 8 6	June, Dec	..	100
St.	25/0	Eastern Ordinary	£3 –128	5 1 9	Ja,Ap,Jy,O	135	152⅝
St.	17/6	Do. 3½ per Cent. Pref. Stock	88 –90	3 17 9	Ja,Ap,Jy,O	89	26⅛
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 –105	3 16 6	May, Nov	103	..
10	2/6	Eastern Extension	13 – 13⅛	5 3 6	Ja,Ap,Jy,O	13⅛	12⅞
St.	4%	Do. 4 per Cent. Deb. Stock	102 –104	3 17 6	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	9 ⅛ – 10⅛	4 1 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71..	£4 –£6	6 19 0	Jan, July	35⅜	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	9¼–101½	4 8 6	June, Dec	..	..
25	£2/6	Indo-European.....	56 – 58	5 12 0	May, Nov	56½	..
100	£1	Mackay Companies Common	68 – 68	5 18 6	Jan, July	..	..
100	£1	Do. Preference	67 –69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅝–¾	..	April	..	..
100	4%	Pacific & Europe'n Tel.4% Guar.Dbs.(red.)	100 —101	3 19 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 –10⅜	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America.....	1⅛–1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	99 –101	3 19 0	Jan, July	97⅝	97⅛
10	..	West India & Panama	⅞–1	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7½–7⅝	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6⅝–7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 –102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	13 –13⅛	5 6 0	Mr,Jn,O,D	13⅛	13
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 –103	3 18 0	June, Dec	100	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust £1,000 4 per Cent. Bonds	90 —92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —104	4 16 0	Mar, Sept	..	..
5	5/0	Chili Telephone	6⅞–7⅛	5 10 6	August ..	..	..
1	0/4⅔	Monte Video Telephone Ord.	⅜–1⅛	4 14 0	Nov	⅝	..
1	0/6	Do. 5 per Cent. Pref.	¾–1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	10⅜ –108	5 11 0	Feb, Aug	107	106
St.	6%	Do. Def. Stock.....	105 –107	5 12 0	Feb, Aug	106	105½
10	0/0	Do. 6 per Cent. Cum. 1st Pref.	11 –13	4 12 0	Feb, Aug	..	..
10	0/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	11¼	10⅜
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛ - 5⅝	4 11 0	Feb, Aug	5⅛	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	95½ – 97½	3 12 0	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100½ - 102½	3 18 0	Jan, July	102½	101⅜
1	0/9⅜	Oriental	1¼–1⅜	5 2 0	April, Oct	1⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 —94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db.Stk.(red.)	£8 –101	4 9 0	Jan, July	..	..
5	5/0	United River Plate.....	6⅜–7⅛	6 18 0	July	6⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜–4⅜	6 6 3	Jan, July	..	..
10	6/2	Globe Telegraph & Trust.....	10⅛–10⅜	5 2 6	Ja,Ap,Jy,O	10⅜	10⅛
10	4/0	Do. 6 per Cent. Pref.....	13⅜–13⅝	4 8 0	Ja,Ap,Jy,O	13⅝	13⅜
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.

1907.
A complete Encyclopædia of Electrical Industries.
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Power Supply and Motor Equipments.

THE progress of electric power supply, like that of gas and oil power, is dependent upon two factors, both of which require to synchronise if rapid development is to take place. These factors are the price of electrical energy and the cost of the motors and machinery utilising this energy. The history of electric power supply is marked principally by the attempts made to cheapen the cost of the generation, transmission and distribution of power. Capacities of plants have been raised to a degree which reduces both the initial cost of installation and the price of the energy produced. Cables, joint boxes and the many accessories of distribution have also been improved and cheapened. In fact, the whole of the plant and apparatus between the coal pile and the consumer is in as efficient a condition as it can possibly be, having regard to the changes which always influence the design and construction of dynamo electric machinery. Now all these developments redound to the advantage of the consumer of electric power. In using motors he also reaps the benefit of research and improvement in the manufacture of these machines. The motor maker endeavours to supply the consumer with a motor which will consume as little energy as possible in proportion to its load.

One of the factors referred to, then, favours the user of electric motors at all points. When he comes to convert the drive of his machinery from some other power agent to electricity he is almost guaranteed a good result. But previous to installing electric motors the second factor in the case requires close consideration. The motors must be purchased and arrangements made to apply them to the apparatus which requires driving. From the consumers' standpoint this matter has the first place in his mind, and the cost of power ranks secondary to it. The electrical installation may pay for itself in a year or two; indeed the prospective consumer will probably be told this. To him, however, the prime cost represents the crux of the matter in its relation to the new power agent. In a word, he wants not only cheap power but inexpensive apparatus with which to utilise it. The cry of "1d. per unit" will mean little to him if he has to spend a great amount to take advantage of it.

That the expansion of the power branch of the electrical industry is absolutely assured cannot be denied in the face of facts. But at the moment there appears to be a wide disproportion between the price of electric energy and the cost of the plant to turn it to good account. The same conditions are not, of course, at work to reduce the price of plant and apparatus as have accounted for the economies now noticeable in electric power generation and distribution. Competition among manufacturers naturally tends to level prices, but it does not lower them in the buyer's interest, although the buyer reaps whatever benefit is to be had. If electric power applications labour under any disadvantage it is that of the first cost of the motors and their accessories. As we have intimated, this initial expenditure may in most cases be wiped out by the economies due to the new power agent, together with the increased output which generally accompanies the introduction of electric power. In a way, of course, the consumer controls the price of apparatus, because this will vary with the average demand. It is for the prospective user of electric power to consider that, in converting from steam or gas, he is not only stimulating the demand for power itself, but also for motors and other apparatus. In each case this stimulus should reflect beneficially on the price to be paid for both.

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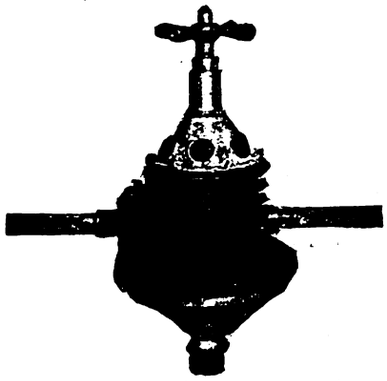
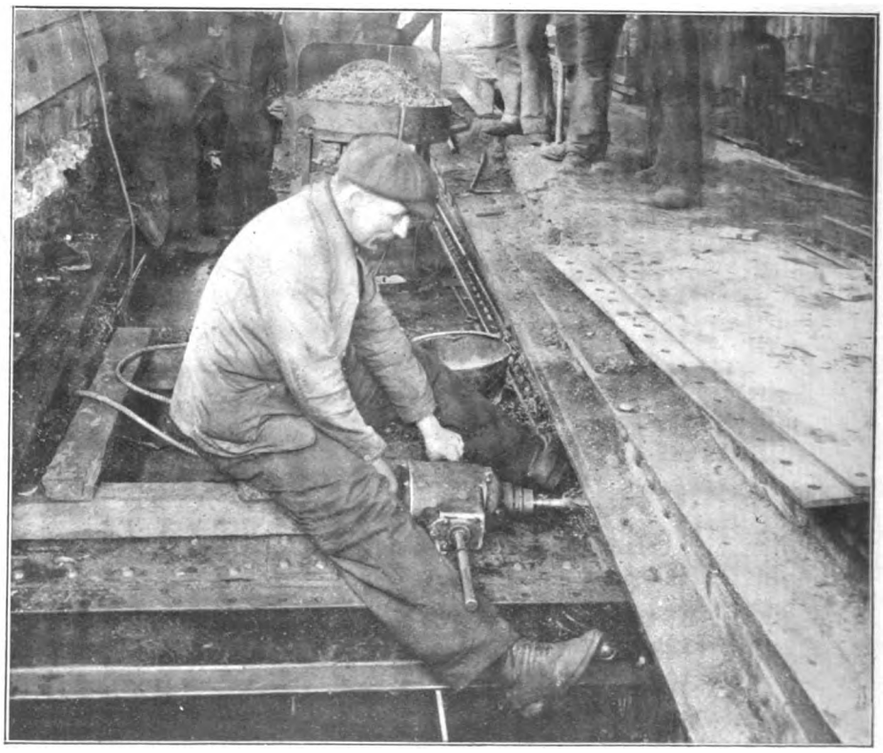


Air-cooled Electric Drill.
(Consolidated Pneumatic Tool Co.)

THE distribution of electric power has demonstrated that not only can very large and powerful machines be motor driven, but that apparatus diminutive in comparison can also be actuated by the same energy applied through a miniature motor light enough to be held in the hand. In some trades and industries, before the advent of electric power, certain work was done by flexible shafts and combination of the rope drive. So necessary was it, in fact, to transmit the power to a point close to the work that a demand was created for the apparatus by which it could be accomplished. The portable electric tool, therefore, entered the field with a good demand already in existence. Still, it has by its own special merits cut much new ground and has been the means of introducing tools which, without the electric motor, would be impossible.

Types. The commonest types of portable electric tools are drills, grinders and blowers, as a use can be found for these in almost every trade and industry. Drills especially are in demand, because it is much more convenient to take the drill to the work than vice versa. To move a mass of metal weighing, say, several tons up to a fixed tool of but a few hundredweights appears to be the opposite of economy, but where this cannot be avoided there is no alternative. The portable drill, and by the word "portable" we mean a tool movable either by power or by hand, takes various shapes, being either mounted on a trolley, sling or cradle, or held in the hand or against the breast. There are drills which only a crane could transport from place to place, but the present article will be confined to a consideration of the lighter patterns. Emery grinders and blowers have created a special demand for themselves since their introduction, and special work is now set aside for them in shops where they are used. Small motors are also adapted for a variety of purposes, and the list of tools driven by them is constantly being added to. The use of these suggests further applications in other trades and industries.



Air-cooled Electric Drill drilling Floor Plates on Westminster Bridge for L.C.C. Tramway Extensions.
(Consolidated Pneumatic Tool Co.)

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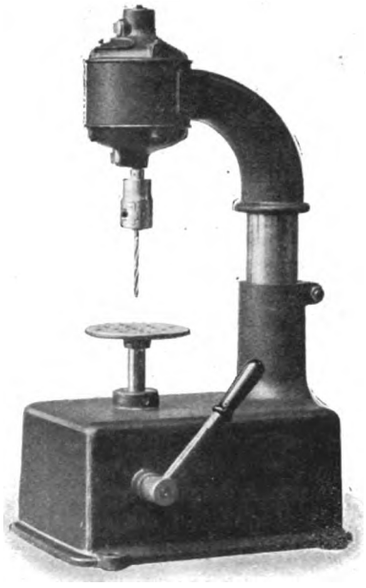
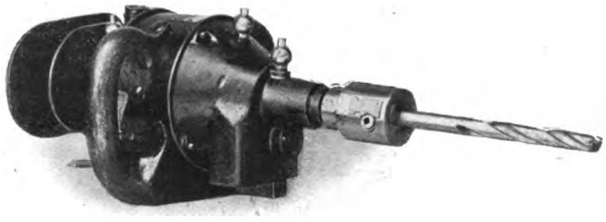


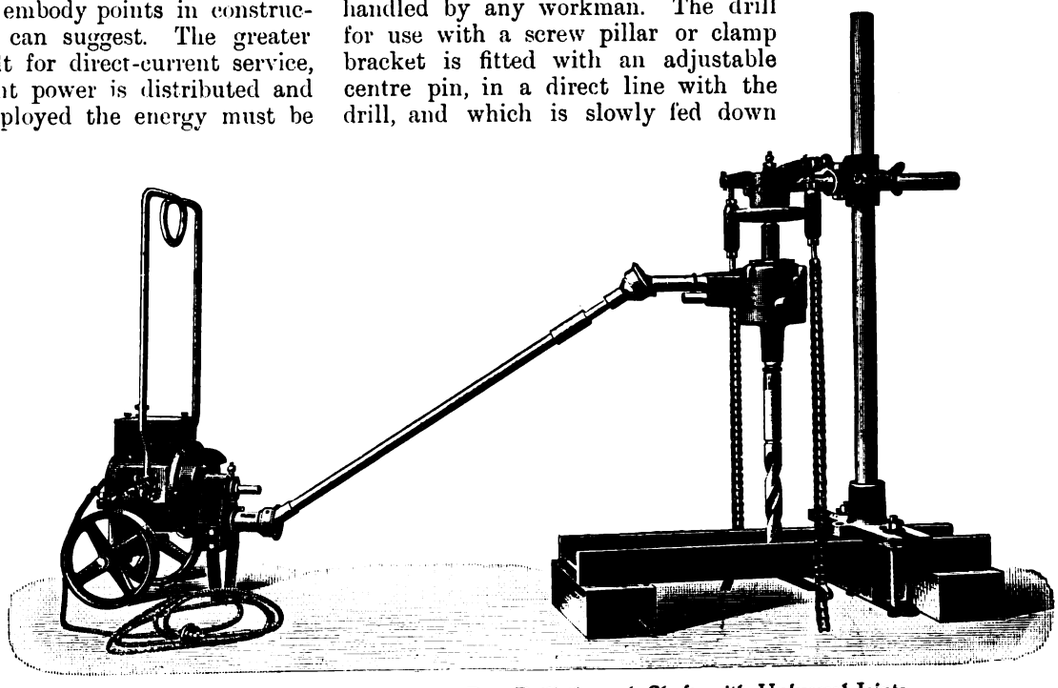
Bench Type Direct-acting Motor Drill.
(Siemens.)

The Motors. A word may be said here for the small motors used with these little tools. They are the product of careful design based on practical experience, and they embody points in construction which only actual use can suggest. The greater number of the motors are built for direct-current service, so that where alternate-current power is distributed and light portable tools can be employed the energy must be transformed to direct current for the purpose. The motors, however, are in some designs built for alternate currents and can be worked directly from the supply mains. The makers issue specific instructions regarding their use and where these instructions are followed the tools give complete satisfaction. Tools of this type are always subjected to rough usage, consequently the working parts are enclosed as much as possible in iron or sheet-steel cases. The supply of electrical energy is generally given through a flexible conductor well insulated and armoured. A simple plug is attached to the free end, and at the motor itself there is a small push-switch for starting and stopping purposes. No effort has been spared by the specialists who design and build these little tools to make them reliable, efficient and economical. The fact that they are the product of manufacturers who make nothing else is a guarantee of their capabilities



Hand Pattern Direct-coupled Electric Drill.
(Siemens.)

Drills. The portable electric drill is built for (i.) hand, (ii.) pillar, and (iii.) trolley work. The hand type is fitted with spade handles at each side of the motor case, and the tool is held firmly without further support against the work to be drilled. The smallest size weighs about 26 lb., and can be easily handled by any workman. The drill for use with a screw pillar or clamp bracket is fitted with an adjustable centre pin, in a direct line with the drill, and which is slowly fed down



Portable Motor on Bogie driving Post Drill through Shaft with Universal Joints.

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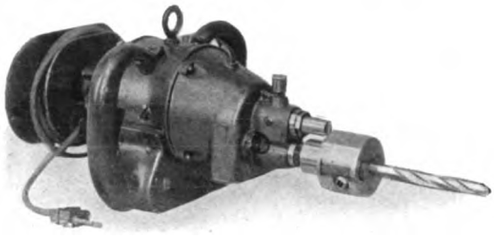

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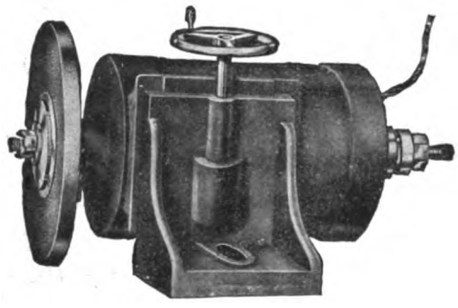
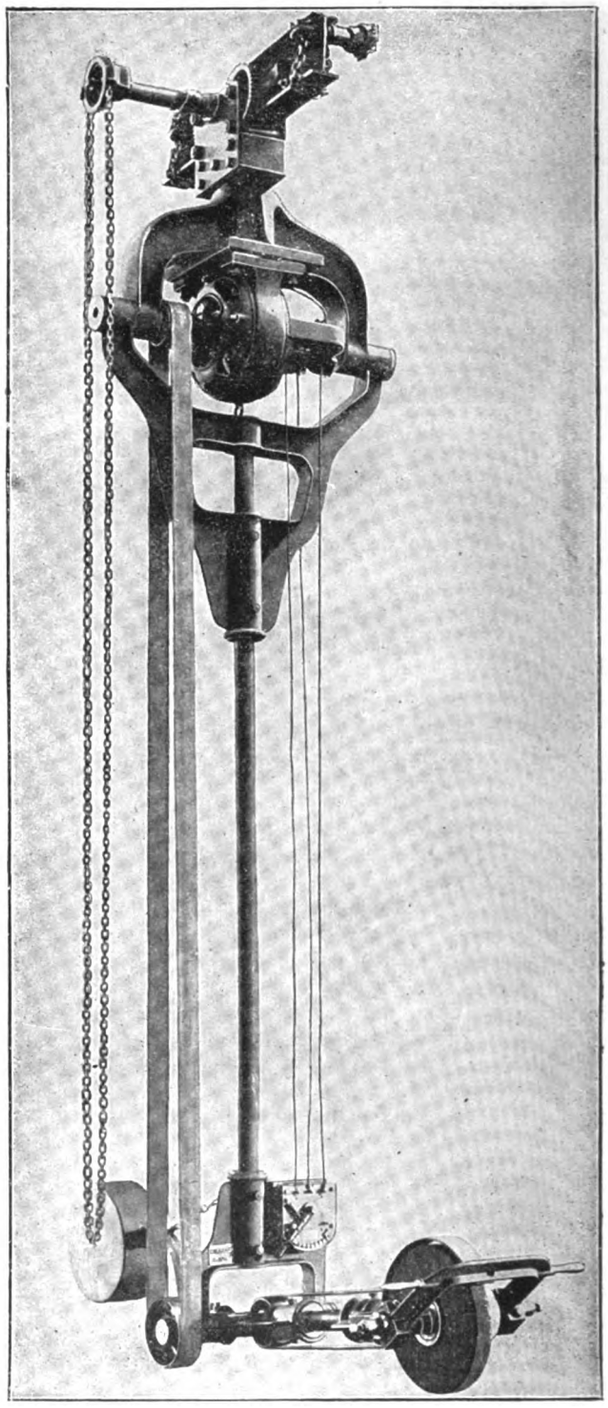
until the hole is cut through the metal. Like the hand drill this pattern can be used in any position where space admits the tool and its holder with room to operate the feed. A drill of this pattern can be fixed up as a kind of "permanent temporary" on a bench, wall bracket or column. It can also be moved about to any point at which it is required. The trolley or bogie pattern of drill is a combination of the electric motor and a flexible shaft, with drill clutch at the free end. The motor and gearing are mounted on a small bogie, which can be



Motor Grinder, suitable for clamping to Slide Rest or Planer Bed for Surfacing Work.
(S. Wolf & Co.)

wheeled near the work to be drilled. The drill end of the flexible shaft is fitted with a screw attachment, which admits of the drill being held by a clamping bracket, and the feed made gradually in the ordinary way. A fitment of this kind is very useful for drilling in awkward corners and at different angles; in fact, in all those many positions which baffle the skill of the best wielders of the hand-ratchet brace. A similar motor equipment can be placed in a cradle and be slung conveniently near the work to be done, the power being transmitted by shafting and bevel wheels. To enumerate the many useful purposes which the portable electric drill can serve would fill all the space we have allotted for a glance at the merits of portable electric tools in general. These handy little tools have a habit of growing on the user, and it must be left to him to decide what duty they are best fitted to perform.



Motor-operated Swing Grinder, with Overhead Travelling Suspension.
(Union Electric.)

Grinders. The combination of a strong abrasive such as carborundum or emery with a convenient form of power agent has given to industry a new tool—the portable electric grinder. The small motor with abraiding wheel attachment is a recognised accessory to the ordinary tools of an engineering workshop. The electric grinder takes three distinct forms: (i.) the hand grinder, (ii.) the bench grinder, and (iii.) the

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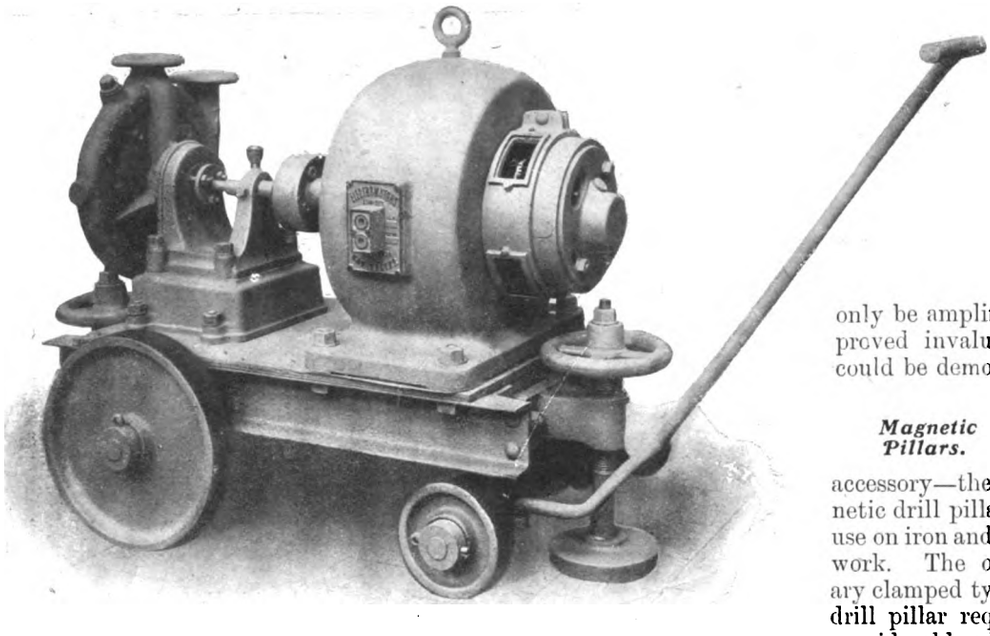
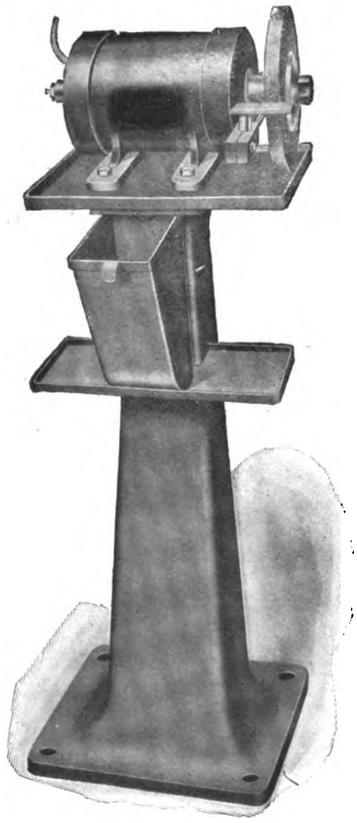


Electrically driven Portable Centrifugal Pump.
(Electromotors.)

machine tool grinder. The hand grinder can be complete with motor in itself, or may be a wheel attachment driven by a flexible shaft from a motor in a trolley or on a bogie. The bench grinder combines a motor and a pair of wheels, one at each end of the motor shaft. This dispenses with

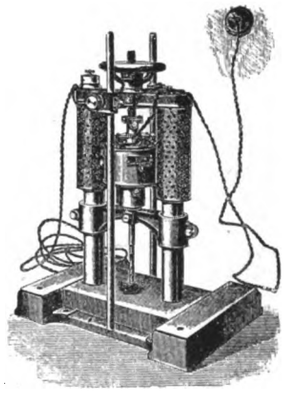


Pedestal Type of Motor driving Grinder.
(S. Wolf & Co.)

belts and pulleys and leaves the grinder a compact unit which can be turned on and off as required. The device has the further advantage of lightness and can be moved about as required. The machine tool grinder is a compact motor-driven wheel provided with a special clamp bracket for attachment to a slide rest, planer table, slotting machine or similar tool. The motor is kept running and is either moved back and forth over the surface to be ground or the work itself is moved in this way. As we have already said, the electric grinder has made a name for itself, and the purposes it will serve can only be amplified by experience. That it has proved invaluable in engineering workshops could be demonstrated to the fullest extent.

Magnetic Pillars.

A reference to electric drills would be incomplete were no mention made of their latest accessory—the magnetic drill pillar for use on iron and steel work. The ordinary clamped type of drill pillar requires considerable adjustment before it can be placed correctly, and even after an approximation a final accurate setting is always needed. The magnetic drill pillar can be moved to the point required for proper drilling, and on the closing of a small switch will adhere tightly to the work as long as the magnet is excited. A mag-



Magnetic Drill Pillar with "Little Hustler" Electric Drill.
(Armorduct.)

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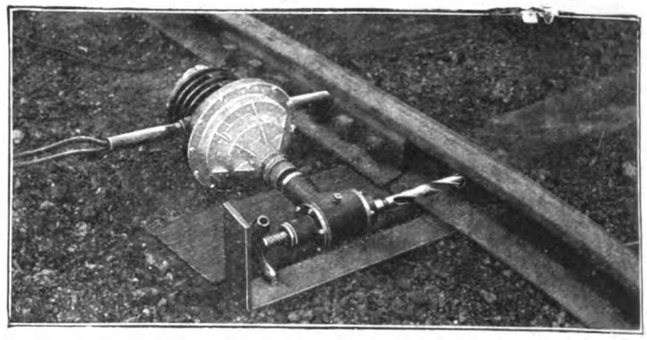
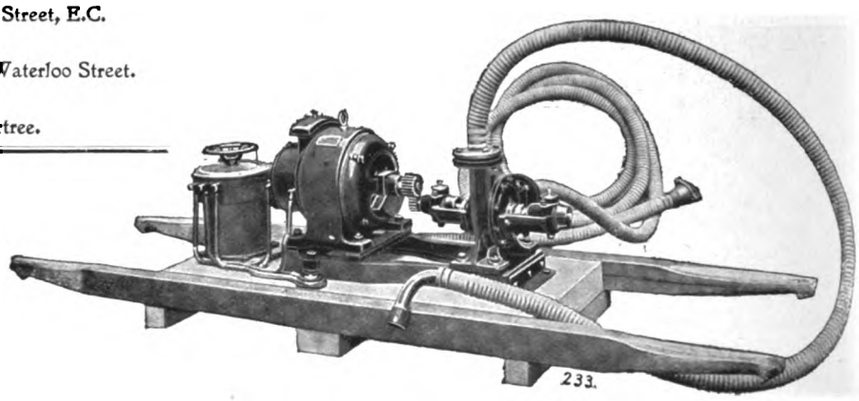
net drill pillar, a portable electric drill and a magnetic lamp holder make up an ideal combination for steel and iron work, and one which can be operated from a pair of flexible insulated conductors. The pillar can be placed in any position, and as long as the switch to the magnet is closed will remain in that position, at the same time resisting the pressure on the drill. Certain types of magnet are capable of holding the weight of a man, while the work of drilling can also be continued. It must be borne in mind that this form of drill pillar is useless on wood, brass, aluminium, gunmetal and all non-magnetic substances.



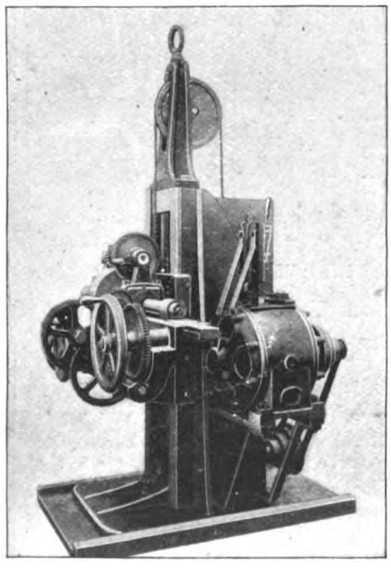
Electric Drill in Use for Rail Work.
(S. Wolf & Co.)

Hand Blowers. Just as the portable electric grinder has filled a distinct want in the world of tools, so also the small electric blower is taking up a prominent position among portable power-driven apparatus. The motor shaft in this pattern of tool is fitted with a small propeller fan which delivers a stream of air through a special nozzle attached to the motor case. The entire apparatus weighs but a few pounds and can be conveniently held in the hand to direct the air blast in the direction required. A variety of purposes can be met with this tool, but it is specially handy for removing dust from crevices which are inaccessible to the ordinary hand blower.

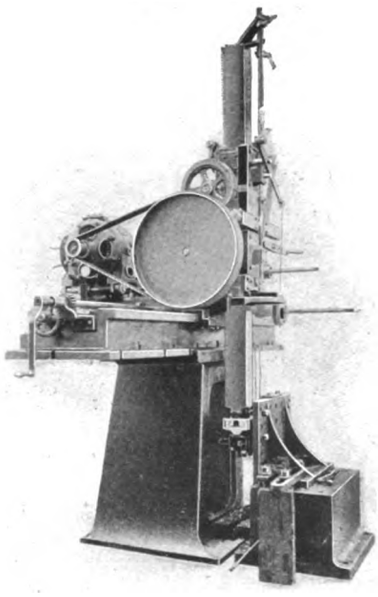


Motor-driven Centrifugal Pump on Hand Carriet.
(Union Electric.)

Buffing and Polishing. In the same way that metal work can be ground by the abraiding wheel driven by the small electric motor, so also can polishing and buffing be done in the same way. The motor shaft is extended at each side into a long taper, such as is common to buffing spindles, and on these extensions suitable polishing and buffing discs can be placed. The equipment, complete with motor, is very light and can be fixed in any desired position, without regard to existing shafting, &c. A small switch starts and stops the motor, which is powerful enough to overcome any pressure which may be put on the buffing and polishing discs.



Motor driving Portable Horizontal Boring Machine. (E.C.C.)



Motor-driven Portable Planer.
(E.C.C.)

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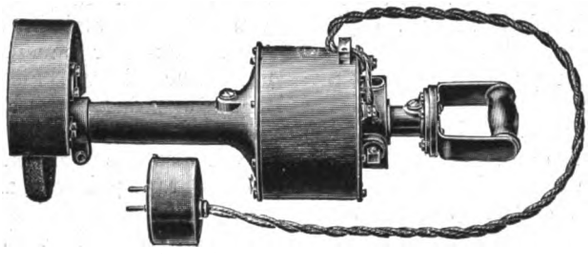
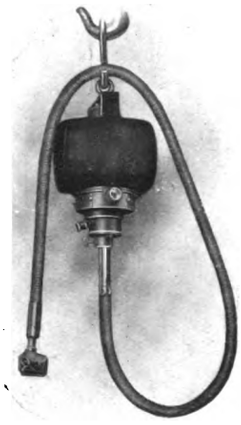


"Little Hustler" Electric Hand Grinder.
(Armorduct.)

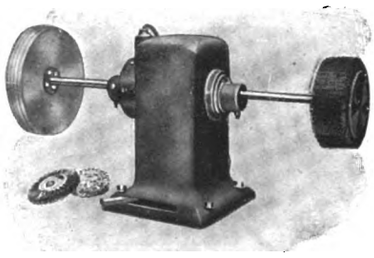
The bulk of the appliances referred to above as driven by small electric motors comprise useful tools for factories and constructional work. There are also portable electric pumps, horse clippers, &c., which fill a distinct and useful purpose, and are coming into general use. The portable electric pump, for instance, is usually of the centrifugal pattern, which can be direct connected to the motor, thereby dispensing with belts and gear wheels. In breweries such devices are exceptionally useful for emptying vats, filling tanks or the transference of liquids from one place to another at points far removed from the engine-house or pumping plant.

General.



Small Motor driving Horse Clipper through Flexible Shaft.
(Electromotors.)

The bulk of the portable electric tools now manufactured are supplied for the pressures commonly in use on electricity supply undertakings, and where there is already an electric power service such tools can be easily put into commission. The makers are able to furnish reliable data as to the operating economy and mechanical reliability: indeed, in this respect, we think the electric motor has served the cause of industry too well in the heavier branches to give rise to doubts as to its capacity for light work. The consumption of electrical energy is small compared to the work done, and where energy is purchased from an outside source the charges for power are sufficiently low to make machines of this kind very economical. Prospective users of these tools are now able to draw upon much useful experience, which has been gathered from their employment in various industries, and they can feel that in taking up portable electrical apparatus they are not being supplied with laboratory toys but sound commercial machines.

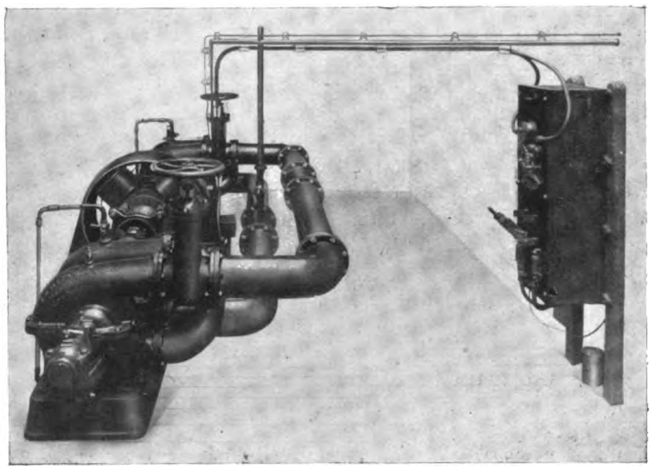


Electric Buffing and Polishing Machine.
(Electromotors.)

In the space of a brief survey of the portable electric tool motor and its uses we cannot do full justice to all the details of the various machines, but we feel that the illustrations accompanying this article will have served their purpose in depicting the latest forms manufactured.

Electrical Operation of Paper Mill Auxiliaries. . . . . .

MANUFACTURERS in every industry are coming to recognise that electric power has a distinct purpose to serve in the operation of machinery, and that there are few processes to which it cannot be easily and directly applied. Factories in which electric motors are not doing useful work are, in certain districts, the rule rather than the exception, and from the electrical engineer's



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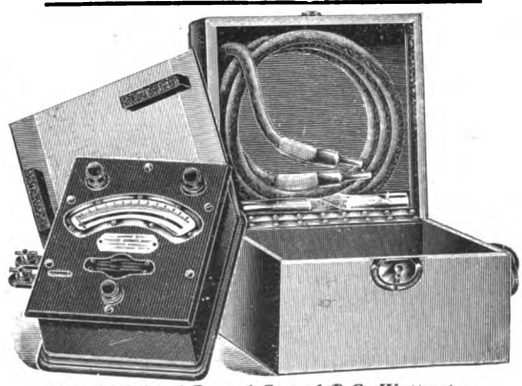

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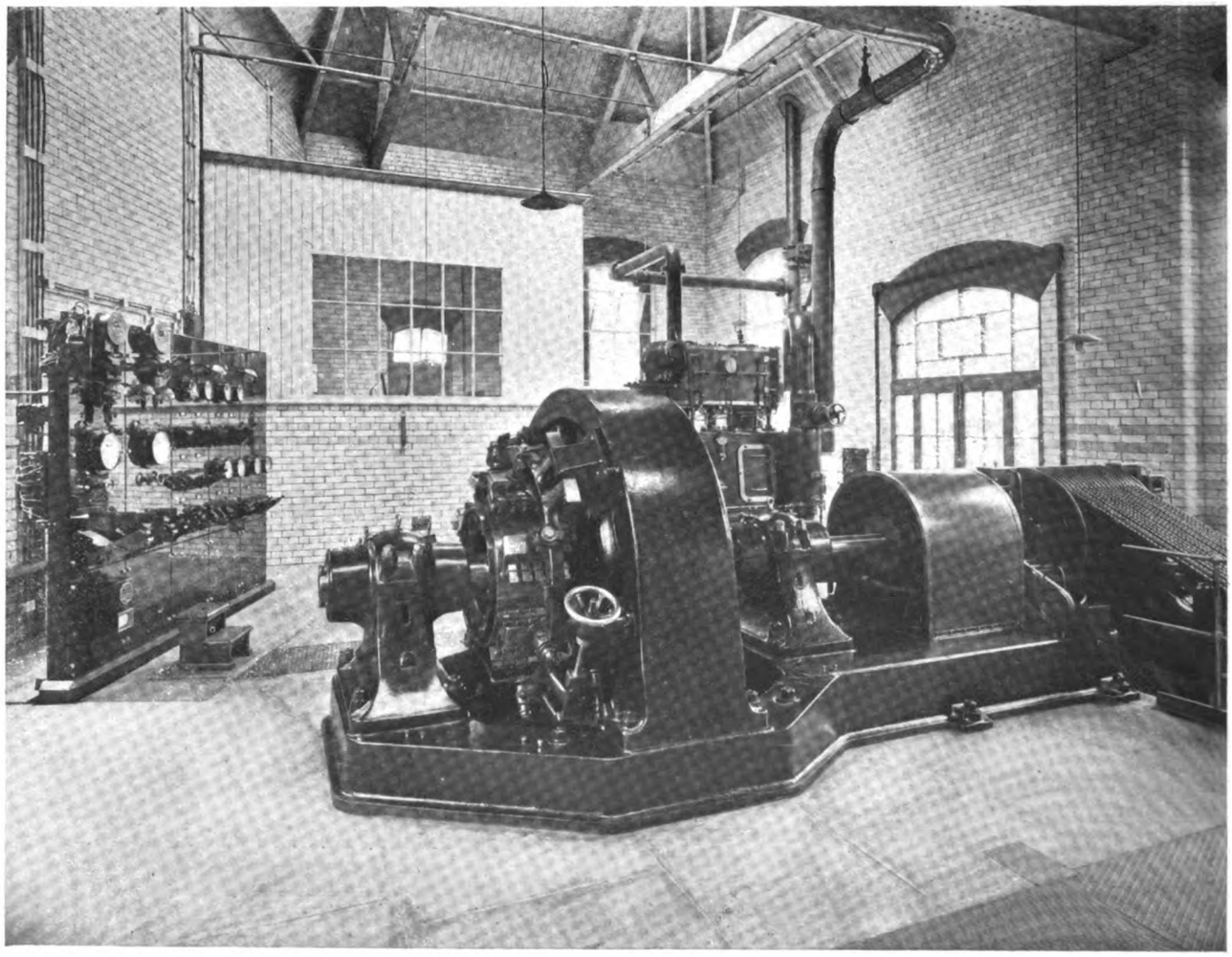
standpoint a mass of useful data is already available, upon which the conversion of similar power plants can be based. Where the factory machinery demands regular quantities of power on a large scale, and the problem of conversion is under consideration, it is not infrequently approached from the side of initial economy with a strong bias towards the retention of the old plant. The result is a policy which introduces the thin edge of the wedge for electric driving without disturbance of the larger sections of the earlier power agents. In a word, the more scattered and smaller units will be motor-driven, but the larger and more compact machinery will remain in *statu quo ante*. This method of "cure by degrees" is adopted both in power installations which employ separate power plant and the electric power service. In each case it is equally convenient and, from the electric power point of view, equally satisfactory. The driving of the larger machines by electric motors will be merely a matter of time. The manufacturer with the large steam engine will be less favourably disposed towards the outside supply for this initial installation because he can drive a small generator from shafting and furnish current to the motors without much difficulty.

As we have already intimated, the manufacturer with an extensive works would rather begin introducing electric motors among his auxiliaries than with the greater and more important machines. An excellent case in point is afforded in an installation recently put down by Dick, Kerr & Co. at the Star Paper Mills near Liverpool. Here a large horizontal steam engine drives the paper-making machines, and the auxiliaries are electrically operated by motors supplied from an independent steam generator and a machine rope-driven from the main engine. The generating plant is illustrated below in the general view of the engine room. In the background is a Hick-Hargreaves-Dick Kerr 125 kw. engine-driven dynamo, and in the foreground may be seen a 300 kw. Dick-Kerr generator with rope drive coming up from the floor below. This set is working from Monday till Saturday, day and night, without stopping. The small steam unit is run during week ends. The illustration shows also the Hele-Shaw disc clutch between the dynamo and rope-pulley shafts. This clutch is fitted to allow of the disconnection of the generator should this be desired at any time. The shafting from which this machine is driven is primarily driven by a 2,000 H.P. steam engine.

The motor installation, which is confined to the auxiliaries, comprises one 100 H.P. motor-driving, two centrifugal pumps dealing with effluent water for the effluent tanks, one 8 H.P. motor also coupled to two centrifugal feed-water pumps, three 30 H.P. motors, driving respectively the machine shop, reeling machines and cutting machines, and one 15 H.P. motor-driving condenser air pumps for the high speed engine. With the exception of the condenser motor these machines are run continuously night and day. Their performance in this respect is typical of the capabilities of electrical machinery to stand up to hard service and give complete satisfaction.

The driving of the auxiliaries is not necessarily a reflection upon the abilities of the electric motor which operate the larger machines. Where the present drive gives satisfaction there is little object in changing it. Auxiliaries, however, are often scattered and the distribution of power can be then economically entrusted to electric power.



View of 300 kw. Rope-driven Machine showing Hele-Shaw Clutch. The 125 kw. Machine is in the background. (Star Paper Mills.)

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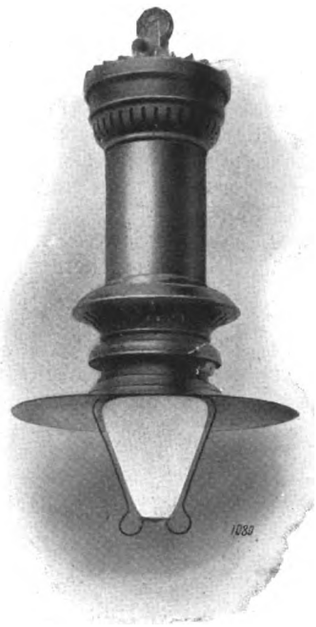

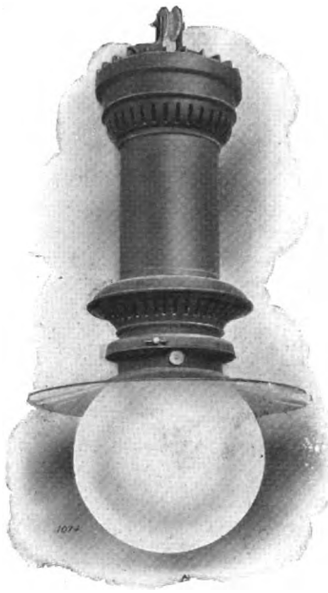

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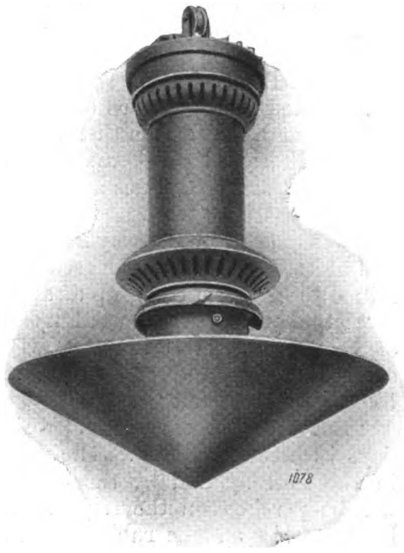

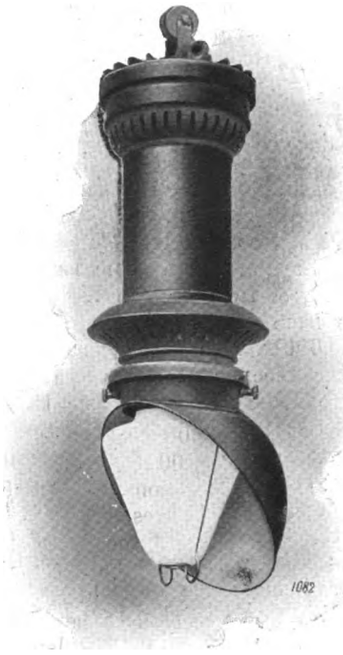

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Industrial Electric Power in Mexico.

WE have frequently referred to the national importance of water power and its relation to the conduct of industry, especially new industries in practically undeveloped countries. Where such natural power sources are in existence, and industrial opportunities also present themselves, rapid strides can be made in the expansion of these industries even to the extent of manufacturing for the home market and exporting to sell in competition with other nations. In the near future we may look for the industrial rise of countries naturally rich in water power and iron and other useful minerals. Mexico, for example, has, by the aid of its electrical developments, improved its industrial position by utilising hydro-electric transmitted power for railways, factories and mines. Under the stimulus of Canadian capital important electrical undertakings have arisen and expanded until they have assumed a pre-eminent position in Mexican affairs. A writer in *The Times* (Eng. Supp.), Mr. P. F. Martin, F.R.G.S., has recently directed attention to the growth of electric power plants in Mexico, and more especially laid stress on the industrial extensions now in progress in connection with them.

"Although they have been but recently introduced, the newer methods of electrical distribution for motive power are making headway in the esteem of many Mexican factory owners, while they have already been employed in numerous instances and with marked effect by the more go-ahead American owners. Primarily intended for street lighting purposes, electricity has gradually asserted itself as the most economical means of providing power for factories, and in a country like Mexico, where fuel has always been scarce and is to-day becoming almost prohibitive in price, this new motive power, produced as it is in a highly economical manner, is of undisputed advantage." In these words Mr. Martin practically sums up the situation in the country. He also furnished some interesting statistics of the plants already in operation there. The largest plant is at Necaxa, the property of the Mexican Light & Power Co., situated 95 miles from Mexico City, and having a capacity of nearly 50,000 H.P. in six generating units. This supplies 600 miles of electric tramways in and around Mexico and the El Oro Mines, 76 miles distant from the plant. In the Federal district 37,500 H.P. is at present in use, and new plants aggregating 6,000 H.P. per annum are being added. The same company is completing plans for a 60,000 H.P. station at a point 600 metres above the present power house so that the fall of the same water can be utilised in both places. The Tuxpango Falls on the Rio Blanco near Orizaba are being made to yield 20,000 H.P., and the plant for its utilisation will shortly be completed. In the City of Campeche the use of oil or petroleum is forbidden for lighting purposes in the streets, under penalty. The great mining districts are utilising electrical apparatus representing an aggregate of 35,000 H.P.

These developments would appear to indicate that the immediate future of Mexico will be strongly identified with hydro-electric power. Although the bulk of the energy at present produced from water power is employed for railways, tramways, and gold and silver mines, the above particulars contain references to factories and workshops as being operated by electric power. Once the advantages of this method become better known and when the distribution of energy is undertaken on an extended scale, the number of these factories will certainly increase and Mexico will wake up one morning to find itself famous in the industrial world.

Notes and Observations.

XI.—A Tale of a Tripod.

YOU'VE seen those things that rear up above the foundations of growing buildings—three-legged affairs that could, with a little imagination and sheet iron, be made to resemble Mr. Wells' Martians in "The War of the Worlds." They stride across some erstwhile bit of waste land, and passers-by wonder what is to be done to the innocent-looking strip and why it should be thus marked out for public notice. The average town dweller can tell at once the fate of the little plot, and the inquisitive are soon satisfied when a boiler and engine are hoisted to the giddy height and a boom begins to scrape the sky.

Now I have a grievance against the men who set up engines and boilers on these wooden tripods. It is to me like open defiance of the electric power service which is available at the foot of these lattice legs employed by the builder. In fact, I almost wonder that the cables do not come out on to the pavement in mild protest of such neglect.

You know there are hundreds of these hideous Martians raising their heads wherever a good building is to go up, and probably in every instance they neighbour the electric cables.

I told Brown, the builder, emphatically, that if he wanted the new Bank, the new Council Offices and the new Insurance Building to go up at all he would have to use electric power on the sites in question.

He refused point blank. I told him there wasn't an old boiler to be had within miles, and a steam engine could not be got for love or money. He did not believe me, and within a week was able to prove it by bringing up a ramshackle portable to drive the mortar mills and mixers and a vertical boiler for the tripod on the site of the Municipal Buildings.

He called at the power house the morning following his triumph and, finding me there, proceeded to "rub it in."

"You'll learn the geography of the district before you talk about steam engines and boilers again, young man," he started, almost before he got into the room.

I was nettled by the way he had obtained the machinery, and did not seem at all pleased to see him. I was determined to keep the thing up at any price.

"I told you once you wouldn't build the offices without electric power, and I repeat now that you can't do it," I said, getting up and putting on my hat. I did not want him to stay as I felt "ratty."

"But I've got the rig, and we shall be going in a few days with the whole lot. The portable will have steam up in the morning, and by the end of the week the vertical will be perched on the tripod. We shall then cry 'Yo, heave ho!'" and he rubbed his hands with ill-concealed delight.

"I say otherwise, and I'm going to prove it. Let me know when steam's up in the portable," I said, leaving him in possession of the office.

I got out the motor car and drove down to the quay, about a mile and a-half away. I had my suspicions about the source of the machinery and wanted to confirm them. Arrived at the waterside, I called at a yard we had dubbed the "Scrap Heap" and asked the guv'nor if he had sold a vertical and a portable lately.

"No, sir, I aint," he replied, ejecting a quid into a heap of steel turnings, "nur likely to, seeing as the last wur sold twelve month agone."

I hinted at Brown's purchase of steam boilers and other gear. He merely looked wise and rolled up another quid.

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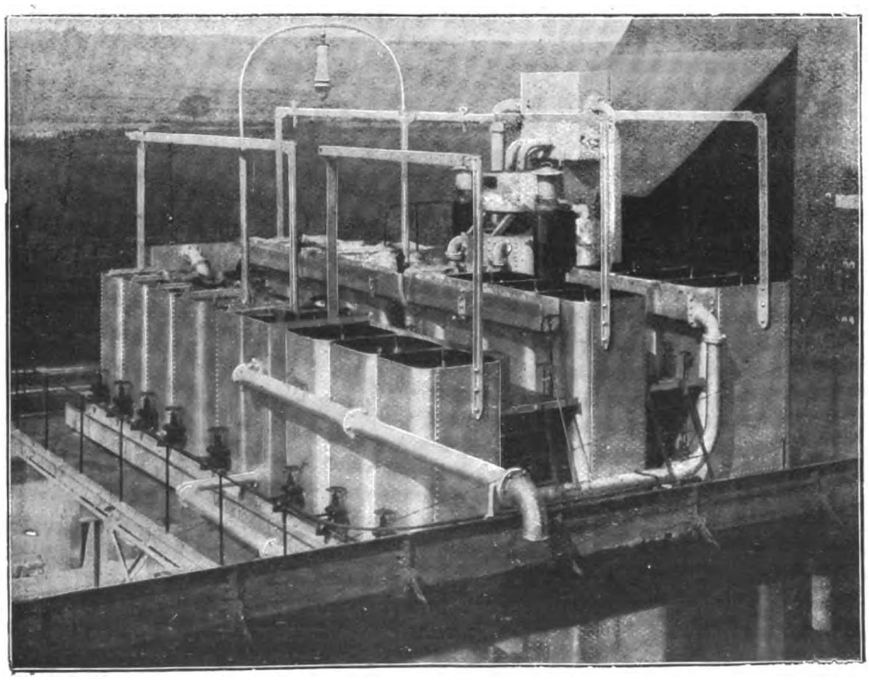

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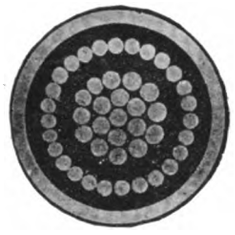

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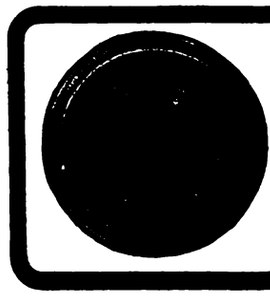

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I tried palm oil and it took effect at once. Till then I didn't know a shilling would go such a long way.

"They cum up the river, sir," he vouchsafed, "and I saw um took off the boat. I believe he bot um at Dashmouth fur 'n old song."

When the shilling had got as far as the date and place of the sale I sidled down to the gate, where I had some excuse to start the engine of the car. I left "Bosey" still talking and headed for Dashmouth, determined to get to the bottom of Brown's steam rig-out. I was fortunate in gleaning several interesting scraps of news, and was able to return hopeful and expectant of developments when I reached town.

In the morning it was my turn to greet Brown, this time at his office. I had made up some caustic remarks on the way down, but they were never uttered, as he monopolised all the talk.

"Now don't begin by asking if steam's up yet, because it isn't," he began.

"Never will be!" I jerked out.

"We found a sprung tube in the portable and it's being the devil's own job putting a blank in," he went on, taking no notice of my comment. "But I'm determined to get steam somehow, and for the time I want it that outfit will have to work."

"You niggardly builders can't see a yard in front of you," I remarked, in order to give him a breather. "Because a mortar mill is only needed during construction you think any old puffing-box good enough to turn it. It's about time some of you fellows in this district learned a lesson. From what I have discovered since our meeting yesterday you are going to get it before very long."

I saw him get up from his chair, as if to argue the matter from a better position, but I was in no mood for discussion, so simply walked away, leaving him to draw his own conclusions.

Passing the foundation works at the new offices a few days later, I noticed a portable engine at work, and the tripod was completed ready for the steam crane. From a neighbouring point of vantage I witnessed the raising of the boiler and other tackle to the giddy height, the steam engine on the portable being used to wind up the heavy weights. Because circumstances have made me a dispenser of electric power, I wished that the hauling rope would break and bring the clumsy boiler clattering down. Because I try to be a good citizen and think no evil of my neighbour, I refrained from indulging such thoughts longer. After my inquiries at Dashmouth, however, I had grave doubts about the vertical boiler. Brown might have been told, but I knew it was waste of time, breath, and good wholesome temper. That's why I kept my peace and hoped for the best—that is, the best for Brown.

"We're going strong, young 'un!" he shouted across the street to me one morning. "That vertical on the tripod 's a beauty. Got steam in her yesterday, and she's pulling away like fun this forenoon."

This was in the High-street, about half a mile from the new buildings. I had hardly gone a few yards after passing Brown when a loud report, followed by a dull thud and a "spattering" near by, made me turn and run towards the new building. I could see Brown scurrying ahead of me, so I kept at a convenient distance.

Passing the fire station I heard the alarm bell ring and was cut off from Brown by the engine which dashed between us. It turned down towards the municipal buildings and, taking the corner, I saw it stop opposite to them. My thoughts flashed at once to the vertical boiler on the tripod, and I ran with the crowd, expectant of disaster. On the spot my fears were vividly confirmed. The tripod boasted but one lame leg and the splinters of the others were anywhere around the foundations.

The boiler had burst and the fire was scattered over the woodwork of the tripod, so it was thought advisable to ring up the fire engine. There was no conflagration, however, as luck would have it—or I should say, as Brown's luck would have it. He was certainly lucky. I dared not think of the flight of that boiler or the luckless man attending it. Both were picked up, as the local paper had it, "unrecognisable," at different points of the compass, and the collection of scattered chimney pots was worthy a pageant episode.

The coroner's jury returned a verdict of "Death by misadventure" on the body of the craneman, and Brown got off. I did not split about the Dashmouth sale, but I made him know, before the inquest, that any other power business in the district was to be done with me, and not scrap-mongers vending boiler death-traps. He turned all colours when I laid down my cards and delivered what was to him an ultimatum. I did not actually threaten him, but he could not fail to see what a strong case I had got. He did not forget to privately lay the facts before one or two of his confrères, and I have had hints dropped recently that in future building operations requiring tripods the views of the electric power department would be consulted before patched boilers were put up.

Brown has since admitted that he had to fall back on electric power to complete his three largest building contracts. He told me in confidence that he would have put in electric motors if he had known how useful they were, and what knocking about they could stand. He thought they were laboratory toys, poor man!

W. E. W.

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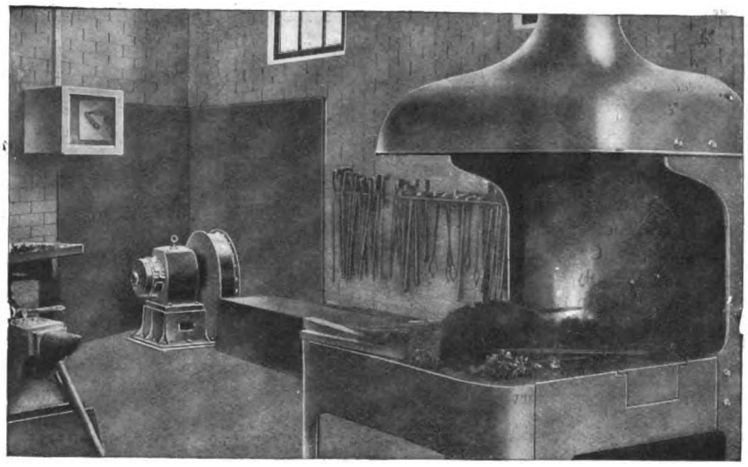

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All communications should be addressed "The Electrician" Industrial Supplement, 1, 2 and 3, Salisbury Court, Fleet Street, London, E.C.

Copy for text or advertisement pages for next issue should reach the above address not later than **September 14th.**

Manufacturers, Contractors, Central Station Engineers, and those interested in Electrical Industrial Developments are cordially invited to contribute original matter to the SUPPLEMENT, and when suitable this will be inserted as space permits.

Filing Case for "The Electrician" Industrial Supplement.

The INDUSTRIAL SUPPLEMENT is holed for filing, and we are distributing cases which will hold twelve issues. On request a case will be sent to Consulting, Manufacturing, or Contracting firms; to Chief or Resident Engineers of Electricity Supply, Traction or Power Stations; to any firm of Merchants or Agents; to Railway, Tramway, Dock, Harbour, or other companies interested in the applications of Electric Power, &c., to their undertakings; and to other large consumers of electrical energy, either at home, in the Colonies, or abroad.

A portion of each issue of the SUPPLEMENT is reserved for special circulation oversea.

Editorial.

Portable Tools. We are able in this issue to present illustrations of typical modern electric portable tools. Unfortunately limitations of space will admit of merely a casual comment upon the good points of these machines. We should like to have said more about their many uses. As we have indicated, the portable electric tool has found work to which it is peculiarly suited, and it is doing that work well. Previous to the development of the small motor and its direct application to individual tools the practice in all industrial work was to bring the work to the tool. The portability of electric motors has reversed that axiom, and the tendency is for many of the older and clumsier tools to give place to a number of smaller ones, applied simultaneously at different points of the work to be done. This is but the natural consequence of a form of energy which can be employed in small power units, even small enough to be held in the hand. An intermediate step in the evolution from the single large machine to the many small tools is the driving of these single machines by separate motors. In the case of drills and boring bars, this practice has been followed by that of lifting the entire tool with a crane and placing it alongside the "piece" on the face plate for operations to be proceeded with. These tools, though very heavy, are still portable in that they are intended to be moved round the work and not vice versa. Now that the small motor has reached a stage of practical efficiency we shall doubtless hear of certain trades and industries in which new uses have been found for it. The feature of these tools is the remarkable efficiency of the motors. Although these machines are powerful, the fact that they occupy so limited a space renders them liable to serious overheating when constantly overloaded. The difficulty seems to have been satisfactorily met by turning the revolutions of the motor to account to provide ventilation for its windings.

The Electric Loaf. At Niagara Falls a factory is in operation motor driven from the hydro-electric plant at the Falls, converting whole wheat into pleasing and tasty articles of food. The advertising literature of this concern, which seems to find its way into the corners of the earth, lays stress upon the production of comestibles by electricity. "Baked by electricity" is the legend, and a remarkable one it is. Now British bakers are apparently bestirring themselves in the use of machinery and want power—electric power. From the electric bakery should naturally emanate the "electric loaf." Already the observant may see "Electric power bakery" on the delivery vans of enterprising bakers, and if there is anything in a name here is evidently an opportunity worth embracing. At any rate, the "electric loaf" sounds much more light and airy than the steam loaf or the gas loaf or even the oil loaf. These latter have doubtless been unworthy of exploitation on the bread carts of the bakers troubled with steam, gas and oil engines. Doubtless in the near future we shall regale ourselves on the "electric loaf."

The Case of Mexico. In another column a brief reference is made to the progress made in Mexico with hydro-electric power transmission and distribution, and the industrial possibilities which lie at the back of those developments. On every available occasion we have emphasised the importance of this utilisation of natural water powers and its influence upon the industries of other countries. The case of Mexico serves as an admirable example. Naturally favoured, in the matter of water power, with high mountains having snow-capped peaks, and high lands forming extensive catchment areas there are few difficulties in the way of turning these mountain waters to account. Unlike some of the American schemes, in which the water must be piped many miles, the Mexican stations can be built on some rocky escarpment, with a minimum of cost for civil engineering work. So steep and long are the declivities down which certain rivers fall that in one instance, at any rate, two power stations are being built "in series," to apply an electrical term, in the flow of the river. The water from the upper station after passing through it and doing useful work will descend to the plant at the lower level and there be used again for operating turbo-generators. By this means some 120,000 H.P. is made available and will be transmitted to convenient points for utilisation either for transport or factory purposes. As these hydro-electric schemes proceed, as they undoubtedly will do, the industrial importance of Mexico will be enhanced by the presence of a cheap and convenient power supply which should attract manufacturers and bring about the formation of important industrial centres. The mineral wealth of the country can then not only be yielded up, but it may also be turned on the spot into useful and marketable articles of industry and commerce. Like Switzerland, Mexico is a country which should blossom out under the ægis of cheap hydro-electric power. We may remark here that in the building of some of the stations the whole of the plant has been transported into the interior on mules, and this lack of transport facilities has necessitated the building of the machines in small sections.

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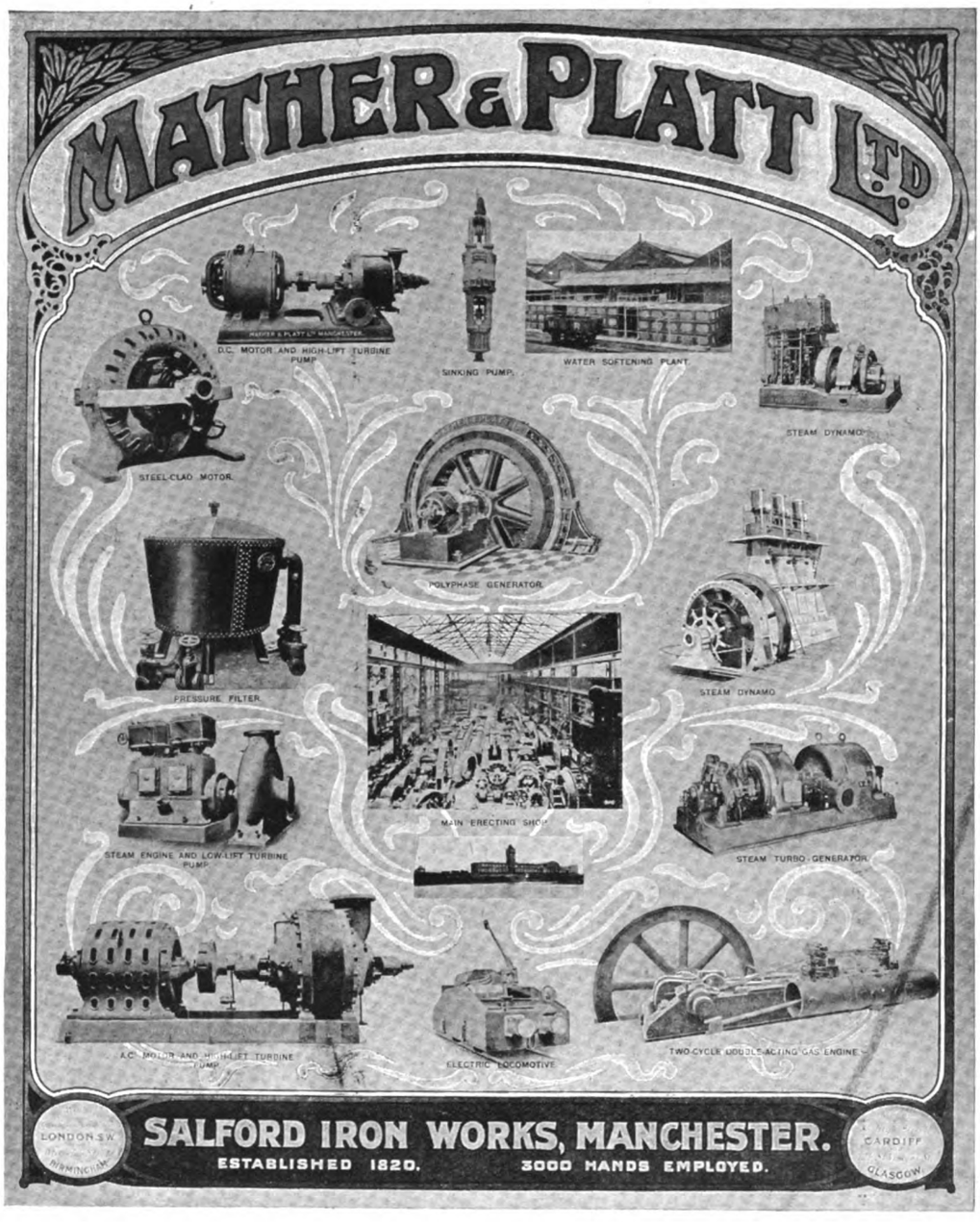

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The Smokeless City.

WE have frequently urged in these columns that the future city will be innocent of the smoke and soot and dirt which town dwellers have patiently suffered for many decades. In an electrical age we shall have outdistanced the grime of steam, and industrial centres and country towns alike will enjoy the advantages of clear skies and clean lungs. That this "good time coming" is also apparent to electrical engineers generally, and that they are sanguine of its arrival at no distant date, the following, taken from the columns of the "Electrical Review," New York, fully indicates:—

"The electrical engineer has an ideal before him of the city of the future from which the wasteful steam engine and the smoking factory and station chimney has been banished. He confidently anticipates that in this city of his imagination the electric motor will do all the work, illumination will be furnished by electric lamps of many kinds and, perhaps, some of the necessary heating may be done electrically. The power for this work will be supplied from waterfalls, or, if there be none available, from large power houses placed well outside the city proper.

"There is no question that the city of the future will depend largely upon electrical energy for its motive power and for lighting, but there is a possible, or rather probable, competitor for much of the work of the smokeless city, and this is the gas-producer plant. Quickened by the competition of the electric lamp, gas engineers are bringing about changes in their methods and apparatus which are just as revolutionary as those which seem to be here in the electric field. The production of a satisfactory inverted Welsbach mantle lamp introduces a competitor which the incandescent lamp, even though of the most efficient type, must recognise and be prepared to meet. Moreover, the mechanical engineer has turned his attention to the gas engine again, and he has now eliminated many of the troubles of the earlier types; and since this motor not only has a high thermal efficiency but is itself a prime-mover, it is not handicapped by generating-station losses, and this feature is a telling one where the cost of power is an important item.

"Realising the excellence of these devices and the advantage held by a system which supplies a cheap, clean fuel for heating, and, perhaps, underestimating the peculiar and desirable features of the electric lamps and motors, the gas engineer is now looking forward with as much confidence as the electrical engineer. He believes that the light and power in the ideal smokeless city will be supplied, largely at least, by means of producer gas made in large works outside of the city. The heating of the city will be done partly by gas, but mainly by the coke made in the producers, which is an excellent fuel when one knows how to use it, and is smokeless. The gas engineer does not expect to eliminate the electric lamp and motor entirely. For certain purposes he recognises their advantages, but he thinks they will take a subordinate position, or even where used they will be operated by current supplied from a gas-engine driven station; the main supply of energy will be by gas.

"It must be admitted that the gas engineer can make out a pretty strong case for gas. The electrical engineer believes he can make out a stronger one for his system, and is counting on gas as an auxiliary where water power is not available. It is very evident that these two systems will, in the future, co-operate largely in city work, yet it must not be overlooked that they will be competitors for much of this, and it would be unwise for the electrical engineer to underestimate the strength of the gas system if he intends securing for his own that part of the work which he thinks he should have. It would be better to overestimate the advantages of gas than to be led to a false feeling of security and thus left behind in the march of industrial development."

While appreciating the point raised by our contemporary upon the competition of the gas engine, we are disposed to feel that, being a prime mover, and a reciprocating one at that, the gas engine cannot seriously rival the electric motor for town service. The gas engine cannot be made in small enough sizes to be applied directly to the driving of individual pieces of machinery. It can only run in one position, and its power is usually transmitted by belt to the machines driven. Our contemporary appears to overlook the fact that electric power applications in towns are rapidly extending and that no industrial power user would forsake the electric motor for the gas engine to drive his factory or workshop. Gas engineers appreciate that where the electric motor is once installed they have no hope of introducing suction gas plant. The difference is not one of efficiency but of convenience between the two power agents. The gas engineer, however, should abandon the idea of making gas on the outskirts of the future city and piping it thereto for use in stoves and gas engines. Let him co-operate with the electrical engineer at the power plant by furnishing the best producer and the best engine. The dynamo, the transmission line, the distributing network and the stoves, lamps and motor can be left with the electrical engineer as his by right of superiority over anything before tried for the particular purpose.

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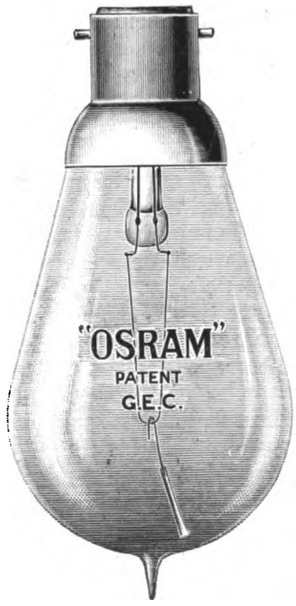

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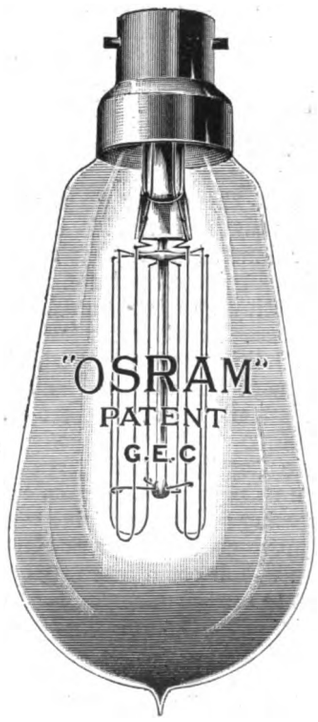

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Commercial Development of Central Stations. . . . .

SUPPLIERS of most trade commodities take advantage of the advertising value of their customers' shops by using them for publicity purposes. This is noticeable in every business establishment. The supplier sends along an elaborate and attractive show card, which is put up by the shopman in a prominent position, and in a quiet way it does its work. The shopkeeper may or may not be allowed something for this use of his windows and shelves though he naturally benefits if sales result. Electricity supply, of course, differs from business in proprietary articles, and station managers cannot exactly imitate the methods of trading concerns. Still, the "location" offered by a shop counter is worth much for advertising purposes and might reasonably be exploited. It would have to be done judiciously, but it could be done, and without appearing unduly obtrusive. We have recently seen a record of a chemist's shop being made use of in this way on the understanding that in the lighting account (the installation was a new one) a rebate was allowed for the privilege of the advertisement. This latter took the shape of a sign hung over the doorway, and attention was directed on it to the value of the electric service particularly for chemist shop lighting. This method of publicity should not be carried on persistently with one customer. It might with advantage be tried at one time in shops representing different trades, and then employed in other business houses on a modified scale. A small counter sign illuminated at night, a table card or ornamental frame hanging in a good position, would suffice to hold advertising matter which could not fail to attract attention. The plan could probably be carried out only in certain shops, but they would give the best reiurn. We refer to middle-class establishments with a good custom and all-round trade.

Trade Advertisements.

The Winter Season.

Although the summer has not yet reached us this year, we can, doubtless, look forward to a normal or abnormal winter. Station managers have an opportunity for seeking the heating and cooking load, but more especially the former in the colder days. The introduction of lamps which reduce light bills to perhaps a quarter of their former dimensions, is a serious matter for stations doing a lighting business, and compensation should be sought in the building up of the connections for cooking and heating appliances. Local contractors will do much to secure business of this class, but with the help of the electricity department the way of the undertaking can be directed into pleasant places. If there ever was a time when it was possible to work up something approaching a boom in electric heating, cooking and power it is now, and the station manager can do wonders to help this boom along. Canvassing and circularising need to be vigorously pressed just previous to the dark days and during the winter. People will become interested after a time and may be taught to see the advantages of electricity supply if these are laid before them in the right way.

We have already had several seasons of exhibitions, and these have sown good seed. We now want to set about the gathering in of the harvest, and we hope that station managers will make good use of their opportunities during the coming season.

Industrial Topics. . .

THE most modern of our great engineering workshops and factories are now equipped for the electric drive, and frequently the electrical energy is made use of wherever possible for lighting, lifts, cranes, hoists, &c. From our experience of large factories, of which we have inspected not a few, we have noticed the comparative scarcity of the electric locomotive, either battery or trolley types, and the electric telpher. Large electric cranes are installed as a matter of course for lifting and transporting heavy and light weights in the works, but these have a limited sphere of action and are also used somewhat carefully. Although fitted with a supplementary hoist, they cannot always be requisitioned for the lighter lifts. Even when handling a small load they appear almost ridiculous when travelling down a broad aisle with it. The electric telpher is one of those convenient methods of transport which might be used to greater advantage if its merits were better known. Its first cost is not prohibitive, and unskilled labour can be placed in charge of it. The power consumed is, in addition, not excessive, and the traveller may be run at fair speeds. Overhead runways for hand pulley blocks and travelling tackle have a use in foundries, but little attempt appears to have been made to bring in a power-driven equipment to replace hand labour. The electric telpher confers the enormous advantage of taking up space seldom required and of leaving vacant floor-room which can be turned to good account. Then there is the electric locomotive. Why a steam locomotive should go puffing about a works with electric power plant and full motor equipment installed whereas an electric tractor would be more convenient is difficult to understand. The trolley locomotive is not always convenient because of overhead wires, and objection can also be raised to third rails. Battery locomotives can fill the gap, however, and, judging by experience, the results obtained are highly satisfactory. The operating conditions appear to favour this form of traction, as the batteries can receive attention at the hands of electricians, and the load does not impose great strain upon the plates. Locomotives of this pattern have met with some favour in America, and, though they are not "pushed" as a "strong selling line," they do good service in large works. Probably the field is better for the telpher than the battery locomotive. Each has, however, its uses, and the manufacturer with a lot of ground to cover should ascertain the peculiar value to himself of these transporting devices.

Electric Transport in Factories.

Singularly enough the electric telpher was one of the earliest forms of electrical transport experimented with. The first line was quite automatic and was placed overhead. The conducting wires also formed the running rails and were ingeniously placed so that the wires beneath the two collecting wheels were of opposite polarity. By this means overhead trolley wires were not needed and the car collected the necessary energy by the wheels. Automatic telpher lines are standardised for the transport of materials, such as coal, iron, earth, &c., also sacks and boxes, and this fact should encourage their use in workshops and factories for the transport of unfinished and finished parts.

The electric pulley block also is a device which might find its way into factories. These hoisting appliances are also made to travel, and in this way combine the advantages of the telpher with those of the electric crane. For light work they are quick and efficient and are also controllable from the floor. These machines are standardised, and can be obtained for certain definite duties. They are also equipped with motors for most of the ordinary voltages in use.

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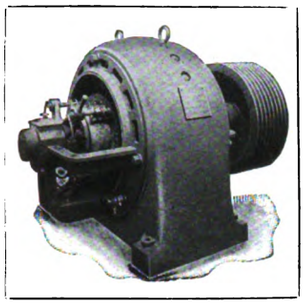

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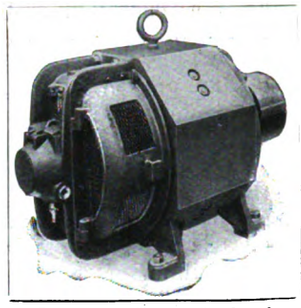

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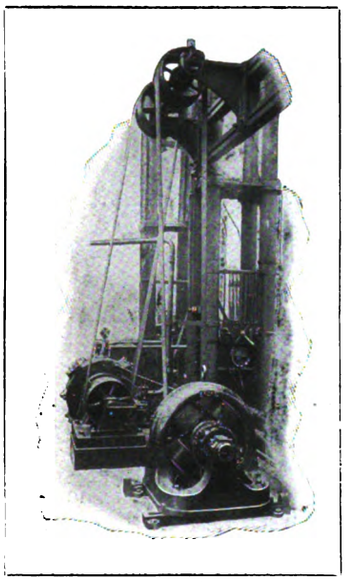

Motor Driving Shafting by Belt.

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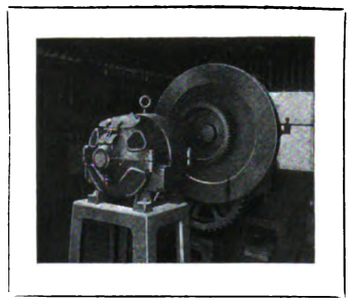
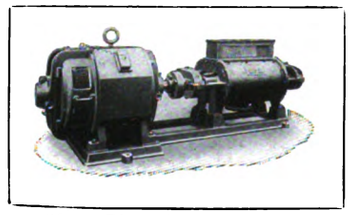
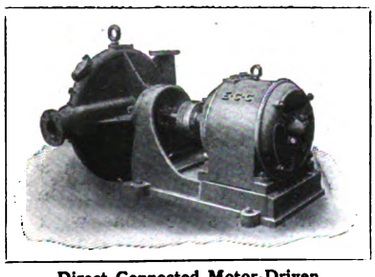


Motor Driving Cold Shear in Steel Works.



Motor Direct-Coupled to Root's Blower.



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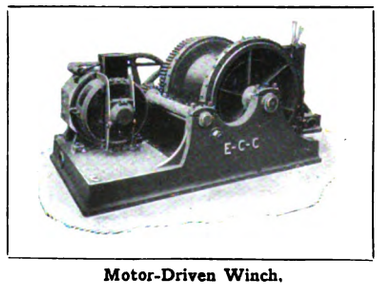

Motor-Driven Winch.

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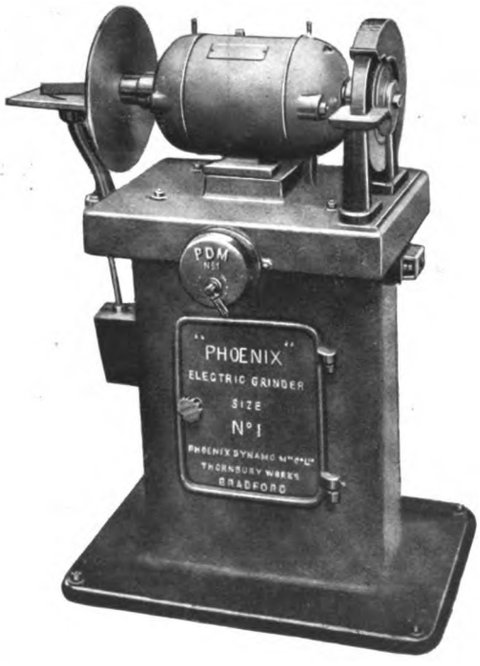
Portable Electric Bench Tools.

THE compactness and efficiency of the small electric motor are mainly responsible for its direct adaptation to types of tools originally driven by belts from countershafting. The distribution of electric power in machine shops has also influenced the employment of small motors for the operation of individual tools. When electric driving is introduced group driving may be done away with, consequently the smaller tools require to be motor driven as much as the larger ones. Here, then, is the opportunity for the electric bench tool, more particularly the drill and grinder. Each complete with its driving motor, these handy devices are light enough to be conveniently portable and prove both effective and economical in operation. The Phœnix Dynamo Mfg. Co. specialise in tools of this description, and already have standardised drills and grinders, which are in extensive use. As makers of dynamo electric machinery their experience is especially useful in the building of the small motors required for this class of work. Fig. 1 illustrates the "Phœnix" electric bench grinder mounted on a cabinet base for the storage of tools, &c. The base of the grinder is attached to a swivelling table which can be moved vertically through an angle of 45 deg. The shaft of the motor carries clamps at each end for an emery wheel and grinder disc. The motor is a two-pole machine substantially built, with laminated poles, slot-wound armature having former windings, and hard-drawn copper commutator bars. In the standard machines the emery wheels are 8 in. diameter by 1 in. face in two grades, for coarse and fine work. Wheel guards and adjustable tool-grinding rests are provided. Suitable end plates enclose the motor body but by the removal of a few screws these can be taken off to give access to the motor. A suitable starting switch forms part of the grinder equipment. The net weight of the machine is given by the makers as 175 lb. and its principal dimensions are length 22½ in., width 15 in., height 13 in.



Electric Grinder mounted on special cabinet with Swivelling Table.

These figures are, of course, for the grinder only and do not include the cabinet shown in the illustration, The motor develops 1 H.P. and runs normally at 2,400 revs. per min. Standard machines are built for direct-current circuits up to 250 volts, but the outfit can also be supplied for polyphase circuits of certain frequencies.

Sensitive Electric Drill mounted on Floor Pedestal.

Another "P.D.M." bench tool is the "Phœnix" electric sensitive drill which was introduced by the company some years ago. The illustration, Fig. 2, shows the drill complete, mounted on cast-iron tool cabinet for floor use. It is, however, supplied for bolting down directly to the top of a bench or wall bracket. The motor is mounted on a bracket extension of the supporting pillar and the drill spindle is driven by a friction pulley running on the under side of a friction plate. By the movement of a small lever the pulley can be slid towards or away from the centre of the disc, and by this simple means the speed of the drill is altered over a wide range. The lever drops into notches marked with the size of drill in the chuck, so that the correct drill speed can always be obtained. A lever feed motion is also fitted to the drill spindle, the sleeve carrying this being provided with a ball-bearing to take the thrust of the drill. The little motor develops ½ H.P., and the makers state that with the most severe tests they have not found it possible to pull the motor up. They inform us that ½ in. holes have been drilled in brass at the rate of 3 in. per minute, and boiler plate at the rate of 1½ in. to 2 in. per minute. With a ¼ in. drill this rate has been increased to 6 in. and 7 in. per minute. A large number of these drills are already in use, including 35 supplied to the Admiralty, 12 to a firm of motor-car makers, 6 to the Great Western Railway, 5 to Japanese Government, 8 to a large Sheffield steel foundry and various batches of two and three to other users.

The Phœnix Dynamo Mfg. Co. is prepared to send these handy tools on trial—in the case of the grinder for 14 days and the sensitive drill seven days—to engineers and power users interested.

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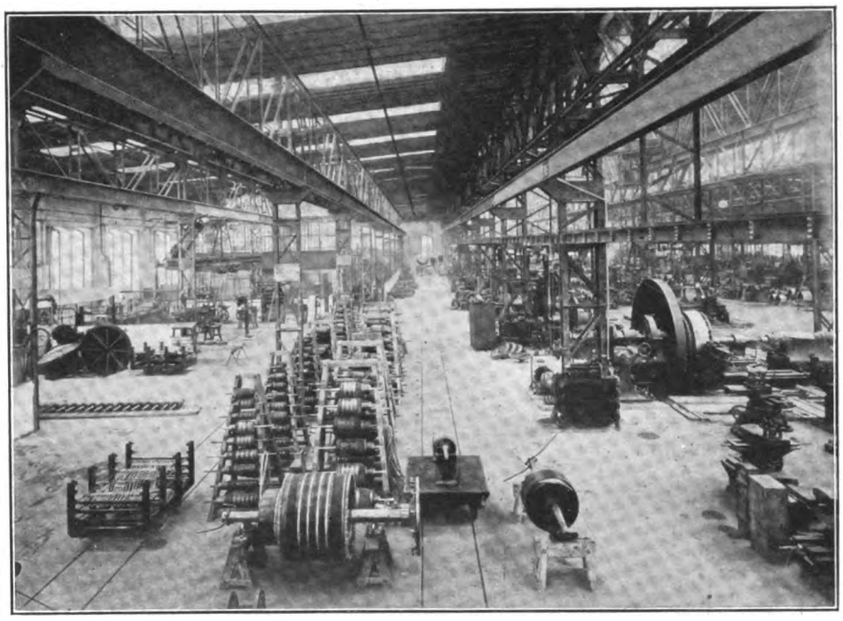
THE FACTORY.



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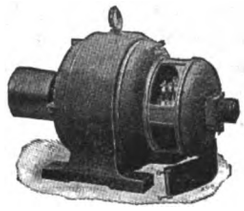

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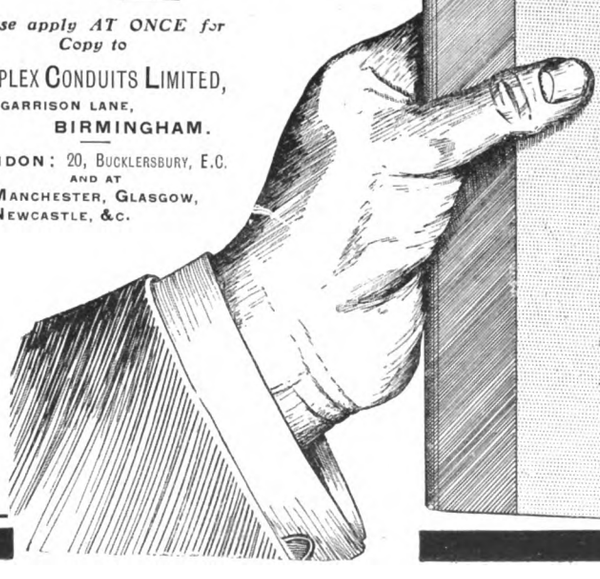

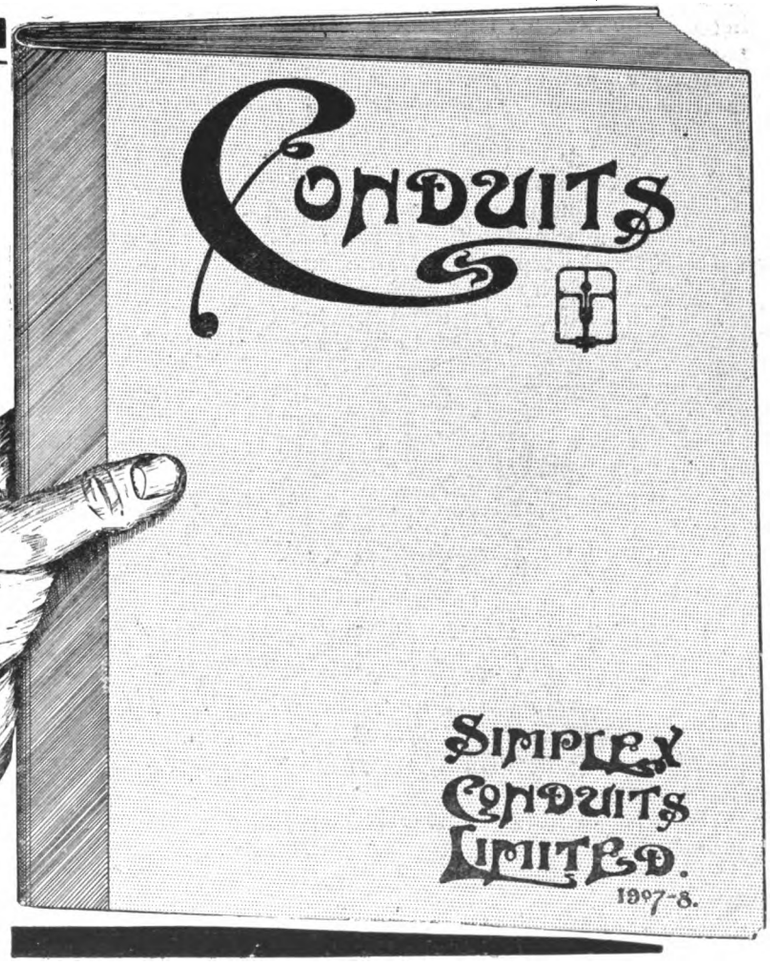

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H.C. Iron-clad Switch Gear.

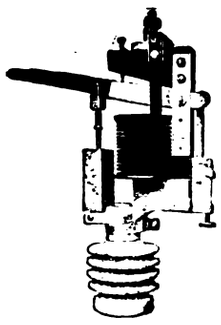

Fig. 1.—Overload Trip Coil mounted on Porcelain Insulator.

THE principal change which is noticeable in the design of high-tension switch gear is the substitution of metal for the support of the current-carrying parts, in place of insulating material such as slate, marble, &c. Oil tank switches may probably be regarded as instituting this change. They were mainly composed of an iron casting supporting lever motion and current-carrying parts (in porcelain insulators) and a sheet-iron tank partially filled with oil, into which the contacts dipped. To place a switch of this description on the front or at the back of a marble panel seemed somewhat incongruous. The most suitable framework appeared to be iron or steel girders, and the transition to this construction followed almost as a natural consequence. The Union Electric Co. in its switch gear designs has adopted this latest practice, building the electrical portions of the gears or switches into metal tanks or supporting framework. The design, of course, entails complete reliance being placed on the insulators employed, but research and experience have done so much for porcelain as an insulating medium that faith in its reliability is practically boundless. With care in design too, the insulator may be made to serve many useful purposes. For instance, in Fig. 1, the initial to this article, an overload release with time limit attachment is shown mounted on the top of a porcelain insulator. Solenoid, tripping-lever, dash pot, and spring adjustment are all self-contained and fixed by a clamping stud to a corrugated insulator which may be placed over the mechanical release of a switch or circuit-breaker. In Fig. 2 this method of mounting is illustrated, the switch shown being three-phase hand operated with two overload magnets and trips fixed on insulators next to the terminals at the top of the tank cover. The coils themselves form part of the high-tension circuit, consequently current transformers are not required. There is, accordingly, no dependence upon direct current for the tripping of the switch release. The same arrangement, instead of being mounted behind a switch panel, as shown, is placed in an iron tank partly filled with oil. The adjustment of the current at which the tripping coil will operate is effected from the outside of the switch by an insulated holder, which fits over a square-ended screw which turns the spring adjustment on the tripping lever. The design is typical of what may be done with insulators and ironwork in a small space. Fig. 3 is an end view of a board in which this oil circuit-breaker is fixed to an iron framework with the necessary cable-sealing chamber instruments and 'bus bars. In Figs. 4 and 5 end and front views of typical ironclad switch panels are shown. The iron framework in this design carries all the necessary parts, so that the gear is self-contained and can be placed anywhere. The oil switch is a type which combines switch and fuse in one holder, the switch lever and moving fuse carrier being attached to the lid of the oil tank, which can be swung back with the moving part of the switch to inspect the fuses or make adjustments. The internal connections are self-contained,

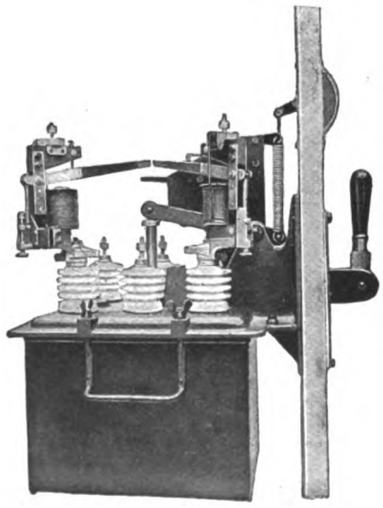

Fig. 2.—Three-phase Oil Switch with Overload Coils in High-tension Circuit.

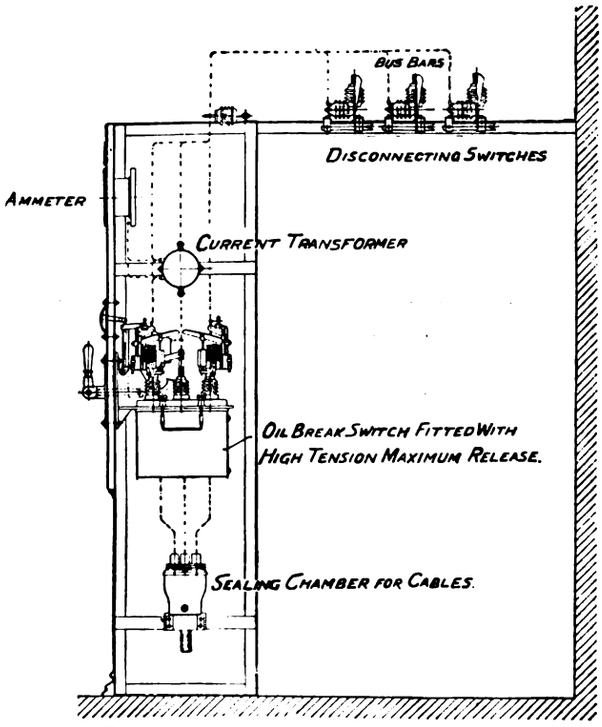

Fig. 3.—End View of Oil Switch mounted on Iron Framework.

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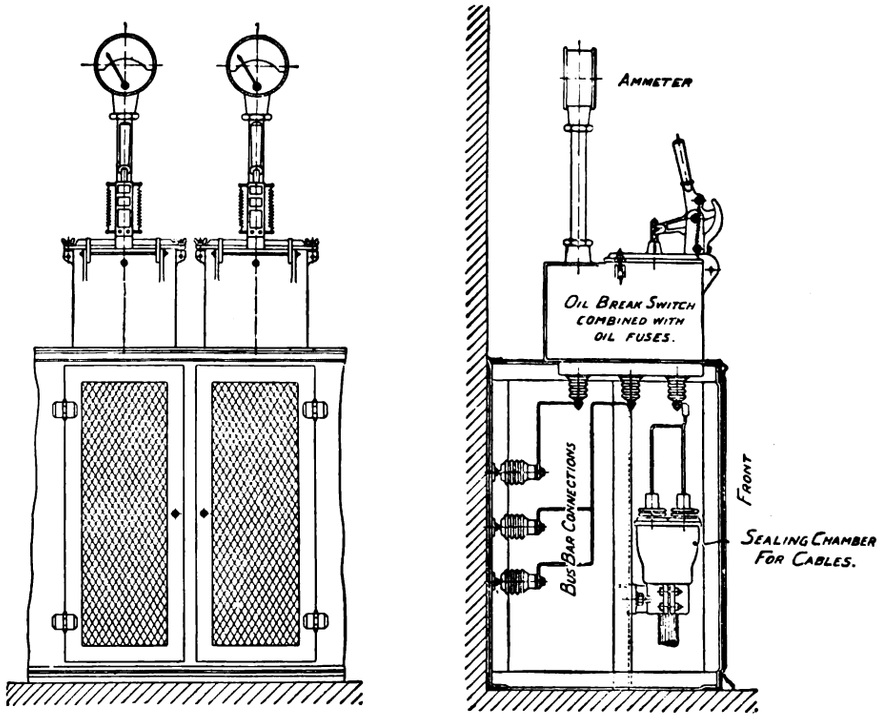
so that the only thing needed to place the gear in circuit is to couple up the incoming and outgoing cables to the terminals in the sealing chambers. These connections are accessible through doors at the front of the gear, below the ledge on which the oil switches are supported. A noticeable feature of this design is the fixed contacts of the oil switch. These are *at the bottom* of the oil tank and do not depend into the oil, as in some designs. The terminals are below these contacts, outside the tank, and we are informed that there is no leakage of oil through the cement used to hold the contacts and the insulators in position. This in itself is remarkable. As the earliest oil switches gave so much trouble on this score, bottom contacts were practically abandoned for those which hung in the oil bath at a point which removed all possibility of leakage.

The advantage of these bottom contacts lies in the facilities afforded for connecting the switch to other parts of the gear. In the examples shown in Figs. 4 and 5 this is well demonstrated. The top of the switch box can also be left entirely free, and the cable connections are removed from the mechanical working parts of the switch.



Figs. 4 and 5.—Views of Ironclad Switch Panels.

Yet another important advantage accruing from the use of metal framework with high-tension switch gears is that of interlocking of the various parts. For instance, the shutter or door giving access to a switch panel can be mechanically locked by a plug switch or fuse. Only on the withdrawal of this can the high-tension chamber be got at and the removal of the plug will make the particular panel "dead." Absolute safety to the operator can, by this means, be provided with a minimum of complication of the gear.

The Union Electric Co. has just issued a very complete catalogue on high-tension switch gears, and a copy should be obtained by all users of high-voltage power, who are naturally interested in efficient controlling apparatus.

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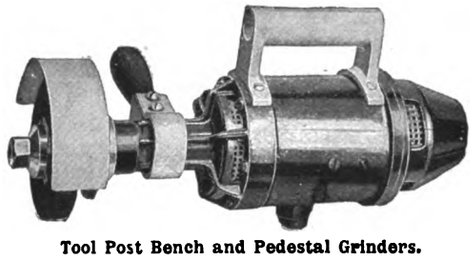

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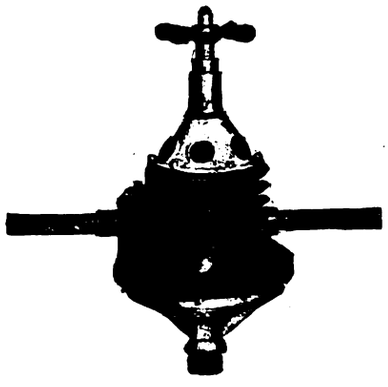

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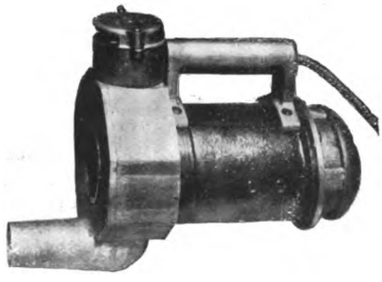

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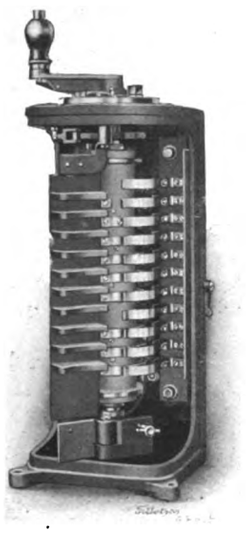
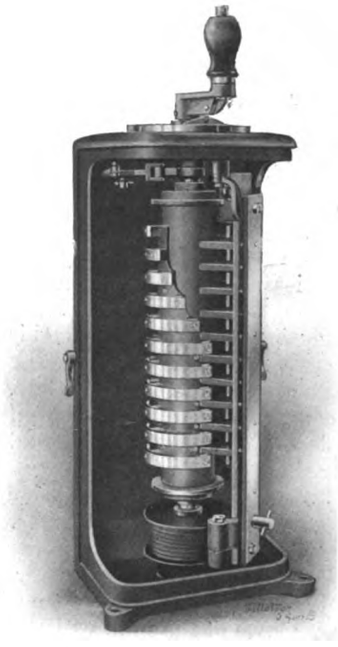
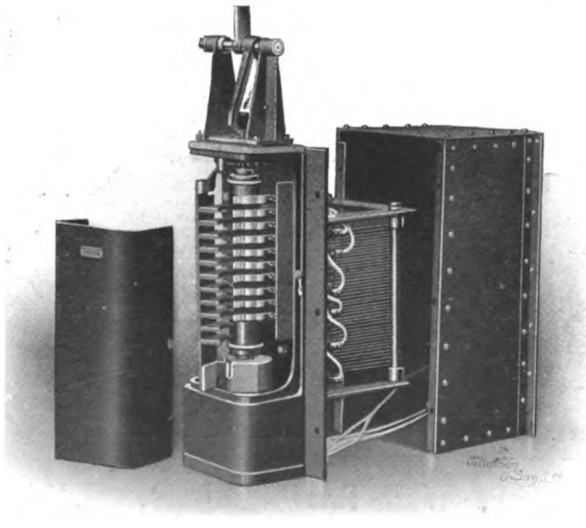


Controller Opened to Expose Contacts.

THE uses to which drum-type controllers can be put are being gradually extended, and now that heavy motors are applied to the driving of large industrial machines there is a growing demand for controlling apparatus of this class. For purely industrial purposes the drum-type controller has been chiefly developed in connection with electric cranes, as it is most conveniently adapted to the small space available in the attendant's cage. It is not a matter for surprise that a firm of electric crane makers should undertake the manufacture of drum-type controllers. No better experience than that furnished by the control of crane motors could be drawn upon for the design of a drum-type controller. Thomas Broadbent & Sons, Huddersfield, who are well known as electric crane makers, have standardised a line of drum-type controllers and resistances which is intended for other industrial purposes as well as that of crane control. The adjoining illustrations depict several types of these controllers. The design resembles that of the standard tramcar controller, and includes magnetic blow-out coils and spark chambers. A separate covered case for the terminals is provided at the back of the controller and cable sockets are furnished with the apparatus. Hard-drawn copper is used for the barrel and finger contacts, the latter being adjustable as to their pressure on the former by set-screws and locknuts. Fireproof insulating material encloses each finger contact, so that arcing between fingers is prevented. The controllers are standardised for shunt-compound and series-wound direct-current motors, and also for two or three-phase machines. Certain types have notches for rheostatic braking in either direction of the motor. The controllers are classified under three sizes, and have respectively five, six and eight running positions.



Controller with Blow-out Shield Closed.



Combined Controller and Resistance.

Electric Power v. Compressed Air.

THE relative merits of the above-named power agents are frequently the subject of discussion among engineers. Practice is, however, always preferable to precept, and practical comparisons are more convincing than much argument. We have recently been supplied with particulars of an instance in which compressed-air power has given way to electric power, and the prime mover used for driving the air compressor is now coupled to a dynamo-electric machine.

Messrs. Ernest Scott & Mountain (Ltd.), Close Works, Gateshead, have just completed an installation of electric

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power plant for the Clifton Colliery Co. (Ltd.), Nottingham, which is certainly interesting in its bearing upon the comparative economy of compressed air and electricity. The engines now driving the alternator are fitted with steam cylinders 30 in. diameter. The compressor cylinders were 30 in. diameter by 48 in. stroke, and when running at 55 revs. per min. required 578 I.H.P. The air at about 70 lb. pressure was delivered to the pit bottom and there drove air engines operating an endless rope haulage gear dealing with 1,500 tons in 7½ hours along a road 595 yds. with a gradient of 6 in. to the yard. A strap rope drove an in-bye haulage at the end of the gradient, and the whole of the power of the engines was absorbed in driving this machinery.

The engines were adapted for electric power driving by fitting Proell governors, and mounting on the crank shaft a Scott & Mountain three-phase generator, 300 kw. 75 revs. and 2,500 volts. The current at the full voltage is taken direct to a motor of 125 H.P., driving a modern endless rope haulage gear, fitted with friction clutches at the shaft bottom. At one of the shafts a distribution board is fixed, and current is supplied to another motor of 60 H.P. at the bottom of the incline. The conversion from compressed air to electric drive has been made without stopping the work at all, the change-over being made at week-ends. The old flywheel, in the case of the engine, was first removed and the new one fitted, and the stator frame built up in halves.

The final result of this change-over has been that whilst the engines originally, when working compressors, developed 578 H.P., they now are doing rather more work and developing only 166 H.P. This demonstrates the great advantage of electric driving over compressed air where electricity can be safely used underground. It is interesting to note that with the engines the Clifton Company now possess they will be able to do the whole of their pumping, electric coal-cutting, additional haulage and shop driving, and lay off two boilers, if not more. The suggestion to make this change-over and the general arrangement of the scheme were due to Major Walker, the general manager of the Clifton Colliery Co. (Ltd.).

The foregoing appears to be an excellent example of the superior efficiency of electric power over compressed air power. It also illustrates how, in plants which have been run with steam for many years, the existing engines can be turned to good account for driving dynamo electric machinery. A colliery installation is one of those few examples of power utilisation in which the absence of an outside electric power service can be immediately remedied by the generation of that power on the spot. To most colliery owners and managers the advantages of electric power seem to be already apparent. Where they cannot take a supply from outside and have machinery in a running condition at the headworks they need defer the use of electricity in the workings only so long as generators can be applied to the engines already installed. That this course is productive of economy the installation referred to above clearly indicates. Doubtless there are many more plants which might be converted with equal, if not greater, advantage to the cost of power about the workings and pit-head machinery.

The question of an outside supply does not directly enter into the present matter, but it still has an important bearing on colliery operation as with cheap fuel at the pit's mouth, power can be generated at very low cost.

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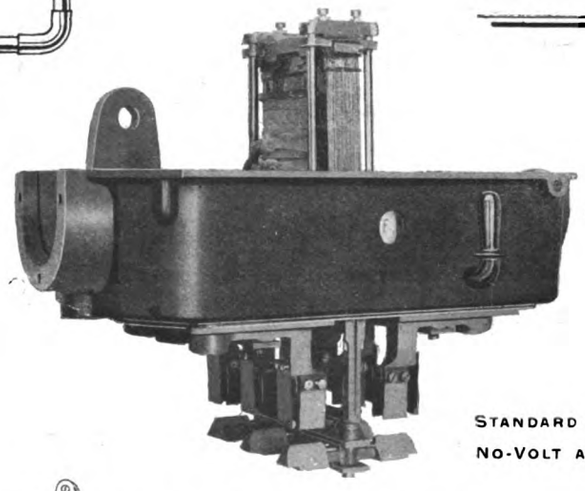

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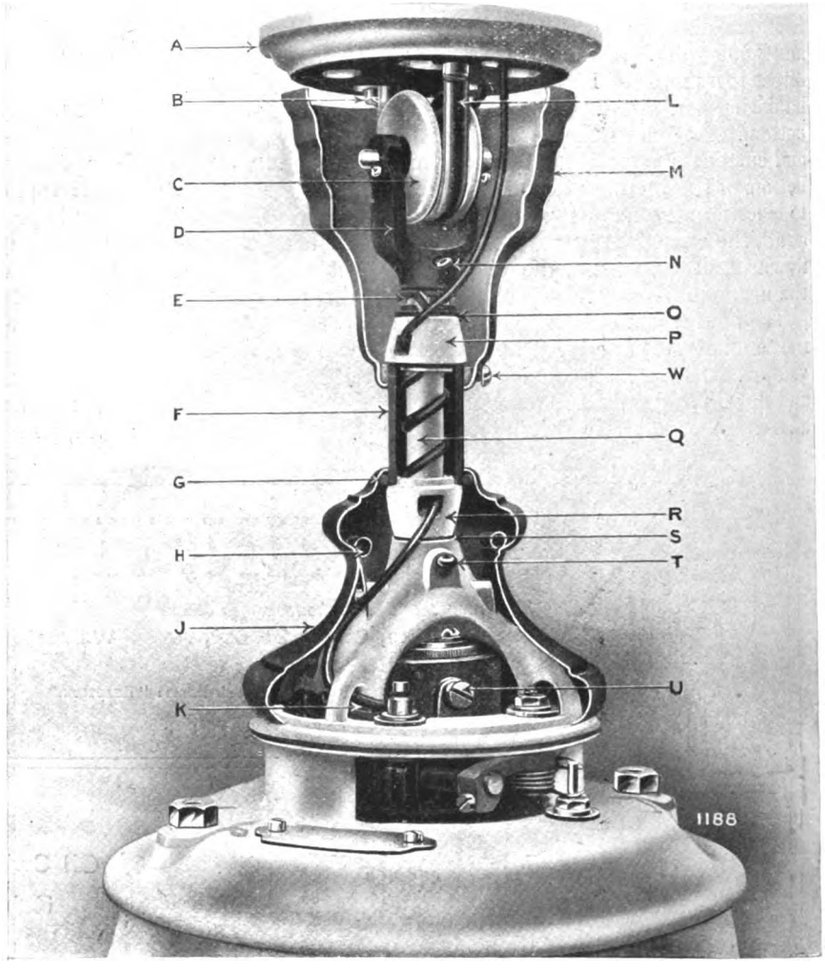
Ceiling Fan Suspension.

THE popularity of the ceiling fan is well deserved. In large rooms it gives the appearance of coolness, its blades slowly turning and keeping the air moving. But to be of neat appearance the suspension of the fan must be carefully designed, otherwise the cable connections will appear unsightly, and there is the further matter of risk of short-circuits to be considered. The fan is preferably suspended and not rigidly fixed to the ceiling, as if it receives a blow it will give, if hanging loosely, and take no harm. The Crompton ceiling fan, also known as a punkah fan, appears to be distinctive in the matter of its suspension, as the adjoining illustration shows. A sectional view of the insulated hanger and suspension tube is given to clearly indicate the neat manner in which the cables are brought in from the ceiling and led down to the fan motor. Referring to the lettering on the sectional view, A is the ceiling plate to which the hook L and wheel insulator C are attached. The shackle suspension D hangs on a spindle passing through the insulator and held by split pins at each end. Into the shackle is screwed one end of the suspension rod Q, the other end screwing into the top of the motor. At each end of this tube, also, are insulators, P, N, which act as guides to the flexible cables leading down to the motor terminals from the conductors in the floor above the ceiling plate. The suspension rod is surrounded by a brass tube, F, which rests on the shoulder of the insulator R, and serves as a rest for a similar shoulder on the upper insulator P. Between this last mentioned insulator and the shackle D is a leather washer, O, and spring washer, E, which is inserted to relieve the insulators from undue stress at any time. Both the motor and the suspension are enclosed respectively by ornamental metal spinnings J and M. The lower spinning J is held securely by the springs H, which keep the small flange round the suspension tube tight down on the rubber ring G, making a dust-proof joint. The upper spinning is secured by the screw W. The suspension rod and tube are shown as quite short in the illustration, but in the standard fan the length of these is 4 ft. The suspension rod can also be fixed rigidly to the ceiling if desired, but the arrangement shown is Messrs. Crompton's standard.

We may mention here that this design has been in use for some time on fans supplied by Messrs. Crompton to India and other tropical countries. It is, of course, none the less suited for more temperate countries where ceiling fans enjoy considerable vogue.



Sectional View of Ceiling Fan Suspension.

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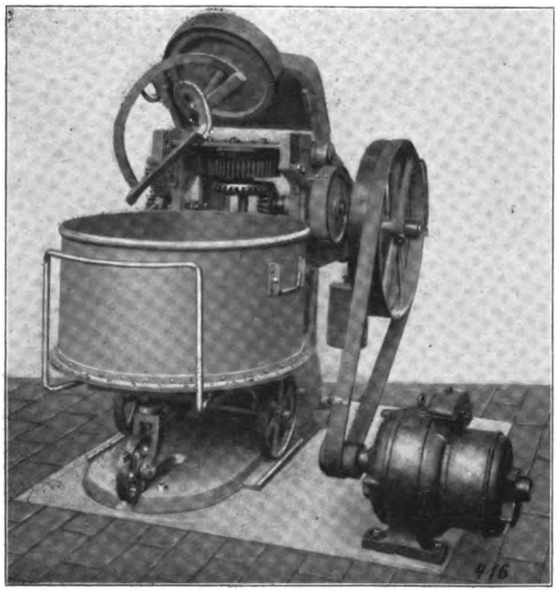
Electric Power in Baking.

WHETHER the availability of a convenient, reliable and cheap source of power such as electricity is responsible for the introduction of machinery into certain trades it would be difficult to state. There are, however, types of labour-saving devices which have been introduced into many of the lighter trades which are eminently suited for driving directly by electric motors. An admirable example is baking. If electricity cannot yet heat the baker's oven efficiently, it can operate such machinery as he finds necessary to economise time and labour in the preparation of the ingredients for his bread and other products. The principal machines used are

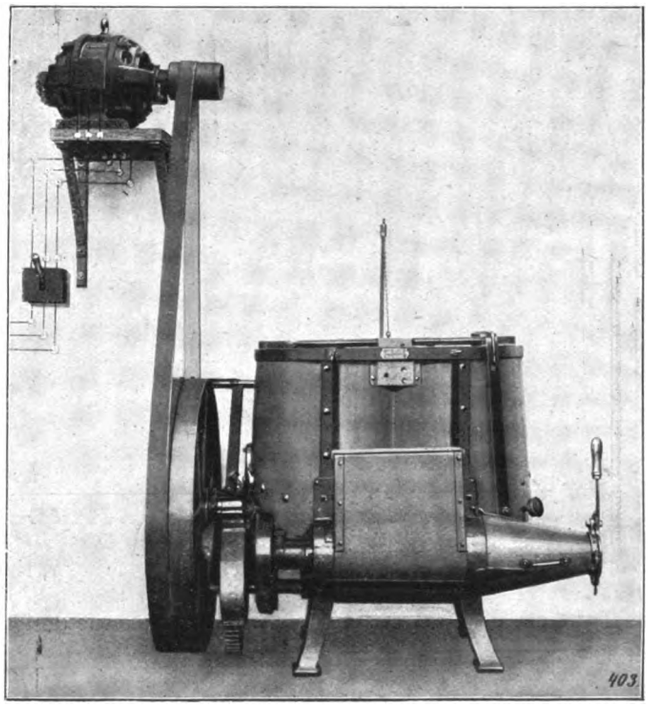


Small Motor on Floor operating Dough Mixer by Belt. (Union Electric.)

mixers and kneaders, and these require direct rotary motion for their operation, consequently are well adapted for motor driving. The same regularity of speed and evenness of turning moment are evidently not required with baking machines as are absolutely necessary in some trades. Still, it is undoubtedly an advantage to have a power agent which runs smoothly and is free from the jerks not uncommon with gas and oil engines.

Cleanliness. If cleanliness is next to godliness in daily life, it is something which the baker must worship if he is using machinery for the production of his goods. Now, cleanliness and steam, gas and oil engines are as far removed as the poles.

The engine is not, of course, set in the midst of the machinery, but the fact that it must be placed apart affords evidence enough of its uncleanness and unsuitability for baking work. Beside, a baker is in business to make bread, not to generate power. He should get this like his flour—from outside. Among his employees bakers only should rank, not engineers and millwrights to attend engines and repair shafting. Because the electric motor can be brought direct up to the machine it is required to drive and because when supplied with power from outside it needs little or no attention it is pre-eminently the machine for



Small Motor Fixed to Wall Bracket driving Kneading Machine by Belt. (Union Electric.)

the baker. If it were dirty and greasy it would not be allowed within the precincts of a modern baking establishment.

The Motor Drive. Baking machinery has now become standardised and the large tradesman who wishes to be "in the swim" cannot afford to be without the specialised apparatus obtainable for the preparation of the materials previous to baking. Mixers, kneaders, whisks, dividers, pie machines, &c., go to make up the equipment of a model bakery, and the electric motor only is needed to put the finishing touches which will make the installation ideal. These machines are peculiarly adapted to driving, by means of small motors, a motor,

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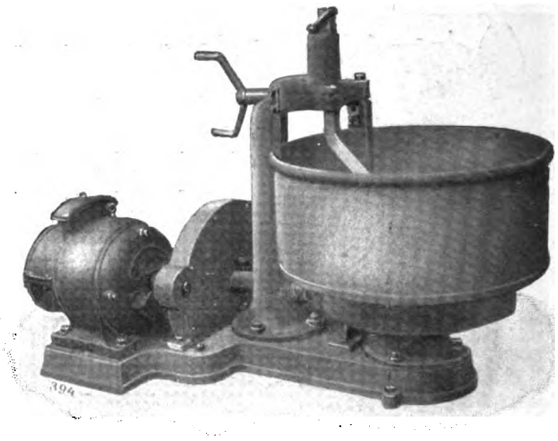
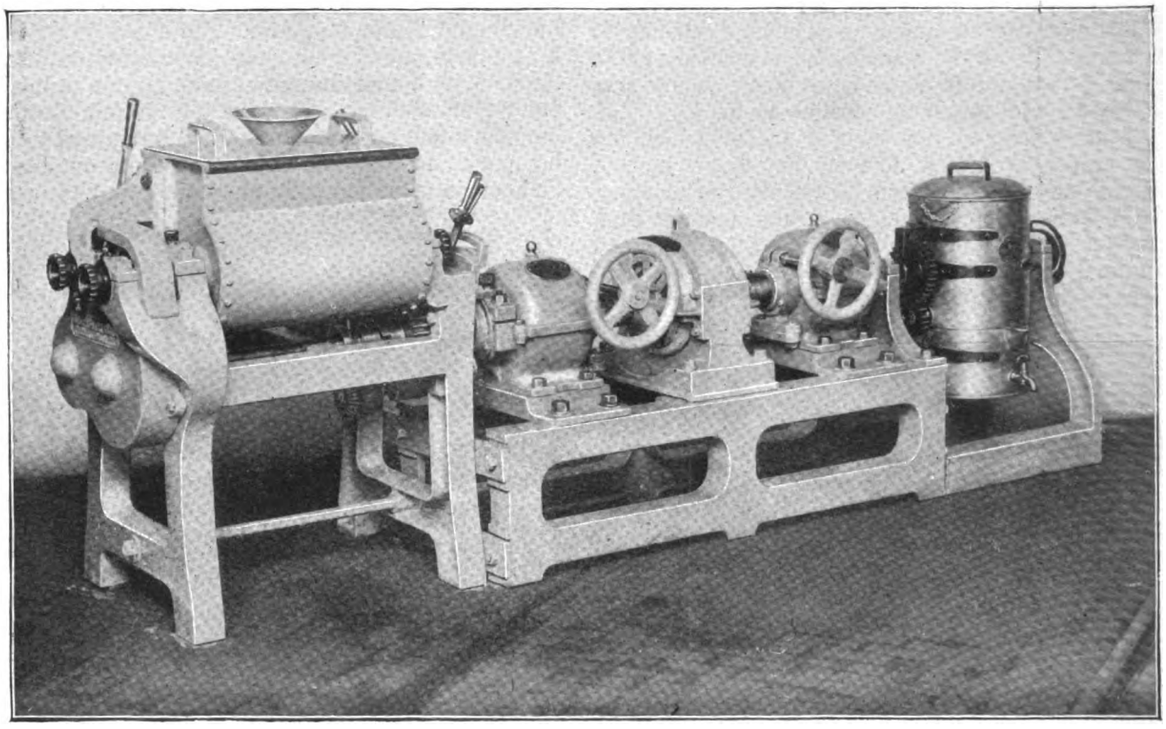
in fact, to each machine. The machines are not necessarily all used at once and some require to be run longer than others. Line shafting and belts are always unsightly, dirty and in a way dangerous, besides which they waste much power both when running light and on load. For these reasons the baker should pin his faith to the small motor, and when he wants the power he can turn it on knowing that only when the machine is running is energy being consumed. Makers of baking machinery, in fact, adapt their designs to accommodate the electric motor, and this may be taken as a complete acknowledgment of the claims of the electric motor for this class of work.

Output. Experience with electric driving has accumulated evidence to show that the output of a works or trade establisment goes up while the operating costs go down. Even if the cost remains the same, the increased output really makes the total cost of the product lower than before. As with other trades, so with baking. Machinery reduces costs below those of hand operation by increasing the output



2 H.P. Motor driving Mixer and Kneader by Gearing. (Union Electric.)

of baking machinery in the direction of increased output. The more bakers employ electrically-driven machines the



Combined Kneader and Cake Mixer Gear driven by Small Motor. (Langdon-Davies.)

enormously. If electric power drives the machinery, the cost becomes reduced again. Indeed, it may be expected that the use of the electric motor will influence the design greater will be the progress made in their design and the better will be the business prospects of the tradesmen taking advantage of them.

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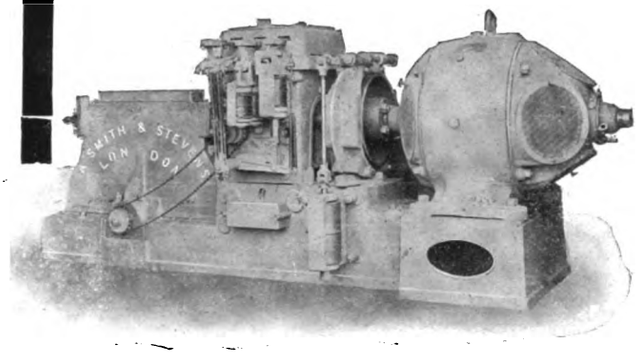

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Portable Drilling Machines.

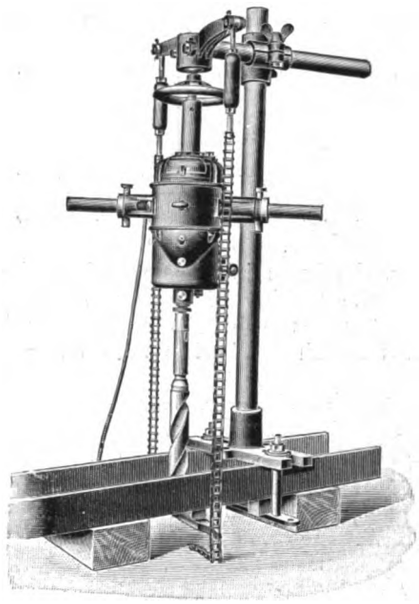
A CONSIDERABLE saving in labour and expense can often be effected by bringing the tool to the work instead of vice versa, as is usually done. This principle is well recognised, and the problem of rendering the tools portable was partly solved many years ago by compressed air, flexible shafting, &c. However, these expedients have manifest limitations, and it is not surprising that the fields of application of portable tools remained restricted until the advent of electrical driving.

The portable drilling machines which are described and illustrated below are specialities of Siemens Brothers Dynamo Works (Ltd.). Tools of this description are not infrequently subjected to severe treatment by unskilled or careless operators, and this was one of the main points which the makers kept in view in designing the apparatus The machines are compact and as light as is compatible with strength. The motor is totally enclosed and drives the drill by means of toothed gear. A number of these machines are provided with two spindles running at different speeds, while other types have a single spindle and change-speed gear. The larger sizes can be used in conjunction with a drill angle and feeding screw or drill post where it is desired to drill large holes.

The motors are of the continuous-current, three-phase or single-phase commutator type to suit all requirements, and are supplied for any standard voltage. The smallest hand-drilling machine is capable of drilling a ¼ in. hole in steel and 25 in./64 hole in cast iron, brass, copper, or beechwood, whilst the largest size will drill holes of about 8 times the diameters mentioned. These figures hold good for intermittent working; for continuous working the holes that can be safely drilled are somewhat smaller. The weights range from about 6½ lb. to 95 lb. These machines can be used for a number of other purposes besides drilling, for instance, for grinding and polishing (in conjunction with a flexible shaft), tapping, reaming, &c.

A particularly useful machine for many purposes is the combined drilling and tapping machine. This consists of a motor, countershaft with spindle, and reversing switch let into the handle. The machine is provided with an eye bolt, by means of which it can be suspended for tapping in a horizontal direction. In all except the smallest size the gear is of the two-speed type, the slow speed being used for tapping and the high speed for drilling. For tapping, the spindle is connected to the tap by means of a flexible connection with safety coupling and chuck to prevent the tap becoming jammed in a hole—a contingency which could not be avoided if the connection were rigid. An exception is only made in the smallest size, which is so light that no flexible connection is needed. The safety coupling also guards the motor against overloads due to blunt taps or variation in the size of hole. The machines are made for tapping holes up to 1 in. Whitworth in mild steel of about 1 in. thickness, or in cast iron, brass or copper of about 1⅛ in. thickness.

Contrasts in Siemens Electric Drills. The larger machine is suitable for Tapping purposes.



Drill Post clamped to girder and supporting Motor-operated Drill.

The thread is cut in a single operation with a taper tap which is supplied with the machine. This tap has a cylindrical fluted extension on the free end which acts both as a reamer and a guide and ensures a straight thread. The tap is withdrawn at a considerably higher speed than obtains during the forward or cutting motion. The illustrations on page 127 also show one of the firm's portable bench drilling machines and a portable motor driving a drilling machine by a telescopic shaft with universal joints.

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Electric Signs. . . . .

IN this country the average tradesman does not push his goods. His shop is the only advertisement in which he indulges and he is generally indifferent to its lighting both by day and night. Thus the value of good lighting, whether natural or artificial, is ofttimes lost upon him. British business is done by stolid British methods without hustle or rush. While disinclined to hold up the U.S.A. as a model of good business we have a leaning towards its methods in electric signs. Our tradesmen want more signs, good signs, by day and night. British signs are, if anything, superior to American. They pay due regard to tone, and generally are compelling without being irritating. A British sign will also bear the stamp of thought in design and strength combined with lightness in construction. Of sign makers, however, we have enough. The sign users are wanted, and when they appreciate that business, we will not say always, but nearly always, comes from intelligent

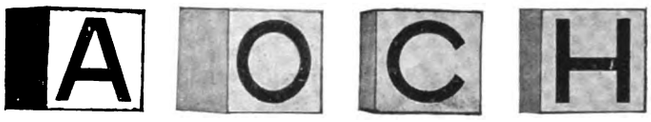

Fig. 1.—Box Letters of Electric Sign.

use of signs, the boom in signs will have begun. Like most things the making of signs needs specialising to give the customer the benefit of accummulated experience and research. We illustrate on this page examples of an interchangeable electric box sign which can be turned to a variety of uses. The letters, as will be noticed in Fig. 1, are of crystalline glass fixed in front of an iron cube, of which the back is of wood. The interior contains a lamp-holder and lamp complete, making each letter a separately illuminated unit. Fig. 2 shows a number of letters with the ornamented iron frame for holding a number in position. The letters are interchangeable, and any desired length of wording may be made up. The letters are clearly visible in daytime as dark letters on a white ground. At night they appear as clear illuminated letters standing out distinct from the surrounding blackness. Any required colour can be employed for the letters.

Fig. 2.—Box Letters with Ornamental Supporting Frame.

Another design, shown in Fig. 3, provides for the interchange of letters in front of a row of incandescent lamps, which may be slid along two conducting rails and adjusted to appear directly behind each letter. The design is similar to that already described, except that the latter portion only is detachable and the lamp-holders are movable instead of fixed. In the illustration the portico of a music-hall is shown fitted with the sign letters. The device is waterproof and the letters are inserted at one end and pushed along into their proper positions.

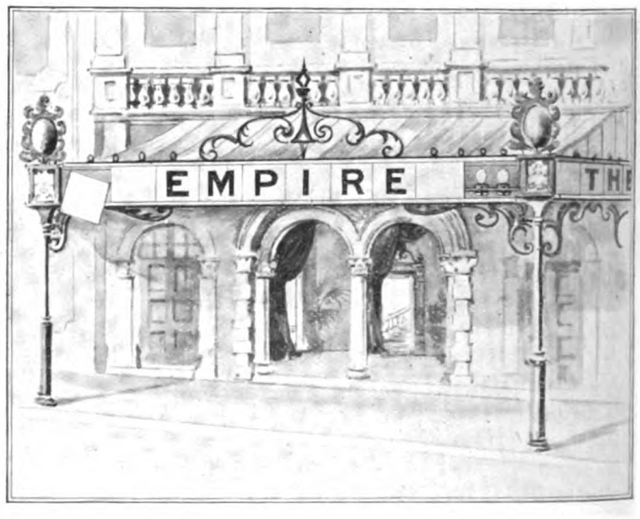

Fig. 3.—Interchangeable Tablet Sign as arranged for Theatre Portico Display Announcements.

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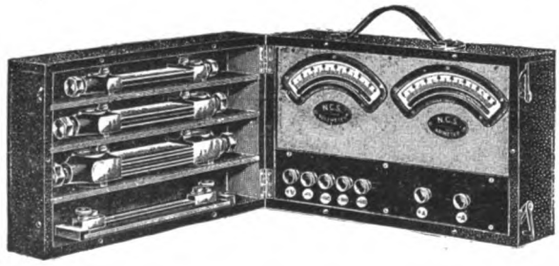
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NOTES.

The Illuminating Engineering Society.

AN organisation bearing the above title has recently been formed in America, and its roll of membership includes considerably more than a thousand names. So vigorous, indeed, has been its growth that a first annual Convention was held at Boston during the last two days of July, and, according to our American contemporaries, this Convention proved a "noteworthy success." The President of this Society is Dr. C. H. SHARP, an abstract of whose address will be found in another column. A considerable portion of Dr. SHARP'S oration consisted of an elementary lecture leading up to the theory of photometry, and the remainder was a plea for the substitution of a unit of intensity of illumination for the present unit of illuminating power. From a purely academic standpoint Dr. SHARP'S argument is invincible, and there is also much in its favour from a technical or practical point of view. Nevertheless, we fear that he will find he is but as a voice crying in the wilderness. Briefly, he wishes to adopt the "lumen" as his unit, and the lumen involves the troublesome factor 4π. It is, as a matter of fact, the total light energy which falls on a surface subtending a unit solid angle with a source of 1 c.p. at its apex. Hence, the total light energy emitted by a standard candle under normal conditions is approximately 12·57 lumens.

THE matter is exactly analogous with the fundamental conception of the unit magnetic pole, which has caused so much discussion and has been the object of considerable abuse. Innumerable schemes have been devised to eliminate the 4π, but it is still with us and is likely to remain, for the simple reason that no system, however ingenious, can alter the ratio of the surface of a sphere to its radius. At present, commercial photometry is delightfully simple, and it is questionable whether anything tending to complicate it will be welcomed by practical men. Of course, if a new society, devoted exclusively to the study of illumination, is formed, then it is only natural that a large number of fresh suggestions should be made. However, as we pointed out in a leading article some time ago, the entire matter might very well be dealt with by existing societies, and we trust that the day is far distant which will mark the birth of an English society having the same functions as that just called into existence in America.

Restricted-Hour Supply.

AN interesting letter from Mr. P. J. PRINGLE, borough electrical engineer to the Burton-upon-Trent Corporation, appears in our Correspondence columns this week. Mr. PRINGLE gives some valuable figures regarding the effects, on the maximum load and output, of a supply of electricity for power purposes on the restricted-hour basis. It appears that 75 per cent. of the Burton power-load has been obtained on this system, and hence considerable support is given to the contention that it constitutes a useful means of securing a remunerative power-load. In nearly all towns there must be a number of tradespeople who use power for only a few hours per day, to whom it would be of small consequence if their supply were cut off during certain hours in the winter months; these would become profitable consumers even if they paid a specially low price for power. In towns, however, subject to dense fogs, during which the evening peak load may be exceeded during the day, the system could not be adopted to any large extent, except in the case of electro-chemical works, with which an arrangement might be made for reducing the demand for power in such emergencies. As, however, most of our towns are not subject to dense fogs, there is apparently no reason why the system should not be more generally adopted.

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Corrugation of Tramway Rails.

NOTWITHSTANDING the fact that this subject is receiving a considerable amount of attention at the hands of tramway managers, who have at their disposal elaborate detailed statistics from most of the towns where electric tramways are in use, no generally accepted explanation of the phenomenon is forthcoming. Mr. WORBY BEAUMONT, as will be seen from the Paper which he read at the recent meeting of the British Association, still maintains that corrugation is brought about by the rolling action of the car wheels on the rails. This explanation, we think, is scarcely sufficient to account for corrugations which frequently appear on the outer rail of curves. Mr. BEAUMONT argues that these corrugations occur only on the outer rail because extra pressure is brought to bear on it by the heeling over of the cars. There is, however, the possibility that it may arise from an irregular motion of the outer wheels, which grip the rails intermittently, the period depending partly on the elasticity of the axle, as explained by Prof. S. P. THOMPSON in the discussion which followed the Paper.

IT is interesting to note that corrugation is of comparatively rare occurrence in the United States of America, in spite of the fact that that country was admittedly the pioneer of electric traction, and that the difference between English and American practice is very slight. This may be due to the fact that lighter cars are in use, but, on the other hand, equally light cars are in use on Continental systems, and there corrugations are not uncommon. Mr. BEAUMONT suggested moderate speed as a remedy; this, however, would scarcely be acceptable to the public, to say nothing of the tramway authorities. Moreover, American speeds are higher than ours, and yet do not produce corrugations. Other remedies suggested in the Paper are lighter cars, harder rails and larger wheels. If Mr. BEAUMONT is right in attributing the trouble to the rolling action of the wheels, harder rails should prove a satisfactory preventive; on the other hand, if his theory is incorrect the wear on the rails will simply be transferred to the wheels.

Aluminium Cables.

FROM time to time discussions have arisen on the merits of aluminium as a substitute for copper in the manufacture of electrical conductors, and there has always been a wide divergence of opinion. The cheapness and low specific gravity of the metal are attractive features, and in the event of the demand becoming much increased there is no doubt that its cost would be even further reduced. On the other hand, its conductivity is only about 60 per cent. of that of copper, and the difficulty of making mechanically sound joints is not a small one. However, Messrs. JOHNSON & PHILLIPS now claim to have overcome this latter difficulty, and they are prepared to supply both bare and insulated aluminium cables. So far as bare conductors are concerned, they are, of course, no novelty, and apart from America, where they have been widely used, instances of overhead aluminium lines are not unknown, in this country. With regard to insulated cables, the whole question seems to turn on first cost and the efficiency of the joints. The first cost of the actual conductor is less in the case of aluminium than it is for copper, but owing to the increased diameter of the conductor to provide an equivalent carrying capacity, it is obvious that more insulation has to be employed. Now, as insulation is expensive compared with copper or aluminium, it is quite possible that the additional cost incurred may offset the saving in the conducting material. Messrs. JOHNSON & PHILLIPS do not quote prices.

Engineering Machinery Exhibition.—It is announced that Sir Alexander Kennedy, president of the Institution of Civil Engineers, will perform the opening ceremony at the forthcoming Engineering and Machinery Exhibition at Olympia on Thursday, Sept. 19. He will be supported by Sir William H. White, and a number of other eminent scientific men.

Constitution of Radium.—In a recent number of *Le Figaro*, Madame Curie replies to Lord Kelvin's recent attack on radium. She is reported as saying that radium is a distinct chemical element in the sense that chemistry applies to the word, and it is improbable that Lord Kelvin considers it to be a composition analagous to a similar molecular combination. It is possible, adds Madame Curie, that Lord Kelvin's argument really consisted more of words than ideas, for probably the items of which radium is composed are all complex, and derived from most simple elements, the nature of which is still almost unknown.

Electric Lighting in the United States.—In connection with the recent meeting of the National Electric Light Association at Washington, the *Electrical World* gives some interesting figures concerning the growth of electric light and power in the United States. It would appear that the United States, Mexico and the West Indies had at the end of 1906 no fewer than 4,900 central stations, or for the North American continent including Canada, more than 5,000. The investment in the United States is estimated to have reached £170,000,000 and the gross income is put at about £33,000,000. The census of 1902 showed that 20 per cent. of the plants were concentrated in six cities, and that they yielded 25 per cent. of the income of all the stations in the country.

German Electric Railway for Handling Goods.—According to the *Railway and Engineering Review*, the German Government authorities have decided to build an electric railway from the Essen coal and iron district, across the semi-mountainous Eifel region, to the Saar and Lorraine districts. The officials have entered into negotiations with one of the electrical companies of Berlin for the equipment of the line. The object is to secure the cheapest transportation for heavy goods from Lorraine, which produces enormous quantities of low-grade iron ore, thus avoiding the costly shipment to the furnaces of the lower Rhine. Lorraine also requires vast quantities of coal, which comes from Essen. The project is based on plans for utilising streams in the Eifel region to generate electricity.

Iron and Steel Institute.—As previously announced (see *The Electrician*, p. 291) the autumn meeting of the Iron and Steel Institute will be held in the building of the Austrian Engineers Society in Vienna on Monday and Tuesday, September 23rd and 24th. Among the Papers which are expected to be submitted are the following:—

"On Steel and Meteoric Iron," by Prof. F. Berwerth; "On the Determination of the Quantity of Blast Furnace Gas for a Given Make of Pig Iron," by Prof. J. von Ehrenwerth; "On the Application of the Laws of Physical Chemistry to the Metallurgy of Iron," by Baron H. von Jüptner; "On Case Hardening of Mild Steel," by Messrs. C. O. Bannister and J. W. Lambert; "On the Hardening of Steel," by Mr. L. Demozay; "On the Structure of Hardened Steel," by Mr. P. Longmuir; "On Case Hardening," and by Mr. G. Shaw Scott; "On the Economical Distribution of Electric Power from Blast Furnaces," by Mr. B. H. Thwaite.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Brest—Dakar	July 22, 1907 ..	—
Kotonou—Libreville	July 18, 1907 ..	—
Acora—Lagos	Aug. 11, 1907 ..	Aug. 24, 1907
Para—Pernambuco	Aug. 21, 1907 ..	Aug. 22, 1907
Maranham—Ceara.....	Aug. 21, 1907 ..	—
Medan—Olehleh.....	Aug. 21, 1907 ..	—

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Electric Traction in Berlin.—At the present time the State railway authorities in Germany have under consideration a project for converting the "Ringbahn" system in Berlin and its suburbs to electric traction. It is expected that the first portion of the scheme, which deals only with the city and circle railways and the inner suburban lines, will be completed in about six years. The power station, which will be erected in the suburbs, will, in addition to supplying current for traction purposes, provide energy for light and power within a large industrial area. The electrification of the other portions is under consideration, and it is hoped that the whole of the conversion work will be completed by 1920. The estimated cost of the electrification for the scheme outlined is £9,000,000.

German Central Station Statistics.—According to the *Elektrotechnische Zeitschrift* the number of stations in operation in Germany on April 1st, 1906, can be placed under the following heads :—

Prime Movers.	No.	Total power installed in kw.
Steam	616	317,430
Water	135	14,683
Wind	1	220
Gas	170	20,226
Diesel engines	9	1,059
Petrol engines	1	5
Electricity	9	1,015
Water and steam	250	96,260
Water and gas or other int. combustion engines	67	4,702
Steam and gas or ..... do. ..... do.	40	12,704
Various	40	141,211
	1,338	609,515

Electrical Manufacture of Calcium Carbide.—In our Editorial Notes last week we commented on the arrangement which had been made between the Yorkshire Electric Power Co. and the British Carbide Factories (Ltd.), with reference to the supply of power to the latter and we are now able, through the kindness of Mr. W. B. Woodhouse, resident engineer of the Power Company, to give some further details of this scheme. The manufacture of calcium carbide is carried out in electrical furnaces, worked at a voltage of about 50 and using alternating current. The raw materials are limestone and coke, of both of which there is a plentiful supply obtainable from local sources. This will be the first case of carbide being made on a commercial scale in England. The advantages of cheap water power possessed by a number of Continental works are largely discounted by the cost of raw material and carriage. These disadvantages also apply to the manufacture of other materials by electro-chemical means. The supply to the Carbide Company will be given by means of overhead lines at a pressure of 10,000 volts, and transformed by static transformers to from 30 to 50 volts, the regulation of voltage being performed by auxiliary transformers. The Power Company hope that their load-factor will be increased by this special load from about 40 per cent. to over 80 per cent.

Wireless Telegraphy Notes.—It is reported that during the course of a cruise from Melbourne to Sydney H.M.S. "Challenger" was able to keep in continuous wireless communication with the flagship (H.M.S. "Powerful"). The longest distance covered was 410 miles, the "Powerful" being at that time in Hobson's Bay and the "Challenger" in Farm Cove, Port Jackson. This distance is the longest so far covered by warships on the Australian station. It is further announced that the Commonwealth Government intend to establish wireless communication between the Australian mainland and its new dependency Papua, formerly British New Guinea.

A recently issued American consular report gives some interesting details of the rapid progress that has been made by the Slaby-Arco system of wireless telegraphy, not only within, but also outside the German Empire. The number of stations equipped with this system is 641, or 41 per cent. of the world's total, which is 1,550. These stations are installed on the territory or vessels of 31 different countries, while 174 are erected on land. The usual radius of action is 125 miles but this is in several cases extended to 310 and 435 miles, or even greater distances, and the large experimental station at Nauen can signal over 1,860 miles. The United States has 20 stations equipped with this system, Russia has 17, Austria-Hungary 10, Denmark and Spain 7 each, Holland 6, and Norway and Sweden 5 each. There are also 22 stations in non-European countries. The majority of the stations are on ocean-going vessels. There are 22 on Dutch and German steamers and 389 on warships. The latter include vessels of the following nationalities : German 140, Russia 126, American 43, Swedish 19, Austrian 17, Dutch 10, Norwegian 8, Argentinian 6, Danish 5, Brazilian 5, Spanish 5, Greek 3, and Indian 2. Fifty mobile military stations have been installed in several countries, more particularly in Germany 14, in America 8, in China 5, in England 4, and in Austria-Hungary 4.

It is reported that the Dutch Indian Government has granted a concession for establishing wireless telegraphy communication between Java, Celebes, Borneo and the neighbouring islands to a company whose capital will be £265,000.

New System of Wireless Telephony.—At a recent meeting of the Associazione Elettrotecnica Italiana Prof. Majorana described his new system of wireless telephony, which is based on the use of a spark gap. For generating the spark a special rotating arrangement is used by which it is claimed 10,000 single sparks per second can be obtained. In wireless telephony a microphone is required that can be used with high-tension currents. It must be capable of withstanding a pressure of several thousand volts and of carrying a considerable current. These conditions gave rise to the Majorana hydraulic microphone, which depends on the capillary properties of fluid jets. A stream of liquid flowing from a suitably constructed opening divides itself into drops which follow each other at practically constant intervals. The frequency may be noticed acoustically by allowing the drops to fall on an elastic membrane which then gives out a sound of corresponding frequency. When mechanical oscillations are superimposed on the fluid jet periodical constrictions may be noticed which are of very nearly the same frequency as the superimposed oscillations. The drops thus force the membrane on which they impinge to give out sounds of a corresponding frequency. If the drops fall on a level surface at right angles to their direction, a covering of thickness, varying with the frequency of the drops, is formed. Prof. Majorana has constructed his microphone on this principle and has thus obtained telephonic currents of extraordinary clearness and strength. This microphone consists of the usual mouthpiece and of a membrane fixed to a glass tube which moves freely under the oscillations of the membrane and through which slightly acidulated water flows. The liquid passes out of a special opening in the glass tube and strikes the upper surface of a "collector," consisting of two cylindrical pieces of platinum insulated from each other. On striking the middle of the "collector" the fluid spreads itself over the surface and puts the two halves in permanent connection. Thus a battery whose poles are connected in circuit with a telephone and this "collector" will send a constant current through it so long as the membrane is not affected by sound waves. When the membrane vibrates the aperture begins to oscillate, and varies the flow of the drops so that the fluid on the "collector" is continually altering in thickness. If this circuit is connected in a suitable way with the spark-gap mentioned above, the intensity of the spark will correspond with the sound waves and will transmit to the receiving station the appropriate words and sounds. Prof. Majorana obtained good results with this experimental arrangement, but found it an advantage to use a Poulsen arc in nitrogen instead of the spark-gap.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, September 7th.

JUNIOR INSTITUTION OF ENGINEERS.

3 p.m. Visit to the Works of the Metropolitan Water Board, Hampton-on-Thames.

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LIGHTNING PHENOMENA IN ELECTRIC CIRCUITS.*

BY C. P. STEINMETZ.

The term "lightning," which originally applied only to atmospheric discharges, has, since the advent of power-transmission schemes, been used to describe all those phenomena arising from abnormal voltage or frequency conditions in the transmission line. In this Paper Mr. Steinmetz describes the causes which may give rise to these abnormal conditions, with their resulting surges. He also shows how the power of the oscillations may be calculated, and explains the methods whereby a circuit may be protected against such phenomena.

Originally lightning denoted electric discharges between clouds or between cloud and ground, and, when applied to an electric circuit, the results of such a discharge striking the line. Later it was found that during atmospheric disturbances, such as passing thunderstorms, disturbances occurred in electric circuits even without the discharges striking the line. These disturbances—caused by induction—were also classed as "lightning," and, applied to electric circuits, lightning then came to mean all the effects of atmospheric electricity.

With the introduction of electric circuits of higher voltage and larger electrostatic capacity, phenomena were observed in such circuits of the same character and effect, and requiring the same protective devices, as the disturbances caused by atmospheric electricity,

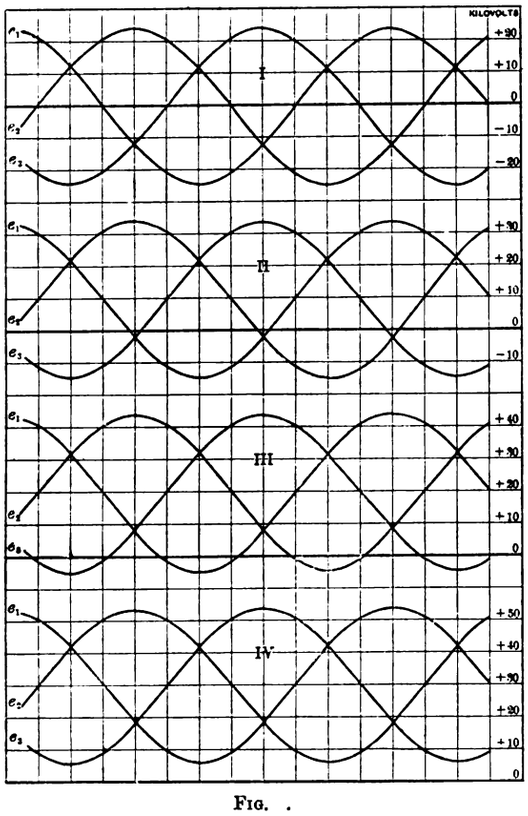

FIG. .

even in cases where atmospheric effects were excluded, as in underground cable systems. Frequently most of the damage is done by the power generated in the system; the atmospheric or other disturbance merely starting the phenomenon.

In its most general meaning, as understood now when dealing with electric circuits and their protection, lightning denotes all phenomena of abnormal voltage and abnormal frequency.

The lightning phenomena in electric circuits then comprise:—(1) External lightning, the disturbances due to atmospheric electricity. (2) Internal lightning, the disturbances due to defects of the circuit or its operation, &c. (3) Surges, that is, disturbances in the flow of generated power, brought about by the external or internal lightning and depending for their energy on the power of the generator system, hence frequently destructive.

The phenomena of abnormal voltage and frequency in electric circuits are the same three classes of phenomena met with in the disturbances in any medium which is the seat of energy:—(1) Steady stress or gradual electric charge. (2) Impulse or travelling wave. (3) Standing wave or oscillation and surge.

* Abstract of a Paper read before the American Institute of Electrical Engineers.

Electric Charge.—The potential difference against earth, or pressure of the total electric circuit, may gradually rise by an electric charge accumulating in the circuit until the electric charge discharges across the lightning-arresters, or punctures the insulation, whichever is the point of least resistance.

Some causes of such steady and gradual accumulation of electric charge are:—

(*a*) Collection of static charge from rain, or snow-drift, or from fog, carried by the wind across the line. Illustrating this on a three-phase system with insulated neutral, it will be seen that the potential difference against ground, which normally is symmetrical, Fig. 1, curve I., gradually, by the simultaneous static charge of all three lines, changes to curves II., III. and IV., until the maximum potential difference against ground is sufficient to discharge to ground. The system then returns to the condition curve I., and then traverses the same cycle again. This electrostatic accumulation of charge, in the case of efficient lightning protection, may appear as a series of discharges over the lightning arresters, which periodically follow each other.

(*b*) Electrostatic induction from a passing cloud.

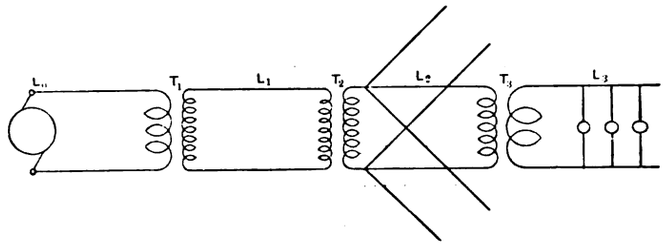

FIG. 2.

Assuming, for instance, a positively charged cloud passing over a transmission line. The ground below the line then carries a negative electrostatic charge, corresponding to the positive charge of the cloud. The line should have a negative charge also, even higher than the ground, since projecting above it. If the line is insulated from the ground, without the negative charge required for electrostatic equilibrium, it thus appears at a positive potential against ground—that is, at cloud potential. With the approach of a positively charged thunder-cloud to the transmission line, the positive potential of the line against ground rises until a discharge takes place from the ground to the line, charging the line negatively. Inversely, with the cloud receding from the line, the line remains negatively charged; this charge, not being bound any more by the positive charge of the cloud, discharges to earth. That is, during the approach and during the recession of a thunder-cloud, discharges may occur between a transmission line and the ground.

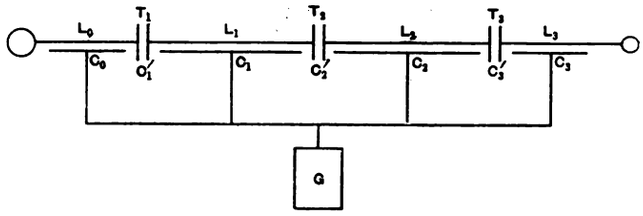

FIG. 3.

(*c*) P.D.s between line and ground due to differences of atmospheric potential in different regions traversed by the line, especially if the line passes through different altitudes, as valleys and mountain ranges.

(*d*) Accidental electrostatic charges entering the circuit, as friction electricity from the belt of belt-driven machines.

Somewhat similar phenomena result from: (*e*) Unsymmetrical conditions of the generator potential. (*f*) Existence of higher harmonics in the E.M.F. wave of a polyphase system, of such order that they coincide in the different phases; that is, the whole system rises and falls with their frequency. So in a three-phase system the 3rd, 9th, 15th, &c., harmonics coincide and may cause trouble, where they appear, as for instance, by star connection of primaries and secondaries of transformers with grounded neutral.

The danger of such accumulations of potential lies in their liability to damage the insulation of the system by puncture, and in their liability of producing, by their discharge, other and more serious disturbances.

In taking care of them by lightning-arresters arranged to discharge at a safe margin of voltage above the normal, the main problem is to arrange the discharge path so that the discharge passes harmlessly; that is, without producing other disturbances.

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The effects of steady electrostatic stress, whether unidirectional, *a* to *d*, or alternating as *e* and *f*, appear not only in its own circuit, but also in circuits in inductive relation thereto, and may even be more serious in secondary circuits. For instance, let Fig. 2 diagrammatically represent a transmission system, comprising generating station L_0, step-up transformers T_1, transmission line L_1, step-down transformers T_2, primary distribution circuits L_2, a local lighting transformer T_3, and house-lighting circuit L_3.

All these circuits have capacity against ground, and the transformers also capacity between primary and secondary, and as regards the electrostatic capacity, the system can diagrammatically be represented by Fig. 3.

Let C_0, C_1, C_2, C_3 represent the capacities against ground respectively of the generating station L_0 and the circuits L_1, L_2, L_3 (including the capacities of the corresponding transformer coils against ground) and, C_1', C_2', C_3' the capacities between primary and secondary of the transformers T_1, T_2, T_3.

An electrostatic charge of line L_1, giving the P.D. against ground e_1, also has an electrostatic path to ground, over the two capacities C_1' and C_0 in series, and so produces a P.D. against ground, e_0, in the generator circuit L_0, which is intermediate between e_1 and 0, in the proportion of capacities C_1' and C_0; that is,

$$e_0 = \frac{C_1'}{C_1' + C_0} e_1 \quad . \quad . \quad (1)$$

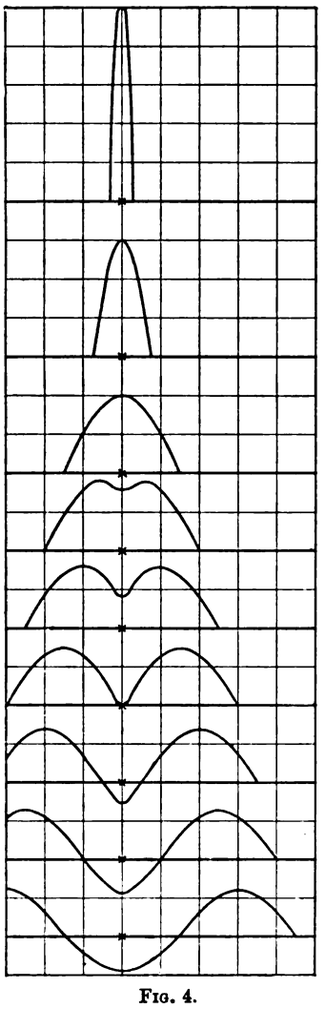

FIG. 4.

e_0 is very much lower than e_1, but the circuit L_0 is of very much lower voltage than the circuit L_1, and while e_1 may be a safe voltage for the high-potential insulation of L_1, the lower voltage e_0 may be beyond the safe limit of the insulation of the low-potential circuit L.

If L_0 is a generating station, or sub-station, its capacity against ground, C_0, is so large compared with the capacity C_1', that for steady stress the voltage e_0 is generally negligible, and this phenomenon is appreciable only when e_1 is an alternating potential, or the high frequency of an impulse or oscillation. Hence, this phenomenon is of importance only where the capacity of the low-potential circuit against ground is small. This may be the case in a house-lighting circuit. An electrostatic or alternating voltage (case *e* and *f*) e_2 in the primary distribution L_2 gives an induced voltage:

$$e_3 = \frac{C_3'}{C_3' + C_3} e_2 \quad . \quad . \quad (2)$$

in the circuit L_3, and with the short extent and so low capacity C_3 of a local house-lighting circuit, and a voltage e_2 of several thousand volts, e_3 may be sufficient to involve under unfavourable conditions at least a fire risk. The voltage e_3 is reduced by reducing the effective capacity C_3' by earthing the transformer core and case of T_3, but entirely eliminated only by earthing the circuit C_3.

Impulse and Travelling Wave.—A sudden local electrostatic charge of a transmission line, as by a lightning stroke, or inductively by a lightning flash suddenly discharging a cloud, or any other sudden local change, produces a wave of potential and of current which runs along the line, just as a water wave over the ocean surface.

Such a potential wave or impulse is very high and of steep wave front at its starting point or point of impact, but gradually broadens and flattens out, and ultimately disappears, if the line is of unlimited length. Successive stages of such a travelling electric wave are illustrated by Figs. 4 and 5.

Such a wave, when reaching the end of the line, is reflected and thrown back, thus returning again and so forming a system of nodes, and maxima, as shown diagrammatically in Figs. 6 and 7; that is, a standing wave.

When reaching the station—generating or sub-station—such a travelling wave is partly reflected by inductance of reactive coils, transformers, instruments, &c., partly transmitted. The different reflected and transmitted waves so superpose upon each other—that is, the impulse is broken up into a number of secondary impulses and local standing waves, which may reach voltages far higher than that of the travelling wave.

The complex system of phenomena resulting from the approach of a travelling wave to a station is analogous to the breaking up of an ocean wave into surf, and may indeed be called "electrical surf," and the complete predetermination of all the electrostatic and electromagnetic effects of an electric wave entering the complex system of circuits of a station is impossible of exact calculation.

The breaking up of an impulse or a series of impulses or travelling waves, in entering a station, appears as electrostatic displays, sparks, streamers and brush discharges, at conductors, switchboards, &c, the so-called "static," which signals in the station the existence of a disturbance on the line.

Some of the causes of such travelling waves are:—

(*a*) Direct or secondary lightning strokes entering the transmission line. This usually gives a single impulse, or very few impulses of extreme steepness of wave front, but short extent, and capable of exerting very considerable power only locally, but not after travelling considerable distance—that is, a direct lightning stroke may shatter several poles, but do no damage to the station if not very near to it.

(*b*) Electrostatic induction by the clouds. Every lightning flash in the cloud, and between cloud and ground, represents an abrupt change of the electrostatic potential and requires a rearrangement of the electrostatic charge on the section of the line below the cloud, and thus gives an impulse of an intensity corresponding to the intensity of the flash, or, rather, the magnitude of the change of electrostatic potential of the terrestrial field. Travelling waves

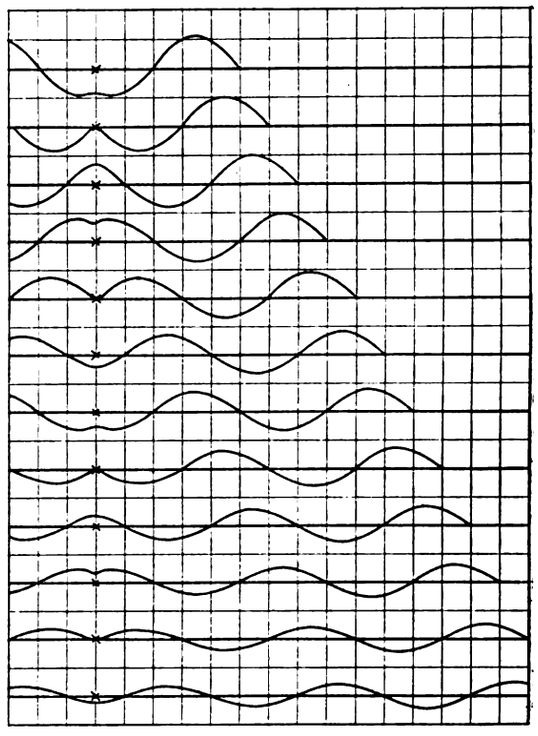

FIG. 5.

resulting from this electrostatic induction are usually of lesser voltage, but their origin is of greater extent—that is, they do not cause local destruction at the point of origin, but travel considerable distances, and their effect is, therefore, far more generally felt through the system. They probably are the most common manifestation of atmospheric electricity in electric circuits.

(*c*) Discharges of slowly-accumulated potential, resulting in a series of successive impulses.

(*d*) Any spark discharge from the line to another line or to the ground.

(*e*) An arcing earth on one phase of an insulated system, or, in general, the existence of a "self-rupturing arc" in the system.

(*f*) Sudden changes of load, connection and disconnection of apparatus, &c., also cause impulses. For instance, when connecting a dead transformer to the system an impulse traverses the transformer and usually penetrates beyond the transformer into the circuit.

Standing Waves, Oscillations and Surges.—Just like a violin string, the electric circuit may oscillate either as single wave without nodes or a number of nodes form, and the different sections

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oscillate separately at higher frequencies. This phenomenon of standing waves or oscillations in transmission lines has been investigated repeatedly. It is usually approached by considering the distribution of current and potential in a circuit of distributed capacity, inductance and resistance.*

The lowest frequency of oscillation of a line is the frequency which makes the line a quarter wave-length. That is, if l = length of line, v = velocity of light, it is $N_0 = \frac{v}{4l} = \frac{47{,}000}{l}$ (where l is in miles). From the line constants this fundamental frequency can be expressed, approximately by $N_0 = \frac{1}{4\sqrt{L_0 C_0}}$ where L_0 = total inductance, C_0 = total capacity of the line. In addition to the fundamental frequency L_0, all its odd higher harmonics, or any frequency $N = (2k-1)N_0$ may exist.

In general, an oscillation of a transmission line is a complex wave, containing fundamental and higher harmonics. The relative proportions of the different harmonics in the oscillating wave depend upon the distribution of potential and of current at the moment of the start of the oscillation. If the distribution of potential and of current at the start of the oscillation were perfectly sinusoidal only

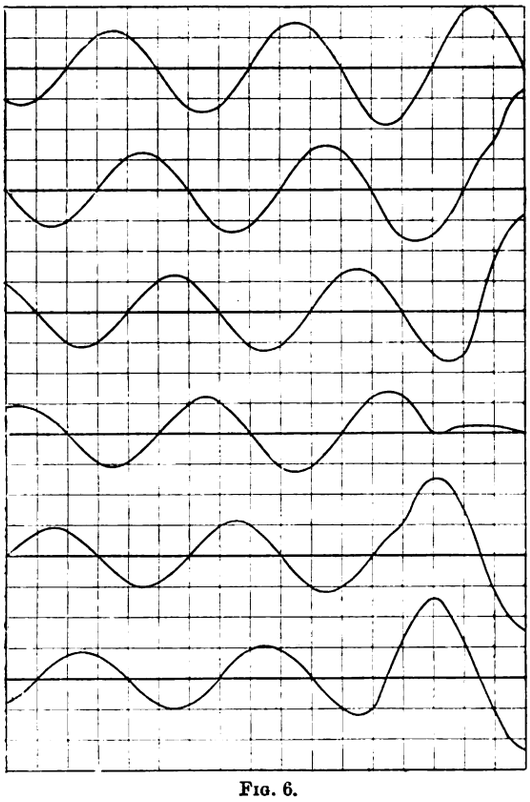

FIG. 6.

the fundamental wave would appear. The more irregular the distribution is, the more prominent are the higher harmonics; with a very irregular and abrupt distribution, the fundamental wave does not appear at all, but only higher harmonics. A transmission line thus has not only one frequency of oscillation, as a combination of condenser and separate inductance, but an infinite number of frequencies, of which one is the lowest or fundamental, the other its odd multiples or higher harmonics. These frequencies depend on the resistance, inductance and capacity of the line. Neither of these quantities is entirely constant. For instance, at high voltage the capacity increases by electrostatic glow, brush dischargers and streamers; inductance and resistance vary with the unequal current distribution throughout the section of the conductor, &c., so that at the very high harmonics, which are close together—for instance, the 199th and the 201st harmonics differ in frequency by 1 per cent. only—the gap between successive harmonics is bridged by the variability of the frequency, and a line for very high frequencies thus can oscillate at any frequency whatever. In other words, a transmission line can oscillate at a fundamental frequency, the lower harmonics thereof, and at any very high frequency whatever—that is, the line has definite frequencies of oscillation only at low and moderate frequencies, but not at very high frequencies. This is analogous to the formation of other standing waves.

The oscillation is the phenomenon by which in an electric circuit after a disturbance of the circuit conditions the flow of power restores its equilibrium. Any circuit disturbance may, and usually does, produce an oscillation which may be local only—that is, contain only the very high-frequency harmonics, if the disturbance is local; but it may become universal by including the fundamental and the lower harmonics. In the latter case it is usually called "surge."

In some respects, therefore, the oscillation is a result of a disturbance, as an impulse, and the power which oscillates is the generated power of the circuit; hence the possible destructiveness of the oscillation is limited only by the available power of the generating system, but does not directly depend upon the severity of the disturbance which caused the oscillation.

The power, which oscillates, is the energy stored by the flow of generated power in the electric field of the transmission line, as electromagnetic energy, $i^2L/2$, and as electrostatic energy, $e^2C/2$, and the shorter the section of line which oscillates the higher is the frequency of the oscillation. The smaller, however, is also the power and the destructiveness of the oscillation, and considerable damage results, therefore, only from low-frequency oscillations—that is, oscillations of the whole or a large part of the system. Local high-frequency oscillations are dangerous chiefly by their liability to destroy insulation by puncture, and to produce a low-frequency surge of higher power.

Since, as a rule, the maximum amount of energy which can be

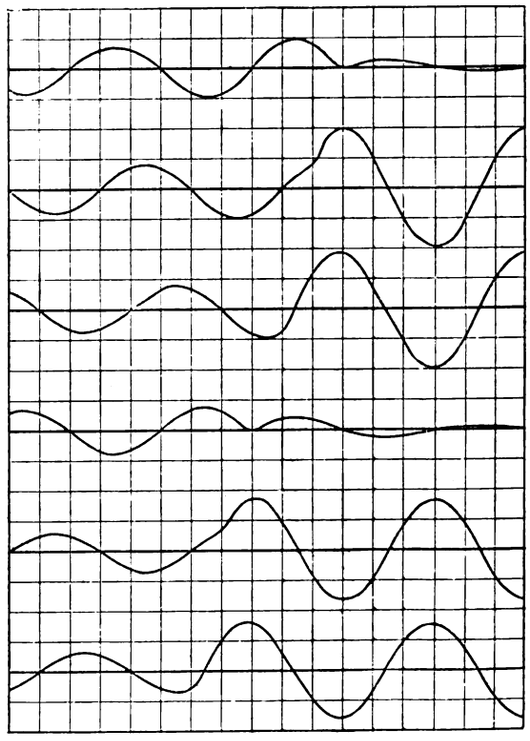

FIG. 7.

stored in the electric field of a circuit is the electromagnetic energy of the short-circuit current $i_0^2L/2$, the short-circuit surge is the most powerful and destructive.

Some typical forms of oscillations are: (*a*) Spark discharges to and from the line, as over some lightning arresters. (*b*) Arc discharges to earth from a line of an insulated system; reflected travelling waves, &c., give oscillations which, while still of very high frequency, reach considerably further down in frequency than (*a*). (*c*) Charge and discharge of the line, as when discharging an accumulated electric charge over a path of low resistance; connecting a dead transformer into the circuit, &c., results in high-frequency oscillations containing also an appreciable low-frequency component. (*d*) In general, changes of circuit conditions, as sudden changes of load; connecting or disconnecting a transmission line; opening a short-circuit suddenly, &c., give oscillations in which the fundamental frequency predominates. (*e*) Low-frequency surges, consisting primarily of the fundamental wave, may be produced by certain transformer connections in polyphase systems, in which, in case of an accident, an unequal distribution of load or other causes, the open-circuit inductance of a transformer coil is in series with the line capacity, in the circuit of a live transformer.

Looking at the oscillation as a surge of energy between the electromagnetically-stored energy, $\frac{i^2L}{2}$, and the electrostatically stored energy, $\frac{e^2C}{2}$, it can well be seen that the electrostatic energy is far more limited than the electromagnetic energy; and the maximum

* See Steinmetz, "Alternating Current Phenomena." 3rd edition, p. 181.

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possible energy which can be stored in the electric field is the electromagnetic energy of the short-circuit current, as stated above. The most powerful oscillation is, therefore, the short-circuit surge of a system or oscillation produced by instantaneously rupturing a short circuit, as by a self-rupturing arc. In this surge the fundamental predominates, and the equations of the surge potential are—

$$= \sqrt{\frac{L}{C}}\{1{\cdot}26 \cos \omega \sin \phi + 0{\cdot}40 \cos 3\omega \sin 3\phi + 0{\cdot}22 \cos 5\omega \sin 5\phi + 0{\cdot}18 \cos 7\omega \sin 7\phi + 0{\cdot}07 \cos 9\omega \sin 9\phi + 0{\cdot}03 \cos 11\omega \sin 11\phi + \ldots\}$$

where i_0 = short-circuit current; L = inductance of line; C = capacity of line.

$\omega = \frac{\pi u}{2l}$, where l = length of line; u = distance along line, from point where the short circuit was ruptured, as zero point; $\phi = 2\pi N t$; t = time.

$N = \frac{1}{4\sqrt{LC}}$ = frequency of fundamental wave of oscillation.

For instance, for a line of 50 miles, consisting of wire No. 0000, and transmitting 30,000 volts at 25 cycles, it is, approximately: L = 0·2 henry, hence: $x = 2\pi N_0 L = 31{\cdot}4$ ohms, C = 0·4 mf., hence: $N = \frac{1}{4\sqrt{LC}} = 880$ cycles, and $\sqrt{\frac{L}{C}} = 707$:

Also $r = 26$ ohms, $\therefore z = \sqrt{r^2 + x^2} = 40{\cdot}8$ ohms, and, assuming that the supply voltage, with a short circuit at the other end of the line, drops instantly to one third, or $e_0 = 10{,}000$ volts: $i_0 = \frac{e_0}{z} = 245$ amperes.

Hence the surge voltage $e = 174{,}000\{1{\cdot}26 \cos \omega \sin \phi + 0{\cdot}40 \cos 3\omega \sin 3\phi + 0{\cdot}22 \cos 5\omega \sin 5\phi + \ldots\}$ volts.

At $i_0 = 245$ amperes, this gives the power of the oscillation $ei_0 = 42{,}500$ k.v.a.

Standing waves or oscillations in electric circuits may vary from the very low frequency of the fundamental surge of very long transmission lines, which approaches commercial alternating-current frequencies, to frequencies of several hundred million cycles per second, in the discharge oscillation between the cylinders of a multi-gap lightning arrester. Due to this enormous range of frequency, the physical effect of the oscillation also varies greatly. In very high-frequency oscillations the power is very small; the electrostatic effects, as luminous glow, brush discharge, streamers and sparks are prominent, but the direct damage usually insignificant and the effect local. Inductance opposes a fairly effective barrier. On the other extreme, low-frequency surges show little or no luminous display; inductance offers no obstruction, but due to their high power and wide extent, considerable damage may be done all over the system.

Oscillations therefore are frequently sub-divided into high-frequency oscillations, in which the lower harmonics are absent, and low-frequency oscillations, in which the fundamental predominates. The name surge is frequently applied to denote the latter.

Between these two extremes, however, the low-frequency surge and the high-frequency oscillation, oscillations of intermediate frequency are found—against which inductances do not give sufficient protection—which have considerable power, and also give luminous displays, as streamers and brush discharges.

The four types of lightning disturbances here discussed: static charge, impulse, oscillation and surge, may occur singly, in groups, or all occur together, or rather, successively, the one preceding and causing the other. A static charge, for instance, rises, until it breaks through to earth and discharges, thus producing an impulse or travelling wave. A travelling wave breaks at a station and produces high-frequency oscillations. A high-frequency oscillation, puncturing the insulation, causes a short-circuit, which ruptures itself, and thus produces a low-frequency surge. A static charge, discharging over lightning-arresters with insufficient damping, causes a high-frequency oscillation. A static charge, short-circuiting the system by its discharge, causes a low-frequency surge. Lightning-arresters, when discharging a high-frequency oscillation, may fail to hold back the machine current, and the short-circuit resulting therefrom produces a low-frequency surge.

The problem of lightning protection then is threefold: (1) Prophylactic, to guard against the entrance or origin of disturbances; (2) restrictive, to guard against a disturbance leading to other disturbances; (3) curative, to discharge a disturbance harmlessly.

The location of the transmission line should be chosen so as to avoid exposed positions as far as possible. An earthed overhead wire of good conductivity offers considerable protection. Earthed side wires increase the protection and discharge side drift. The question of barbed wire against plain wire also is still open to discussion. Emergency arresters in the lines or arresters at intermediate stations may shunt travelling waves toward earth.

Earthing the neutral of the high-potential circuit offers some protection against static charges and against arcing earths, but increases the liability to short circuits and shutdowns due to other causes.

A study of transformer connections and their operating conditions, of generator wave-shape and connections, of the possible origin of higher harmonics of the potential wave, the construction and location of underground cables, the protection of their joints, the desirability, size and location of reactive coils—all are subjects requiring careful consideration from the point of view of lightning protection. In short, the most important problems of lightning protection are met and should be solved before the question of lightning arresters is approached.

BOROUGH OF STEPNEY ELECTRICITY ACCOUNTS.

The general tendency of electricity supply authorities to reduce their rates, especially to power consumers, has in some cases led to disastrous results. In the case of Stepney, however, a substantial reduction in the price per unit for both power and light has actually resulted in a larger surplus than last year. This is curious for the following reason: The revised rates came into force in October 1905, and the financial result for the year ending March 31, 1906, was a surplus of £1,989. Although the reduced tariff was in force for the whole of the twelve months ending March 31, 1907, this surplus has been increased to £2,126.

The engineer and manager (Mr. W. C. P. Tapper), in his report to the Electricity Committee, attributes this result to the reduction which has been effected in the works cost of production, which is roughly 10 per cent. less per unit than in the previous year. This reduction is mainly owing to economies in the use of coal, as will be seen from the following figures. The units generated during the 12 months were 5,277,898 as against 4,357,577 in the previous year, an increase of 920,321. Of these 3,945,643 were generated on coal and 1,332,255 on destructor steam. The following table gives a comparison of the last two years' results:—

	1905-6. Coal.	1905-6. Destructor Steam.	1906-7. Coal.	1906-7. Destructor Steam.
Units generated.....	2,841,893	1,515,684 ..	3,945,642	1,332,255
Total cost of fuel	£5,630	£3,158 ..	£6,651	£2,776
Cost per unit generated	0·475d.	0·5d. ..	0·405d.	0·5d.

The total coal used during the year was 9,366 tons, of which 4,097 tons was best smokeless Welsh, costing £3,614, and used principally for carrying the heavy load during a few hours each evening, while 5,269 tons consisted of cheap bituminous coal slack, costing £3,037, and was used throughout the greater part of the 24 hours. On the latter coal 2,387,140 units were generated, giving a cost of 0·312d. per unit generated by means of coal burnt in mechanical stokers.

The revenue from all sources has increased from £47,938. 12s. 4d. to £52,896. 4s. 11d. During the year the capital has increased from £238,428 to £243,982. 2s. The total capital expenditure is £257,273. 2s. 6d., £13,291. 0s. 6d. of this amount having been spent during the past financial year. The loans to date amount to £262,141, of which £23,713 has been borrowed during the year. This results in a surplus balance of £4,867. 17s. 6d. on the capital account.

We give below an analysis of the expenditure during the year, together with the cost per unit sold for the past year and for the year 1905-6.

		1906-7	1905-6
Generating Costs.			
Coal, &c.	£9,426 15 2 ..	0·47d. ..	0·52d.
Oil, Waste, &c.....	642 10 8 ..	0·03d. ..	0·03d.
Wages	2,246 15 11 ..	0·11d. ..	0·12d.
Repairs and maintenance	1,130 1 11 ..	0·06d. ..	0·06d.
Total generating costs	£13,446 3 8 ..	0·67d. ..	0·73d.
Distribution Costs.			
Wages	£39 11 4 ..	— ..	—
Repairs and Maintenance	668 2 4 ..	0·03d. ..	0·03d.
Public lamps.....	2,004 2 8 ..	0·10d. ..	0·15d.
Total distribution costs	£2,711 16 4 ..	0·13d. ..	0·18d.
Rates and Taxes.			
Rates and Taxes	£1,953 15 8..	0·10d. ..	0·08d

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Management Expenses, &c.			
Wages and salaries	£2,119 8 7	0·10d.	0·10d.
Stationery and printing	161 11 8	0·01d.	0·01d.
Establishment charges	455 6 4	0·03d.	0·01d.
Legal and Parliamentary charges	361 1 7	0·02d.	0·06d.
Insurance, &c.	125 14 11	0·01d.	0·01d.
Total management expenses	£3,223 3 1	0·17d.	0·19d.
Total working expenses (excluding capital charges)	£21,334 18 9	1·07d.	1·18d.
Capital Charges, &c.			
Interest on mortgage debt	£8,398 16 8	0·43d.	0·48d.
Instalment of principal of money borrowed	4,936 7 6	0·25d.	0·18d.
Cost of temporary work written off	443 0 7	0·02d.	0·03d.
Total capital charges	£13,778 4 9	0·70d.	0·69d.
Total expenses	£35,113 3 6	1·77d.	1·87d.
Total revenue (from all sources)	£37,239 1 6	1·87d.	2.01d.
Net balance (placed to appropriation account)	£2,125 18 0	0·10d.	0·14d.

The income side of the net revenue account shows the balance of £15,657. 3s. 5d. brought from the revenue account, together with other small amounts, making up a total of £15,904. 2s. 9d.

The capital spent during the year amounted to £14,570. 19s. 7d., of which £3,834 was expended on buildings, £3,767 on machinery and £3,547 on mains. We give below the details of the total capital expenditure, together with the amount in £'s per kilowatt expended on the various items:—

Capital Account.	Total.	£ per kw.	Per cent.
Land	£22,649 15 1	6·10	8·56
Buildings	59,289 17 11	15·94	22·34
Machinery	53,878 7 7	14·49	20·32
Accumulators	2,565 6 1	0·62	0·90
Mains	98,157 1 4	26·37	36·92
Services	10,351 13 2	2·78	3·92
Meters	6,616 0 4	1·77	2·50
Instruments	2,872 12 7	0·77	1·10
Tools	770 9 5	0·20	0·31
Other items	7,921 2 7	2·22	3·13
TOTAL CAPITAL EXPENDITURE	£265,072 6 1	71·26	100·00

The total units generated were 5,277,898 as against 4,357,577 in the previous year, an increase of 920,321. The total units sold were 4,751,182, this being an increase of 704,977 over the former year's amount, which was 4,046,205. 2,528,228 of these units were utilised for private lighting, 1,229,000 for power and 993,554 for public lighting. The numbers for the previous year were 2,208,492, 844,187 and 993,526, the increases being respectively 319,736, 384,813 and 428. The dynamo capacity remained the same—*i.e.*, 3,720 kw., while the maximum demand has increased from 2,012 kw. to 2,414 kw.

The average price per unit was, for private lighting 2·30d., for power 0·97d. and for public lighting 1·29d. The average price for the total supply was 1·74d. The corresponding figures in the previous year were 2·43d., 1·00d. and 1·38d. The average price for the total supply was 1·87d.

The equivalent number of 8 c.p. lamps connected was 108,033 for lighting, 70,450 for power and 8,650 for public lighting, a total of 187,133. The figures in the previous year were 85,348, 50,814 and 8,202 respectively, a total of 144,364.

GLASGOW CORPORATION TRAMWAYS.

The report of the Tramways committee of the Glasgow Corporation, setting forth the results of working for the year ending May 31, 1907, has recently been issued, and shows that the high standard set by this undertaking in former years has been maintained. It is one of the oldest municipally-owned tramway systems in the country, having been acquired in 1894. The first section to be converted to electric traction was the Mitchell-street and Springburn route in 1898.

The total mileage worked by the Corporation is 176¼, of which 109 miles is within the City of Glasgow, the remainder being in the Counties of Lanark and Renfrew and in several neighbouring burghs. An extra 7½ miles of track has been opened during the past year. The alterations which it was found necessary to make at Whitevale depot for the housing of top-covered cars have been completed, and alterations to the Pinkston generating station in connection with the switchboard extension are being proceeded with. It has been decided to instal two new turbo-generator sets, each of 3,000 kw. capacity, at the Pinkston generating station. The total number of cars in stock is 780; 100 cars, 70 of which are to be fitted with top covers, are now in course of construction.

The net result of the year's working is a surplus of £70,279. 0s. 5d., of which £45,000 has been applied in meeting special depreciation on buildings and power station plant, and the balance of £25,279. 0s. 5d. has been added to the general reserve fund. The receipts have increased from £820,938 to £895,841 and the working expenses from £456,268 to £485,256. The gross balance, therefore, shows an increase from £369,415 to £414,096. The gross revenue shows an increase of £74,902 over that of the previous year. The working expenses show a slight reduction per car-mile, the year's figures being 5·721d. as against 5·797d. in the previous year. The increase in the amount of interest on capital is caused by the high borrowing rate which prevailed throughout the year. The total amount of expenditure on capital account at May 31, 1907, was £3,104,060. 15s. 9d. No sums have been borrowed during the year for capital purposes and the balance of tramway debt owing to the "Common Good" is £1,079,252. 18s. 2d.

We give below an analysis of the expenses during the year, together with the cost per car-mile during 1906-7 and 1905-6.

	£ s. d.	Per car-mile 1906-7.	1905-6.
Traffic Expenses.			
Superintendence	5,002 9 2	0·059d.	0·060d.
Wages and bonuses	188,987 11 6	2·229d.	2·253d.
Cleaning and oiling cars	25,326 5 3	0·299d.	0·286d.
Fuel, power, light, water and depots	2,452 5 6	0·029d.	0·025d.
Ticket check	10,424 9 2	0·123d.	0·122d.
Uniforms	5,431 8 9	0·064d.	0·134d.
Miscellaneous	3,076 12 3	0·036d.	0·031d.
Cleaning track	4,320 2 7	0·051d.	0·050d.
Total Traffic Expenses	£245,021 4 2	2·890d.	2·961d.
General Expenses.			
Salaries and wages	£7,036 11 6	0·083d.	0·085d.
Store expenses	990 5 4	0·011d.	0·011d.
Rents, rates and taxes	46,640 16 9	0·550d.	0·594d.
Printing and stationery	1,952 16 0	0·023d.	0·022d.
Fuel, light, water for offices	417 2 4	0·005d.	0·005d.
Law and insurance	22,418 8 6	0·264d.	0·251d.
Parliamentary expenses	210 8 2	0·003d.	0·005d.
Travelling expenses	353 1 0	0·004d.	0·007d.
Decorations and expenses in connection with Royal and other visits	1,045 6 3	0·012d.	—
Miscellaneous	2,081 10 5	0·025d.	0·023d.
Contribution to friendly society	3,644 4 7	0·043d.	0·044d
Total General Expenses	£86,790 10 10	1·023d.	1·047d.
General Repairs and Maintenance.			
Permanent way	£63,777 15 0	0·752d.	0·838d.
Electrical equipment of line	7,597 2 1	0·090d.	0·092d.
Building and fixtures	5,608 1 3	0·066d.	0·075d.
Workshop tools & sundry plant	1,898 19 11	0·022d.	0·025d.
Cars	23,724 15 11	0·280d.	0·228d.
Electrical equipment of cars	17,793 9 9	0·210d.	0·162d.
Other rolling stock	1,631 11 11	0·019d.	0·017d.
Miscellaneous	94 9 4	0·001d.	0·006d.
Total Maintenance Expenses	£122,126 5 2	1·440d.	1·443d.

		1906-7. Per unit.	Per car-mile.	1905-6. Per unit.	Per car-mile.
Power Expenses.					
Salaries and wages	£9,179 16 8	0·088d.	0·108d.	0·098d.	0·116d.
Fuel	13,657 13 3	0·131d.	0·161d.	0·115d.	0·136d.
Water	339 3 7	0·003d.	0·004d.	0·003d.	0·003d.
Oil and waste	1,297 16 10	0·013d.	0·015d.	0·010d.	0·011d.
Miscellaneous supplies	461 17 7	0·004d.	0·005d.	0·004d.	0·005d.
Repairs	6,381 14 3	0·062d.	0·076d.	0·063d.	0·075d.
Total Power Expenses	£31,318 2 2	0·301d.	0·369d.	0·293d.	0·346d.

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	£	s.	d.	Per car-mile. 1906-7.	1905-6.
TOTAL WORKING EXPENSES (*ex.* capital charges)	485,256	2	4	5·721d.	5·797d.
Capital Charges, &c.					
Rental of leased lines	£9,953	0	7	0·117d.	0·124d.
Interest and sinking fund....	113,546	4	11	1·339d.	1·310d.
Income tax	9,931	19	5	0·117d.	0·158d.
Parliamentary expenses.....	6,977	9	5	0·082d.	0·036d.
Payment to "Common Good"	35,000	0	0	0·413d.	0 318d.
Depreciation and renewals ..	168,408	7	8	1·986d.	2·031d.
Total Capital Charges	£343,817	2	0	4·054d.	3·977d.
TOTAL EXPENSES (*inc.* capital charges)	**£829,073**	**4**	**4**	**9·775d.**	**9·774d.**
TOTAL INCOME (from all sources)	**£899,352**	**4**	**9**	**10·606d.**	**10·492d.**
Surplus Balance (carried to appropriation account)	**£70,279**	**0**	**5**	**0·831d.**	**0·718d.**

The balance carried to the net revenue account is £410,585. 11s. 11d., which, together with interest on surplus revenue amounting to £3,510. 10s. 6d., makes up the total of £414,096. 2s. 5d. on the credit side of this account. The traffic revenue was £887,380. 14s. 1d., as against £813,768. 11s. 1d. in the previous year. Other items on the credit side of the revenue account include an amount of £475. 15s. from the Fairfield Shipbuilding & Engineering Co. for the use of tramway lines and an amount of £5,734. 16s. 8d. for electricity supplied to the Corporation electricity department and to the Fairfield Shipbuilding & Engineering Co.

We give below the total capital expenditure under the various items:—

Capital Account.	£	s.	d.	Per cent. of total.
Permanent way	980,697	8	5	31·7
Electrical equipment	639,111	14	0	20 7
Ground	136,222	7	4	4·4
Buildings	426,248	9	8	13·7
Power station plant	390,569	11	8	12·5
Tools	27,551	4	9	0·9
Cars	269,719	11	6	8·7
Electrical equipment of cars	195,275	11	3	6·3
Other rolling stock	10,701	12	4	0·3
Miscellaneous equipment	18,743	6	4	0·6
Office furniture	5,162	16	2	0·1
Lease of Govan and Ibrox tramways	4,057	2	4	0·1
Total Capital Expenditure	**£3,104,060**	**15**	**9**	**100·0**

The total units generated during the year were 29,653,678, as against 25,370,859 in 1905-6. 1,545,940 high-tension and 98,928 low-tension units were sold to the electricity department; 1,532,973 were used in the car depots, 1,100,620 at the power stations and 196,357 at the sub-stations. The total used in actually driving the cars was 22,487,336, as against 19,820,686 in 1905-6. The maximum load on the station was 9,486 kw. or, excluding the load required by the electricity department, 8,139 kw. The load factor on the total load was 35·6 or, excluding the electricity department, 39·2.

The total number of car-miles run during the year was 20,350,367, as against 18,886,910 in 1905-6, an increase of 1,463,457. The passengers carried numbered 224,063,098. The number in 1905-6 was 208,059,833 or 16,003,265 less. The average traffic revenue per car-mile was 10·465 as against 10·34 in 1905-6.

The population served was 1,050,000 and the average traffic revenue per head of population was 16s. 11d. The average total revenue per car-mile was 10·565d. The average working expenses (excluding power works costs) per car-mile were 5·353d. and including power works costs 5·721d.

Telegraphy in Central Africa.—It is reported that the French Government has voted £80,000 for the construction of a telegraph line from Timbuctoo to Niamey and Zinder. The length of the line will be some 1,100 miles, and it is expected to prove more especially of military importance for France's possessions on the Niger and in the Tchad Lake district.

THREE-PHASE POWER SUPPLY OF THE MANCHESTER CORPORATION.

(*Concluded from page 750.*)

In certain installations both alternating-current and continuous-current supply are needed from the three-phase mains, and both static transformers and converting plant are required in one station. Fig. 13 illustrates a plan and elevation of a typical sub-station for this purpose. The sub-station is placed in one of the bays of an existing engine-room, containing a number of steam generators now out of commission. The high-tension switchboard is arranged to divide off the static transformers from the rest of the station at one end, and the motor converters occupy the other end. There are six 150 kw. static transformers and two 200 kw. motor converters, a total of 1,300 kw., or about 1,700 H.P. The floor area of the station is about 460 sq. ft., so that the space occupied per horse-power is about 0·27 sq. ft. In this instance there is no provision for extensions, and the space referred to does not include the low-tension switchboard, which is placed in another bay of the station. The high-tension switch gear contains two feeder panels, a total output panel, two three-phase static transformer panels with control for six transformers, and two motor-converter panels. The feeder panels each have a hand-operated oil-switch, and the transformers are each fitted with double-pole oil circuit-breakers overload relay and ammeter. The board is of the Ferranti type; alternating-current tripping coils are used, as a continuous-current supply is not always available, for these and the other circuit-breakers. The motor-converter panels provide for a single triple-pole circuit breaker on each panel, an ammeter, and overload relay. The whole of Messrs. Beyer, Peacock's works are now driven from the Corporation supply. Fig. 12 shows the diagram of connections for this sub-station.

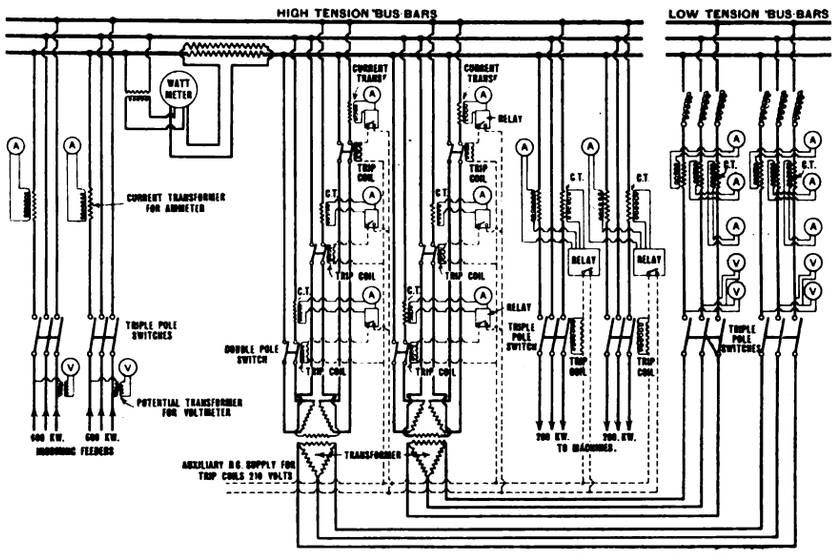

FIG. 12.—DIAGRAM OF CONNECTIONS FOR MESSRS. BEYER, PEACOCK'S SUB-STATION.

The cable connections between the high-tension switch panels and the static transformers are laid in trenches covered with chequer plating, as are also the cables between the motor converter panels and the machines. The static transformers are of the Berry pattern mounted on trolley wheels, as already explained.

Not infrequently it is difficult to find a large building in which to accommodate the sub-station plant. Fig. 14 illustrates a sub-station in which the minimum of space was available for housing motor converters, but from the plan and elevation it will be seen that a neat and safe arrangement has been arrived at. The building has been erected of fireproof material on a concrete foundation. It adjoins the economiser house of an existing steam plant and on the opposite side is a railway siding which restricted the width of the station considerably. The plant installed has a capacity of 500 kw. in

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two 250 kw. motor converter units, and the necessary high and low tension switch-gear. The station is 36 ft. long by 11 ft. wide, or an area of, say, 400 sq. ft. The capacity of the plant

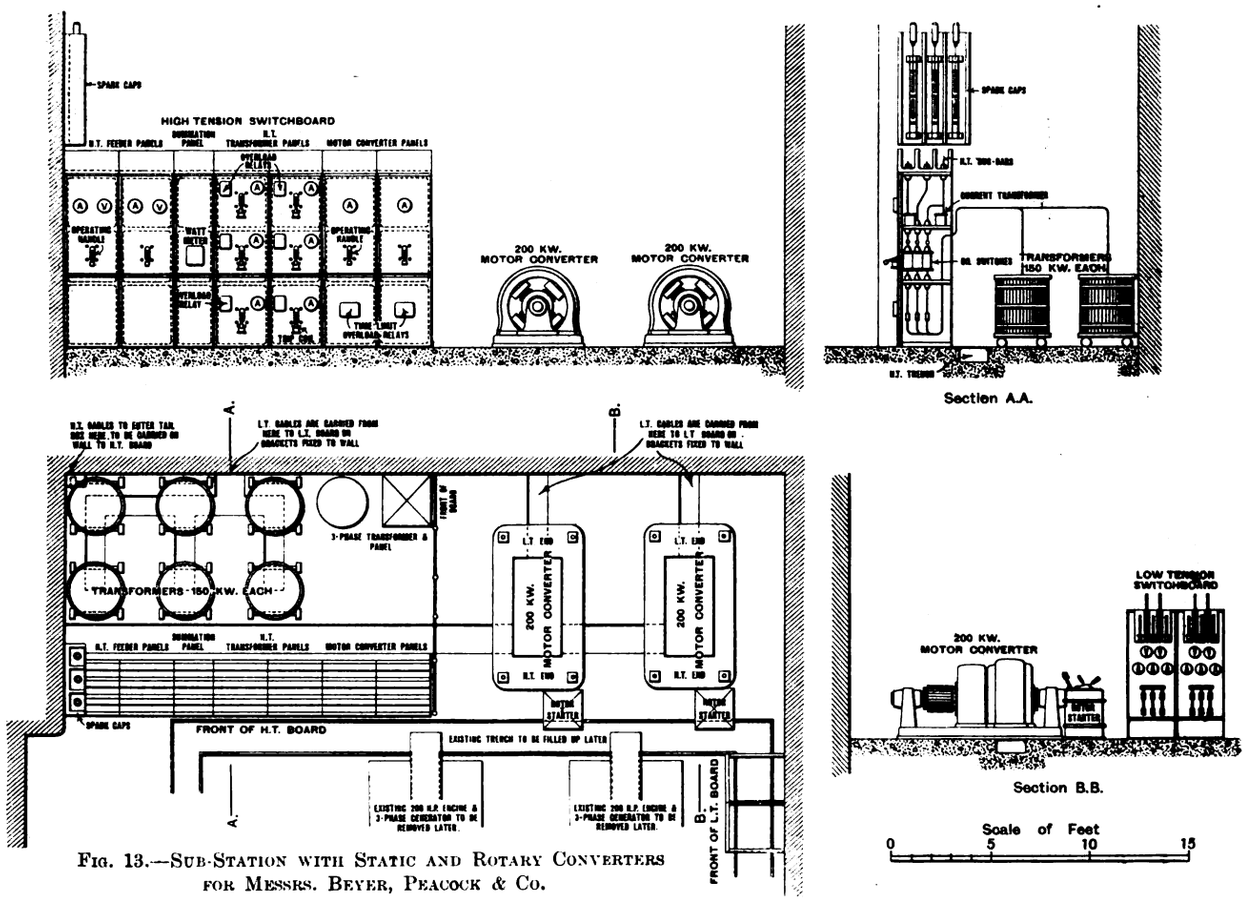

FIG. 13.—SUB-STATION WITH STATIC AND ROTARY CONVERTERS FOR MESSRS. BEYER, PEACOCK & CO.

on the opposite side of the station for the low-tension cables. The motor starter resistance boxes and switches are placed in the position shown on the plan, adjacent to their respective

in horse-power is 670, so that the floor space per horse-power may be taken at about 0·6 sq. ft.

The motor converters each occupy a corner of the station and between them is the high-tension switch gear. In the floor and in a line with the machines and gear is a cable trench for the high-tension connections, and similar provision is made

machines. Space behind the high-tension board is left for access to the connections and this space is normally enclosed by an expanded metal door which is kept under lock and key.

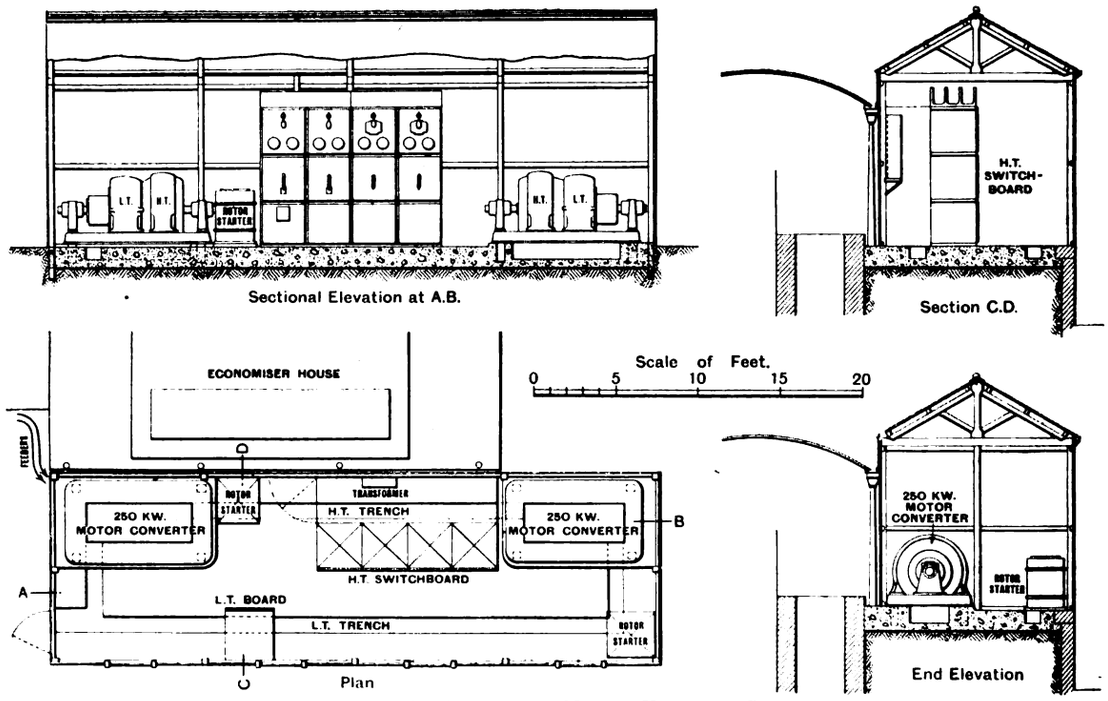

FIG. 14.—SUB-STATION FOR MESSRS. KENDAL & GENT.

The design of this station is typical of what can be done where space is valuable and cannot be conveniently spared.

In contradistinction to the foregoing example the arrange-

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ment shown in Fig. 15 illustrates the disposition of plant and switch gear where ample room is available. This shows a station employing induction motor-generators for the conversion of the alternate-current supply to continuous current. The floor area of this building, which is substantially built of brick, is about 1,650 sq. ft., but as space is not at a premium the floor area per horse-power installed is somewhat high. With 800 kw., or 1,080 H.P., as the plant capacity, 1·5 sq. ft. per horse-power is the amount of room given to the plant and switch gear. Substantial concrete foundations have been provided for the motor-generators and an abundance of space is available around these, below the floor level, for the cable connections. Large spaces have also been left round both the machines and switch gear. Each motor-generator comprises induction motor and continuous-current generator. The motor switch gear consists of a three-pole oil circuit-breaker and a water resistance, the former mounted on the main switch gear and the latter placed in a corner of the station. This station may be taken as typical of the generous use of space for the plant and switch gear.

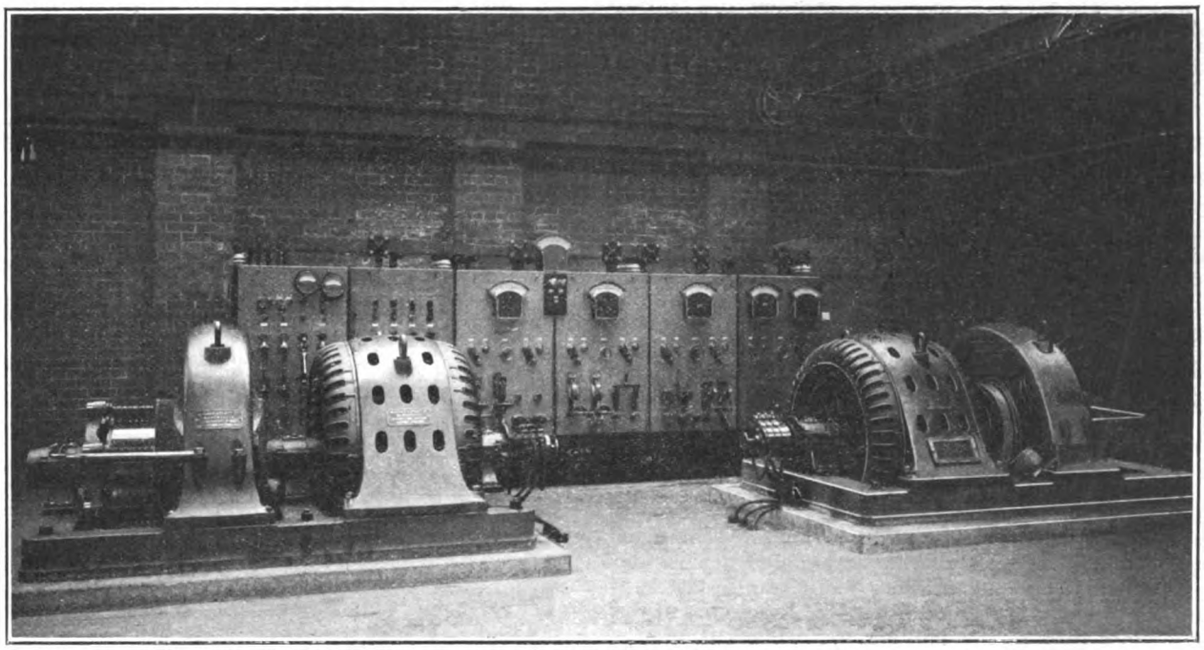

FIG. 15.—INTERIOR OF SUB-STATION AT THE WORKS OF MESSRS. MATHER & PLATT.

The agreements made by the Manchester Corporation, with consumers taking supply in the manner indicated above, arrange that the sub-station building shall be supplied by the consumer. Unless special provision is made the Corporation furnishes the transformers, either static or rotary, the high and low-tension switchboards and the cable connections between these and the plant. The building has to comply with the plans of the Corporation when specially built, and when existing premises are utilised the consumer provides cable trenches and enclosing gratings, doors, &c. Of course, the heavier capital outlay is that of the Corporation, and we understand that the cost per kilowatt installed is approximately £2 with static transformers and £3. 5s., excluding expenditure on high-tension mains, with motor converters, for installations of 500 kw.

The rate per unit for electrical energy is a matter for settlement between the customer and the Corporation, and it depends mainly upon the demand, character and time of the load, and special capital expenditure incidental to each supply.

The number of power consumers on the three-phase mains of the Manchester Corporation at present is 10, and the total capacity of the sub-station plant installed is 7,160 kw. Some 3,800 kw. of this total is in motor converters and the balance in static transformers. The combined consumption of the above 10 firms is over 12 million B.O.T. units per annum.

The varied character of the load sustained may be gathered from the industries supplied with power. Among the present three-phase customers are two spinning mills, a wire works, a locomotive works, armour-plate works, chain works, electric motor makers, machine-tool makers, and chemical works, &c. The motors installed in these works range in size from 7½ H.P.

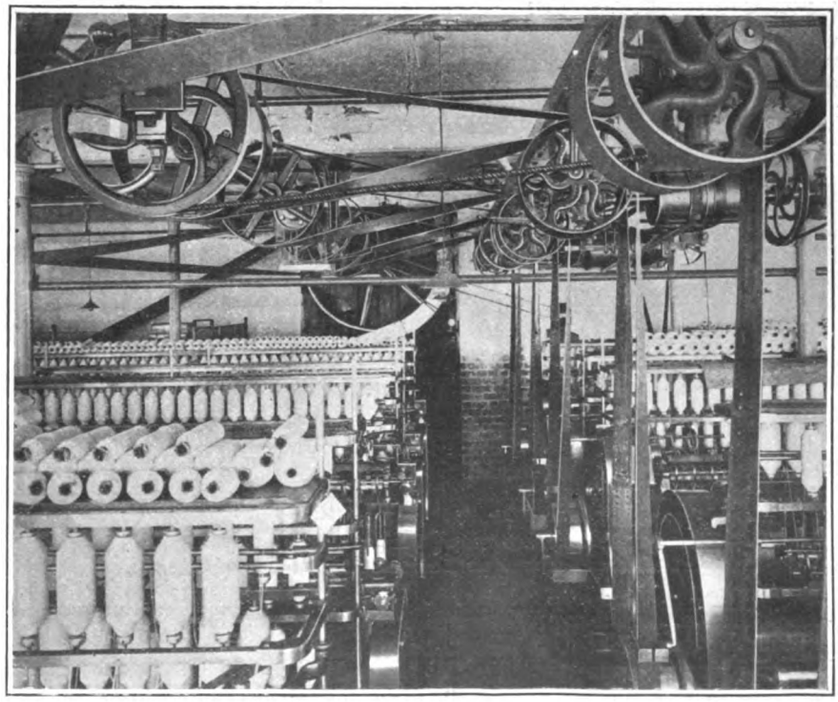

FIG. 16.—VIEW IN SPINNING MILL OF MESSRS. SHAW-JARDINE.

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to 150 H.P.; the largest induction motor supplied from the mains has an output of 150 H.P. and is employed in one of the spinning mills referred to.

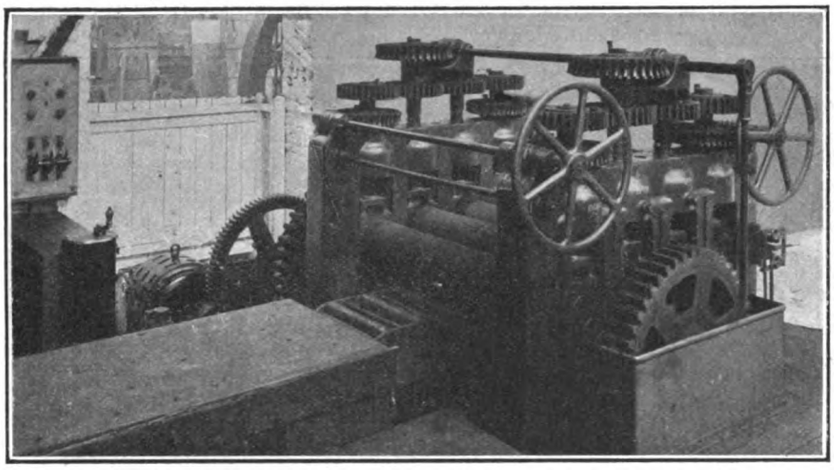

FIG. 17.—THREE-PHASE MOTOR DIRECT-GEARED TO PLATE-STRAIGHTENING MACHINE IN MESSRS. BEYER, PEACOCK'S WORKS.

Fig. 16 illustrates a spinning-room in a cotton mill which is driven by ropes from a large induction motor. The main driving pulley can be seen in the background against the wall. This motor is supplied from a static transformer sub-station in the basement of the mill itself. Extensions of the supply to other parts of this mill are, we understand, in progress. In Fig. 18 a large lathe is depicted driven by a direct-current motor supplied from the motor converter station shown in Figs. 7 and 10 (in our last issue). The same consumers, Messrs. Armstrong, Whitworth & Co., have many fine specimens of machine tools in their Openshaw works, operated from the Corporation supply. Fig. 17 shows a Mather & Platt three-phase slip-ring motor geared to a plate-straightening roll in the works of Messrs. Beyer, Peacock, reference to whose sub-station is made in Figs. 12 and 13. The illustrations also show the convenient location of the switchboard and drum-type reversing controller.

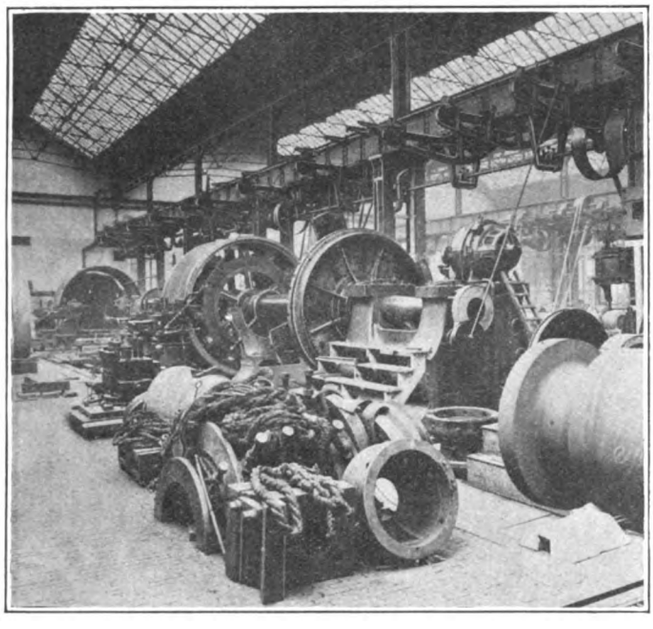

FIG. 18.—VIEW IN MESSRS. ARMSTRONG, WHITWORTH'S WORKS, SHOWING LARGE LATHE DRIVEN BY DIRECT-CURRENT MOTOR.

The Corporation has a number of important applications for power in hand, which include additional cotton mills and further extensions at the works of Messrs. Armstrong, Whitworth, and Messrs. Johnson & Nephew, amongst others.

It is anticipated that in another 12 months the three-phase power demand will exceed 20 million units per annum.

Our thanks are due to Mr. S. L. Pearce, chief engineer to the Manchester Corporation, for his kindness in allowing us to view the sub-stations and for the facilities afforded us for collecting the data and illustrations in the foregoing article.

NEW METHOD OF WINDING THE ARMATURES OF H.T. ALTERNATORS

A means of overcoming the various disadvantages attendant on the usual methods of preparing and fixing the armature coils of high-tension alternators has been introduced by the Maschinenfabrik Oerlikon Co. The new arrangement, which is applicable to both single and polyphase alternators, as well as to alternating current motors with open slots has several advantages over the methods usually employed. The old way was generally to wind the wire, which was either of round or rectangular section and insulated with a covering of cotton, on a former. Afterwards the

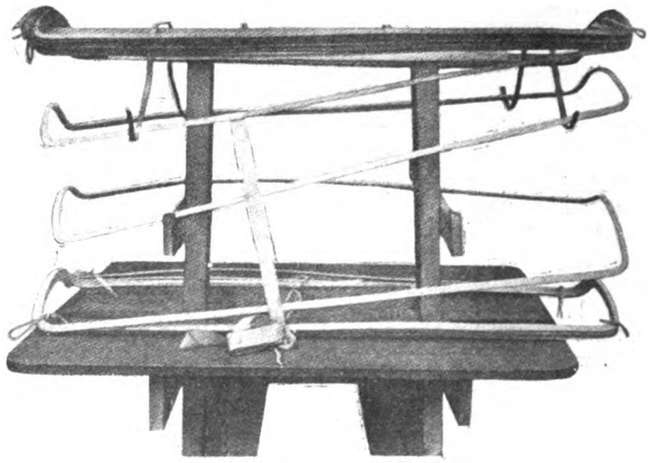

FIG. 1.—COIL IN PROCESS OF WINDING.

coils were further insulated by micanite or paper on the sides which rested against the slots. In the new method strips of bare flat copper are, at the outset, given a definite shape on formers. When

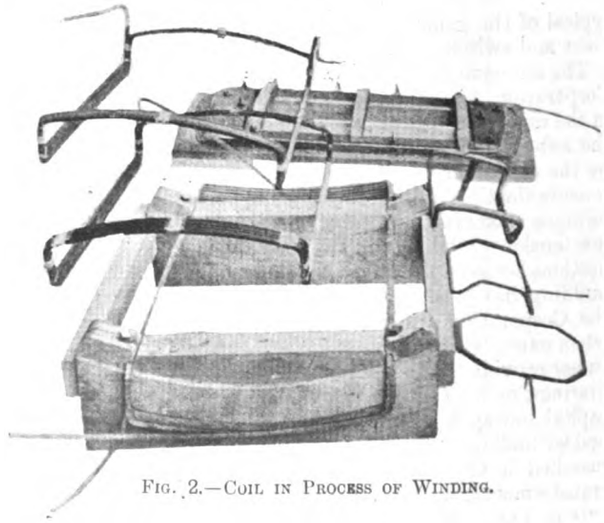

FIG. 2.—COIL IN PROCESS OF WINDING.

the copper strip has received this definite shape it is insulated throughout its length by cloth or paper strip or, in special cases, with micanite. The whole is then impregnated. Figs. 1 and 2

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show the winding at different stages of construction. Lastly, the turns are assembled and are insulated on the sides, which press on the slots by a covering of micanite or some other insulating material. A section of the finished coil is shown in Fig. 3.

By means of this covering it is claimed that a seamless insulation is obtained between the winding and the iron, capable of resisting three times the working voltage, whilst two adjacent conductors in the neighbourhood of the terminals can be safely insulated for voltages up to 10,000. It is also claimed that this new winding possesses the following advantages over that in general use: the method of arranging the copper bands allows the winding space to be used to the best advantage; the surfaces of the conductors being flat it is easy to protect them in a permanent manner by insulating layers; there is only the voltage of a single turn between two adjacent conductors; the insulation is applied very carefully and a higher insulation resistance is thus obtained, which is very necessary for two adjacent coils near the terminals; no free space exists between the conductors in which decomposition of the air may take place; the wires of the coil are, on the contrary, like those of a cable, entirely covered by the insulating material; as the copper bands are first formed and then covered with the insulated layers any damage which might be done to the insulation during the forming process is completely avoided; a coil which has been damaged by carbonisation, spark discharges or other accidents can be insulated afresh at a small cost, as the copper strips keep their shape and it is only necessary to reinsulate them.

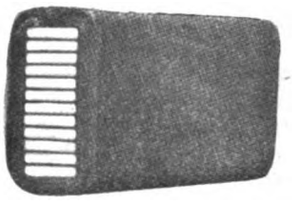

FIG. 3.—SECTION OF A WOUND COIL.

THE ROLLING STOCK OF THE SINGLE-PHASE VIENNA-BADEN INTER-URBAN LINE.*

Summary.—The car equipment of this line, which runs in the suburbs of Vienna, is described. The electrical portion is adapted for use on both single-phase and direct-current circuits. Full details of the controlling and braking systems are given.

The rolling stock for the Vienna-Baden railway, which has been converted to electric traction, consists of 14 motor cars and 18 trailers, all of them bogie cars, and presents several points of interest. The main portion of the Vienna-Baden line is supplied with single-phase current, but since the cars are required to run on the Vienna town tram-lines, and also on the Baden-Voeslau tram-lines, they had to be arranged to work with both single-phase and continuous current. Provision had also to be made for the speed in both towns to be considerably less than on the connecting line, where at present speeds up to 50 km. per hour are used, which, when some further safety arrangements have been erected, will shortly be raised to 60 km. per hour.

The whole line is equipped with overhead trolley wire, which is mostly at a height of between 5½ and 6 metres above the rail level. Under three of the bridges the trolley wire had to be brought down to a height of only 3·9 metres, which has had an important bearing on the design of the cars, collecting gear and overhead construction.

The trailer cars are built exactly like the motor cars, except for the electrical equipment, so that they can be converted into motor cars at a later date if necessary. Each car is carried on two bogies with equal-sized wheels, and with the bogie centres 6 metres apart; the wheel base of each bogie is 1·85 metres. The cars are divided into two compartments, each capable of seating 22 passengers. There are platforms at each end, which are covered in and fronted with glass. The entrances to the platforms are provided with doors of the double-swing type, while the compartments themselves and the dividing partition are fitted with sliding doors. The ends of the platforms have small doors, and a hinged footway with a railing is also provided, so that the conductor can pass from one car to another during the journey. The cars are exceedingly well ventilated, air being drawn in to the upper part of the car. All the windows can be opened and the ventilating arrangements are also under control. The floor of the platforms is made of wooden grating, while inside the car there is a covering of linoleum. The frames of the bogies are of rolled steel and the springs are duplicated. The axles are constructed of Siemens-Martin steel, while for the tyres a special make of steel is used. Each wheel is fitted with a brake, so that there are four brakes to each bogie, and all of these can be operated from either driving platform. The cars are equipped with central buffers and coupling arrangements, and simple rail-guards are also provided.

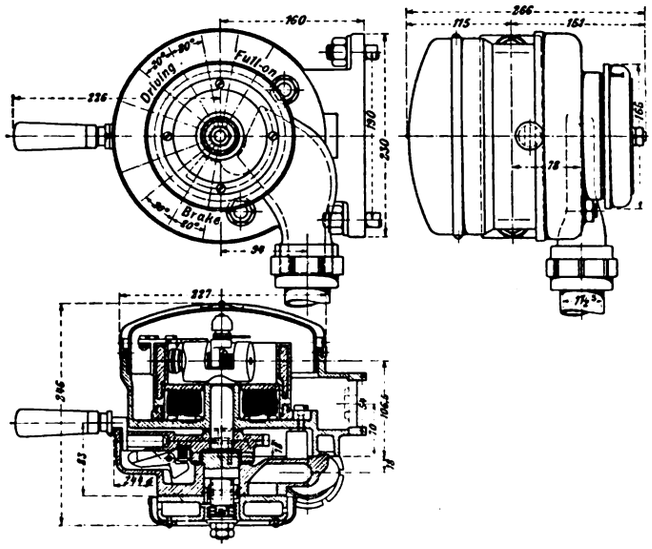

FIG. 1.—COMBINED BRAKE-VALVE AND SWITCH.

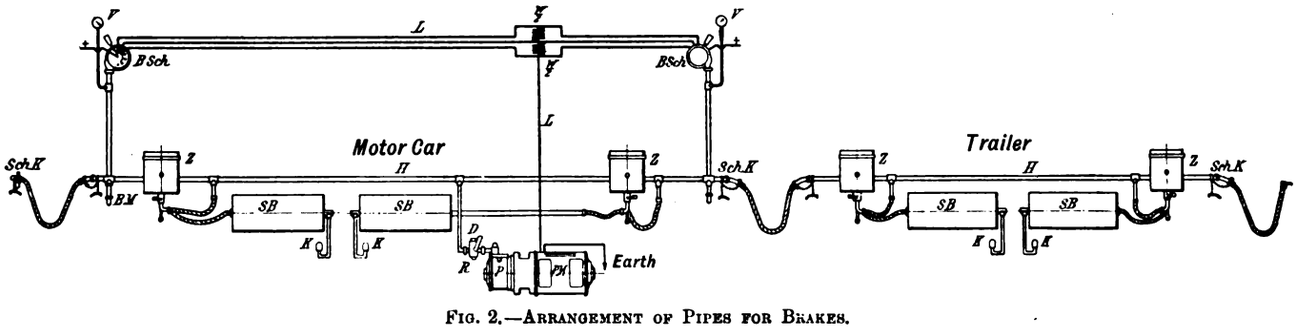

FIG. 2.—ARRANGEMENT OF PIPES FOR BRAKES.

P Pump. R Valve. D Pressure regulator. H Main connection. SB Special holder. BM Blind coupling. Z Brake cylinder. Sch K Flexible coupling. K Exhaust valve. V Vacuum gauge. B Sch Brake controller. PM Pump motor. W Starting resistance. S Fuse. L Electrical connections.

The motor cars are fitted with mechanical hand brakes and electrical short-circuit brakes, and also with Hardy automatic vacuum brakes. The trailer cars are fitted with hand brakes and vacuum brakes, but the automatic vacuum brake is the one used in regular service.

The vacuum is produced by a 2½ H.P. single-phase commutator motor coupled to an enclosed pump of Siemens-Schuckert design. The pump consists of two eccentric pistons 180 deg. apart and is fitted with a special arrangement so that the admission and exhaust valves can be simultaneously closed. Spring valves are fixed at the exhaust outlet which close automatically under atmospheric pressure and are so arranged that the exhaust always works against the existing air pressure. Owing to this arrangement the load on the motor decreases as the vacuum increases. In order that the lubrication may be good, and also for cooling purposes, the lower halves

* This article is based to some extent upon a description which appeared in the *Elektrotechnische Zeitschrift*.

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of the cylinders are immersed in oil. The motor is arranged for working with either 500 volts continuous current or alternating current, and runs under normal load at about 900 revs. per min. The stator is wound with a single winding and the armature with

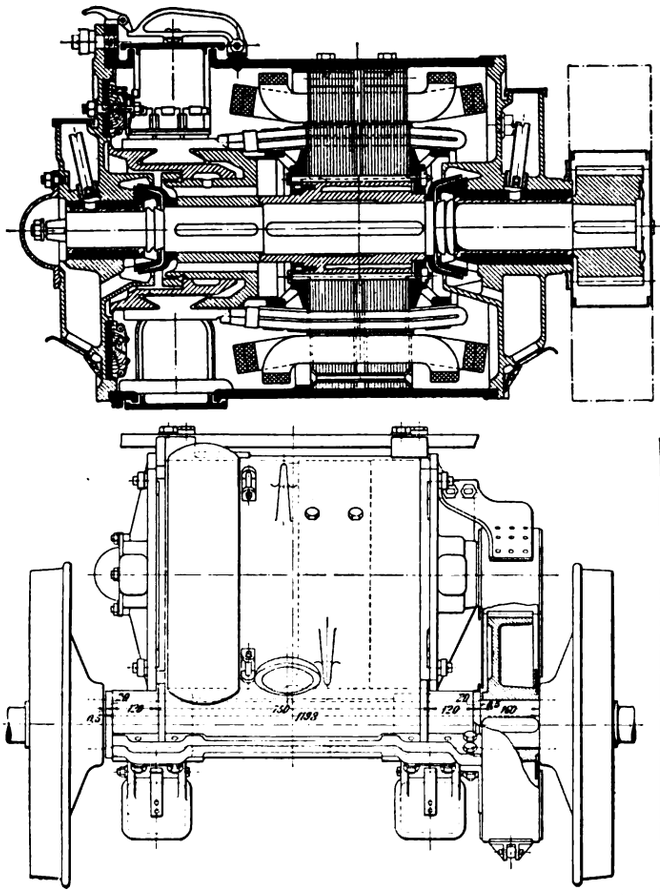


FIG. 3.—SECTIONS AND ELEVATION OF ONE OF THE SINGLE-PHASE MOTORS.

two separate windings connected to two commutators, each of which takes half the working voltage. The motor is completely enclosed and is mounted under the car body.

The motor is started by means of a combined brake-valve and switch (Fig. 1). The brake-valve and pump-switch are moved simultaneously by a single handle which can only be removed in the "off" position, when the valve is closed and the motor switched off. The handle has 11 positions, as follows:—

Position 1. Motor switched off. Valve closed.

Position 2. Motor started with all resistances in circuit. Valve closed.

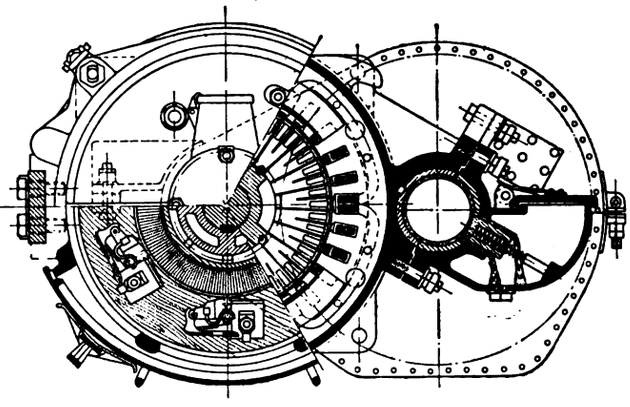
Position 3. Motor running with half resistances in circuit. Valve closed.

Position 4. Motor running without resistances. Valve closed.

Position 5. Motor running with half resistances. Valve closed.

Position 6. Motor running with all resistances. Valve closed.

In positions 8 and 9 the motor is running with all resistances in



circuit, and air is being admitted through the valve. The admission commences immediately after position 7 and increases the further the handle is moved forward.

In positions 10 and 11 the motor is switched off, and the air admission attains its maximum value in position 11. By the simultaneous action of the pump and the variable admission of air between positions 7 and 9 any desired pressure can be obtained in the brake cylinders. This is of the greatest use on long gradients. The brakes are applied in position 7 without jerk, and their application can be increased to its maximum and again released without jerk. The contacts of the switch are of elliptical shape, arranged in a circle, and a moving contact provided with a magnetic blowout passes over them.

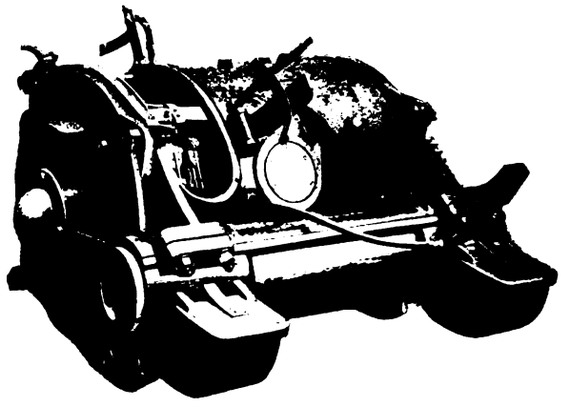


FIG. 5.—VIEW OF ONE OF THE MOTORS.

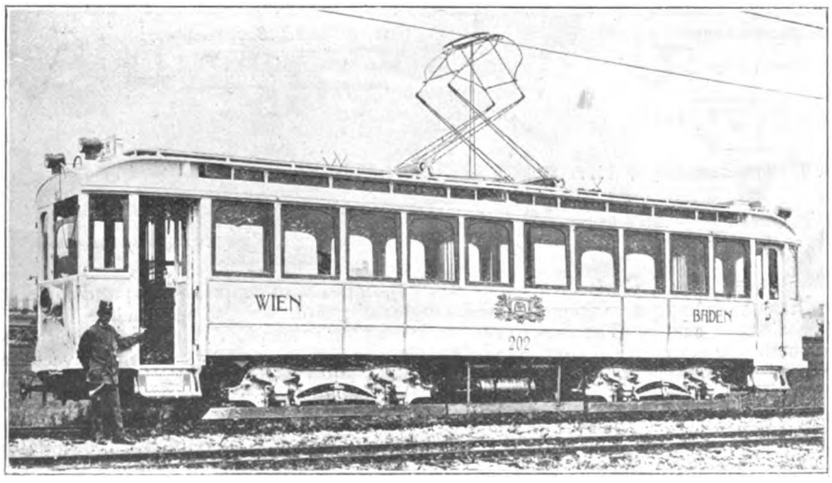


FIG. 4.—VIEW OF ONE OF THE MOTOR CARS.

The drivers' cabs at both ends of the cars are fitted with these valve switches, which are placed close beside the controllers. The arrangement of the pipes for the brakes is shown in Fig. 2.

The starting resistance for the pump motor is air-cooled, and consists of a number of equal-sized resistance elements which are connected in series. Nickelin strip is the material emp'oyed in their manufacture. The coils are wound on hollow formers of box-shaped section, from which they are insulated. Several elements are connected together by hollow or corrugated pieces of metal, and are so arranged that while the car is in motion air passes between them, their temperature being in this way kept within reasonable limits. The pump-motor circuit is protected by a fuse.

The arrangement of the well-known Hardy vacuum brake system is shown in Fig. 2. The lower portion of the brake cylinder (Z) is connected to a continuous pipe (H), by means of a flexible tube, and is also connected directly to the upper part of the cylinder and to the special holder through a ball-cock. To prepare the brake for use the various reservoirs and cylinders are pumped out by means of the arrangements mentioned above until a vacuum equal to 56 cm. of mercury is obtained.

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The pump (P) is connected to the main piping through a non-return valve (R) fitted with a regulator (D). The vacuum can be kept steady at 56 cm. during the run by allowing the motor to

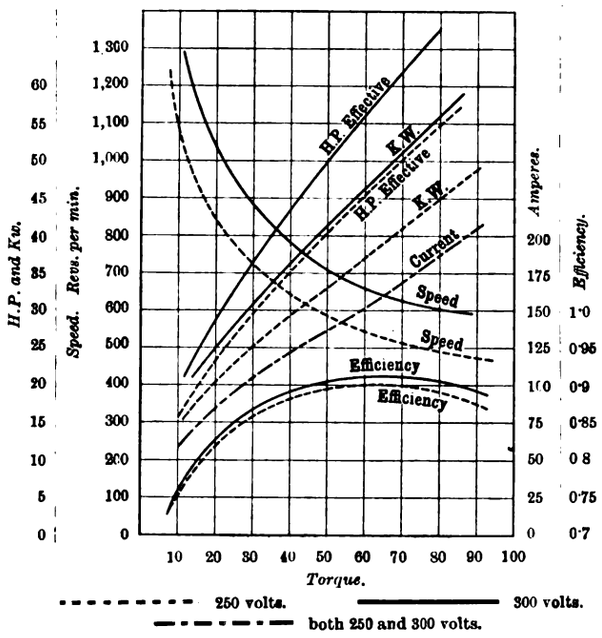

FIG. 6.—CHARACTERISTIC MOTOR CURVES FOR CONTINUOUS CURRENT.

operate at a slower speed with the controller on notch 6. When braking takes place air is admitted into the main piping through the brake shoe. There is, therefore, an increase of pressure in the piping, in the lower portion of the brake cylinder and in the separate holder. This causes the ball-cock to cut off automatically the upper brake chamber and the holder from the piping. This difference of pressure between the upper and lower chamber causes the pump to speed up, which produces the required braking effect depending on

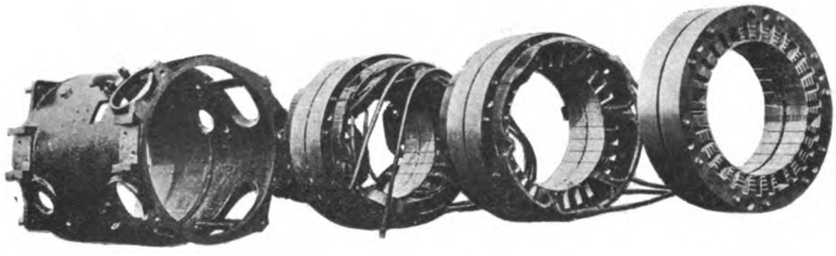

FIG. 7.—VIEW SHOWING PARTS OF A MOTOR.

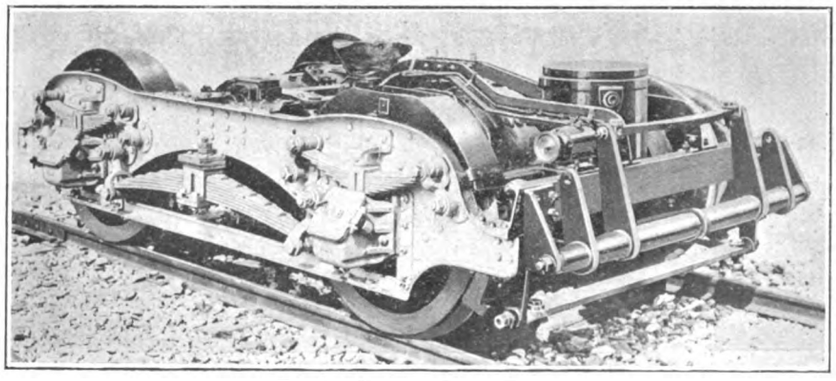

FIG. 8.—VIEW OF BOGIE TRUCK.

the amount of air drawn in. The piping systems of the motor and trailer are connected together by flexible tubes. If these are severed through any cause the brakes will be applied.

Each motor car is fitted with four single-phase commutator motors (Fig. 3), each of 40 H.P. with single reduction gearing. Fig. 4 is a view of one these cars.

The motors, in addition to the magnet and compensation windings, have an additional commutation winding for the purpose of reducing sparking at the brushes.* No resistances are inserted between commutator and the armature windings. The motors have long commutators and six sets of three brushes of 10 mm. thickness. The bearings are very large and arranged for oil lubrication. The construction of the magnets can be seen in Fig. 7, in which : (I.)

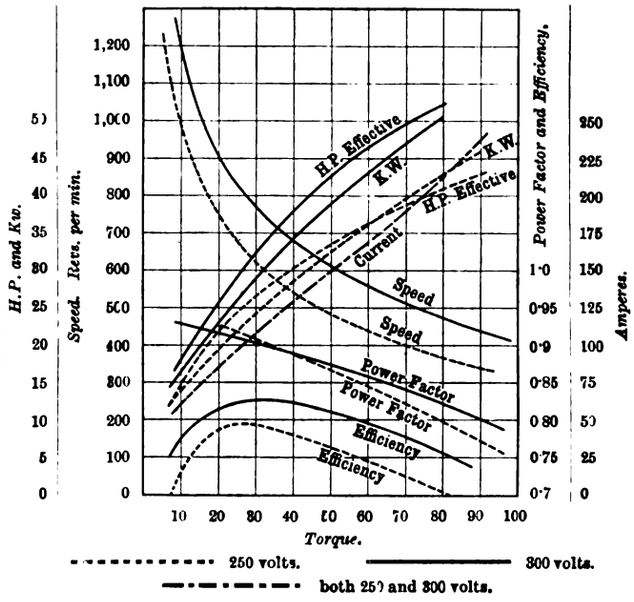

FIG. 9.—CHARACTERISTIC MOTOR CURVES FOR ALTERNATING CURRENT.

represents the iron stampings ready for winding, showing the ventilation holes; (II.) shows the excitation winding in the large slots; (III.) shows the complete stator with compensation and com-

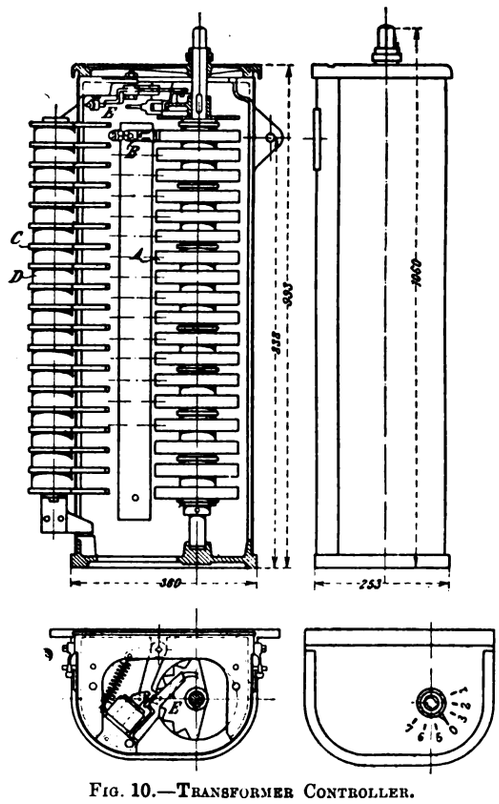

FIG. 10.—TRANSFORMER CONTROLLER.

A Controller drum B Contact fingers; C Dividing Strips D Blow out cock; E Catch mechanism.

mutation windings in place, ready for erection in the frame, and (IV.) shows the frame.

The motor, which runs sparklessly and noiselessly, is shown complete in Fig. 5. The characteristic curves for continuous current and alternating current operation are seen in Figs. 6 and 9, and one of the bogie trucks is shown in Fig. 8.

* See *Elektrotechnische Zeitschrift*, 1906, p. 537, and *The Electrician*, Vol. LVII., p. 207.

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The motors are controlled by a series parallel controller, the motors being permanently connected in two groups of two in series each. The motors are designed to haul a train consisting of one motor car and two trailers, the gross weight being 62 tons, at a speed of 40 km. per hour on a 7 per cent. gradient with 250 volts alternating current at the terminals of each motor; with 300 volts alternating at the terminals of each motor the full speed for the above train is

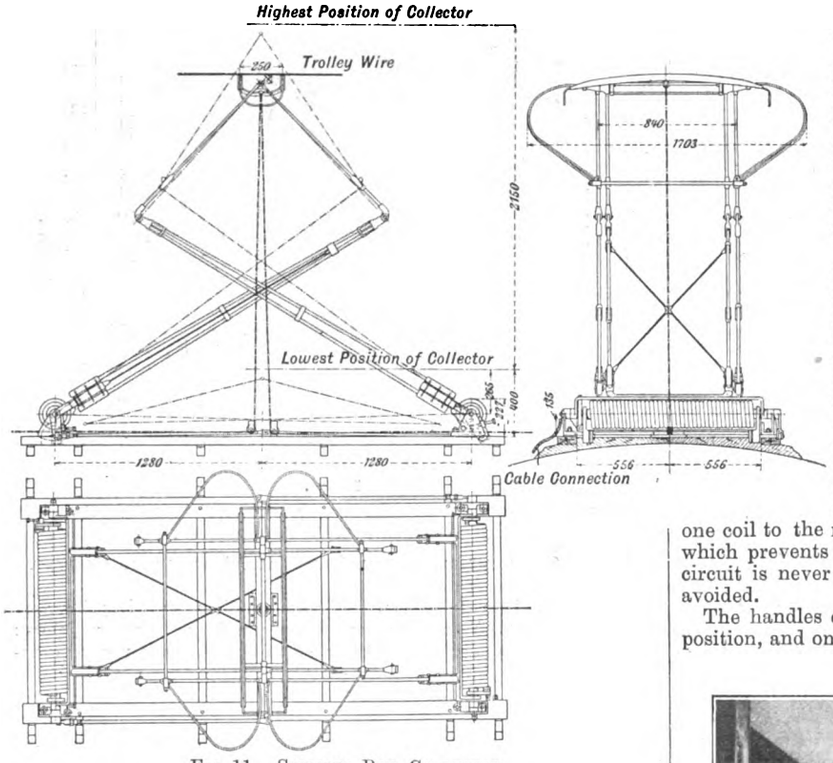

Fig. 11.—Scissors Bow Collector.

60 km. per hour on a 3½ per cent. gradient. When working with continuous current at 500 volts with both the two groups in series, that is to say, with 125 volts at the terminals of each motor, the full speed of the train is 15 km. per hour on grooved rails and a gradient of 15 per cent. The motors are designed not to exceed the standard temperature rise when hauling the express trains, consisting of three cars of 62 tons weight with a maximum speed of 60 km. per hour on the open line.

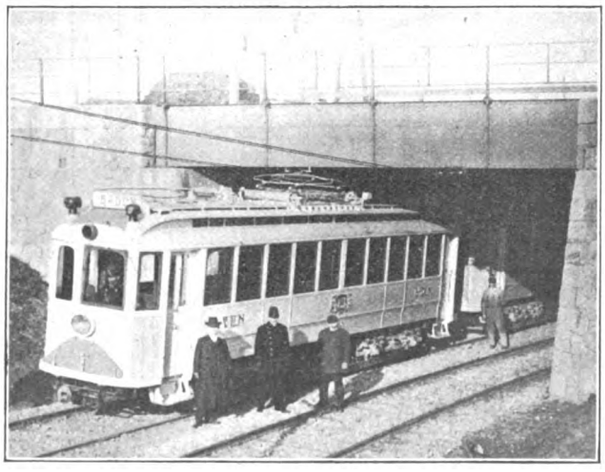

Fig. 12.—View of Car Showing Flexibility of the Bow Collector.

The series parallel controller has eight running steps, four series and four parallel, and six braking steps. It is built like an ordinary continuous-current railway controller, so that it can be used both for continuous and alternating currents. Partly on this account, and partly owing to the large currents which have to be dealt with by the controller, it appeared advisable to use a solenoid blow-out coil by means of which the arcs are blown out parallel to the arc shield and away from the controller barrels. As a result of this, the wear of the sparking contacts is very small even with very large currents, and the spark-gaps can be reduced so that the controller can be kept reasonably small.

In order to avoid damage to the contacts when switching off the short-circuit brake, the circuit is not broken in the usual way, but the excitation of the motor is short-circuited. In order to prevent unnecessary heating of the magnetic blow-out coil the connections of the controller have been arranged so that the coil is switched off at the same time that the last resistance is disconnected.

In order to prevent leakage, or short circuits, between the metal spiders which carry the contact plates and the main spindle, and to provide secure attachment between the spiders and the spindle, screw connections are avoided. The steel drum spindle is fitted with a three-cornered sleeve of hard rubber on which each spider is mounted by running in white lead glycerine cement. The metal spiders are spaced by means of broad stabilit rings.

As the greater part of the route is worked by means of single-phase current it was thought advisable to provide the driver with a special single-phase control gear (Fig. 10) for varying the speed by a transformer, by means of which the line voltage at full load can be raised or lowered in steps to the extent of 125 volts. This controller, which is similar in general construction to the main controller, except that it has no reversing barrel, stands on the left-hand side of the main-controller and serves to switch in and out the coils of the transformer. The arrangement of the switch is similar to that of a battery switch, the change from one coil to the next being made by means of an auxiliary resistance which prevents the short-circuiting of any coil, though the main circuit is never broken. Severe sparking at the contacts is thus avoided.

The handles of the switches are only removable in the "off" position, and only one set is provided per car. The transformer-

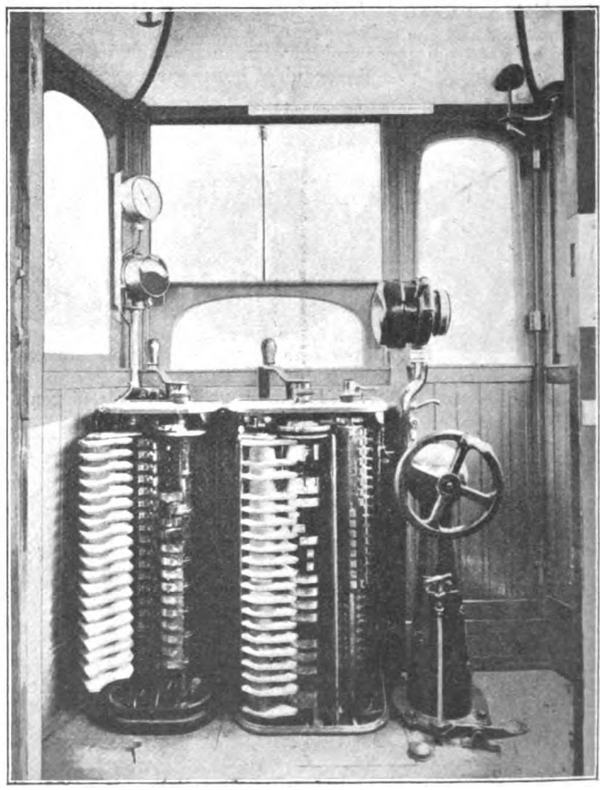

Fig. 13.—View showing the Controlling Apparatus in the Driver's Cab.

controller is interlocked with the main-controller and when it is in the "off" position the transformer is entirely disconnected from the circuit. When working with continuous current the main-controller alone is used and the transformer controller remains in its off position. In order to ensure that this should be so the spindle of the transformer-controller is always locked when continuous current is in use or when the current supply fails. When alternating current is being used a small electromagnet connected

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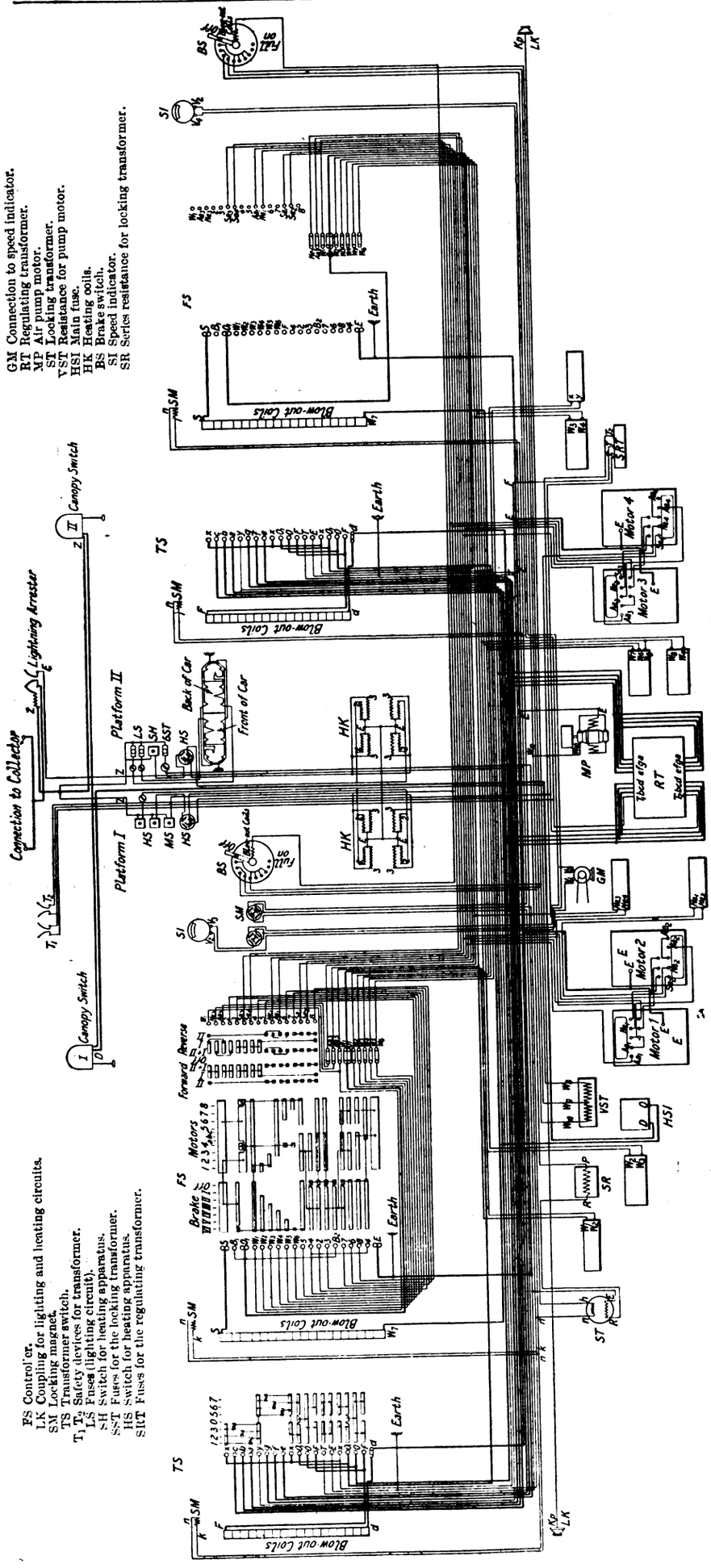

FIG. 14.—DIAGRAM OF CONNECTIONS ON THE CAR.

in the secondary circuit of a small auto-transformer withdraws the lock and leaves the spindle free. The small auto-transformer is placed under the platform, and has a primary winding of sufficient resistance to prevent excessive current flowing in it when the car is connected to the continuous-current supply.

Similarly the main-controller is locked so that when working with continuous current (or when current fails) it cannot be turned beyond the full-series position (position 4). This prevents the possibility of running at too high a speed within the city boundaries. The alternating current relay magnets of the main-controller and the transformer-controller are connected in the same circuit, so that only one auto-transformer is required for supplying them. Fig. 14 shows the whole of the connections on the car. As a protection against breakdown of insulation the frame of the controllers is well earthed.

The transformer used for controlling the speed of the motors on the single-phase section of the line is constructed as an auto-transformer. It is hung under the middle of the floor of the car, supported in a cast-iron frame. The coils and their terminals can be got out without removing the transformer from the car by opening the sheet-iron cover.

Each car is equipped with a set of starting and regulating resistances made of spiral coils of German-silver strip, wound on edge. These coils are well ventilated, so that they are able to carry a large current.

Each car is fitted with one scissors-bow-collector carrying two aluminium contact strips, which is balanced for wind pressure, and designed to allow for the extreme differences of level of the trolley wire without appreciable variations of pressure on the trolley wire. The contact strips are of "U" section, as shown in Fig. 11, and are supported in such a way that both sides of the U are in contact with the trolley wire in whichever direction the car is running. This ensures the best possible contact and allows the grease, contained within the U, to lubricate the wire, which reduces the wear of both trolley wire and contact strips. This type of bow does not require to be reversed when the direction of running is changed. The collector can be pulled down to the roof of the car in a moment by a cord which leads into the driver's cab at each end of the car. The position of the bow when passing under a bridge in Baden is shown in Fig. 12.

To protect the apparatus in the car against excessive current a maximum automatic cut-out is placed in each cab under the canopy. The switch can be opened by hand, and also serves as an emergency cut-out, for which purpose it is arranged to be opened by the alarm-knobs in the car. Each car is also provided with an overload-fuse, which is mounted in an easily accessible position under the car. The fuses can be safely replaced by withdrawing the bridge in which they are mounted from the fuse-box. The primary winding of the regulating transformer is protected by two fuses and also by a horn-lightning-arrester from over-voltages.

In addition to the above each motor car is provided with a horn lightning arrester and arrangements for electric heating and electric lighting of all the cars. Each car is lit by 20 16 c.p. 60 volt incandescent lamps, which are connected in two circuits, each circuit being provided with a fuse and switch. The cars are heated by four Prometheus heaters, connected in two circuits, each of which has a fuse and a switch. The temperature can be regulated by occasionally switching off one heating circuit. The heating and lighting current for the trailer cars is taken from the motor car by means of coupling cables and plug connectors.

E

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Each motor car is fitted with a Siemens & Halske speed indicator, consisting of a small magneto-electric machine with a stationary winding, the rotor of which is coupled to the car axle by means of a spiral-spring-shaft. The voltage generated by this machine is measured by means of a voltmeter, fixed in the driver's cab, close beside the vacuum gauge, and the indicator is calibrated in kilometres per hour. Fig. 13 shows the arrangement of the apparatus in the driver's cab.

The four-wheel motor cars for the shuttle service between Baden and Traiskirchen are fitted with two motors connected permanently in series, controlled by the old controllers, which were modified for this purpose. These cars have only mechanical hand brakes and electrical short-circuit brakes.

All the cars were supplied by F. Ringhoffer, Smichow, the complete electric equipment by the Austrian Siemens-Schuckert-Werke in Vienna, and the vacuum brake equipment by the Vacuum Brake Co., Vienna.

OPTICAL PYROMETRY.*

BY DR. L. HOLBORN.

If one wishes by means of the radiation from a body to obtain its temperature, it is necessary to recognise that the radiation depends, not only upon the temperature, but also upon the emissive power of the radiating body. We deal first, therefore, with the radiation of a black body, which we take as the standard. For each temperature and wave-length it emits the maximum possible amount of radiation, and can be realised by means of a uniformly heated enclosure from which the radiation escapes through a small opening. For this radiation, which may be called "black-body radiation," the following laws hold good:—

$$(1) \qquad \int_0^\infty E_\lambda d\lambda = aT^4 \quad \text{(Stefan-Boltzmann)}$$

$$(2) \qquad \left.\begin{matrix}\lambda_{max.}T = C_1 \\ \text{and } E_{max.}T^{-5} = C_2\end{matrix}\right\} \quad \text{(From Wien's displacement law)}$$

$$(3) \qquad E_\lambda = C\frac{\lambda^{-5}}{e^{\frac{c}{\lambda T}} - 1} \quad \text{(Planck).}$$

Here T denotes the absolute temperature, E_λ the energy radiated between the wave-lengths λ and $\lambda + d\lambda$, and a, C_1, C_2, C and c are constants.

On all these equations can measurements of temperature be based. The most important from this point of view is the third law (which gives the increase of each portion of the radiation with the temperature), especially in the simplified form

$$(3a) \qquad E_\lambda = C\lambda^{-5}e^{-\frac{c}{\lambda T}} \quad \text{(Wien),}$$

which is valid for small wave-lengths in the visible region. In this case the eye can be employed instead of a bolometer, so that the measurement of temperature can be carried out by means of a photometer. If the luminosities E_1 and E_2 correspond to the radiation E_λ at the absolute temperatures T_1 and T_2, we have—

$$\log_e \frac{E_2}{E_1} = \frac{c}{\lambda}\left(\frac{1}{T_1} - \frac{1}{T_2}\right).$$

If the constant c is known one must select an initial temperature, and can then determine all other temperatures by a comparison of luminosities with that at this standard temperature. For λ one chooses for this purpose a narrow region in the red, in order to have sufficient brightness even at low temperatures.

The accuracy of the constant c depends upon data obtained with the gas thermometer at temperatures corresponding to the visible region. The most recent measurements which are based on the nitrogen thermometer between 800°C. and 1,600°C. give for c the value 14,200, which in the visible region is independent of the wave-length.

The accuracy of c may amount to about 1 per cent., so that the temperature measurement, if the melting point of gold (1064 deg.) is taken as the starting point, is accurate to 6 deg. at 1,500°C., to 16 deg. at 2,000° C., and to 48 deg. at 3,000° C. Every spectrophotometer can, therefore, be employed as a pyrometer. The comparison of the radiation to be measured with a constant source of light is effected in a known way by the reduction of intensity by means of a polariser or a rotating sector. For pyrometric purposes attempts have been made to simplify the spectrophotometer. We shall give the following examples:—

The instrument of Wanner is a photometer with polariser which permits observations to be made in the spectral region of the red hydrogen line. The comparison source of light is a small glow-lamp, the brightness of which can be controlled from time to time by comparison with an amyl-acetate lamp. The angles which are read on the divided circle of the polariser after adjustment has been made of the two halves of the field of view to equality of brightness are translated into temperatures with the help of a table.

The pyrometer of Holborn and Kurlbaum employs a variable comparison source of light, and this also is a small glow-lamp, the brightness of which can be adjusted by means of an alteration of current-strength, so that the middle of the carbon filament becomes invisible when in front of the glowing surface whose light is being determined. The indication of temperature is furnished, therefore, by the strength of current through the lamp, which before use is standardised by reference to a black body of measurable temperature.

Instead of an arrangement for producing a spectrum, the second instrument employs coloured glasses. The less homogeneous light which is furnished is of no disadvantage if we base the standardisation of the readings of the instrument on the black body. But if in the measurements made with the pyrometer one wishes to employ Wien's law, for example, by which one somewhat extrapolates the temperature scale, so must the effective wave-length first of all be determined from the law of radiation by means of a special investigation. Determinations up to about 1,600 deg. indicate that the effective wave-length transmitted by the most common copper-oxide glass is constant, and is equal to 0·650μ.

From optical measurements based on the melting point of gold (1,064 deg.) are obtained the following melting points: Palladium 1,580 deg., platinum 1,790 deg., rhodium 2,000 deg.

The highest temperature which up till now has been determined with the gas thermometer is that of palladium. The value obtained was 1,575 deg.

If we employ the optical pyrometer, which has been standardised by means of a black body, on a body of smaller radiating power, we do not obtain the true temperature, but a less value, which in distinction from the true temperature we call the *black temperature*. It is that temperature at which a black body will be if it radiates in the region of the spectrum which is investigated with the same brightness as the body of less radiating power. In many cases one can enclose the radiating body, if its emissive power is not known, in a cavity or in a reflecting envelope, and in this way make its radiation that of a black body. In other cases the emissive power must be specially determined.

For the noble metals, such as silver, gold and platinum, measurements have furnished a simple result. The emissive power (relative to that of a black body at the same temperature) for these metals for a given wave-length in the visible region is independent of the temperature within the accuracy of the measurements of temperature. Thus platinum emits red light of about one-third, gold of one-eighth, and silver of one-fourteenth of the brightness of a black body at the same temperature. The law is valid down to low temperatures where we can determine the emissive power from the absorption of good metallic mirrors.

* Abstract of a Paper read before Section A of the British Association at Leicester, August, 1907.

THE HIGH-RESISTANCE CONTACT THERMO-ELECTRIC DETECTOR FOR ELECTRICAL WAVES.*

BY L. W. AUSTIN.

If two metals standing far apart in the thermoelectric series be so brought in contact that their contact resistance is sufficiently high, and if the surfaces of the metals are of such a nature that heat is not conducted away too rapidly from the point of contact, then the passage of electrical oscillations through the junction will produce direct E.M.F.s which may be detected in a galvanometer or telephone in series with the thermo-element. The principle is extremely simple, but in practice it is found that there are very few pairs of metals which give suitable contact conditions. If the contact is of too low resistance the heating is insufficient, and if the contact is too loose as in the coherer the action is irregular and the instrument less sensitive.

On account of its extreme position in the thermoelectric series tellurium seemed desirable for one of the metals, and it was tried with a large number of others. Fair results were obtained with several of the more easily oxidised metals and also with carbon, but with all these the action was irregular and adjustment difficult. Finally, aluminium was fixed upon as being not only the most sensitive but by far the most reliable among the common metals. Silicon has also proved very satisfactory.

The instrument has been made in three forms. The first form is shown in Fig. 1. D is a hard rubber support at the top of the upright piece of which the pointed rod of aluminium a is mounted. b is a bead of tellurium melted on to the tip of a piece of brass wire, the latter being soldered to the top of the spring c. The closeness of the contact between a and b is regulated by the screw s. A

* From the *Physical Review*, June, 1907. A similar detector using silicon and copper was independently devised by G. W. Pickard.

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second form was also made in which the aluminium is in the form of a rod fitted in bearings and rotated slowly by means of a pulley. The tellurium is pressed against it by a spring as before. The constantly-changing contact point seems to keep the conditions more constant and does away with any necessity of readjustment even when heavy atmospheric discharges have passed through it. The sensitiveness is about the same in the two types. As certain portions of the tellurium surface seem to be more sensitive than others, it is desirable in both forms to have the point of contact adjustable.*

An exhaustive comparison of the thermoelectric receiver with the well-known electrolytic type, extending over several months and including some long-distance work, showed that in sensitiveness it compared favourably with the latter, being slightly less sensitive on an average than the free Wollaston wire electrode type, but more so than the type with the small platinum electrode sealed into glass. The comparisons were made by the shunted telephone method, in which the loudness of the signals is measured by the smallness of the shunt *s* (Fig. 2) across the telephones necessary to produce silence. The telephones used were of the ordinary head type, and had a resistance of about 1,200 ohms.

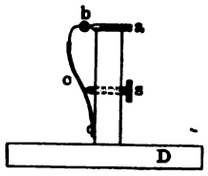

FIG. 1.

In the figures L represents the inductance, D the detector, E a condenser of about 0·05 mfd. used to prevent the thermal currents flowing around through the inductance, T is the telephone and I (Fig. 2) is a choking coil preventing the oscillations flowing through the telephone circuit when the shunt *s* is closed; B (Fig. 3) is a tuning condenser.

Experiments were also made using 120 cycle alternating currents, various alternating P.D.s being applied to the detector from a fall of potential wire. The direct currents were measured by a D'Arsonval galvanometer having a sensitiveness of about 1.10^{-9} ampere per millimeter of scale. The results are shown in the following table:—

Volts. a.c.	Galvanometer deflections. mm.	Volts. a.c.	Galvanometer deflections. mm.
0·015	 210	0·005	 25
0·010	 105	0·002	 5
0·007	 50	0·001	 1

The resistance of the detector under sensitive conditions varies between 1,000 and 3,000 ohms, therefore the alternating current corresponding to a deflection of 1 mm. lay between 1.10^{-6} and 3.10^{-7} amperes.

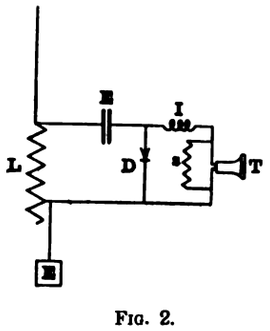

FIG. 2.

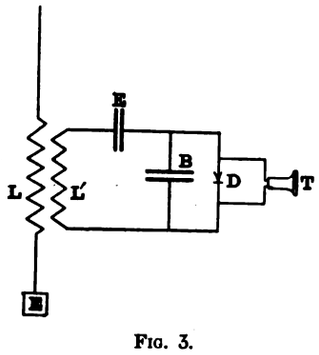

FIG. 3.

On account of its high resistance in working with high frequency currents the detector is not placed directly in the oscillating circuit, but is shunted across the inductance, as shown in Figs. 2 and 3.

ELECTROLYSIS OF MIXTURES.†

BY G. ROSSET.

Although water is to be regarded as a neutral substance its action can in no wise be neglected in discussing electrolytic problems involving the use of aqueous salt solutions. This is especially the case with salts of weak acids and bases where a considerable amount of hydrolysis takes place. The electrolysis of such substances must be considered, therefore, from the point of view of a mixed solution, and not as one composed simply of two ions. Each substance in solution requires a definite minimum E.M.F. in order to bring about a separation at the electrodes, and in many cases this is very considerable. One must constantly keep this in view in dealing with electrolytic problems. Thus, in the case of an acidified solution of copper sulphate between copper electrodes two substances have to be considered—viz., sulphuric acid and copper sulphate.

Suppose now a P.D. is applied at the electrodes below that required for the decomposition of sulphuric acid, then only copper takes part in the reactions at the kathode. As the E.M.F. increases, however, sufficient potential energy is supplied to decompose the acid present, and from this point onwards both hydrogen and copper are liberated side by side. During this reaction the amount of copper deposited is proportional to the applied E.M.F., but not so the hydrogen. This is due to the fact that copper in these circumstances requires only the smallest possible P.D. to start the decomposition, but for sulphuric acid this has a considerable value. Thus the current passing through a mixture of dissolved electrolytes divides itself between the different groups of ions, and these perform their functions quite independently of each other. This rule is qualitative only as the influence of ionisation is considerable. This same reasoning is capable of application to a large class of substances and has been experimentally verified by the work of Hollard, in connection with the electrolytic separation of the metals. For mixtures of sulphates and sulphuric acid, for example, there is in each case a certain critical concentration of acid, the resistivity of which is unaffected by the addition of a saline solution of a particular salt. This concentration decreases as the atomic weight of the metal increases, as is verified by the author's calculations. Introducing the current density factor with these relations it is possible to construct a curve representing the three relations, current density, E.M.F. and resistivity, and thus to gain *a priori* valuable information for the successful manipulation of a refining bath. These facts have been verified by the electrolysis of a mixed solution of copper sulphate and sulphuric acid and agree with the calculations. It is apparent that the nature of the deposited copper changes as soon as hydrogen makes its appearance, the change being from a red to a black form. The same black form is found in the zincs of a Daniell's cell obtained by precipitation from the diffused copper sulphate. It is probably an allotropic form of copper, and requires a certain definite amount of energy for the change. The red form is precipitated until the E.M.F. reaches 1 volt approximately, but with higher E.M.F.s both hydrogen and the black form are produced. A piece of iron deposits red copper, but the P.D. is here only 0·67 volt. These same considerations have been applied to the electrolysis of zinc chloride with full agreement with the above. With lead acetate a critical voltage is reached at about 1·8 volts, at which point it is possible to see a change in the crystalline state of the deposited metal.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Everybody's Guide to Electricity." By E. Pierce. (London: Madgwick, Houlston & Co.) 6d.

"Praktisches Handbuch der drahtlosen Telegraphie und Telephonie." By Johannes Zacharias and Hermann Heinicke. (Leipzig: A. Hartleben.) M.4.

"Munro & Jamieson's Pocket-Book of Electrical Rules and Tables." 18th edition. Revised by Prof. A. Jamieson. (London: Charles Griffin & Co.) 8s. 6d.

"Beiträge zum Kommutierungsproblem." By Karl Waldmann. (Berlin: Universitäts-Buchdruckerei von Gustav Schade.)

"Der eingeschlossene Lichtbogen bei Gleichstrom." By Dr. Ing. Karl Stockhausen. (Leipzig: Johann Ambrosius Barth.) M. 6.

Application of Electricity to Matchmaking.—According to the *Electrical Review* (*N.Y.*) a complete power equipment, consisting of variable-speed induction motors and a number of constant-speed machines, was recently erected at a match factory at Oshkosh, Wis., all of the apparatus being three-phase 60 cycle, 440 volts. The unusual feature in connection with this installation is the fact that the match machines, which have always heretofore been group-driven, in this new plant will each be driven by one 5 H.P. induction motor. It was shown by careful tests that individual drive in this plant will decrease the power consumption at least 1 H.P. per machine by eliminating the use of a mechanical speed changer as well as the long countershafts joining the groups of machines in the older installation. The test showed that 0·65 electrical H.P. is required to drive the speed changer. The machine proper requires 2·5, 2·7 and 3·4 electrical H.P. at speeds corresponding to 160, 194 and 220 strokes of the cutters. Five H.P. motors were, therefore, chosen as being of the proper size for the work.

* A third form in which the contact metals are tellurium and silicon, made up like form 1, promises in some respects to be even more satisfactory than the others. The contact surfaces should be cleaned frequently with petroleum.

† Abstracted from *L'Eclairage Electrique*.

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ELECTRICITY SUPPLY TARIFFS.

In looking over the published data relating to electricity supply stations one cannot help being struck with the great variety in the tariffs adopted, a variety which tends to increase rather than to diminish. First of all, it becomes evident that the maximum demand system of charging is favoured very considerably, the upper limit being frequently 7d. and the lower limit 2d., although there is a good deal of variety. For example, we have 7d. and 3d., 6d. and 3d., 7d. and 4d., 6d. and 2½d., 7d. and 1½d., and so on. This variety, of course, is natural enough, as the stand-by charges and running charges must both vary considerably with the size of the undertaking and with local conditions. The maximum-demand system is undoubtedly correct in principle, but it is generally inadvisable to give this system without any alternative, and consequently any number of systems more or less simple are found in addition. Thus Buxton, besides having a rate of 7d. for the first hour and 3d. after the first, has rates of 6d., 4d., 3d. and 2½d. Some towns have simply a flat rate, others having a sliding scale with limits. Hornsey gives a rate of 5d. with rebates, and Hertford includes free wiring if 8d. and 2d. are paid in place of 7d. and 2d. A difference of price according to the voltage of supply is noticeable in one or two instances. Thus Hove gives a supply at 220 volts

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for 7d. and 4d., but for a supply of 110 volts the charge is 8d. and 4d. Similarly, Kensington gives a supply of 200 volts at 5d. and 3d., but charges 6d. for a 100 volt supply. Halls are charged at 3½d. and churches at 3d. at Govan. At Horsham churches have to pay 5d., while at Hackney a 3d. rate is allowed. At Whitehaven the charge is based on £8 per kilowatt per annum and 2d. per unit, whereas at Norwich a yearly charge is made of 12 per cent. on the net assessment, and a further charge of 1d. per unit. Flat rates, in addition to being subject to rebates, are frequently quite complicated. Thus at Westminster the first 1,000 units are charged at 5½d., and the next 3,000 at 4½d., and after 4,000 the charge is 3½d. St. Pancras, again, has a number of different charges.

Undoubtedly the flat rate, with or without discounts, is altogether an unfair way of charging for a supply, for by the average price that is obtained the good consumer pays for the consumer that is unprofitable. But, as pointed out by Mr. GEORGE WILKINSON last year in his Presidential Address to the Leeds local section of the Institution of Electrical Engineers, that kind of charge is not likely to be tolerated when consumers become better educated to the simple fact that the longer a supply is required per day the lower is the rate at which the charge should be made.

In addition to the different kinds of charges made for light just referred to, there are further rates for power. Generally speaking, the published rate for power is a flat rate of 1d. to 2d. per unit, though, as a matter of fact, large consumers are always considered on their merits and prices are arranged in accordance with load factor and quantity. In addition to a flat rate, some supply authorities graduate the charge according to quantity: thus Woolwich supplies 10,000 units at 2d. and 40,000 units at 1¼d. Some authorities make the more rational charge of a certain sum per kilowatt of demand per annum and a low rate per unit.

It would be well if greater uniformity could be adopted in such matters, though in some respects it is difficult. The position is frequently complicated by a small demand for power as well as light. Thus, if the consumer desires the advantages of the maximum-demand system for his lighting load, and also requires a certain amount of energy for power and heating, he finds it necessary to choose between two alternatives. If he wishes to take advantage of the maximum-demand rate for light and of the power rate for heating and power, he must be prepared to pay for two meters and put in duplicate wiring. On the other hand, if he simplifies matters by avoiding duplicate wiring, having only one meter, then it is practically impossible for him to make use of the maximum-demand system, as any but the most judicious use of electrical energy for heating and power would raise the maximum so considerably that he would gain nothing by this system; indeed, he might lose heavily. There is another alternative, which does not seem to have been considered seriously in such cases (at least, for the average householder), and that is the use of a time switch. If two meters were installed and a time switch to change over from one meter to the other during times of peak load, or the equivalent arrangement of a single meter with a shunt, then all the energy used during the greater part of the day and registered by one of the meters might be charged for at quite a low rate, and that used during the time of peak load could be charged at a comparatively high rate. It is quite immaterial to the suppliers of electrical energy for what purposes the electrical energy is used during times of light load. Their one endeavour is to raise the light load and to keep down the peak. During times of peak load the consumer would naturally avoid using power and heat as far as possible. Such a system has the disadvantage that it takes no account of load factor, but it has the advantage of simplicity, and the further advantage that it would tend to encourage the small user of power who cannot see his way to go to the expense of duplicate wiring, and, therefore, does not use electrical power at all. It must not be forgotten that the small consumer is becoming increasingly important from the point of view of the universal use of electrical energy.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Commutatrices et Transformateurs Electriques Tournants. By J. PARAF. (Paris: Gauthier-Villars.) 2fr. 50c.

This little book is another addition to the series entitled "Encyclopédie Scientifique des Aide-Mémoire," of which several volumes have recently been noticed in these columns. It deals with rotary converters and other forms of transforming machinery involving mechanical rotation. The treatment is clear and concise, and the high standard characteristic of other volumes in the same series is well maintained. After a brief introduction, devoted to some general considerations, the author deals with the voltage and current ratios in rotary converters, heating, armature reaction, methods of voltage regulation and of arranging the connections of three-phase and six-phase converters, hunting, parallel operation, methods of testing and separating the losses. The various applications of converters are next briefly considered, and then follows a fully worked-out design of a 200 kw. converter. The detailed specifications which are given of three typical converters by leading makers are of great interest. A concluding section deals with rotating transforming machinery other than converters, and includes, among others, an account of motor-generators, of the cascade converter, of the permutator and of the interesting but little known Auvert and Ferrand rectifier. In some respects, perhaps, the author is too conservative in his views, as he appears to regard 40 as the practical limit of frequency for converters, whereas a number of 50-cycle converters of large output are now running quite successfully. It is a pity that the author did not rest content with the simple line diagrams and drawings—which are excellent—but has thought it necessary to include some half-tone reproductions of photographs, which are so badly executed as to constitute regular blots on the book. Apart from this purely typographical blemish, the book is one which we can heartily recommend to our readers.

Die Forging and the Construction of Dies. By JOSEPH G. HORNER (London: "Engineering.") Pp. 104. 7s. 6d. net.

This volume forms, the author believes, the only attempt yet made to deal with die forging in a comprehensive manner. Die forging is one of the remarkable developments of workshop practice, too often believed to be adaptable only to the production of small forgings in large quantities, but the examples described in this volume show such a view to be incorrect.

Part I. relates to the practice of die forging. In the introductory chapters are discussed the advantages of die forging as regards accuracy and economy, die forging supplementary to and independent of anvil work and die forging considered as a finishing process only. Separate chapters are devoted respectively to bossed work with holes, forked ends, flanged work, bent work, drop forgings and railway work. In the

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chapter on drop forgings the actions of the press and the hammer are compared, and the characteristics of work done by the two systems are discussed fully. The relation between the smithy and the machine shop is always to be borne in mind when designing a die-forging process. Thus, with accurate dies, the old time-honoured instruction to the smiths to "leave plenty on" may be discarded. On the other hand, holes, especially if of a fair depth, are more economically drilled than punched out during forging.

Part II. relates to machines and die making, and consists of chapters on steam hammers, pneumatic hammers, spring hammers, drop hammers, bulldozers and forging machines, machines for cutting dies, the preparation of dies, shop arrangements. The tendency now is to standardise everything; the use of die forgings helps to this end, and it would be well if draughtsmen and managers would help the idea forward by selecting from a list instead of making new drawings.

The volume should be of great value to all concerned in the production of forgings in large quantities.

THE ORIGIN AND PRODUCTION OF CORRUGATION OF TRAMWAY RAILS.*

BY W. WORBY BEAUMONT.

That which is known as "corrugation" of the surface of tramway rails has given rise to much speculation and some investigation concerning its cause. Although known as corrugation, it is hardly perceptible as of a form usually understood when so described. It consists of an approximately regular alternation of hard and soft, or of hard and less hard, patches of the surface rolled by the tramcar wheels. The surface of the hard patches is very slightly higher than the general surface, but it becomes sufficiently so to declare its existence by the noise made by the tramcar wheels as they roll along the rails as though running over a rack with teeth of almost no assignable height.

Corrugation declares itself variously as to time of its appearance after a rail is first used, as to position of rail, somewhat differently in different towns, but it has become general since the introduction of electrically-propelled tramcars, and particularly the latter-day heavy cars. It is the cause of considerable annoyance, and considerable expense is incurred in grinding down the raised hard prominences by emery grinding blocks.

Many Papers have been written upon this corrugation, offering almost as many suggestions and speculations as to its origin. None of them have, however, been accepted as being in accordance with the facts of the phenomena of the appearance and growth of corrugation, and some have invoked as causes conditions which are equally attendant where corrugation does not arise. These Papers have been too numerous for reference here, and as the hypotheses appealed to, though in many cases very interesting, do not affect the conclusions of the author, he may be pardoned if for the present he only refers those interested to the *Journal* of the Tramway and Light Railways Association.

Although the physical and mechanical conditions involved in the origin of corrugation may be said to be somewhat complex, the mode of operation of the causes is simple, and for an explanation simple phenomena of known recurrence and adaptation in engineering works may be appealed to for this purpose, and for some of these the author may refer to a Paper he read before Section G at Liverpool "On the Causes of Fracture of Railway Rails": "When a piece of cold iron or steel is subjected to pressure exceeding the limit of elastic compression by a rolling or hammering action, or by both these combined, the result is spreading of the material and general change of the dimensions. This is equally the case with a plate hammered on one side or rolled on one side while resting on a flat surface, or with a rivet when hammered over. In all these cases, and many others, the hammering or rolling work done upon the surfaces tends to compress the material beneath it, but being nearly incompressible and unchangeable in density, the material flows and change of form results.

"Generally the material thus changed in form suffers permanently no greater stresses than those within its elastic limit of compression or extension. When, however, the material is not free to flow or change its form in the direction in which the stresses set up would act, the effect of continued work done on the surface is the growth of compressive stress exceeding elastic resistance.

"In the case of railway rails the freedom for the flow of the material is very limited, especially when considered with reference to the rolling and hammering media and the surface contact between rails and wheels. Hardening of the surface takes place, and destructive compression of the surface material is set up. If the materials be cast iron, the destructive compression causes crumbling of the superficial parts and the consequent relief of the material immediately below it from stress beyond that of elastic compression; but when the material is that of steel rails the stress accumulates, the upper part near the surface being under intense compression, differentiating from a maximum at the surface."

The repeated running of the heavily-laden tramway wheel over the rail does thus gradually compress the surface of the crown of the rail. Of this stress transversely the material relieves itself partially by the detrusion at the edges of the rail, where it forms a lip both on the outside and the groove side. This lip remains on the outside of the rail, but is worn off on the inside by the wheel flange. In the longitudinal direction the stresses arising from the compression of the surface material are not thus relieved, and the result is the formation of an extremely hard surface in patches of various shapes and lengths. Sometimes this hard surface is continuous, with but slight breaks of intermediate slightly roughened surface. In many places the surface between the hard bright patches is pitted with various degrees of coarseness of pitting. Where the bright hard patches alternate with an approach to regularity with the dull and rougher surface patches, the result is known as corrugation. This character of surface may be found on every heavily-worked tramway under conditions of such impartial contrariety that it may be ascribed to conditions of origin which are general. They are found on straight level lines and on straight gradients. They are found on curves, and especially on curves of moderate and large radii, and they generally appear soonest on the outer rail of a curve.

The author offers the following, then, as an explanation of the origin and production of the corrugation of tramway rails: (1) The compression of the material of the table of the rail by the tramcar wheels; cold rolling. (2) The microscopic deformation of the surface of the rail on the small area of contact between wheel and rail, that deformation being attended by a depression under the wheel. (3) That the material of the surface in front of the wheel and the depression recurrently forms a slight ridge of unassignable height, over which the wheel mounts. (4) That the area of contact between wheel and ridge is minute, and the pressure, therefore, very great per unit of area, and hence the severe pressing of the ridge into the material of the rail table and its hardening or its crushing. (5) That the distance between each ridge thus formed by the rolling wheel will vary slightly with the strength, hardness, and toughness of the rail, and with the speed of the car wheels. (6) That the originating ridge forming the incipient hard patch is added to on the formative or rear side, thus gradually extending from a mere transverse line to an area of increasing length. (7) That the hard patch thus formed for a time resists the destructive deformation by the wheel, but that it increases the rate of local side detrusion, and that the extruded material is in some positions of the rail worn off by the flanges of the wheels, which are thereby pushed laterally against the other side of the rail groove, and make more or less distinctive marks thereon. (8) That a steel rail loses a large part, if not most, of its weight in wear by separation of the compressed and crushed surface by minute exfoliation, the surface film exceeding the dimensions of the sub-surface, and separating itself by disintegration, flaking or crumbling, as shown by pitting. (9) That this disintegration of the surface partially relieves the surface film of the destructively compressed parts and the sub-surface of the corresponding tension. (10) That the hard bright patches depend for their duration upon the strength of their supporting materials, and in many cases should disappear, though they reappear in different position. (11) That the appearance of the hard patches on the outer curves of some lines where none appear on other of the rails of the same line is due to the heeling over of the cars on the curve and the extra weight thereby put on the outer wheels. (12) That it is possible that the final passes of some rails through the rolls at a comparatively low temperature may produce a condition in the rail conducive of initiation of corrugation, and thus accessory before the rail is laid. (13) That there are numerous circumstances and conditions in the working life of a tramway rail which produce great contrariety in results, including (*a*) its correct laying, which causes a greater or lesser width of the table to present itself to the wheel tread; (*b*) the grinding slip of the propelling wheels on one side of the car affected by the condition of the rail surface and by the heavier load on the outer rails on curves causing or permitting the wheels on the inner rails to slip; (*c*) the speed of the cars; (*d*) the character of the dirt and grit on the rails, the constitution of the rail, &c. (14) The remedy appears to be (*e*) lighter cars, (*f*) harder rails, (*g*) moderate speeds, (*h*) larger wheels. (15) Some excellent examples of the corrugation in numerous stages of production, with long, short, narrow, wide, somewhat irregular, extremely irregular and other illustrations of the vagarial appearance of the disease, may be seen on the new tramway of the London County Council on the Thames Embankment between Blackfriars Bridge and the Temple Gardens.

* Paper read before Section G of the British Association at Leicester, August, 1907.

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FUSES.*

BY DR. GEORG J. MEYER.

There is little information in technical literature on the subject of the heating and arcing of fuses, and it is here proposed to attempt to fill the gap by giving the results of some work done on the subject. Let us first consider the case in which the current is insufficient to melt the fuse, and let the current be denoted by pI_0, where I_0 is the limiting current, which is just sufficient to melt the fuse in an infinite time, and p is less than unity. The following curves in Fig. 1 show graphically the temperature finally reached in the middle of the fuse for different values of p with the various metals. If a copper fuse carries 90 per cent. of the limiting current, its maximum temperature will not be above 510°C., and may c n-

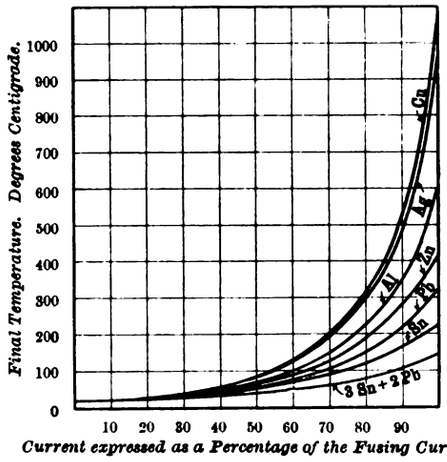

FIG. 1.

tinue at that temperature almost indefinitely. Let us assume on the other hand that its normal load is 66 per cent. of the limiting current; in this case, the temperature of 510°C. will only be reached if the fuse is overloaded to the extent of 35 per cent. Copper seems a very suitable material for fuses, at any rate as compared with silver, and if plated with silver or nickel is protected from oxidation. At the highest temperature the silver might melt, and nickel shows a tendency to strip off. But a preference for silver is unreasonable, as it is only when the load nears the breaking point that any serious disintegration of copper takes place.

Let us now consider what takes place at the moment when the fuse melts. The tables of Landolt and Börnstein show that at the moment of fusing the resistance of lead has increased by 90 per cent., of zinc by 100 per cent., and of tin by 112 per cent. Aluminium and zinc oxidise at this temperature, the oxide being infusible; on the other hand, copper oxide is fusible at the melting point of copper, while silver shows no tendency to oxidise at all. Fig. 2 shows the various stages through which a zinc fuse passes when it is on the point of melting, and the distribution of temperature along its length is roughly shown by the curves at the side of each. At *a* the fuse is shown in its ordinary state, the distribution of temperature being shown by a curve that is somewhat of the nature of a catenary. At *b* the wire is beginning to fuse and is held together by a superficial coating of oxide. At *c* the pressure of the fluid

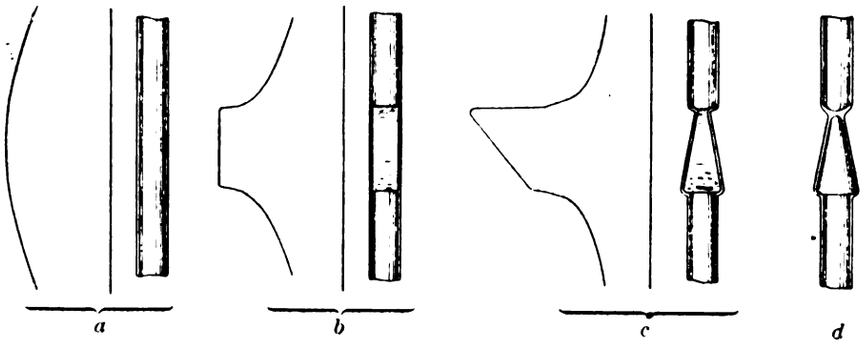

FIG. 2.—DIAGRAMS REPRESENTING THE STAGES THROUGH WHICH A ZINC WIRE PASSES BEFORE FUSION ON A LOW VOLTAGE.

portion expands the coating of oxide at the bottom, and this expansion is particularly noticeable in the case of heavy wires. The deformation causes a further rise of temperature at the upper end of the fluid column, and at this point the arc is formed. Schwarz and James have objected to the use of aluminium fuses, on the ground that the formation of a superficial coating of oxide prevents their action from being reliable; but there is no force in this, as the following experiment with a zinc fuse shows.* A zinc wire, 0·92 mm. in diameter, was tested with a gradually increasing load, and three successive experiments gave the fusing current as 29, 26 and 25 amperes. It was then more gradually loaded until the middle showed signs of beginning to fuse. It was then allowed to cool and the process was repeated. On a third attempt the wire was allowed to fuse, and the current at the moment of breaking was 28 amperes, which seems to show that the formation of oxide in the middle had not altered the current the wire was capable of carrying.

Let us consider next those metals which form an oxide which is fluid at the temperature of fusion of the metal, or which form no

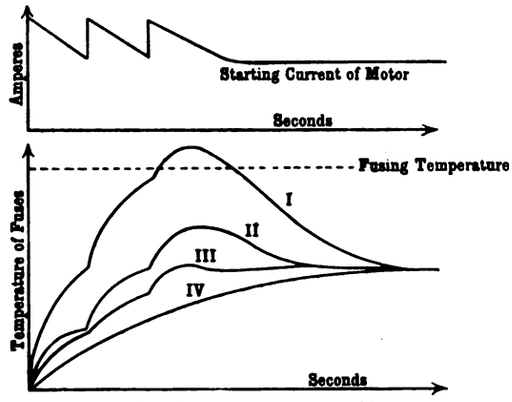

FIG. 3.—THE STARTING OF A MOTOR.

oxide at all. Of these copper may be taken as an example. It is, perhaps, not typical in every respect, seeing that the temperatures of fusion and volatilisation are very near one another. The result is, that when a copper fuse blows the surface is formed into irregular shapes and contains small holes, which are due to the escape of volatilised metal through the fused mass, the inside being hotter than the outside. Some of the escaping gases are condensed on the surface, and small excrescences are formed in this way. The length of the fuse which is melted depends on the amount of the overload and on the voltage. In the case of copper fuses, the surface is covered with bright and dark patches, the dark ones being covered with cupric oxide, and the bright ones being due to cuprous oxide or to the metal itself.

A case of considerable importance is the choice of a fuse for motor circuits. Fig. 3 gives curves showing the starting current of the motor and the heating of fuses of different sluggishness. The four fuses are made of the same material and have therefore the same fusing point. Fuse I. heats quickly, and when the normal current is slightly exceeded it melts; fuse II. also exceeds its final temperature, but without melting; fuse III. heats rather more quickly than IV. Fuse I. is obviously impossible, and the choice between II., III. and IV. must depend on the conditions under which the motor is worked; if no overload is likely, fuse II. is clearly possible; otherwise we must have recourse to III. or IV.

With lighting circuits the conditions are different; any overload generally means that there is some disturbance of normal conditions, and the circuits should therefore be supplied with fuses which melt with very slight increase of current. Sluggish lead fuses have therefore been replaced by much more sensitive silver ones, and with fittings of the nature of wall sockets a fuse which melts at once if overloaded is an absolute necessity. If the circuit contains arc lamps, the conditions approximate to those which have been noticed under the head of motors. The normal current is very likely to be exceeded during the starting period, and these recurrent excesses may continue till the mechanism settles down to a condition of steady working; the fuse must therefore be capable of surviving such shocks, but must be so proportioned as to blow if the regulating mechanism were to cease to work properly.

* Abstracted from the *Elektrotechnische Zeitschrift*, April 23 and May 2, 1907.

* In this connection the reader should refer to a letter by Messrs. Schwarz and James, which appeared in *The Electrician*, Vol. LIX., p. 525.

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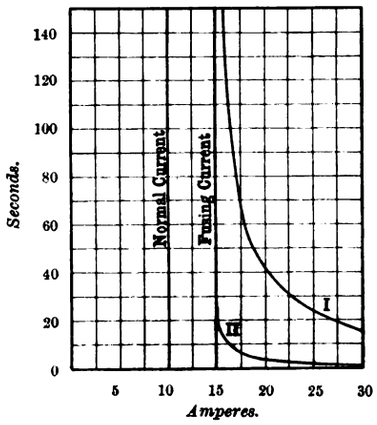
The temperature which the fuse reaches before melting is a matter requiring examination. It has already been pointed out that in the case of the common metals the permanent temperature of a fuse not carrying more than 90 per cent. of its breaking load is insufficient to alter its structural peculiarities. Nickel might, indeed, reach high temperatures, but the metal has not been carefully studied from this point of view, and it is impossible to give any very precise information. But with any other metal likely to be used as a fuse, a load short of that sufficient to melt it is not likely to affect it. On the other hand, a high temperature might affect some of the surrounding parts. If a metal, such as nickel, copper or silver, with high melting point is used, the temperature might be sufficient to affect the structure of parts in its near neighbourhood and to leave them in a highly inflammable condition. The fuses would, therefore, require to be enclosed in a space of considerable size, or to be so arranged that the terminals were of sufficient mass to conduct the heat safely away, thus allowing only a small portion at the middle to reach a high temperature. If all the fuses get very hot, this may lead to a considerable loss of energy and should not be entirely left out of account.

If the fuses are of considerable size, a high voltage may cause unpleasant splutterings at the moment of fusion, and there is, therefore, a general tendency towards reducing their size as far as possible. But unless the fuse is to be very sensitive, a certain volume of metal is needed, and if it is mounted behind the switchboard the spluttering is unlikely to do any great harm. Lead is, however, far less sluggish than zinc; even if its mass is 2½ times that of a zinc fuse, it is still less sluggish. Considerations of a different nature govern the choice of a metal for very small fuses, seeing that a very minute wire is undesirable from many points of view.



I. Zinc Wire having a diameter of 1·1 mm.
II. Copper Strip 0·1 mm. by 0·8 mm.

FIG. 4.

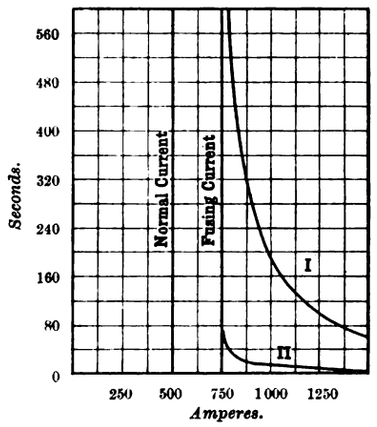
The following table gives the properties of a series of metals which have been examined by the author. All the fuses melt with the same current, and are circular in section and of considerable length; the sluggishness and mass of the copper fuse are taken as unity, and the others are referred to this standard.

Comparison of Long Circular Fuses of Different Metals, Melting with the Same Current.

Metal.	Sluggishness.	Melting point.	Mass.
Aluminium	3·04	600°C.	3·08
Lead	6·08	325°C.	20·25
Copper	1·00	1,054°C.	1·00
Brass	0·47	about 1,015°C.	1·61
Nickel	0·362	about 1,400°C.	1·72
Prima-prima	1·065	about 1,250°C.	2·60
Silver	1·66	954°C.	1·47
Lead-tin alloy, containing 60 per cent. tin and 40 per cent. lead	3·10	135°C.	14·40
Tin	7·00	230°C.	13·90
Zinc	7·60	412°C.	8·18

Prima-prima, which is included in the above table, is a resistance material made by the United German Nickel Works of Schwerte, Westphalia. Brass and nickel are the only metals which are more sensitive than copper, but their masses are also greater. Brass must, however, be excluded, seeing that it is impossible to reproduce an alloy with sufficient uniformity. For small currents nickel might be available, but for heavy loads its high melting point would be a disadvantage. If silver and copper are compared it will be found that they are very similar. The fusing point of copper is slightly higher, but the difference is not great. As for sluggishness and mass, those of copper are about two-thirds of those of silver; and if very sensitive fuses are wanted, copper is to be preferred to silver, quite apart from question of cost. The alloy called Prima-prima is nearly as sensitive as copper, but its mass is greater. Passing to the less sensitive metals, we come to aluminium, and a mixture which is of the nature of soft solder. Aluminium has small mass with high melting-point, and in the case of thin wires the coating of oxide must be taken into account. With the lead-tin alloy the mass is great but melting-point is low; it is suitable for small currents, whereas aluminium is better for heavier loads. The really sluggish metals are lead, tin and zinc, the last being the most sluggish and suitable for use when this property is specially desirable. Tin is of no account for use as a fuse, and the great mass of lead makes it useless for heavy currents.

A metal that can be drawn presents obvious advantages, and the usual form has a circular cross-section. For heavy currents, another sectional shape may have the preference with a view to decreasing the mass and sluggishness. In the case of silver, strip may be employed instead of wire, in order to decrease the cost. With the heaviest currents, the usual plan is not to have a uniform section throughout, but to decrease it towards the middle. This tends to reduce the explosive effect when the fuse melts, and the shape chosen is generally such that it can be stamped out. The normal current which such a fuse will carry is generally stamped on it, and the question arises as to the overload which a fuse should be designed to carry. No regulations have been made with regard to this point, the only provision adopted in Germany being that the fuse shall melt within two minutes if twice the normal current is passed. The limiting current—*i.e.*, the current which would only just melt the fuse in an infinite time—might therefore be nearly twice the normal load in the case of small fuses, and rather less in the case of heavier ones. In America the conditions are that an enclosed fuse must carry an overload of 10 per cent. for any length of time, but must



I. Zinc Strip 2·5 mm. by 39·45 mm.
II. Copper Strip 0·3 mm. by 24·5 mm.

FIG. 5.

melt under an increase of 25 per cent.; if the fuse is not enclosed, it must carry 25 per cent., but not 50 per cent. overload. In Austria the fuse must just melt with an overload of 33 per cent. There is, therefore, a considerable difference between the regulations in various countries, and it would seem advisable to reduce the overload, which could be carried according to the German regulations to 50 per cent. But on circuits with motors and arc lamps this might cause the fuses to blow too frequently, and the author would, therefore, propose that in these cases the fuses should just be able to carry an overload of 70 or 80 per cent.

The question then arises as to whether the sluggishness of fuses should be limited by any regulations. In order to compare zinc and copper, Fig. 4 is given, which shows the behaviour of fuses of these metals, which would just melt if carrying 15 amperes. They would normally carry 10 amperes, and the sluggish zinc fuse would melt in 40 seconds if carrying an overload of 100 per cent. Fig. 5 shows similar results for heavier fuses, and the zinc fuse here melts in 184 seconds under an overload of 100 per cent. The question is whether a sluggishness of this order is permissible. It must be remembered that if the fuse takes this time to heat, the cable with which it is in series, being much larger, will take a much longer time, and a considerable degree of sluggishness is allowable, Therefore the condition that the fuse should melt within two minutes under an overload of 100 per cent. might be replaced by another which should take into account the size of cable and current. The following proposals might, perhaps, meet the case—viz., that fuses on lighting circuits should carry overloads up to 50 per cent., but not more; and that fuses for motor circuits should carry overloads of 70 or 80 per cent., but not more. In both cases it would be understood that the fusion by currents exceeding the normal by 50 or 70 per cent. respectively should take place within a reasonable time, and should not require an indefinite interval to elapse before the circuit was interrupted.

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THE CONCEPTS AND TERMINOLOGY OF ILLUMINATING ENGINEERING.*

BY DR C. H. SHARP.

In the infancy of a science the concepts regarding it are necessarily neither very clear nor definite. The terminology of a science always lags far behind the actual state of the science itself. As long as the treatment of the science is qualitative only, no particular need is felt for an exact terminology. As, however, the science becomes quantitative and involves exact measurements of the quantities entering into it, the need for a terminology which is correspondingly precise is felt.

After giving examples from the early history of electricity and magnetism, the state or condition of the science of illuminating engineering is considered in regard to its terminology and its concepts.

This science is founded on the ancient science of optics, which is, in many respects, an exact science. In spite of this, however, the science of optics has remained in a rudimentary condition in so far as its terminology and concepts relating to light as an output, used for purposes of illumination, are concerned.

Just as in the case of magnetism, where the elementary notion of pole-strength was long regarded as the fundamental point of departure for calculations, so the strength or intensity of light sources has been the principal concept in dealing with light as a product. Until illuminating engineering began to take its place as a quantitative science, measurements of the candle-power of luminous sources were all that were required, and by candle-power was usually meant the candle-power in a given direction. Within a very few years the term "mean spherical candle-power" has come into use among engineers. This marks a distinct advance in the practical application of illuminating engineering, since it implies a recognition of the difference between a candle-power in a given direction and the average candle-power in all directions in space. The notion of intensity of illumination, as distinct from intensity of a luminous source, has become a familiar one and an awkwardly named unit for it has been used. These are sure indications of the practical progress of illuminating engineering.

What should be, or are likely to be, the lines of further development? These may be determined, in some directions, largely by action which our committee on nomenclature and standards may take. In other directions this committee will be impotent, since it cannot enforce the adoption of its recommendations in practice. The practitioner must feel the need of some novel term or idea before he will adopt such term or idea. Such a need is sometimes unfelt, because the practical value of novel terms and concepts is not clearly enough recognised by those to whom they would be useful. Having this in mind, I desire to bring to your closer attention the bearing of some terms and concepts which have not, I believe, established themselves in the practice of illuminating engineering to the extent to which their practical convenience and utility entitle them.

At the present time, in his quantitative work, the illuminating engineer deals chiefly with candle-power in its various aspects and with intensity of illumination. He does not, as a rule, employ any term which expresses directly the quantity of light which is being emitted by the source with which he is dealing. This is surprising, for the quantity of light which he has at his command is of vital importance to him. The distribution of this light he can arrange according to his own wishes by the use of various devices. Now, the proper term for the quantity of light is easily found by a consideration of the physical nature of light itself. Light consists in ether waves propagated with a velocity of 300,000 km. per second. A source of light is simply a wave-maker. It agitates the ether continually and sends out a constant stream or flow of such waves in all unobstructed directions. If we take any transparent plane on one side of which is a source of light, we may think of a continual flow of wave-trains in the ether across this plane. If we surround our source of light by a closed, transparent surface, say an imaginary sphere, the total flow of ether-trains through this surface measures the luminous output of the source. For the sake of uniformity with the usages of other branches of physics, &c., the wave-flow is referred to by using the Latin name for flow, namely, "flux."

We should form a concept, then, of all sources of light, whether primary or secondary, as the starting points of a luminous flux, and of all spaces surrounding such sources of light as traversed by this luminous flux. Having formed the concept of luminous flux, the following definitions and relations are a direct consequence: The output of any lamp is measured by the total luminous flux which it emits; the brightness of a diffusely reflecting or transmitting surface is proportional to the luminous flux which it emits per unit of area; the reflecting or transmitting power of such a surface is the ratio of the luminous flux which it emits to that which it receives; the intensity of illumination on any surface is the flux which it receives per unit of area. All the above quantities are of vital importance in illuminating engineering, in view of which fact it would be surprising if the concept of luminous flux should not prove itself to be very useful in the everyday work of the illuminating engineer.

It is necessary first to define a unit in terms of which luminous flux is to be measured and to establish its relation to the unit of luminous intensity, the candle-power. This is done in a way analogous to that employed in magnetism and electrostatics—that is, unit flux is defined as the flux emitted by a light of unit intensity, or 1 c.p., in a unit solid angle. A unit solid angle is the solid angle subtended at the centre of a sphere by a portion of the surface of the sphere bounded by four lines, each equal in length to the radius of the sphere. There are 4π or 12·57 such solid angles in the entire sphere. This being the case, we have approximately the relation that a unit solid angle is the one subtended at a point by a surface one foot square one foot distant from that point, or by a surface one metre square one metre distant from the point, or a surface one yard square one yard distant from the point, &c. If at the apex of such a solid angle a light source of 1 c.p. be placed, a unit luminous flux will pass through any transverse plane through the solid angle, no matter what the inclination of the plane or its distance from the light. In terms of this unit, luminous flux is measured.

The relation between the total luminous flux of a source of light and the mean spherical candle-power of that source is at once seen. If we consider a source of light having an intensity of 1 c.p. in all directions, its mean spherical candle-power would be one; and since there are 4π solid angles in a sphere surrounding that source, the total flux from it will be 4π units of flux. If the mean spherical candle-power of a source is I_s, its total flux will be equal to $4\pi I_s$ or ϕ equals $4\pi I_s$, where ϕ represents the total flux and I_s the mean spherical intensity. Thus the total flux is numerically equal to 12·57 times the mean spherical candle-power of the source.

We have next to consider the relations existing between flux of light and intensity of illumination. As we have seen, the flux falling on a plane surface 1 ft. square placed 1 ft. distant from a light of 1 c.p. is approximately a unit flux. But the illumination on that surface is unit illumination if we measure in English units. If the same plane surface is removed to a distance of 2 ft. from the light, only one-fourth of the total flux falls on it and the illumination is one-fourth as intense. In other words, the intensity of illumination on any surface is measured by the luminous flux per unit of that surface or by the flux density. This relation may be expressed thus: $E = \phi/S$, where S is the surface. From this relation the familiar inverse square law may at once be deduced.

The above equation becomes of practical importance in computing average illumination results. If, for instance, we know that from a given source or sources of light a certain flux falls upon the plane of reference, we can determine at once the average illumination on this plane by dividing the flux by the area of the plane. Thus the average illumination is determined without direct reference to the candle-power of the sources. Conversely, measurements of illumination on a given plane enable us to determine the flux of light falling on that plane. This is a quantity of great importance, since it leads us to a value for what we may term the net efficiency of the installation, or the efficiency of utilisation of the light. By the net efficiency of the installation, or the efficiency of utilisation, would then be meant the relation of flux which falls upon the horizontal plane of reference, to the total luminous flux emitted by the lamps in the room.

In order to make the use of the notion of luminous flux a convenient one in practical work of the computation of illumination, it is necessary to use it also with reference to the sources of light employed. In other words, when we wish to arrive at average values for illumination rather than exact illumination curves, we may ignore the candle-power and the distribution of the luminous intensity of the lamp, and may start out from a value for the flux of light which the lamp, together with its reflector or globe, sends in the direction of the plane of reference. Multiplying this flux by the number of lamps, and dividing it by the area of the plane, we have approximately the illumination on the plane, neglecting reflections from walls and other objects. The effect on the flux of multiple reflections by the walls of the room can be found according to the usual procedure—that is, the flux must be multiplied by $1/1-K$, where K is the average coefficient of reflection of the walls and ceiling, and where this value is subject to large modifications according to the location of the lamps in the room. The maximum and minimum points of the illumination in a given installation can usually be told at a glance, and the values of these illuminations can be computed if required. The advantage of the procedure outlined above is that it gives an average value for the illumination over the entire plane of reference without the necessity for going through the computation of the actual illumination at a large number of points in the room. The procedure for determining the value of the

* Abstract of the Presidential Address delivered at the Convention of the Illuminating Engineering Society, Boston, July 30th.

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luminous flux from a lamp, either its total flux or the flux within a certain solid angle, is similar to that pursued in determining the mean spherical candle-power and mean hemispherical candle-power, &c. For instance, the well-known Rousseau diagram so generally employed for the determination of mean spherical candle-power, is really a flux diagram. If the Rousseau diagram extends over 180 deg. polar distance, the total area which it encloses is proportional to the total flux of light from the lamp, and the part which is enclosed between any two angles as marked on the axes of the abscissas is proportional to the flux from the zone or from the solid angle. Consequently, any method which will yield the mean spherical, mean hemispherical or mean zonular candle-power will give, with practically no modification, the luminous flux corresponding thereto. The Matthews integrating photometer may be calibrated so as to give directly the total luminous flux from the lamp measured by it, or other integrating devices may be employed. By the use of such devices as are at hand to-day, it would not be at all impossible to rate lamps according to their total luminous flux, rather than according to their candle-power. Thus at one stroke the difficulty would be cleared up which arises from the actual difference in performance of incandescent electric lamps, which are rated alike according to our present arbitrary method. Using one of the methods indicated above, it is a matter of no difficulty to determine what the total flux of light will be, for instance, from a lamp with a conical reflector inside the angle subtended by the sides of the cone. Imagine, then, a number of lamps with such reflectors illuminating a room, and so placed that the angles of the cones of the reflectors do not in any case fall outside the boundaries of the plane of reference. Then the total amount of light which these lamps are throwing on the plane of reference will be approximately equal to the number of lamps multiplied by the flux which is sent out inside this plane, and, as said above, the average illumination is obtained by dividing this flux by the area of such plane. This method is of such extreme simplicity that it seems that it ought to be developed in practice. It is concededly approximate, but since any method yields results which are so strongly affected by the reflections from walls and ceiling, it is a question whether an approximate method like this might not in the end yield results which are quite as reliable as those which are obtained by the more laborious calculations involved when illumination curves are computed.

As regards the question of terminology, we have at the present time a name for the unit of luminous intensity. We call that the candle, and we measure luminous intensities in candle-power. It is usual in this country to express illumination in terms of the candle, and of the foot as the unit of distance. We have no suitable name for this unit of illumination; by some it is called the candle-foot, by others the foot candle. Some make the plural candle-feet, others make it foot-candles. The name is inappropriate and awkward, since ordinarily, when we place two words in conjunction like this, we mean the product of the two quantities involved, as, for example, in foot-pounds, where we mean the product of the feet by the pounds. The foot-candle or the candle-feet, however, means candles divided by, not feet, but feet squared; consequently the term is doubly inappropriate. It would, therefore, be very desirable, if we are going to adhere to this unit of illumination, to have a suitable name for it. If we use the metric system, a name for the unit of illumination is at once at hand. In this system the candle may be the unit of luminous intensity, but the metre is taken as the unit of length. The illumination produced by one candle at a distance of one metre is called the "lux." On account of the relation existing between the foot and the metre, it happens that the lux is about 10 times the size of the foot-candle (actually 10·8). The use of the lux, however, involves the use of an unaccustomed unit of length and it is consequently found awkward.

When it comes to the unit of flux of light, as we have seen, the unit of length does not enter. The unit of flux depends only upon the chosen unit for luminous intensity, and consequently we may adopt the name which has already been suggested and used for this purpose—namely, the "lumen." By the lumen we mean the flux of light emitted by a source of 1 c.p. through a unit solid angle, and, as we have seen, the number of lumens falling on a surface, divided by the area of the surface in square feet, will give the illumination in foot-candles, or the number of lumens falling upon a surface, divided by the area of that surface in square metres, will give the illumination on that surface in lux. It would, therefore, seem to be an obvious thing to do to adopt the lumen as the name for the unit of luminous flux.

A point in terminology, which it may not be out of the way to bring up at the present time, relates to the use of the term "efficiency" in illumination work. We have in this kind of work at least three kinds of efficiency to consider. We have, first, the efficiency of the illuminant as such; second, the efficiency of the illumination installation irrespective of the lamp (this may be called the net efficiency of the installation, or the efficiency of utilisation of the light); and third, the efficiency of the installation including the lamp (this may be called the gross efficiency of the installation). The efficiency of the lamp, if it be an electric lamp, would properly be determined by its lumens per watt; this term has not come into use, but deserves to do so. Instead of lumens per watt, we speak of watts per candle. Watts per candle measures, for a given type of lamp, the specific consumption of that lamp. True specific consumption would be measured by watts per lumen. The term watts per candle, while a very convenient one from the lamp-maker's point of view, is not so good a term for the use of the illuminating engineer. It is to be hoped, therefore, that in time lamps will be designated by their efficiencies, and the efficiencies will be expressed in terms of lumens per watt. What we ordinarily at the present day call a 16 c.p. 3·1 watts per candle lamp would, under that system, have a rating of 163 lumens and an efficiency of 3·3 lumens per watt. In the case of gas lamps, the efficiency could be expressed in terms of lumens per cubic foot per hour.

Going next to the net efficiency of the installation, irrespective of the lamp. This is the efficiency which it is the especial province of the illuminating engineer to attend to. Given any illuminants whatever, there is some best way to equip and to arrange them so as to produce a maximum result in illumination. This efficiency may be expressed in terms of the lumens received on the horizontal plane of reference, divided by total lumens emitted by the lamps. The gross efficiency includes the efficiency of the lamps themselves. This is the efficiency with which the user of the installation, the man who pays the bills, is most interested. This efficiency can be expressed in terms of lumens on the plane of reference per watt, or per cubic foot per hour expended in feeding the lamps. In the *Transactions* of the Illuminating Engineering Society it has appeared that the need is felt for an expression of the gross efficiency of an installation, since the term foot-candles per watt per square foot has been used for this purpose. Those who have used this term have recognised its awkwardness as well as its usefulness, and it has even been proposed to give a name to this unit. If we stop, however, to analyse this expression, we see that foot-candles per watt per square foot is equivalent to foot-candles multiplied by square feet and divided by watts. But, as we have seen, the foot-candles multiplied by the square feet gives the luminous flux in lumens, consequently the expression foot-candles per watt per square foot is equivalent numerically to lumens per watt; so that here again the introduction of the notion of luminous flux, and of the term lumen, justifies itself by reducing an expression of unusual complexity to one of very great simplicity.

A NEW SOUNDER.

As telegraph engineers in this country are aware, the present forms of polarised sounder in use have been adversely criticised on account of the sound emitted by the instrument. These sounders are based on the single-needle principle, the necessary sounds for reading purposes being formed by an extension of the armature which plays between two sounding-pieces. Much time and money has been spent in the endeavour to overcome this defect, but so far the results obtained have not been entirely successful.

The recent introduction and extension of those systems for which polarised sounders are essential has resulted in the question of the polarised sounder becoming of pressing importance. There has been introduced recently a new form of polarised sounder, which not only overcomes the acoustic defects of the old type of instrument, but which, so far as can be judged at present, represents a great advance in telegraphic apparatus.

The new instrument, known as Vyle's direct-reading polarised sounder, is the invention of Mr. C. C. Vyle, of the engineering department of the British Post Office. This sounder can be placed directly in the line circuit without any relay or local battery being necessary, and, with currents of 4 to 5 milli-amperes only, gives firm readable signals, identical in sound with those of the ordinary type of pony sounder familiar to telegraphists.

The general appearance of the instrument is shown in Fig. 1, and it will be observed that, with the exception of four terminals in place of two, the instrument is made to resemble in appearance the ordinary single-current pony sounder, the feet being provided with fixing holes at exactly the same centres as in the ordinary instrument. The winding is differential, and, as the result of a long series of trials with a view to finding the best value for practical work, each coil has been wound to a resistance of 500 ohms. For simplex working the coils can be joined in series with a total resistance of 1,000 ohms, or in parallel, the resistance then being 250 ohms. When in use on

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duplex circuits, the inner terminals of the sounder are strapped together, the Vyle sounder being joined up in circuit in place of the ordinary relay. The chief feature of the instrument is the permanent magnet which is placed in the base and connected to the cores of the electromagnet.

The interposition of a permanent magnet in the magnetic circuit with a view to reinforcing the electromagnetic action produced by the signalling current is interesting, particularly in view of the fact that by means of this arrangement condenser working on the leak principle is possible.

The inductive effect of the permanent magnet on the cores of the electromagnet results in the armature being attracted,

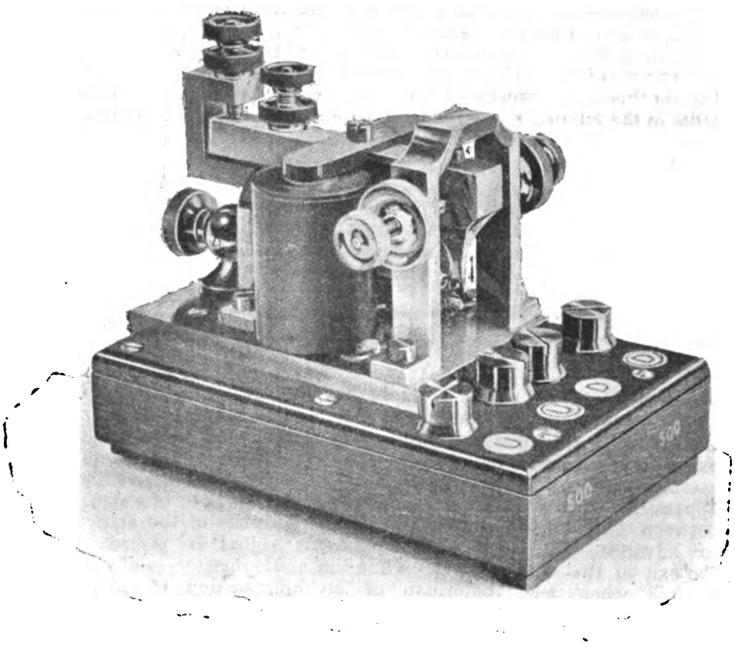

Fig. 1.

this force of attraction being overcome by the tension of the antagonistic spring. If the latter is in excess of the former the instrument works in the ordinary manner. If, however, the effects due to the spring tension and to the permanent magnet are equal, a remarkable result is obtained. The passage of a very small current will disturb the balance and the armature commences to descend. But the force due to the spring tension varies as the displacement, while the force due to the magnetic attraction varies as the fourth power of the displacement. As the armature descends, therefore, the force of the permanent magnet rapidly increases its effect, and the momentum increasing accordingly, the lever finally strikes the lower stop with

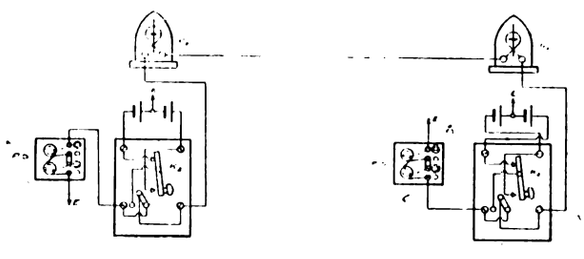

Fig. 2.

sufficient energy to give a firm, readable signal. If the marking current is followed by a spacing current, the reverse conditions obtain: the spring tension falls off at a much slower rate than the magnetic force, the armature gaining momentum during the whole of the upward movement.

The reader will be at once struck with the similarity between the Vyle sounder and the Hughes type-printing receiver. In both cases the energy necessary to work the instrument is brought into action by a small external force under the control of the transmitting station. It is this property that enables the Vyle sounder to be worked on those circuits which it is necessary to work by small impulsive currents through a condenser or transformer. In such systems there is, of course, no permanent current on the line, and the sounders are adjusted to their most sensitive condition. The initial part of the signal—say, a dash—is formed by a momentary current in one direction, and terminated by a current in the reverse direction, the armature being held down for the formation of a dash by the attraction of the permanent magnet.

The simplicity obtained by the use of the instrument is apparent in Fig. 2, which shows the connections for a simplex double-current circuit working from a split battery. The absence of the relay will be noted, and the employment of the single-current key with switch enables a number of circuits at each station to be worked from one split battery.

In view of the fact that the Vyle sounder can be worked through condensers, the instrument becomes especially valuable in preventing disturbances due to the leakage of currents or magnetic storms. The sounder has also been designed to possess a high inductance, which renders it insensible to inductive disturbances, whether electrostatic or electromagnetic. The new sounder is now working (direct-reading) duplex on the London–Glasgow cables—*i.e.*, over 400 miles of underground work. When the sounder is adjusted no effect whatever is produced by extraneous inductive disturbance.

The figure of merit of the Vyle sounder is 1 milli-ampere, and, as previously stated, the working current is of the order of 4 to 5 milli-amperes.

The British Insulated and Helsby Cables, Prescot, Lancs., are owners of the foreign patent rights for the instrument.

THE ELECTRIC SIGNALS ON THE PARIS METROPOLITAN RAILWAY.*

BY A. SOULIER.

The Hall automatic block system, which has been adopted on the Paris Metropolitan Railway, comprises two quite different types of installation: (1) The track circuit system, in which the control of the block apparatus is effected by the train axles short-circuiting the Hall relays; (2) the pedal system, in which the apparatus is controlled by a pedal worked by the wheels of the cars.

Track Circuit System.—This consists essentially of an electric circuit. From a battery the current passes along one rail through a relay and returns by the other rail, as shown in Fig. 1. When a car comes between the battery and the relay, the former is short-circuited and the latter neutralised. The track is divided into a convenient number of sections. Each section is insulated from the next by a special insulated joint, or more simply by insulating certain of the ordinary rail joints. There must be as many track sections as there are signals. The sections begin at one signal and finish at the next, so that each insulated joint will be to the right of a signal and will control the putting to danger of the same.

Block sections which are covered by two or more signals have also an insulated joint at their ends. The fundamental difference between a block and track section consists in the fact that the battery placed at the end of a block section and exciting the last track section of that block section is connected directly to the track. The track section battery, on the contrary, is connected to the track through the relay switch of the track section in advance, so that if this latter is occupied, the track section in the rear will remain as it is with its relay neutralised, its battery current being cut off by the relay of the section in advance. In Fig. 1 R is the relay and P the battery. The relay contacts are shown with the relays R′ and R″; they are closed when the relay is excited and opened when it is neutralised. J and J′ are insulated joints. A car on the track section C will neutralise the relays R and R′. If it is on section D it will neutralise R, R′ and R″. As soon as the car leaves the last track section of the block section, the battery P″ will re-excite R, which by closing its contact will excite R′, &c. The relays connected across the track, which are known as *track relays*, can thus control the most varied circuits as required.

The most general method of working is the following: A block section is the distance between the exits of two consecutive stations. As soon as a train leaves a station, it passes over the joint "*j*" and neutralises the relay of the first track section of the block in advance. This causes an indicator to fall and a bell to ring at the station which the train has just left and at the station in advance. These rings denote, first, that a train has left the station in the rear, and

* Translation (slightly abbreviated) from *L'Industrie Electrique*.

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secondly, that a train is approaching the station in front. Thus, as soon as a train is between two stations, they are both automatically advised of its presence, and according to the position or colour of the indicators, the station can tell whether the train approaches or leaves. This same relay at the same time neutralises a relay at the station in front, which closes the circuit of the signals between the two stations. This circuit cannot, however, be closed until all the track relays are excited; that is, unless the block section is quite clear.

This system has also been adopted on the Paris-Lyons-Mediterranée Railway between Laroche and Cravant, where it is worked in the following way: (1) The track is normally closed. (2) A train on leaving a station puts to "line clear" all the signals protecting the block section in advance of that which it is entering, if this latter is unoccupied. (3) A train on leaving a station automatically advises the station in rear that it is leaving and the station in advance that it is approaching. (4) A train on passing a signal puts it to "danger" and locks it in that position. (5) A train on entering a station unlocks the rear section of the rear station. At this moment it is covered by a permissive disc and a "stop" semaphore. (6) When a train, having passed a permissive disc at "danger," arrives at the home signal, this latter will come to "line clear" if the station is free, although the block section in front may be occupied. (7) All signals are automatically interlocked with the points on the main line. Thus, if any points are half-open, all the signals will be locked at danger and no movement can bring them to "line clear." (8) All turn-outs from the principal tracks are locked, and to unlock them all signals covering them must be first locked. (9) Each station has an indicator with two shutters. A train approaching the station rings the bell and causes one of the shutters to appear; a train leaving the station rings the same bell and the other shutter appears.

Keys placed on the same board as the indicator allow the station-master to operate the points, to lock the signals on one or both lines or only the home signals. In order that the signals may be put to "line clear," it is not sufficient that all keys are at *autorisation*, but that no points are half-open, that the section in advance is not occupied and there is no other obstacle. (10) An arrangement has also been devised so that if a wagon in a siding should for any reason foul the main line all the signals covering the obstacle are locked at danger. The system then allows all the engaging gears to be worked either by the track or signal relays, and its operation is absolutely safe. The Hall block system installed on the Paris-Lyons-Mediterranée Railway consists essentially of a track circuit between stations. The relays of this circuit control those of the signal circuit. The signal circuit relays control in their turn the motor placed on each signal, which is of the ordinary disc or semaphore type of the "Code français des signaux."

Pedal System.—On the Paris Metropolitan Railway the sole requirement is to leave a minimum interval, consisting of the distance between two successive signals, between two trains. All are absolute "stop" signals and have the same meaning. They are generally placed about 65 yds. before a station and at its exit.

When the distance between two stations is great or when the gradient requires slow operation, a supplementary or intermediate signal is placed between the two stations. The circuit on the Metropolitan is most simple, and if it does not afford so much interest as a block system established on lines with complicated service, it proves in a practical fashion the security of this system when applied to heavy traffic. It may be remarked that the Vincennes-Maillot and Dauphine-Trocadero sections have been working since about the middle of 1900. They contain 104 signals working 20 hours a day. Those on the Vincennes-Maillot section go through a cycle of operations every three minutes. All the signals have made a total of more than 50 million movements since the opening of the line. The Hall block system has thus ensured the safety of about 140,000 passengers a day for several years without any failure.

Principle.—When the first wheel of the train passes on to the pedal lever it raises a piston contained in a cast-iron cylinder. After the passage of the wheels the descent of this piston is checked by a current of air and it takes an appreciable time to fall back again. During this time it works the switches fixed on the surface of the pedal in the following way: The upper end of the piston is conical.

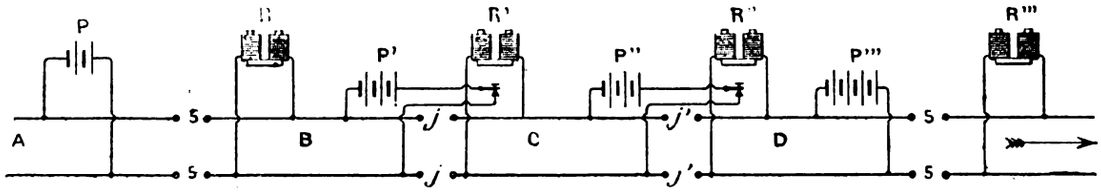

FIG. 1.—DIAGRAM OF CONNECTIONS FOR THE HALL SYSTEM OF AUTOMATIC SIGNALLING.

When it rises it moves a piece pivoted on a vertical axis and this piece opens or closes the switches. Connected in the circuit is an apparatus which advises the station in advance that a motorman has just passed a signal at "danger." This indication is given by a bell. Each signal has a special controlling apparatus, which in the case of a departure signal, or of a signal between two stations, is placed at the entrance of the station in advance; the control of the home signal is placed at the exit of the same station. Thus the stationmaster is always advised when the motorman of an approaching train has committed an infringement of the rule by overrunning a signal at "danger." The signal consists of a cast-iron box divided into two compartments by a partition. The front compartment contains the signal, the rear contains the lamps for lighting it. There are two series of incandescent lamps, so that if one becomes damaged a change-over switch allows the other to be lighted. These two compartments are separated by a glass division. The door on the front of the box is pierced by two holes (Fig. 2) both provided with white lenses. Behind the white glass in the upper half is a red glass. The indicating instrument consists of an electro-magnet whose cores are expanded into circular arcs; the armature of this magnet is also circular in shape. An aluminium disc, which when in equilibrium hangs vertically, is fixed to the armature covering the lower opening and showing "red." When the electro-magnet is excited this apparatus is attracted and takes up a horizontal position covering the red light and uncovering the white. In order to excite this electro-magnet the local signal relay must be neutralised and the two relays of the signals in front must be excited. The signal also cannot show "clear" unless the track in front is

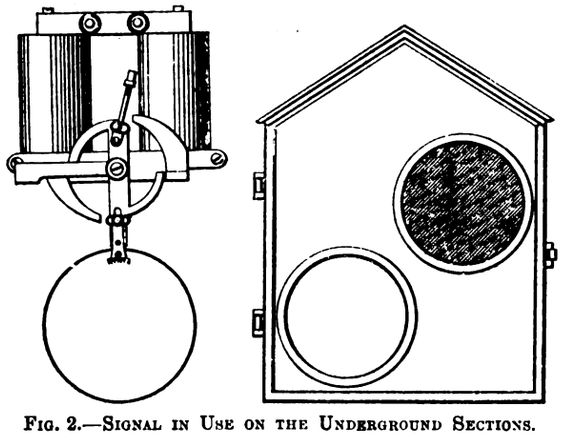

FIG. 2.—SIGNAL IN USE ON THE UNDERGROUND SECTIONS.

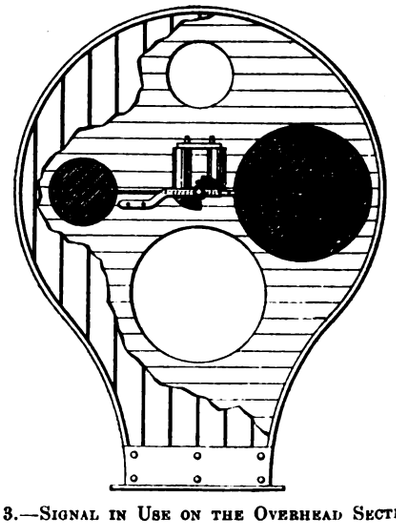

FIG. 3.—SIGNAL IN USE ON THE OVERHEAD SECTIONS.

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free (seeing that the two relays in front must be excited), and, further, unless the train has passed the signal in rear, thus neutralising the local signal relay as in the Hall track circuit system (Fig. 1). For open-air lines a similar type of signal known as the "banjo" (Fig. 3) has been adopted, but here the signal is given by a red silk disc covering or uncovering a window according as the line blocked or clear is indicated. The counterpoise of the silk disc is of red glass, which covers or uncovers an opening in the signal casing, at the same time as the silk disc covers or uncovers the first opening. The details of this apparatus are identical with those employed underground, except that the banjo instrument has two coils, one of low resistance for raising the movable part, the other of higher resistance for holding it when raised.

It is to be hoped that the fear of the automatic block system will soon disappear in Europe when a serious trial of the Hall system has been made, and that little by little all our railways will apply it to their lines. This innovation will avoid accident, especially those due to mistakes of signalmen or to a wrong position of the points, not to speak of frequent accidents which occur with the block system itself. Accidents due to a rail or coupling breaking can also be avoided. The Hall system effects an important economy in upkeep and working expenses in a block lay out.

THE EXPERIMENTAL DETERMINATION OF THE LOSSES IN MOTORS.*

BY C. F. SMITH.

Summary.—In this Paper, which is divided into two sections, dealing respectively with continuous and alternating-current motors, the author describes the methods in use for obtaining a separate determination of the iron and friction losses, and discusses the advantages and disadvantages of the various methods. Special attention is devoted in the Paper to the testing of alternating-current motors.

1. Direct-Current Motors.

Electrical Separation of Losses.—In 1887 Mr. Swinburne published his method of determining the losses in dynamos and motors. He distinguished between the copper losses which may be directly calculated, and the stray power consisting of losses due to eddy currents, friction and magnetic hysteresis. It is remarkable to notice how little this method of determining the losses in a motor has been improved upon in the 20 years since it was published. The publishers of more recent methods have only succeeded in carrying the separation of the losses somewhat further (always under no-load conditions). The assumption made in the Swinburne test, that the friction losses may be taken to be constant for all loads, has been proved by Dettmar and other writers to be true, for well-designed bearings, even when subjected to the stresses of a belt drive.

A method for the more complete separation of the iron and friction losses was proposed by Kapp and Housman† 12 years after the publication of Swinburne's test.

By this method the losses occurring in the machine when running as an unloaded motor are divided into two parts—viz., losses which vary in direct proportion with the speed, and those which vary as the square of the speed. It is then assumed that the constant torque losses are due to hysteresis and friction, while the losses producing the slope in the current-volt curve are due to eddy currents, which produce a torque proportional to the speed. These assumptions have since been found not to be accurate. The torque due to hysteresis is probably not a strictly constant quantity, while even brush friction has been found not to be a simple function of the speed, but to depend upon the current. Further, the increased loss due to windage at higher speeds is not taken into account.

A more accurate method, which is really a development of the last, enables the total frictional losses to be first determined, after which the iron losses are separated, as in the Kapp and Housman test. The friction losses for any speed are obtained from a curve showing the relation between driving watts and volts applied to the motor, plotted for a constant speed but variable excitation. By continuing this curve back to cut the vertical axis, corresponding to zero volts generated—*i.e.*, zero armature induction—we obtain the value of the watts overcoming friction alone. In order to obtain the point at which the curve should cut the axis with more certainty, the values of the squares of the volts, instead of the voltage, may be plotted horizontally. The lower points on the curve are thus brought nearer to the vertical axis.

By obtaining a number of such constant-speed curves for a range of different speeds, a curve of friction loss may be obtained, each constant-speed curve furnishing one point upon the friction curve. From the friction curve may now be obtained the current supplying the friction torque. By subtracting the current overcoming friction from the curve of total current obtained in the Kapp and Housman test, we determine the iron loss current alone. This remaining current may then be separated into eddy current and hysteresis components as in the former method.

Incidentally it may be noticed that the increase with speed occurring in the friction current determined as above must be due to windage. The separation of the losses by this method gives very good and consistent results when carefully carried out. The method has the great advantage that no second machine is required; it is, however, so laborious that its usefulness is much restricted.

Use of Auxiliary Motor.—The use of an auxiliary motor to drive the machine under test forms one of the simplest and most direct methods of measuring the no-load losses of a machine. In this method the no-load losses of the auxiliary motor are measured and subsequently subtracted from the power supplied to it when driving the machine to be tested, allowance only being made for change in C^2R loss. From the point of view of accuracy, the method suffers from the introduction of the losses occurring in the driving motor, which must in each case be measured with the losses to be determined.

Load Tests of Efficiency.—Methods directed primarily to the measurement of efficiency under load rather than the determination of the losses will not be considered to come within the scope of this Paper. The Hopkinson tests will not, therefore, be referred to, as they are not primarily directed to the separate determination of losses, and, in fact, necessitate assumptions as to the distribution of losses between two machines which at best are only approximately true.

Retardation Methods.—A number of methods for separating the losses in a motor or generator, all depending on the study of the retardation curves of an unloaded machine, have been widely adopted, and are described in many text-books dealing with the subject of testing electrical machinery. The machine to be tested is run up to full speed, or to a speed slightly higher than full speed, and the armature is then disconnected from the source of power. The machine will be brought gradually to rest under the influence of the forces opposing its rotation. These forces are due to the frictional and iron losses which occur in the rotating machine. The kinetic energy lost per second is then the power overcoming the losses. By plotting a curve of speeds on a time base, the rate of change of speed, and consequently the rate of change of kinetic energy, may be deduced when once the kinetic energy at any single speed has been determined.

The chief variations in the form of the experimental determination of losses by this method are to be found in the methods adopted for the determination of the moment of inertia. These are in outline: (1) By time of torsional vibration, the armature being suspended by a bifilar suspension of wire rope. (2) Measuring the time of retardation of the armature with and without the addition of a disc of known moment of inertia. The alteration in windage loss is likely to affect the accuracy of this method. (3) A comparison of the electrical power taken to maintain rotation at a certain speed with the rate of retardation when allowed to retard at the same speed from a higher speed. (4) Allowing the machine to retard from a high speed, both with and without an added retarding force obtained by allowing the armature to generate current in a resistance connected across its terminals. (5) Similar to the last, except that the added torque is produced mechanically by applying a brake, instead of electrically.

To these methods might be added the coupling of the machine to another whose constant has already been determined. From measurements of driving power required by the coupled machines, and from the retardation curve of the combination, the constant for the second one may be found.

An excellent method of taking the retardation curves where the time of retardation is short has been brought to my notice by my friend Mr. U. A. Oschwald, B.A. According to this method the curves were traced automatically by the Hospitalier ondograph, which was used as a recording voltmeter, The synchronous motor of the ondograph was driven by an alternator working at a constant speed, whereby the drum carrying the records was rotated at a uniform speed, making the horizontal scale of the record proportional to time. By an ingenious arrangement, the galvanometer of the instrument, which produced the vertical motion of the recording needle, was connected to the terminals of the machine experimented upon in series with a voltmeter, which served as a series resistance for the galvanometer movement, and also made it possible (by merely closing a switch) to determine the value of the vertical scale of volts upon the chart. A simple form of recording voltmeter might be substituted for the ondograph, but it need hardly be said that the recording instrument must be most carefully chosen, in order that friction of the pen or uncertainty in the speed mechanism may not render the results valueless.

Employment of a Flywheel to Increase the Inertia.—Since the losses in small motors are relatively high, and the inertia of the armature is relatively low, the method can only be made applicable

* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers.

† *The Electrician*, Vol. XXVI., p. 699.

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to such machines by making the readings automatic as just described, so that retardations of very short duration may be observed, or by increasing the time of retardation by increasing the inertia of the rotating parts—for instance, by mounting a disc, or heavy pulley, on the shaft in place of the ordinary pulley or coupling. The addition of a moderate weight to the shaft will probably not increase the friction losses in the bearings, but will add to the loss in windage. A correction for this increased loss due to the added weight may easily be made by running the motor at the same speed first with and then without the additional weight: the difference between the two driving powers would then represent increase in loss due to this cause.

Experimental Determination of Stray-power Losses under Load.—One of the principal objects which I had in view in employing a flywheel to obtain load curves on a motor was to see if it was possible by this method to obtain the value of the stray-power losses of a *loaded* machine, so as to compare them with the stray power at no load, which is measured comparatively easily by the several methods already summarised.

The author describes a series of experiments which show a definite, but small, increase in the stray-power losses with load in the case of the machine experimented on, apart from increased loss due to contact resistance.

Use of Separate Flywheel in Test Room.—For machines of small size, the heat run in the test house is most suitably and economically carried out with the machines coupled in pairs, as for a Hopkinson test. As is well known, this test does not give good results for the efficiency of machines of less size than 10-15 kw., since in calculating the efficiency from the observations, the losses in the two machines must be assumed equal, or else the efficiencies of the machines must be taken as equal. Neither of these assumptions is justified in the case of small machines when driving one another under load. It is therefore suggested that after the usual

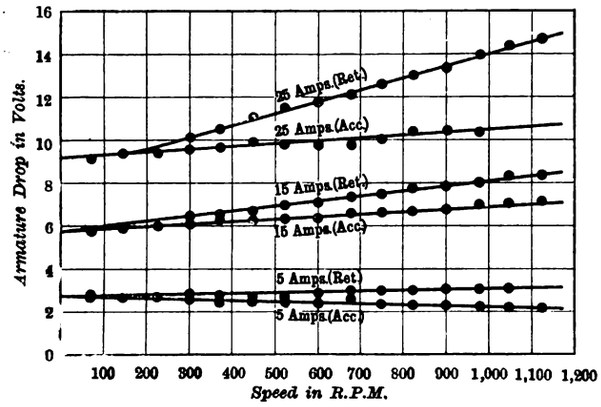

FIG. 1.—COMPARISON OF VALUES OF ARMATURE DROP FOR MACHINE ACTING AS GENERATOR AND MOTOR.

heat run has been taken, such machines should be coupled to the flywheel and an acceleration curve taken, at constant full-load current. The necessary connections are of the simplest character, and the time required for the observations would only be a couple of minutes. The characteristics and frictional losses of the flywheel would be known, and it would, therefore, be easy at any time to calculate the efficiency of the motor from the acceleration curve. The author shows that a flywheel about 5 ft. diameter, with a rim 6 in. by 6 in., would, allowing 1 min. for the time of acceleration, permit of motors up to 150 H.P. being tested. It is not suggested, however, that motors of that size should be so tested.

Determination of Armature Drop.—If, while the motor is driving the flywheel, the armature circuit is suddenly opened, the terminal voltage will at once fall to the voltage which the machine will have when working as a dynamo on open circuit at the speed at which it is then running. The inertia of the flywheel maintains the speed sufficiently constant for the drop of voltage on opening the circuit to be easily observed.

If the armature circuit is opened while the machine is being driven by the flywheel and while, it is then acting as a generator, the terminal voltage rises, by an amount equal to the armature drop, to its no-load value. It is thus easy to determine very exactly the armature drop due to any current, and also to find its amount for any brush position and speed.

In taking the retardation curves, it was thought at first that in order to obtain the speeds of the motor while retarding or accelerating it would be sufficient to obtain the armature drop at several speeds for each value of the constant current, and, after subtracting this drop from the terminal voltage, or adding it to the terminal voltage, to take the resulting voltage as being proportional to the speed.

This was afterwards found not to be admissible in the case of the motor experimented upon, as the strengthening of the main field when the machine acted as a motor with brushes displaced slightly backwards was not equal to the weakening effect of the same armature reaction ampere-turns when the machine was running as a generator. This effect was probably specially marked in the case of the machine used for these experiments, because of the high saturation of the pole tips. It was further found that, even with the brushes set in the neutral position, it was not possible to depend on obtaining exactly the same value of the armature reaction drop when accelerating and retarding.

The considerable divergence from proportionality between speed and terminal voltage is shown on the curves given in Fig. 1, where the armature drop is shown, as measured by opening the armature circuit at various speeds. The brushes in this case had a backward displacement of about 1½ segments of the commutator. With a forward lead of the same amount the upper (retarding) curves became practically horizontal and the accelerating curves sloped downwards, making about the same angle with the retarding curves as those shown in Fig. 1.

As a result of this effect I decided in my experiments to measure the speeds by using a small auxiliary generator having constant excitation coupled to the shaft of the flywheel.

The curves shown in Fig. 1 are not without interest, as showing the extent to which the armature drop in a machine may depend on the direction of the armature current. They also show that it would not be correct in such a case to assume the volts generated in the armature to vary in simple proportion with the speed.

It may be well to enumerate the special points mentioned above in connection with the use of a separate flywheel employed as an inertia load: (1) By using a flywheel a motor may be tested under load, the output being accurately determined by observations of speed and time only; (2) Acceleration curves taken in this way on the same flywheel might form a direct check on the satisfactory construction and adjustment of motors without further calculation; (3) The use of combined acceleration and retardation curves forms the most satisfactory method of determining the "constant" of the rotating system; (4) By the use of these curves the losses or efficiency may be determined without evaluating the constant; (5) The employment of a flywheel affords a means of determining the stray power losses of a loaded machine; (6) The armature "drop" is readily determined on the machine when acting either as generator or motor.

(To be concluded.)

CORRESPONDENCE.

RESTRICTED-HOUR SUPPLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was very interested in reading your leading article on "Peak Loads in Electricity Supply" in your issue of August 16th. You refer to the value of restricted-hour supply as a means of reducing the peak load and improving generally the working conditions. It is quite possible that electrolytic work, such as you mention, may be obtainable in some towns on the restricted-hour system, although such work in all probability would call for a 24-hour supply, and there would be the difficulty you mention of shutting down during the restricted hours.

I am a very strong believer in the principle of power supply on the restricted-hour system, and I feel sure that every undertaking would, to a more or less extent, find a certain proportion of its consumers willing to accept this system, if they were conceded a sufficiently low price to attract them. It will be found that many users of power can, without the slightest difficulty, take their power supply at times other than the restricted hours, and it only requires a reduction in the price per unit to induce them to conform to this. In these cases I do not refer to the ordinary factory, but to the many users of power where the work has not to be undertaken strictly between the customary working hours. In some towns the amount of power thus obtainable may be small, but even one can restrict a tenth of the total, there is no question about its advantages.

The restricted-hour supply system was initiated a little more than a year ago in Burton-on-Trent, and its effect on our last year's return was most marked. The introduction of this system caused several of our important power users to at once transfer to it, with the result that, although we had further connected

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last Christmas time, compared with the year before, 220 H.P. in motors and 30 kw. in lighting, the peak on the station only increased 19 kw. Another important advantage obtained was the postponement of an extension of plant, and in all probability high-tension feeders, for some two years, instead of this being immediately required. The output at the end of the last financial year for motor and heating units increased from 103,000 to 260,000. The load factor at the station, exclusive of traction supply, was improved from the low figure of 9·67 to 12·7, or an increase of over 30 per cent. The results at the end of the present financial year will be considerably more marked, as we shall probably more than double last year's output of motor units without any appreciable effect on the peak beyond that due to the additional lighting connected. The price charged for this supply is 1d., varying down to ¾d., per unit, according to quantity, and these low prices have been the means of attracting many consumers who would never otherwise have been obtainable. With the elimination of all station and mains capital charges, other than those due to extensions or service connections, &c., directly required for these motor consumers, the rate of profit on such a supply becomes undoubtedly much higher than that usually obtainable.

With some 750 H.P. in motors and heating connected nearly 75 per cent. of this is on the restricted-hour principle. It has been argued that it is impossible to get users to consider such a system. I must contend that this need not be the case, as we have several works here who have altered their hours to suit our requirements, although, of course, it must be admitted there are many cases where such a course cannot be agreed to. I think that if this system was more seriously considered than at present there would be found a big field for extensions in this direction, which would help to improve the economical running of the station, and minimise the frequent increase in capital expenditure and the difficulty in meeting the annual charges connected with same.—I am, &c.,

Burton-upon-Trent, Aug. 22. P. J. PRINGLE.

WIRELESS TELEGRAPH SIGNALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of July 19 you describe and illustrate an unearthed horizontal receiving loop for wireless signals, described by Mr. G. W. Pickard. This device and description is identical with that for which U.S. Letters Patent were issued me on October 11, 1904, No. 771,819, filed May 28, 1904, notably as shown in Fig. 3 of that patent.

In that patent I not only describe the horizontal loop, but the single and double horizontal receiving "antennæ" concerning the re-discovery of which by Mr. G. Marconi so much was printed last year. These antennæ I showed mounted on a vertical axis so as to act as "localisers" to determine the direction from which the signals were coming.

Nearly a year previous to the issue of this patent I had discovered the remarkable selective powers of a horizontal (or approximately horizontal) wire, either grounded at one end, or unearthed and the receiving device located at its middle point. The horizontal, unearthed loop was an immediate outcome of the first discovery.

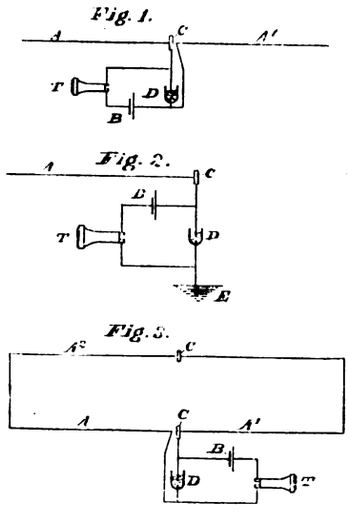
New York, Aug. 13. LEE DE FOREST.

[Dr. de Forest encloses with his letter the specification referred to, which relates to apparatus and devices for localising or determining the direction of a station which is emitting wireless signalling waves, the object of the invention being to improve and simplify such devices. The figures in the specification we reproduce. Fig. 3 is thus described:—

In Fig. 3 I have shown a device like that of Fig. 1, except that I have made a direct connection between the extremities of the two parts A and A′ of the collecting-conductor, thus forming a closed circuit containing therein the wave-sensitive member D. This return connection A^2 need not be separated any great distance from the parts A′ and A^2, but may, if desired, be somewhat separated therefrom. In any event I prefer that the horizontal component be much the greater of the two, as this is what I principally rely upon in the arrangement for producing the desired effect.

It is not necessary that the collecting-conductor be proportioned to the wave-length. In fact, considerations of convenience and practical operation will limit their length. I have also found that a great length of conductor is not necessary in order to secure satisfactory results sufficient for the practical needs of most cases. As the waves progress along the conductor variations of potential are produced therein, which variations are communicated to the wave-sensitive member, and produce indications which when varied by swinging the horizontal conductor enable the direction of the transmitting station to be judged.

In the operation of the device, as herein shown, the maximum indication will be obtained when the direction of the collecting-conductor cor-



responds with the direction of propagation of the signal-waves and the minimum indication at 90 deg. from this.

The description of Mr. G. W. Pickard's loop, which appeared in our issue of July 19th, was extracted from the *Electrical Review* of New York, and was duly credited to that source.—ED. *E.*]

PARLIAMENTARY INTELLIGENCE.

Patents and Designs Bill.—In the Committee stage of this Bill in the House of Lords on Saturday last, the Marquess of Salisbury moved the omission of clause 7, which gave the Controller power to refuse an application for a patent if he thought the patent had been anticipated. He protested against a bill making a most important innovation being submitted to the House in the last days of the Session.

After the Lord Chancellor's reply, the amendment was negatived.

The Bill then passed through Committee with the Government amendments.

On Monday the Bill, as well as the Patents and Designs (Consolidation) Bill, were read a third time and passed.

Royal Assent.—On Aug. 21 the Royal assent was given to the following new Acts of Parliament:—Aberdeen Corporation Electricity, Oxford and District Tramways, London County Council (Tramways and Improvements), Glasgow Corporation.

LEGAL INTELLIGENCE.

Ozonair (Ltd.) v. Craig.

Last week Sheriff-Substitute Davidson, of Glasgow, delivered judgment in this action by plaintiffs against Mr. J. Richardson Craig, jun., of Glasgow, for alleged infringement of patent. Plaintiffs are holders of letters patent for the manufacture of ozonising apparatus, and defender is patentee of an invention for the production of ozone for commercial purposes by the silent discharge of electricity. Plaintiffs alleged that defender had made and sold apparatus which in substance copied their invention.

The Sheriff-Substitute dismissed the action as irrelevant, upon the ground that the intention of sec. 29 of the Patents Act, 1883, was obviously to prevent a party from coming into Court with a general averment that something was an infringement of his patent. Plaintiffs merely alleged that defender had made and sold apparatus which in substance copied their invention, or the invention assigned to them. By the act plaintiffs must give particulars of the breaches complained of, but it could not be said that there was anything whatever in the shape of particulars supplied in that case.

Proposed International Exhibition at Manchester.—A deputation waited upon the Lord Mayor of Manchester (Mr. J. Harrop) on Tuesday to urge him to take steps for the organisation of an international exhibition in Manchester in 1910. Mr. Harrop's reply was favourable, but a further meeting will be held to settle the general outline of the scheme, and to obtain guarantees from merchants and traders before a town's meeting is called.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Walsall Corporation invite applications for the appointment of electrical engineer for their electricity undertaking. Commencing salary £400 per annum, to be increased to £450 by additions of £25 for each two years of approved service. Applications to the town clerk (Mr. John R. Cooper), Council House, Walsall, by Sept. 9. See an advertisement.

Applications are invited for the position of chief lecturer in electrical engineering at the Bradford Technical College. Commencing salary £200 per annum. Particulars of duties and forms of application may be obtained from Prof. G. F. Charnock. Applications to the secretary of the Education committee (Mr. Thos. Garbutt), Education Office, Manor-road, Bradford, by Sept. 16. See also an advertisement.

A selling representative is wanted for a first class firm, to energetically push the sale of rheostats, starters, circuit-breakers, &c. See an advertisement.

An instrument maker is wanted, with experience in the suspending and handling of delicate electrical instruments. See an advertisement.

The resident engineer of an electricity supply and tramway station has a vacancy for a premium pupil. See an advertisement.

Mr. Hilton Walker has been promoted to the position of engineer-in-charge at Huddersfield electricity works.

Mr. H. B. Woodford, of the Isle of Wight Electric Light Co., has obtained an appointment on the staff of the Shanghai Municipal Electricity Works and leaves England on Sept. 30.

EDUCATIONAL NOTICES.

University of Birmingham.—The engineering courses in this university extend over four years, and students who enter after matriculation and who pass successfully the examinations at the end of each year will be entitled to the degree of B.Sc. in that branch of engineering to which they devote themselves. The technical engineering classes include lectures on the strength of materials, theory of steam, gas and other heat engines, hydraulics, machine design, strength of structures, distribution of power, drawing (including the design of tools), prime motors, dynamos and other forms of machinery. The courses in civil engineering include constructional work in masonry and steel, railway work, &c., with practical surveying in the field throughout the summer term. In the engineering laboratory the work will include the determination of the strength of materials, including compressive, bending, tensile and tortion tests, experimental study of the steam engine and boiler, frictional efficiency tests, the flow of water over wires and through orifices, &c. There will be lectures and demonstrations on all branches of electrical engineering, and the work in the electrical laboratory will include testing of continuous and alternating-current machinery, electrical instruments, meters, lamps, batteries, &c. The session 1907-8 commences on Oct. 1. Full particulars can be obtained from the Secretary.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

University College, Bristol.—The 1907-8 session begins on Oct. 1. There are lectures on inorganic, organic and physical chemistry, and the laboratories are fitted with the most recent improvements for study and research in chemistry and metallurgy. Prospectuses, &c., from Mr. James Rafter, registrar and secretary.

Glasgow and West of Scotland Technical College.—The session begins on Monday, Sept. 23, in the new buildings. The diploma of the college is granted in civil, mechanical and electrical engineering, mining, naval architecture, chemistry, metallurgy, mathematics and physics. The courses of study extend over three sessions, and holders of the diploma are eligible for the degree of B.Sc. in engineering of the University of Glasgow after attendance for at least one session at prescribed university classes. There are new and well-equipped laboratories in the departments of physics, chemistry, technical chemistry, metallurgy, mechanics, motor-power engineering, electrical engineering, &c. The preliminary examination begins Sept. 16. Calendar (price 1s. 4d.) and prospectuses (gratis) from the Secretary.

Hackney (London) Technical Institute.—The next session commences on Sept. 23. Evening lectures and laboratory courses are held in electrical engineering subjects, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses, &c., from the Principal, Dalston-lane, London, N.E.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms. Particulars as to fees, &c., can be obtained at the Institute, St. John's street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Sunderland Technical College.—The Education committee of Sunderland Corporation have decided to expend £10,000 in extending the Technical College by adding a day training college and engineering laboratories.

Tuition by Correspondence.—Prof. Andrew Jamieson, M.Inst.C.E., M.I.E.E., (16, Rosslyn-terrace, Kelvinside, Glasgow), prepares pupils, by correspondence, for all examinations in mechanical, electrical and engineering science. Prof. Jamieson's announcement appears on another page.

Accrington Tramways Award.—The Board of Trade Arbitrator (Sir Colin Scott Moncrieff) has issued his award in regard to the purchase of the undertaking of the Accrington Steam Tramway Co. by Haslingden and Rawtenstall Corporations.

For so much of the undertaking as lies within Haslingden £14,203 has been awarded, the company claiming £24,203. From Rawtenstall the company asked £7,375, and are awarded £4,252. The Corporations bear the costs. Haslingden propose to commence electrifying the system soon after Christmas, and meanwhile are negotiating with Accrington and Rawtenstall Corporations as to through running powers.

Aldershot.—Electric lighting mains have been extended to the Manor Park estate, an important residential area in this town. The Council are advertising for tenders for cables, troughing, &c. (See p. xi.).

Australasia.—The "Australian Mining Standard" states that Balmain (N.S.W.) Council have accepted the proposal of Kenway & Co. to supply electricity for public lighting at 4½d. and for power at 1½d. per unit and to erect a destructor and burn refuse at 2s. per load.

Brazil.—Into the port of Bahia there was imported in 1906 electrical machinery to the value of 458,453 milreis, showing small increases over 1905 and 1904.

British Commercial Attaches and Agents.—In a recent report by Sir Eldon Gorst and Mr. H. T. Llewellyn Smith on the system of British Commercial Attachés and Commercial Agents it is stated that the expectation that British firms would utilise the services of these agents for conducting special inquiries at a distance has not been realised. A large number of applications for commercial information have, however, received attention. The present arrangements for commercial agents are temporary and provisional and there is no reason (says the report) why their functions should not be equally well discharged by the consular staff, strengthened where necessary for that purpose.

The following recommendations are made:—

1. The existing commercial attachés residing in European capitals, including the present commercial agent in Russia, who should be made a commercial attaché, to have their headquarters in London, and to divide their time between special investigations abroad, particularly in districts of interest to British manufacturers, work in the Board of Trade or the Commercial Department of the Foreign Office, and visits to manufacturing districts in the United Kingdom. This measure would not be applied to the commercial attaché at Paris, as it would not be practicable to make any change in the position of Sir H. A. Lee, who holds the dual appointment of commercial attaché and Resident British Director of the Suez Canal Co. in Paris.

In view of the very wide areas which are at present assigned to commercial attachés, it would not be appreciably more inconvenient that they should start on their travels from London than from any other centre, while the value of their inquiries would be greatly increased if definitely directed to special objects by instructions from the Department or from the Commercial Intelligence committee, or by the experience gained in systematic visits to British commercial centres. An additional advantage would be that it would be unnecessary to define rigidly the districts to be covered by each commercial attaché, who might be directed from time to time to travel in any country with whose language he was acquainted.

2. The commercial attachés at the more distant posts and in the countries where special qualifications other than commercial are the chief requirements, such as Turkey, China, &c., to continue to have their headquarters in those countries, but to be relieved as far as possible of the current commercial work at the Embassies and Legations, to be required to move about freely within their districts, and to pay periodical visits on duty to the principal centres of industry in this country, and to the departments charged with commercial matters. Those visits should be

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annual in the case of the commercial attaché at Constantinople, and at least biennial in that of the commercial attachés in the Far East.

3. The present temporary arrangements for commercial agents to be discontinued, and the functions now performed by those agents to be assigned to the members of the Consular Service, which must be increased in places where the commercial work necessitates such a course. It is clear that, owing to the increase of commercial inquiry at New York, the Consulate-General cannot dispense with an extra officer, and that a salaried consular officer would be required in Switzerland to take the place of Mr. Milligan.

4. The current commercial business of the diplomatic missions, including many of the duties hitherto carried out by the commercial attachés, to be in charge of a specially selected member of the diplomatic staff, designated by the head of the mission, and receiving a special allowance whilst actually discharging his functions. It is estimated that an annual sum of £1,000 would cover the necessary expenditure. It is important that the member of the staff selected for this purpose should, while so acting, have some distinctive title such as "Secretary in Charge of Commercial Matters," so that the commercial community may clearly realise that there is a special officer in each mission with whom they can communicate direct on commercial questions,

Chichester.—Mr. Horace Boot (who is retained by Tunbridge Wells Corporation as their consulting engineer) has been appointed consulting engineer to prepare plans, specifications, &c., for the Chichester Electric Light & Power Co.

City of London.—In the annual report of the city engineer (Mr. Frank Sumner) it is stated that the number of arc lamps used for street lighting is 449, each costing £26 per annum.

The total length of city subways is 1 mile 947 yds.; electric light conduits, nearly 5 miles; pneumatic tubes, 1 mile 1,353 yds.; and telegraphs and telephones, 2 miles 1,145 yds. All overhanging clocks should (Mr. Sumner thinks) be synchronised; at present it is a rarity to find two alike.

Customs Duties.—The New Zealand Government propose to increase the import duty on electrical machinery and appliances from 10 to 20 per cent., ad val.

Damages against an American Electric Lighting Co.—The "Western Electrician" for Aug. 10, reports an action in New York where an insurance company obtained a verdict for damages by a fire alleged to have been caused by defective wiring.

The action, which was originally tried before Mr. Justice Truax in December, 1906, was brought by the Continental Insurance Co. against the New York Gas, Electric Light, Heat and Power Co. and others. Plaintiffs contended that a building was destroyed by a fire which was started by the contact of a secondary wire upon a tin roof, or cornice, the wires having sagged on account of the negligence of the electric lighting company. Plaintiffs also attempted to prove that a transformer was faulty, but it was shown (and ultimately admitted by plaintiffs) that it was in perfect order and no trouble could have resulted on account of its condition. No evidence was given to show that more than one wire touched the roof, or in what condition the secondary wires were elsewhere. The electric light company contended that only one wire touched the tin cornice, and that under such conditions no fire could have resulted; that the cornice was considerably rusted, and that the fire burned outward rather than inward. Experts for the National Electric Light Association gave evidence that an arc would not have lasted long enough to burn a hole in the tin and set fire to the wood, because the fuses in the transformer would have melted. Inspectors from the Board of Fire Underwriters and city inspectors testified that the wiring was in good condition when installed, and was put up in a proper manner. Employés of the electric light company also proved that when the wires were first installed, and several times previous to the fire, they were all in good condition. The question before the jury was whether the electric light company had been negligent in allowing its wires to sag and rest uninsulated upon the tin cornice.

The jury decided that the company was negligent, and judgment was given for plaintiffs. Defendants appealed to the Supreme Court of New York State, but the decision has been affirmed.

Electric Traction in the Caucasus.—A project has been laid before the Russian Government for constructing an electric railway across the Caucasus mountains from Beslan to Vladikavkas on to Tiflis in Transcaucasia, a distance of 135 miles. The railway would be laid down within 4½ years of the date of the concession, which would be for 80 years.

Electro-Chemical and Electro-Metallurgical Industries in France.—Reporting upon the trade of the Lyons district of France for 1906, Mr. Consul Vicars states that the electro-chemical and electro-metallurgical industries continued to make good progress in 1906. An addition of some 5,000 H.P. has been applied to the production of aluminium and about the same increase for carburet of calcium. These increases have been obtained by the completion of existing hydraulic works, but 1907 will witness the harnessing of further waterfalls in the service of these industries, not only in the Alps, but also in the Pyrenees. The use of "white coal" has attained remarkable development in South-Eastern France within the last few years.

The production of aluminium (he continues) has especially made rapid strides of late—from 1,647 metric tons in 1904 to 1,905 metric tons in 1905—and though the actual figures of actual production for 1906 are not yet accessible, the export alone increased by over 50 per cent. compared with the previous year, so that the rate of progression in production was at least maintained. The extraction of bauxite, the raw material of aluminium, has risen from 75,000 metric tons in 1905 to 103,000 metric tons in 1906. A large part, however, of the quarried bauxite is of no use for the manufacture of aluminium and is employed for making fire-proof ware. The water power employed in the various chemical industries in 1906 amounted in the aggregate to 100,000 H.P., distributed as under:—Aluminium 35,000 H.P., carburet of calcium 25,000 H.P., chlorate of potassium or sodium 15,000 H.P., metallurgic products, steel 22,000 H.P., soda chlorine, hypochlorates 1,000 H.P., and various 2,000 H.P.

The success of the Société Grenobloise de Force et Lumière in bringing water power 112 miles from Moutiers to Lyons has given birth to a scheme for bringing many thousands of horse-power from Bellegarde (Ain), on the Rhône, to Paris.

The production of nitrates is about to be revolutionised by the manufacture of cyanamide and nitric acid inan electric furnaces. Cyanamide is obtained by the action of nitrogen upon carburet of calcium in the temperature of the electric furnace. This substance in the soil turns into salts of ammonia and can thus enter into competition with the sulphates of ammonia produced in gas and sewage works. A cyanamide factory is being established in the district of the Tarentaise. The production of nitric acid in the electric furnace by the direct union of oxygen, nitrogen and steam is carried on in a Norwegian factory. The nitric acid, neutralised by lime, gives solid nitrate of lime, which may be advantageously used in place of nitrate of soda for agricultural purposes. When it is remembered that France imported 241,272 metric tons of nitrate of soda in 1906, it is clear that, if the net cost can be kept sufficiently low, this new industry has a great future. So far, however, only samples of cyanamide and nitrate of lime have reached France, but it is announced that large works are being organised in Germany and Italy for the production of cyanamide and in Norway for nitrate of lime.

Phosphates of soda and oxygenised water are coming into more general use for dyeing purposes, and a factory has been established in Lyons for producing oxygenised water by a new process, in which bioxide of sodium, produced in an electric furnace, is used instead of bioxide of barium.

Gutta-Percha Substitutes.—It is reported that the Boissac Works at Lyons (France) are introducing new products as substitutes for gutta-percha for insulating purposes.

Huddersfield.—The Corporation have resolved last week to apply for sanction to the adoption of the three-phase system of supply, generation at 6,600 volts, transformed to 400 volts on consumers' premises for power. Various tenders for requirements at the electricity works (set out in another column) were accepted.

Light Railways.—The County of Hertford Light Railways (Watford and Bushey Extension, &c.), Order, 1907, has been submitted to the Board of Trade for confirmation. Objections by Sept. 21.

Limerick.—The following comprehensive resolution was passed at the last meeting of the Corporation anent a matter of electrical interest at the generating station:—

That while expressing the utmost reprobation of the recent conduct of Mr. Kelleher, and approving the action of the Electric Light committee in sanctioning his suspension by the borough electrical engineer, we, having read all the minutes bearing on the question and fully considered all the facts and circumstances of the case, recommend to the Council that it be referred back to the Electric Light committee to inflict such pecuniary punishment on Mr. Kelleher as advisable, recommend that the action of the Whole House committee in reinstating him be confirmed, and we also recommend that the Council should declare to the Electric Light committee that Mr. Rooney has not been elected to and does not fill the position of assistant engineer at the electricity works, and that the Electric Lighting committee should take such steps as in its opinion may be necessary to put an end to the friction at present existing at the works by an equitable distribution of the work between the assistants there.

L.C.C. Tramways.—The proposal to equip the tramway route from Aldgate to Bow on the "G B." surface contact system is meeting with opposition from West Ham and East Ham Corporations and Leyton and Ilford Councils. The objections are raised in view of the necessity for through running from the City to the districts of the Essex local authorities above mentioned, whose lines are equipped on the overhead system.

A system of medically examining the Council's tramway employés has been initiated, and meetings have been held at which the employés have passed resolutions protesting against the innovation. It has been decided to postpone carrying out the order until October.

Lourenço Marques.—An interesting report on the trade of this division of Portuguese East Africa has been issued. In this report Mr. Vice-Consul Horsfall of Inhambane states that it was confidently anticipated that the Government of Lourenço Marques would have taken action in the matter of the construction and working of a light railway from the head of Delagoa Bay (Matamba) to Imharrime, some 50 miles south-west of Inhambane, and thence ultimately to the west to tap the northern districts of Gazaland. The scheme has long been talked about, and would open up a large and fertile district which is waiting for light railway connection to afford transport facilities to what might become one of the most prosperous of the Portuguese possessions.

Electrical and telegraphic material imported into Lourenço Marques in 1906 was valued at £1,918, the bulk of which (41 tons weight) came from the United Kingdom. There was, in addition, landed at Lourenço Marques for transit to the Transvaal, &c.,

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electric and telegraphic material to the value of £75,267, representing a large increase over former years. The United Kingdom stands for £61,278 of these imports, Germany £13,873. The value of railway material imported at Delagoa Bay for transit was £413,148, of which the United Kingdom and British possessions stand for £318,500, Germany £81,450, Dutch possessions £11,287.

Municipal Electrical Association.—Southend Council have invited this association to hold its 1908 annual conference at Southend.

Municipal Tramway Employes and Friendly Societies.—The general manager of the Manchester tramways (Mr. J. McElroy) recently drew up a report on the condition of the sick and benefit society for the employés of the tramways department, and recommended the Tramways committee to put the fund on a sound financial footing. The Manchester and Salford United Friendly Societies' Council have taken the matter up and held a special meeting on Tuesday when the following resolution was passed.

That this meeting of the Friendly Societies' Council, representing nearly 50,000 members of friendly societies, respectfully protests against any sick and benefit society being established on the lines suggested by the report of Mr. McElroy, as to subsidise such society from the revenues of the tramways would be manifestly unfair to the many friendly societies at work in the city, and we believe would be detrimental to the interests of the citizens at large. Also that the Tramways committee be requested to receive a deputation with reference to the matter.

Councillor Gilchrist, who presided at the meeting, explained that the tramway employés formed a society in 1902, and there were now 1,614 members. Since its formation the society had paid £6,000 in sick and funeral allowances, &c. There was no provision for old age or incapacity. The members were not able to keep it in a sound financial condition, and they had appealed to the Tramways committee to assist them by establishing a sick and benefit society for the tramway department upon the lines of similar societies in Glasgow and Liverpool. Those societies were subsidised by the tramways committees, but he held that it was unfair that money from the rates should be employed for that purpose, to the detriment of existing friendly societies, the large majority of whose members were ratepayers. At Glasgow the scales of benefit paid on the subscriptions of the members could not possibly be maintained but for the subsidy from the rates. Mr. McElroy strongly recommended that the matter should be taken up by the committee, and was of opinon that a society on lines which had proved so successful in the two cities named would be a great benefit to the employes of the department. The employés pointed out that the department at present was not incurring the expense to which it would have been put had the men been called upon to join the general thrift fund of the Corporation, and their request was that the sums which the committee in the ordinary course would have contributed to that fund should be diverted and paid over as a contribution in aid of the proposed sick and benefit society. Either the committee were not paying the tramway employes a fair wage, and so felt that they ought to subsidise their sick and benefit society, or if they were paying them a proper wage, they should not, as a department of the corporation, contribute to the fund.

New Book.—Messrs. Constable & Co. announce the publication in the autumn of a new work on Electrical Measuring Instruments: Recorders, Meters, &c., by Mr. Kenelm Edgcumbe, M.I.E.E.

Oswaldtwistle.—The Council have declined to entertain a proposal to apply for a provisional order which would be transferred to Accrington Council.

Overhead Wires in the City of London.—At the meeting of the Court of Common Council last week it was reported that since 1899 24½ miles of derelict overhead wires had been removed.

All owners of overhead wires are required to identify them by having a perforated zinc label of approved pattern attached. This system has proved of great service, and is the means of immediately locating the owners of wires in the event of same requiring repair. During the past year there were 48 derelict and unidentified wires removed, of a total length of 2,193 yards, together with their insulators and attachments. During 1906 the number of private owners of overhead lines increased to 133, and the number of companies to 21. Both have considerably added to their number of spans during the last twelve months, and these now total about 731,500 spans crossing public thoroughfares, compared with 699,300 last year and 260,000 in 1899. Theee has been a net increase of about 1,526 miles of National Telephone Co.'s wires.

Provisional Order Revocation.—The Board of Trade have revoked the Lees Electric Lighting Order, 1902, as from Aug. 20.

Rubber.—In reporting upon the trade of Bahia (Brazil) for 1906 Mr. Consul O'Sullivan Beare reports that it has lately been discovered that the State of Bahia is very rich in a rubber-producing tree known locally as "Jiquié Maniçoba." The tree is said to be a new and distinct species of Manihot, apparently peculiar to the State of Bahia. The discovery is regarded as one of great importance not only to this State but also to the rubber trade generally, inasmuch as the substance obtainable from the "Jiquié Maniçoba," when properly prepared, is said to be fully equal in quality to the best product of Para. Mr. O'Sullivan Beare gives some interesting particulars of this product, from which we extract the following:—

The Maniçoba of Bahia is a tree which attains to a height of 30 ft. and upwards, with a diameter of some 2 ft., when fully matured in suitable soil. It belongs to the family of Euphorbiaceae, as does also the Syphonia elastica, which produces Para rubber, yet it is closely akin to manihots, aipins or macacheiras, mamomeiras, seringueiras, &c. Its zone, so far as at present known, extends from Maranhão to the southern borders of the State of Bahia. It flourishes throughout the "Sertão" (vast spaces in the interior of Brazil, covered with brushwood and diversified by great tracks of forest) within the limits specified, but is found in greatest abundance in the regions adjoining the town of Jiquié, hence its local name. Jiquié Maniçoba is undoubtedly a new and distinct species of Manihot, and must not be confounded with the Manihot of Ceará (Manihot glazovii, Amell. Aug.). The seeds of Jiquié Maniçoba are much larger than those of the Maniçoba of Ceará.

The season for extracting the latex from Jiquié Maniçoba extends from August to March. The latex possesses the valuable property of coagulating spontaneously when exposed to the air, and requires no acid or other artificial coagulant of any kind. It has been found, from experiment, that the Jiquié Maniçoba tree can be made to yield its latex between the fourth and fifth years from first planting, but yields its maximum returns from the age of eight years onwards. The planters of Bahia have awakened to the fact that in the cultivation of Jiquié Maniçoba they possess a source of much potential wealth. Already several fazendeiros have begun to lay down plantations of the tree on a large scale. The two most extensive of those plantations are situated one upon the Island of Joannes, close to the city of San Salvador, the other in the district of Machado Portella. The Agricultural Institute, which has recently been established by the State, proposes to devote special attention to the systematic cultivation of Jiquié Maniçoba and to the preparation of the rubber derivable therefrom. A planter established in the Jiquié district recently prepared a considerable quantity of rubber obtained from Maniçoba trees growing wild in that neighbourhood, and despatched it to New York. The consignment was classified in the New York market as being equal to the best Para rubber, and fetched $1.20 (5s.) per pound.

Southend-on-Sea.—The Council have applied for sanction to loans of £20,940 for extensions of the electricity works and £6,974 for car-shed extensions.

The proposal to extend the tramways to Shoeburyness has been abandoned.

Sweden.—In reporting upon the trade of Gothenburg and district for 1906, Mr. Consul J. Duff notifies that amongst recent decisions of the Town Council is one to construct and equip large electricity works for the district at an estimated cost of about £320,000. Current will be generated at a water-power station on the Trollhättan Canal, where large power is available.

At *Warberg* a company has been granted a 25 years' concession for the supply of electricity for lighting and power. Current is to be generated at the Yngeredsfors Waterfall, about 22 miles distant east of Warberg, any shortage in water supply being provided for by a steam power reserve at the station.

At *Hamstad* the Electric Installation Co. are inviting tenders for the erection and equipment of a generating station.

At *Helsingborg* the first electrically driven railway in Sweden is now in operation carrying goods and passengers via Helsingborg-Råå-Ramlösa.

At *Malmö* electric tramways were completed last year and are becoming increasingly popular.

Tientsin (China).—A new company (the Société Franco-Belge de Tientsin) has been formed in Brussels for erecting and working electricity and gas undertakings, &c., in China.

Todmorden.—The Council have referred back a proposal to increase the charge for electricity for lighting from 3d. to 4d. per unit.

Village Lighting.—Penshaw (Durham) Council have decided to join the Newbottle Council in an endeavour to induce the Durham Collieries Electric Power Co. to give a supply of electricity in these districts.

Wellington Council are considering an offer from Crook Council to supply electric current at 3¾d. per unit.

Willesden.—An inquiry was held last week into an application of the Council for sanction to borrow £4,068 to defray the cost of purchase of land for an electricity generating station and a sub-station.

Mr. Graves, deputy clerk to the Council, explained that a provisional order was obtained in 1898. Land in Taylor's-lane was purchased for a generating station in 1900, and the site of the distributing station in Salusbury-road was also acquired. The L.G. Board sanctioned the borrowing of £3,544 for the purchase of sites, &c., and of £139,040 for buildings, machinery, mains, &c. In August, 1903, the North Metropolitan Electric Power Supply Co. purchased the Council's generating station in Taylor's-lane and agreed to supply the Council with current in bulk. In February, 1904, the Council conveyed the station to the company for £72,034. There was no intention of terminating the agreement with the company unless the price charged for bulk supply was considered excessive.

Replying to a question from the inspector (Mr. Meade King), the electrical engineer (Mr. J. G. Bruce) said the agreement would terminate in February, 1911.

The assistant accountant (Mr. Toley) said they had bought a site out of the £3,300 profit on the sale of the station site, but now wished its cost and that of a sub-station site defrayed out of loan, except in regard to £768, which was a sum they had to the credit of revenue account.

The Inspector asked why was not the surplus applied to reducing the debt of the undertaking.

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Councillor Griffin (chairman of the Electricity committee) said he was advised that the Council was recommended to buy the land, which was offered to them on exceptional terms.

There was no opposition.

Windsor Castle.—Considerable extensions of the electric lighting arrangements are to be carried out, and an addition of 800 incandescent lamps is to be made before the German Imperial visit in November. A supplementary cable has been laid, and electrical energy will be supplied for illuminating, not only every part of the Upper Ward, but also the subsidiary buildings within the Palace precincts. In the picture galleries a system of concealed electric lamps above and below the principal canvases enables the beauty of the works of art to be appreciated after dark. This system has been introduced with conspicuous success in the Vandyck Room, where the largest group of paintings is to be found, and is also being adapted to the fine portrait of her late Majesty by Benjamin Constant and to the equestrian group of King Edward and the Duke of Connaught. Considerable use is being made of the wall-plug, permitting of the occasional use, not only of reading-lamps on any table, but of music stands and the like in connection with the evening relaxations of the Court.

Wrexham.—At the meeting of the Council last week the new electrical engineer (Mr. W. G. Pickvance) recommended that the consideration of the proposed reduction of the charges for electric current for lighting be deferred because within the next 12 months the new metallic filament lamps which would be on the market would be so much better than the present ones that the consumer would save one-third in current and get 20 per cent. better light. The recommendation was agreed to after a protest by some of the members.

Sports.—The staff and employés of the British L.M. Ericsson Mfg. Co., Beeston, Notts., held their second annual sports on Saturday last at Beeston, in the presence of a large concourse of spectators. At the conclusion of a very successful programme the visitors were further entertained until dusk with an open-air concert, rendered by Messrs. Humbers' prize band and a company of vocal artists.

The second annual excursion of Aberdeen electricity department employés took place on Saturday last, when about 60 members of the staff and lady guests proceeded to Culter. After tea there were sports, for which Mr. Bell (the city electrical engineer) and his assistants (who were unable to be present) provided most of the prize money.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Keighley.—The total revenue of the tramways department for the year ended June 30 was £8,270, compared with £7,659 for the previous year, or 7.73d. per car mile against 6·92d.

1,935,098 passengers were carried, an increase of 63,124. Working expenses were £5,223 and gross profit £3,048. After paying interest and sinking fund charges the net profit (£253) has been transferred to reserve and renewal fund. Capital expended was £46,004, an increase of £1,428 on the year. 1,935,098 (1,771,974) passengers were carried, 256,715 (265,492) car miles run and, 227,137 (226,051) units consumed, or ·88 (·85) unit per car mile. Working expenses per car mile were 3·33d. (3·19d.), or including power 4·88d. (4·80d.)

Plymouth.—The annual report of the tramways manager (Mr. C. R. Everson) states that during the past year 695,250 car-miles were run by the electric cars, compared with 699,235 in 1905-6.

The average consumption of energy per car per day was 112 units in 190 7, against 118 in 1906, and the number of units consumed in 1907 was 938,006, against 937,180. The average units per car-mile were the same in both years—1·34. The total number of passengers carried was 7,324,347. Traffic revenue was £31,265. 12s. 9d. and total revenue £33,753. 5s. 1d. Including power cost and repairs of permanent way, working expenses totalled £23,049. 10s. The average traffic revenue was 11·05d. per car-mile. The average working expenses of the electric cars per car-mile (excluding power and permanent way repair) were 4·29d.; including power 6·67d.; and including power and permanent way 7·74d. The gross profit was £9,404. 7s. 10d., and, with £1,182. 10s. received from the Plymouth, Stonehouse & Devonport Tramway Co., the total sum available was £10,703. 15s. 1d. The expenditure in dividends, interest and stock redemption charges amounted to £9,351. 3s. 11d., leaving a net profit of £1,352. 11s. 2d. The capital expended is £153,764

TRADE NOTES AND NOTICES.

TENDERS INVITED.

London County Council invite tenders for the manufacture, delivery and erection of three electrically-driver boiler feed pumps, each of 9,000 gallons per hour capacity, at the tramways electricity station, East Greenwich. Tenders, upon official forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 11 a.m., Oct. 8. Further particulars are given in an advertisement.

NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

Aldershot District Council invite tenders for supply of cable (4,400 yds), bitumen (12 tons), troughing (1,100 yds.) and insulators (2,200 yds.) in connection with intended extension of mains. Conditions and specifications from the engineer (Mr. F. Garside), electricity works, Laburnum-road, Aldershot. Tenders must reach the clerk (Mr. W. E. Foster), Municipal-buildings, Aldershot, by 9.30 a.m. of Wednesday, Sept. 18 See also an advertisement.

The Committee of Management of the *Londonderry* District Lunatic Asylum invite tenders for supply, delivery and erection of a 22 kw. steam set with brush dynamo, pipe work, switchboard, connections, &c., for extension of plant at the Gransha Asylum. Specifications, &c., may be inspected at the offices of the consulting engineer (Mr. R. V. Macrory), Strand, Londonderry. Tenders by 9 a.m., Sept. 20. See also an advertisement.

The Joint Committee of Management of *Clonmel* (Ireland) District Lunatic Asylum are prepared to receive tenders for the following work in connection with the lighting of the asylum: Sec. 1, suction gas plant, gas engines and electric generators; sec. 2, accumulators, switchboard, underground mains, wiring and fittings; sec. 3, power-house building and foundation. Tenders to the Resident Medical Superintendent, District Asylum, Clonmel, Ireland, by Sept. 7.

The *Metropolitan Asylums Board* invite tenders for alterations and additions to the fire alarm and telephone system at the Gore Farm Hospitals (near Dartford, Kent). Drawings, &c., from the offices of the Board, Embankment, London, E.C., where tenders must be delivered by 10 a.m. Sept. 4.

Torquay Electric Lighting committee invite tenders for the supply of 1,500 to 2,500 tons of smokeless thro' steam coal. Tenders to the town clerk (Mr. Frederick S. Hex), Town Hall, Torquay, by noon Sept. 3.

Dublin Lighting committee invite tenders for the supply of extra-high-pressure and low-pressure cables (*a*) delivered at their Fleet-street stores and (*b*) laid complete on site in Dublin. Tenders to the chairman of the Lighting committee, 3, Cork-hill, Dublin, by Sept. 9.

The *Postmaster-General* requires tenders by Sept. 9 for creosoting Norwegian, Swedish, Finland or Russian red fir telegraph poles. Forms from Mr. S. E. Hooley, Stores Department, G.P.O., 17-19, Bedford-street, London, W.C.

Swinton and Pendlebury Council want tenders by noon Sept. 5 for wiring the town hall (Pendlebury) and the Council offices and public baths (Swinton). Specifications from the clerk.

Hastings Corporation want tenders by noon Sept 17 for six months' supply of best Welsh smokeless coal for the electricity works. Forms from the Borough Electrical Engineer.

Manchester Corporation want tenders by 10 a.m., Sept. 7, for laying underground telephone pipes. Specification from City Surveyor.

Erith Council want tenders by noon Sept. 4 for material for overhead h.t. electricity supply. Specifications from Chief Electrical Engineer.

Croydon Corporation require tenders by 11 a.m. Sept. 9 for trolley-wire and other overhead line material. Specifications from Tramways Manager.

Dover Electricity committee want tenders by Sept. 9 for supply of Welsh steam coal. Specifications, &c., from the Borough Electrical Engineer.

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Halifax Tramways and Electricity committee want tenders by Sept. 7 for supply of pea slack coal at the electricity works. Further particulars from the Borough Electrical Engineer.

Worksop Council require tenders by Sept. 4 for l.t. cables, joint boxes, &c. Specifications, &c., from Mr. J. P. Crowther.

Southampton Corporation want tenders for cables, conduits and earthenware troughs. Particulars from Borough Electrical Engineer.

TENDERS RECEIVED AND ACCEPTED.

Maidstone Council have accepted the offer of Dick, Kerr & Co. to construct the Tovil tramway extension at same schedule prices as charged for the routes already constructed, or an estimated total of £7,500.

Barnes District Council have accepted the tender of the Lahmeyer Electrical Co. for feeder and distributor cables, but the contract for mechanical stokers has not yet been let.

Bristol Electricity committee have accepted the tender of Bruce Peebles & Co., for two 500 kw. and one 300 kw. Peebles-La Cour motor converters.

Huddersfield Council have accepted the tenders of Mark Brook for foundation work for turbine plant at the electricity works, that of W. C. Holmes for exhaust steam valves, and that of Jas. Russell & Sons for steam pipes.

Houghton-le-Spring Council have accepted the tender of Hind & Son for wiring the West Herrington Schools.

Southend Council have placed an order with Ledward & Beckett for a condenser.

Bury St. Edmunds Council have accepted the tender of Heenan & Froude for a refuse destructor at £2,270.

Ferry Hill Council have accepted the offer of Bolckow, Vaughan & Co. for public lighting at Dean Bank.

Admiralty Contracts.—The "Essex Telegraph" reports that orders to the value of nearly £30,000 have recently been placed with Crompton & Co., Arc Works, Chelmsford, and London. A large part of the work is for the Admiralty, and will include one of the largest alternators ever made by the firm. These orders will, it is stated, mean full time and extra hands at the Chelmsford works for some months to come.

Rateau Patent Exhaust Steam Utilisation Turbo-Plants.—Mr. P. J. Mitchell has recently received a number of orders for the Rateau system, including:—

John Summers & Sons (Shotton, Flintshire), 500 kw. d.c. set (220 volts); and Butterley Co. (Britain Colliery, near Derby), 200 kw. d.c. set (230 volts), each with condensing plant, pipe work, cooling plant and water-type accumulator; Edinburgh Corporation, two 1,000 kw. d.c. turbo-generators; W. B ardmore & Co. (Glasgow), one 1,000 kw. (230 volts) d.c. turbo-generator, with condensing plant (suitable for 2,000 kw.), piping, cooling tower and water-type accumulator; Stewarts & Lloyds (Mossend, Glasgow), one 1,000 kw. turbo-alternator, condensing plant (suitable for 2,000 kw.), piping, cooling tower, switchboard, overhead travelling crane and water-type accumulator; Glengarnock Iron & Steel Co. (Glasgow), one 1,000 kw. turbo-generator, condensing plant, pipe work and water-type accumulator; Oakdale Collieries (Argoed, Sirhowy Valley), one patent water-type accumulator suitable for 1,000 kw. (through Dick, Kerr & Co.); Powell Duffryn Steam & Coal Co., one 500 kw. three-phase turbo-alternator, condensing plant and pipe work (repeat order); Nobel's Explosives Co., one 300 kw. 220 volt turbo-generator (through the Mirrlees-Watson Co.)

Mr. Mitchell states that at present there is over 70,000 kw. of plant in operation or under construction.

BUSINESS NOTICE.

Carl O. M. Kuhl and G. H. Vogt, mechanical and electrical engineers, 5, Chester-road, The Brook, Liverpool, have dissolved partnership.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of W. A. Roderick, electrical engineer, 12, Penmaen-street, Swansea, the first meeting of creditors will take place on Aug. 31 at 117, St. Mary-street, Cardiff, and the public examination on Oct. 8 at the Law Courts, Cardiff.

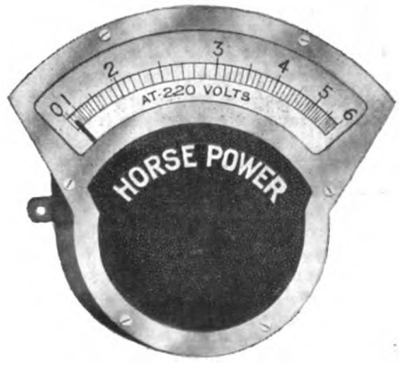
A meeting to receive an account of the winding-up of Christian & Phipps (Ltd.) will be held on Oct. 3 at 41, Finsbury-pavement, London, E.C.

Agents Wanted.—An old-established and well-known German firm, manufacturing electric motors and dynamos, transformers and electric cranes, advertises that it is open to entertain proposals from firms with large connections throughout England and colonies with a view to representation.

Premises to Let.—A conveniently situated factory site at Cheadle, Staffs., is advertised to be let or sold by Messrs. Cull & Brett, solicitors, Cheadle, Staffs.

CATALOGUES, &c.

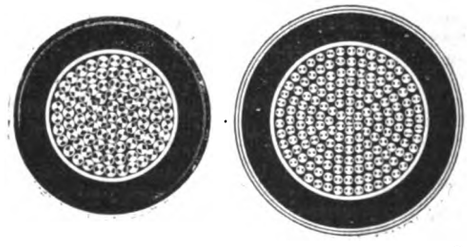
Horse Power Gauges.—The employment of indicating instruments on power circuits has not hitherto been popular, and the reason may probably be attributed to the fact that an ordinary ammeter and voltmeter conveyed little or nothing to the user of electric power. Talk to him of horse-power, he will understand you, but volts, amps, ohms and watts are "mere electric things" to his ordinary mind. An ammeter calibrated in horse-power is just the instrument for a power circuit. The "Ediswan" power gauges are being introduced to supply a distinct need among power consumers, and, judging by the construction of the instruments and their price, the demand should at once become brisk. The accompanying illustration depicts the form of case adopted and the open character of the scale. The instruments are made in a standard size, 6¾ in. by 6$\frac{1}{16}$ in., for alternate and continuous-current circuits and for voltages between 100 and 600. A stock of 10 different sizes is kept, the instruments being for 110, 220, 440 and 550 volts. The



"Ediswan" Horse-power Gauge.

iron movement is jewelled and has dead-beat action, and the case is guaranteed dust-proof. Leaflet No. I. 2,097, issued by the Edison & Swan Co., gives full details.

Underground Aluminium Cables.—It has been a long time "getting there," but the insulated aluminium cable has now arrived. With copper at an abnormal figure, electrical engineers may welcome the statement of the case made by Messrs. Johnson & Phillips in their latest publication for the insulated aluminium cable. This is so completely sanguine that its message cannot fail to find converts, and at no distant date. The makers claim that drawing and jointing of the wire no longer present difficulties, and the diameter of an aluminium cable now compares favourably with that of copper. Mechanical or "sweated" joints can be made as desired, and the makers state that the electrical and mechanical properties of the joints are superior to those of the wire itself. Overhead aluminium cables are already recognised, and many transmission schemes abroad employ them. We now have an opportunity of



Sections comparing diameter of Copper and Aluminium Cables. The latter is the larger of the two.

proving the merits of the underground conductor of the same metal, and as we infer that price is in its favour, the inducement to experiment with it should be proportionately great. There is a 50 per cent. saving in weight, the diameter being increased by 28 per cent. Paterson's vulcanised bitumen is the insulation adopted, mainly because of its lightness compared with paper and its proved insulating properties. The catalogue dealing with the subject is tastefully got up.

We are asked to correct an obvious error on page 3 in the table of comparative figures of copper and aluminium wire. In this the conductivity of the latter is given as 0·61 (per cent. of copper), but should, of course, read 61. Similar correction is necessary also to the figures in the paragraph following the table.

Ignition Accessories.—C. A. Vandervell & Co., of Acton Vale, London, W., have issued a useful catalogue of ignition accumulators, electric lamps, and accessories.

Dynamos.—A well prepared list of dynamos is to hand, from J. P. Hall & Co., Werneth, Oldham. Particulars are included of machines for rope and belt driving, and also for direct coupling to steam, gas and oil engines.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone

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wire and materials, but not including electrical machinery, which is not separately specified) from Aug. 21 to 27, with the ports of destination:—

Africa—Alexandria, £227 (telegraph materials); Cape Town, £54; Delagoa Bay, £59; Durban, £407 (including £87 telegraph material); East London, £30; Sekondi £84 (telegraph material); Sierra Leone £9 (telegraph material); Suakim, £17. *Argentina*—Buenos Ayres, £1,207; Rosario, £140 (telegraph material). *Australasia*—Adelaide, £131; Auckland, £1,494; Invercargill, £40; Melbourne, £1,981; Perth, £34; Sydney, £1,289; Wellington, £180 (including £156 telegraph material). *Belgium*—Ghent, £137; Ostend, £136. *Brazil*—Rio Janeiro, £2,402 (including £2,392 telegraph material). *Canada*—Toronto, £105 (telegraph material). *Chili*—Antofagasta, £33. *China*—Shanghai £55 (including £19 telegraph material). *Denmark*—Copenhagen, £650. *France*—Boulogne, £780. *Germany*—Cologne, £433; Hamburg, £196. *Holland*—Amsterdam, £1,027; Rotterdam, £18 (telegraph material); *Hong Kong*, £1,360 (including £57 telegraph material). *India*—Bombay, £6,793; Calcutta, £1,211; Madras, £72. *Japan*—Kobe, £870; Nagasaki, £32; Osaka, £864; Yokohama, £2,162. *Malta*, £73. *Philippines*—Manila, £73. *Russia*—Helsingfors, £20; Kurch, £529; St. Petersburg, £52. *Siam*—Bangkok, £705. *Spain*—Barcelona, £15; Ferrol, £15. *Straits Settlements*—Singapore, £434. *Sweden*—Stockholm, £23 (telegraph material). Total £28,658, against £59,967 in the corresponding week last year (Aug. 22 to 28).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are no open to public inspection until after acceptance of Complete Specifications Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

June 5, 1907.

13,059 SUNDERLAND & PILLINGER. Holders for incandescent electric lamps.
13,062 BARTELS. Photometer.*
13,069 STEVENS. Circuit-breaker.
13,071 SIEMENS & Co. Electrode for searchlights. (Date applied for, 8/6/06.)*†
13,072 WHITE. Controllers. (Date applied for, 6/6/06.)*†
13,073 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current electric motors.

June 6, 1907.

13,102 JOHNSTON. Insulation of submarine cables.
13,104 PHYTHIAN. Trolley pole mechanism of electric tramcars.
13,107 SMITH & BEAVER. Attaching electrical testing and recording instruments to electrical circuits.
13,110 WEST. Water wheels or similar motors.
13,129 GROB. Electric lighting and heating of vehicles. (Date applied for, 9/6/06.)*†
13,140 SAHULKA. System of controlling and operating motors.
13,147 BROCKIE. Enclosed arc lamps.
13,151 LOEBL. Brackets for electric lamps.
13,175 WATKINS, BOLSTER & GOODSELL. Telephone selecting apparatus.*
13,177 LEITNER. Variable-speed dynamos.
13,184 LOWDEN. Incandescent lamps.
13,190 HARRISON & HIRST. Electrodes for arc lamps.
13,195 B.T.-H. Co. (A.E.G., Germany.) Signalling systems for railways.
13,196 B.T.-H. Co. (G.E. Co., U.S.) Electric insulators.

June 7, 1907.

13,199 WILLIS. (Phillip, U.S.) Turbine.
13,206 ARTHUR. Controlling system for electric railways.
13,248 TURNER. Portable electric lamps.
13,256 TANNER. Supply of electric current by the three-wire system.
13,261 BELLUZZO. Multiple expansion heat prime movers. (Date applied
15,259 HICKLEY. Brush holders for dynamos and motors. * for, 10/1/06.)*†
13,362 ARTON. Receivers for electro-magnetic waves. (Date applied for, 1/10/07.)*†
13,265 ALLGEMEINE ELEKTRICITÄTS-GES. Controller for alternating-current motors. (Date applied for, 8/6/06.)*†
13,270 COSSOR. Mercurial thermostatic circuit closers.
13,274 MIDDLETON & MIDDLETON. Couplings for electric cables.*
13,278 LARSSON. Electric circuit breaker. (Date applied for, 7/6/06.)*†

June 8, 1907.

13,285 ELLISON. Protection of alternating-current induction motors.
13,298 KENNEDY. Continuous-current electricity meters.
13,349 SIEMENS BROS. & Co. (Siemens & Halske, A.G., Germany.) Electrical signalling installation.*
13,354 DRIVER. Attaching filaments to leading-in wires of incandescent lamps.

June 10, 1907.

13,361 EARLAM. Brake blocks for the wheels of tramcars.
13,368 GRIFFIN. Electric sparking plugs.
13,375 ASHWORTH. Auxiliary lighting for tramcars.
13,385 COX. Teaching the direction of currents in electrical machinery and method of operating such machinery.
13,417 CUMBERLAND. Preventing corrosion and decomposition of metals in contact with water or other liquids.*
13,432 SCHATTNER. Fusible cutouts.
13,437 WHYSALL & JACKSON. Electrical device for saving the services of a door attendant.

June 11, 1907.

13,449 GOWER & HAMER. Magnetic circuits for static alternating-current transformers.
13,496 BYNG. Incandescent lamps with metallic filaments.

June 12, 1907.

13,534 FRIEDRICH. Measuring, rectifying and controlling apparatus for X-ray work.
13,543 HIGHFIELD. Apparatus for measuring charges for electrical energy.
13,563 FAIRWEATHER. Apparatus for fault location on electrical conductors. (Friendly, U.S.)*
13,575 QUINCY & HARRISON. Appliances for gas or electric pendants and pipes.
13,577 TANNER & CLAREMONT. High-tension cables.
13,582 JONES. Electrical resistances.
13,596 JAHR. Wireless telegraphy.
13,610 GELLY. Water-current motors. (Date applied for, 2/10/06.)*†
13,617 GRELLS. Apparatus for quick telegraphy.
13,618 GEBRÜDER, SIEMENS & Co. Electrodes for search-lights. (Date applied for, 13/7/06.)*†

June 13, 1907.

13,634 CONATY. Brakes for tramcars.
13,636 THOMSON-BENNETT & CHAMBERS. Quick make-and-break apparatus for induction coils.
13,674 SCHONEBERGER & FRAZIER. Electrolytic ship-bottom protector.*
13,675 BURBEY & KERSLEY. Tram and traction rails.
13,712 PARSONS & LAW. Dynamo-electric machinery.
13,722 MARCONI & MARCONI'S WIRELESS TELEGRAPH Co. High-frequency electric oscillations.
13,724 MAVOR and MAVOR & COULSON. Electrical transmission of power.
13,739 B.T.-H. Co. (G.E.Co., U.S.) Electric resistances.
13,740 B.T.-H. Co. (G.E.Co., U.S.) Metal-working machines.

June 14, 1907.

13,760 RATHBORNE, FIELDING & LATHAM. Automatic point control for electric tramways.
13,761 ELECTRIC CONSTRUCTION Co., BUCHANAN & MCMILLIAN. Automatically regulating the voltage in connection with dynamo-electric machines.
13,786 HEWSON. Controlling electric-light circuits on railway vehicles.
13,821 JENTZSCH. Coin-controlled telephones.
13,837 ALLGEMEINE ELEKTRICITÄTS GES. Signalling apparatus. (Date applied for, 16/6/07)*†
13,838 B.T.-H. Co, & WOODBRIDGE. Protecting devices for alternating electric current distribution systems.

June 15, 1907.

13,840 WAGGOTT, RÓSENBURG, LYNE, DAVIES, SWINDELLS, MOSS & JACKSON. Electro-mechanical automatic switches.
13,842 PETCH, DUNCAN & KING, Motor-generator control apparatus.
13,862 BRUCE PEEBLES & Co. and LA COUR. Dynamo-electric machines.
13,875 B.T.-H. Co. (G.E. Co., U.S.) Electric transformers.
13,882 LOWDEN & WESTINGHOUSE METAL FILAMENT LAMP Co. Incandescent lamps.
13,891 TATE. Treating liquids electrolytically.*
13,898 LEVER. Brake mechanism for automobiles and tramcars.

COMPLETE SPECIFICATIONS.

1906 SPECIFICATIONS.

5,570 PARKER. Electric transmission of power.
10,602 LAKE. (Stromberg-Carlson Telephone Mfg. Co.) Telephonic systems and apparatus.
12,974 ALLEN. Storage battery.
13,023 DE HEMPTINNE. Oxidising liquids by aid of electric discharges.
13,285 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors of the induction type.
13,287 B.T.-H. Co. (G.E. Co., U.S.) Operating electrically propelled vehicles.
13,332 B.T.-H. Co. (G.E. Co., U.S.) Motor generators.
13,414 B.T.-H. Co. & HOPPS. Dynamo-electric power transmission mechanism.
13,427 LINCOLN. Dynamo-electric machines. (Date applied for, 27/6/05.)
13,567 SIEMENS BROS. & Co. & TURNER. Controlling electric motors.
13,594 NORTH. Electric signalling apparatus for use on vehicles.
13,596 B.T.-H. Co. (G.E. Co., U.S.) Incandescent lamps.
13,673 FRICKER. Starting and regulating electric motors.
13,690 B.T.-H. Co. (G.E. Co., U.S.) Reactive coils.
13,782 LEITNER. Electric motor-generators.
13,782A & 13,782B LEITNER. Electric motor-generators. (Date applied for, 15/6/06.)
13,795 BERRY. Electrical production of heat for cooking.
13,956 JUSTICE. (Deutsche Gasgluhlicht Akt.-Ges., Auerges). Metallic filament for glow lamps.
13,969 WENGLIN. Temporarily-acting make and-break devices for electric contact apparatus.
14,006 TUCKER. Switches.
14,058 KALLMANN. Switching devices for electric circuits.
14,060 MUIRHEAD. Hertzian wave telegraphy.
14,090 WHEATLEY. Harmonic signalling for party line telephone systems.
14,511 SCHUIL & REYROLLE. Controllers suitable for electro-motors.
14,590 FRICKER. Selecting switch mechanism.
14,608 BROCKIE. Electric arc lamps.
14,789 B.T.-H. Co. (G.E. Co., U.S.) Current supply systems for tele phone circuits.
15,135 B.T.-H. Co. (G.E. Co., U.S.) Inductor alternators and like dynamo-electric machines.

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COMPANIES' MEETINGS AND REPORTS.

ABERDEEN SUBURBAN TRAMWAYS CO.—The directors' report for the half-year to Dec. 31 states that the traffic and working expenses were £300 less on the year. Complaint is made that the company is handicapped by what the directors consider the excessive charge made by Aberdeen Corporation for electric energy, and, in view of the establishment by the company of an independent generating station, the directors recommend that no part of the balance profit (£1,699) should be distributed as dividend. A service of parcels collection and delivery has been established on the company's system.

BAKER STREET & WATERLOO RAILWAY CO.—For the half-year ended June 30 the capital expended was £54,865. Gross receipts amounted to £63,451, and working expenditure (including rates and taxes) to £42,127. The passengers carried since the opening of the railway (including estimated journeys by season ticket holders) is as follows: To June 30, 1906 (16 weeks), 3,006,276; half-year to Dec. 31 last, 6,799,895; half-year to June 30, 9,936,995. The balance of £6,744 at credit of net revenue account has been carried forward. The directors have decided to postpone the commencement of the construction of the Paddington extension, and an agreement with the Underground Electric Railways Co. of London dealing with the matter will be submitted to the shareholders.

BLACKPOOL & FLEETWOOD TRAMROAD CO.—At the meeting last week, Mr. G. Richardson said the Easter receipts showed an increase of £500, but the wet weather of June caused them to lose all the increase, and they finished the half-year with £250 less than in 1906. In the recent litigation with the Thornton Council re method of rating the tramroad passing through Thornton, the Court of Appeal held the company entitled to be rated at a quarter of the full rates, which made an annual reduction of £93. They had still two urban authorities to deal with. A dividend of 4 per cent. for the half-year was declared.

CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY CO.—The capital expenditure during the half-year ended June 30 amounted to £547,860. 9s. 10d. The work of construction having been substantially finished, the directors thought it desirable that the railway should be opened for public traffic before the final completion, and an arrangement was accordingly made with the contractors (the Underground Electric Railways Co. of London) which enabled the railway to be opened before it was handed over by the contractors. By this arrangement the contractors take all receipts and make all payments from the day of opening up to June 30, they paying the interest at the rate of 4 per cent. per annum on the issued debenture stock for the same period. The railway was opened for public traffic on June 22 last, and upwards of 140,000 people availed themselves of the directors' invitation to ride on the line free of charge. A frequent train service is being run from Charing Cross to Golders Green and from Charing Cross to Highgate. Through bookings are now in operation with the Baker Street and Waterloo, the Great Northern, Piccadilly & Brompton, the London & North-Western, the Midland, the South-Eastern & Chatham and the City & South London Railways, and on Sept. 1 next through bookings will commence with the Central London Railway. Prior to the opening of the railway Sir George S. Gibb was elected a director and chairman, and Lord George Hamilton, Sir Algernon West, G.C.B., and Mr. W. M. Acworth were elected directors.

GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.—The capital expended during the half-year ended June 30 was £165,461. Receipts on revenue account were £106,570, and working expenses (including rates and taxes) £75,794. 11,953,759 passengers were carried. There was a deficiency of £5,270 after paying rents, rent charges and interest on debentures, and this has been paid by the Underground Electric Railways Co. of London. The Holborn-to-Strand extension is nearly completed, and is expected to be opened in December. Receipts were: From passengers £100,568, season tickets £2,268, sundry £3,712, maintenance of way, &c., cost £4,311, running expenses £30,151, repairs and renewals of rolling stock £28,504, lifts £9,252, traffic expenses £18,134 and general charges £3,803.

MERSEY RAILWAY CO.—The train mileage run during the half-year ended June 30 was 411,313, compared with 412,633 in the corresponding period of 1906. The number of passengers conveyed was 5,618,462, against 5,252,867, exclusive of season ticket holders. The total receipts were £49,892, compared with £47,129; and working expenses (exclusive of charges for pumping, ventilation and lifts), £31,418 8s. 8d., equal to 62.97 per cent., against £31,119 16s. 11d., equal to 66·03 for the corresponding six months of 1906. The charges for pumping, ventilation and hydraulic lifts, amounted to £4,058 16s. 11d., equal to 8·13 per cent., compared with £3,926 3s. 9d., or 8·33 per cent. The directors regret that the appeal of Birkenhead Corporation to the House of Lords with regard to the motor omnibus service of the company resulted in the reversal of the judgment of the Court of Appeal, and the consequent stoppage of the service.

PUEBLA TRAMWAY LIGHT & POWER CO.—The control of this company has been acquired by a strong London syndicate, headed by Sir Weetman Pearson, Bart, M.P. (of S. Pearson & Son). The transaction involves the consolidation of the interests of the Anglo-Mexican Electric Co.(Ltd.) with those of the Puebla Company, all the properties of the former company, including its developed water-power plant near the city of Puebla, having been conveyed to the latter company. Sir Weetman Pearson has been elected president, and Dr. F. S. Pearson remains on the board for some time and will give the company the benefit of his advice and experience.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

HUGGETT & WORTHINGTON (LTD.) (94,634)—Reg. Aug. 19, capital £500 in £1 shares to acquire the business of electrical and mechanical engineers and contractors carried on as Huggett & Worthington, and to carry on the same and the business of manufacturers of and dealers in electrical plant, engines, fittings, apparatus, &c.

LIGHTING AND HEATING TRUST CO. (LTD.) (94,687)—Reg. Aug. 23, capital £10,000 in £1 shares, to carry on, assist in and promote lighting, heating and other industries and undertakings, to act as trustees for holders of debentures, to subscribe for, underwrite, and deal in and convert stocks, shares and securities, &c.) Registered by Wainwright, Pollock & Co., 1, Church-court, Clement's-lane, E.C.

MAGNETIC CLUTCHES (LTD.) (6,614.) Registered in Edinburgh on Aug. 24, capital £20,000 in £1 shares, to acquire from H. W. Ravenshaw, V. G. Middleton and W. E. Townsend patents for the manufacture af magnetic clutches and change-speed gears and to carry on the business of manufacturers, proprietors, agents and brokers of and dealers in motor-cars, vans, &c. First directors: J. T. Townsend, W. E. Townsend and W. Mackinnon.

MORTGAGES AND CHARGES.

D. SANTONI & CO. (1906) (LTD.)—Issue on Aug 3. of a debenture for £110, part of series created May 31, 1907, to secure £2,750, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued £2,640.

STATUTORY RETURNS.

CALLENDER'S CABLE & CONSTRUCTION CO. (LTD.)—The capital in return to June 13 gives capital as £500,000 in 60,000 ordinary and 40,000 preference shares of £5 each, of which 35,000 ordinary and 40,000 preference have been taken up. £275,000 has been paid on 15,000 ordinary and 40,000 preference, and £100,000 is considered as paid on 20,000 ordinary. Mortgages and charges, £300,000.

CHADBURN (SHIP) TELEGRAPH CO. (LTD.)—The capital in return to June 28 is £120,000 in £1 shares (60,000 preference), all of which have been taken up. £1 per share has been called up on 50,000 ordinary and 50,000 preference shares and £100,000 has been received. £20,000 is considered as paid on 10,000 preference and 10,000 ordinary. Mortgages and charges, nil.

CHEPSTOW ELECTRIC LIGHTING & POWER CO. (LTD.)—In return to Aug. 17 capital is £10,000 in £1 shares, of which 5,410 have been taken up. £1 per share has been called up on 1,505 and £1,437 has been received, leaving £68 in arrears. 3,905 shares are considered as fully paid. Mortgages and charges £1,000.

CITY OF BIRMINGHAM TRAMWAYS CO. (LTD.)—Return to May 9 gives capital as £1,000,000 in 120,000 ordinary and 80,000 preference shares of £5 each, of which 60,000 ordinary and 40,000 preference have been taken up. £5 per share has been called up on 6,047 ordinary and 40,000 preference, and £1 per share on 53,953 ordinary and £284,191 has been received, including £3 paid on three forfeited shares. Mortgages and charges £300,000.

ROBERTSON ELECTRIC LAMPS (LTD).—Return to May 28 gives capital as £50,000 in £10 shares, of which 4,500 have been taken up. £44,000 has been received and £1,000 is considered as paid. Mortgages and charges, £10,000.

ROWLAND, BARNETT & CO. (LTD).—In return to July 19th capital is £20,000 in £1 shares, of which 5,509 have been taken up. £509 has been received and £5,000 is considered as paid. Mortgages and charges, £1,346.

SOUTH AMERICAN CABLE CO. (LTD.)—Return to Aug. 6 gives capital as £500,000 in £10 shares, of which 24,707 have been taken up. £147,070 has been received and £100,000 is considered as paid. Mortgages and charges, nil.

CITY NOTES.

MEMORANDA (Aug. 29).—Bank rate 4½ per cent. (since Aug. 15, 1907). Price of silver 31¼—31$\frac{5}{16}$d. per oz. Consols 82⅜—82⅝ for money, 82½—82⅝ for account; 2¾ per cent. annuities 80¾—81¼. Consols Pay Day, Sept. 2; Stocks and Shares Continuation Days, Sept. 11 and 25; Ticket Days Sept. 12 and 26; Pay Day, Sept. 13; Mining Share Carry-over Day, Sept. 10.

CHATHAM & DISTRICT LIGHT RAILWAYS CO.—Mr. A. R. Monks presided at the meeting on Friday last, when the directors' report (abstracted in our issue of Aug. 16) was adopted.

COMPANIES STRUCK OFF THE REGISTER.—The following were struck off the Register of Joint Stock Companies on Aug. 27: Albert Electric Lighting Co., Birmingham Art Metal Co., British Electric Installation Contractors, Carboid Oil-less Bearing Co., City of Bath Electric Lighting & Eng. Co., Collier Audible Telephone Synd., Epstein Electric Accumulator Co., Fowler Insulator Synd., Home Telephone Co., International Electric Synd., Lithanode & General Electric Co., Lodge Electric Light & Power Co., London Lighting & Eng. Co., New British Electric Installation Contractors.

OLDHAM, ASHTON & HYDE ELECTRIC TRAMWAY CO. (LTD.)—The directors have declared an interim dividend of 2½ per cent.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 21	1,640	- 33	12	[18,610	- 11
Airdrie	,, 16	225	- 7	32	7,136	- 33
Anglo-Argentine	,, 27	16,192	+ 2,201	34	559,508	+ 56,803
Ashton-under-Lyne Corp	,, 17	442	+ 51	22	8,808	+ 858
	,, 24	440	+ 24			
Ayr Corporation	,, 24	420	+ 14	15	6,059	— 176
Baker St. & Waterloo Ry.	,, 24	2,070	+ 915	8	18,610	+ 8,183
Barnsley	,, 16	223	+ 24	32	5,374	+ 55
Barrow	,, 16	322	- 13	32	8,286	- 115
Bath Electric Trams, Ltd.	,, 21	950	- 135	34	26,766	- 993
Birkenhead Corporation	,, 25	1,058	- 60	...	...	...
Birmingham Corporation	,, 24	6,093	...	20	126,612	...
Birmingham & Mid.	,, 9	1,262	...	32	25,293	...
Blackburn Corporation	,, 21	1,170	+ 94	¶21	24,024	+ 1,097
Blackpool Corporation	,, 22	3,021	- 212	20	29,680	- 1,902
Blackpool and Fleetwood	,, 24	2,183	- 59	8	12,515	- 2,422
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 25	2,360	- 28	21	49,071	+ 2,657
Bournemouth Corporation	,, 21	2,672	+ 163	¶20	37,747	+ 579
Bradford Corporation	,, 24	4,995	+ 213	21	99,789	+ 508
Brighton Corporation	,, 25	1,241	- 146	21	20,823	- 2,401
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 23	5,275	+ 129	7	33,791	- 1,050
Burnley Corporation	,, 24	1,305	+ 85	21	25,021	+ 377
Burton Corporation	,, 25	330	+ 12	21	6,345	- 324
Calcutta Tramways Co.	,, 24	§45,322	† R1,881	7	§330,644	+ R25,835
Camborne-Redruth	,, 24	140	+ 3	34	4,076	+ 50
Cardiff Corporation	,, 24	2,124	- 201	21	47,327	+ 1,869
Cavehill	,, 16	86	- 23	32	2,777	+ 13
Central London Railway	,, 24	4,305	- 674	8	39,486	- 3,940
Charing C., Euston & H'stead	,, 24	2,270	...	8	20,365	...
Chatham & Dist. Lt. Rys.	,, 22	770	+ 38	‡34	24,318	+ 2,112
City & South London Rly.	,, 25	3,064	+ 779	8	23,630	† 5,260
City of Birmingham	,, 16	2,810	...	32	90,054	...
Colchester Corporation	,, 21	243	- 25	...	...	...
Cork Electric Trams Co.	,, 22	511	- 32	34	15,737	- 607
Croydon Corporation	,, 23	1,437	- 149	21	30,698	- 1,887
Devonport & Dist. Trams.	,, 16	499	- 15	32	14,766	- 148
Dover Corporation	,, 24	306	— 60	21	5,210	— 784
Dublin & Lucan Railway	,, 24	170	+ 17	8	1,244	+ 73
Dublin United	,, 23	7,627	+ 1,914	18	58,312	+ 14,228
Dudley Stourbridge	,, 16	856	- 18	32	26,811	- 778
Dundee Corporation	,, 21	1,155	+ 53	14	16,093	+ 408
East Ham Council	,, 24	925	- 56	21	19,628	- 411
Exeter Corporation	,, 23	350	+ 9	21	7,031	+ 590
Falkirk and District	,, 21	304	...	...	...	...
Gateshead & Dist. Trams.	,, 16	1,045	+ 95	32	32,444	+ 827
Glasgow Corporation	,, 24	17,200	+ 198	12	209,697	+ 2,901
Glossop	,, 24	144	...	34	4,636	+ 49
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	,, 16	287	- 3	32	7,871	- 39
Great Northern & City Rly.	,, 24	1,496	- 2	8	12,711	+ 136
Gt. Northern, Piccadilly, &c.	,, 24	3,510	...	8	31,475	...
Greenock & Port Glasgow	,, 16	717	— 95	32	21,462	- 331
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 16	327	- 16	32	9,233	- 539
Hastings Elec. Trams Co.	,, 22	1,733	+ 312	8	10,707	+ 2,987
Hong Kong	,, 24	$8,538	+ $1,114	20	$262,332	+ $36,060
Huddersfield	,, 24	1,632	+ 114	21	34,054	+ 1,444
Hull Corporation	,, 24	2,405	+ 123	21	50,542	+ 2,502
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 21	147	+ 4	21	3,061	+ 170
Ipswich Corporation	,, 24	495	- 65	21	9,131	- 749
Isle of Thanet Co.	,, 24	1,839	- 154	47	25,261	- 722
Jarrow	,, 16	129	...	32	3,940	...
Keighley Corporation	,, 22	172	+ 10	8	1,310	+ 71
Kidderminster & District	,, 16	161	+ 16	32	3,897	- 149
Kilmarnock Corporation	,, 24	146	- 7	14	2,438	- 39
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 22	1,331	+ 392	34	39,121	+ 9,612
Lancashire United	,, 21	1,555	+ 246	34	42,359	+ 10,812
Leamington	,, 16	197	...	32	5,133	- 737
Leeds Corporation	,, 17	6,410	+ 260	21	139,641	+ 5,704
	,, 24	6,737	+ 232			
Leicester Corporation	,, 24	2,124	- 111	8	17,569	- 376
Leith Corporation	,, 24	516	+ 5	†15	8,151	+ 91
Lincoln Corporation	,, 24	125	- 8	21	2,599	+ 54
Liverpool Overhead Rly.	,, 25	1,573	+ 36	8	13,833	+ 1,007
Liverpool Corporation	,, 17	11,153	+ 311	33	359,799	+ 7,353
*London County Council	,, 17	31,267	+ 6,748	20	626,914	+ 98,598
London United	,, 23	7,619	+ 175	‡34	219,304	+ 6,595
Lowestoft	,, 24	463	...	47	9,108	+ 932
Maidstone Corporation	,, 24	109	- 26	21	2,384	- 187
Manchester Corporation	,, 24	15,272	+ 489	21	313,109	+ 23,936
Mersey Railway	,, 24	1,771	+ 95	8	14,660	+ 1,171
Merthyr	,, 16	215	+ 10	32	6,748	+ 333
Metropolitan Dist. Railway	,, 25	6,606	+ 143	8	58,815	+ 470
Metropolitan Elec. Trams.	,, 16	5,217	+ 1,705	32	146,596	+ 32,560
Middleton	,, 16	389	+ 26	32	11,375	— 226
Nelson Corporation	,, 24	154	+ 4	22	3,261	+ 61
Newcastle-on-Tyne Corp.	,, 24	3,955	- 45	21	87,394	+ 491
Newport (Mon.)	,, 24	688	+ 10	21	15,311	+ 1,604
Northampton Corporation	,, 23	455	- 47	‡21	9,408	- 474
Oldham, Ashton & Hyde	,, 16	704	+ 62	32	19,452	+ 917
Oldham Corporation	,, 25	2,006	- 67	22	43,054	+ 2,626
Perth (N.B.) Corporation	,, 21	189	+ 18	14	2,464	+ 51
Perth (W.A.) Elec. Trams.	,, 23	1,285	- 53	34	43,187	- 1,611
Peterborough	,, 16	163	- 7	32	4,076	- 210
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 24	2,657	- 214	21	41,843	- 2,271
Potteries	,, 16	1,673	+ 110	32	60,427	+ 1,617
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 22	676	+ 102	‡21	12,511	+ 1,868
Rothesay	,, 16	620	- 134	32	7,314	- 602
Salford Corporation	,, 26	4,595	+ 73	21	100,006	+ 2,213
Sheerness	,, 14	94	+ 4	32	1,865	- 68
Sheffield Corporation	,, 25	5,658	+ 20	22	122,595	+ 5,264
Singapore Trams	,, 24	$9,432	+ $2,090	21	$206,465	+ $9,455
Southampton	...	...	...	...	...	...

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 5 days. ‡ Minus 2 days. § Plus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southend Corporation	Aug. 21	735	- 5	21	9,310	- 367
South Metropolitan	,, 16	1,218	+ 566	32	25,500	+ 4,343
Southport Tramways	,, 16	472	- 21	32	9,678	- 576
South Staffs	,, 16	835	+ 56	32	28,851	+ 1,963
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	...	...	...	...	...	...
Sunderland and District	,, 21	460	+ 28	34	15,262	+ 1,834
Swansea Trams	,, 16	1,070	+ 77	32	28,452	+ 1,036
Swindon Corporation	,, 14	205	+ 6	...	...	...
	,, 21	182	- 9			
Taunton	,, 16	69	- 7	32	1,406	- 97
Tynemouth and District	,, 16	422	+ 28	32	7,974	- 711
Tyneside Trams Co.	,, 21	489	+ 15	34	15,774	+ 687
Victoria, Elec. Supply Co. of	July 21	1,333	+ 50	...	...	...
Wallasey District Council	Aug. 24	946	- 47	21	18,648	+ 377
Walsall Corporation	,, 24	662	+ 101	34	17,235	- 314
Warrington Corporation	...	...	...	...	...	...
West Ham Corporation	,, 22	2,212	- 96	21	50,105	+ 1,222
Weston-super-Mare	,, 14	413	- 3	32	4,349	- 491
Wolverhampton Co.	,, 16	443	+ 21	32	14,664	+ 790
Wolverhampton Corpn.	,, 21	920	+ 3	5	4,575	+ 57
*Worcester	,, 16	349	+ 2	32	9,078	- 265
Wrexham	,, 16	108	- 8	32	3,283	- 62
Yorkshire W.R. Trams	,, 25	1,203	+ 312	34	39,062	...
Yorkshire Woollen District	,, 16	975	+ 27	32	30,950	+ 1,398

(a) These comparisons are with the corresponding period last year. Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., Aug. 28.	Rate % Yielded.	Dividend Due.	Business Week to Aug 28. Highest.	Business Week to Aug 28. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8 —8¼	4 17 0	Ap, Oct	8¼	8
5	2/9	Do. 5½ per Cent. Cum Pref.	6 —6¼	4 8 0	Ja, Jul	..	..
St.	6%	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	8 3/16—8 1/16	3 2 0	May ..	8¼	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4 7/16—5 1/16	4 18 6	My, Nv	5 1/16	5
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 —132	4 3 6	Mr, Spt	..	..
St.	5%	Do. Pref. Ord. Stock	110 —114	4 7 6	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	103 —106	4 14 6	Ja, Jul	..	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 —102	4 8 0	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4 1/16—4 1/8	3 11 9	Ap, Oct	4 1/8	..
5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4 15/16—5	5 14 0	Ap, Oct	4 15/16	4½
5	3/0	Do. "B"	4 15/16—5	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —110	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 —103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 —97	5 3 0	Ja, Jul	..	..
10	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 —103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 —105	5 14 6	Ap, Oct	10	..
5	4/6	Calcutta Tramways (1 to 137,610)	7½—8	5 0 0	Mr, Spt	..	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5 1/8—5½	4 9 0	Ja, Jul	5 1/16	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —106	4 5 0	Ja, Jul	..	..
St.	..	Cape Electric Tram Shares	15/16—1	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 —87	5 15 0	Fb, Aug	85½	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 —82	7 6 0	Ja, Jul	76	..
5	1/0	Lisbon Elec. Trams. Ord.	1 1/16—1 1/8	3 15 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 7/16—1 9/16	4 10 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb.	95 —98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 —103	4 7 6	Fb, Aug	102	..
St.	7%	Perth E. Trams. 1st Mt. Db. Stock	100 —104	4 18 0	Ja, Jul	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	113 —118	6 16 0	..	120½	115½
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92¾—94¾	5 6 3	Ju, Dec	92⅜	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½—5½	5 14 0	Mr, Spt	..	..
10	4/8⅔	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞—8½	5 16 6	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 —95	4 13 9	Ja, Jul	95¼	94
5	5,3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅞ 7⅜	5 3 3	Ap, Oct	..	..
5	2/3	Do. (80,001 to 100,000)	6¼—7¼	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 —53	4 11 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½—2¾	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	8½—9½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½ 96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 —106	5 13 0	Ja, Jul	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum, Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	3/16—3/8	3 6 9	April ..	1/16	..
1	1 2½	Do. 6 per Cent. non-Cum. Pref.	5/8—1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 —98	5 2 0	Ja, Jul	96½	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 —5½	5 9 6	Ap, Oct	5 1/16	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 —101¾	4 19 0	Ja, Jul	..	..

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., Aug. 28.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO AUG. 28. High- est.	Low- est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	†Bournemouth & Poole Elec. Sup. Ord...	9¾ - 10¾	6 10 0	Mar, Sept,	..	..
10	4/6	† Do. 4½ per Cent. Cum. Pref.	9¾ - 10¼	4 8 0	Feb, Aug	..	..
10	6/0	† Do. 6 per Cent. Cum. Second Pref. ...	10 - 10½	5 14 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	99 - 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4¾ - 5¼	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	£8 —100	4 10 0	May, Nov	..	..
5	4/6	†Brompton & Kensington Elec. Sup. Ord.	7⅞ - 8⅛	5 17 6	March	..	..
5	3.6	† Do. 7 per Cent. Pref.....	7⅞ - 8⅛	4 3 6	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	£9 - 102	3 18 0	June, Dec	112⅜	112
5	2.6	†Charing Cross(W.End & City)El.Sup.Co.	3⅛ - 4	5 11 3	Feb, Aug	3⅞	3⅜
5	2.3	† Do. 4½ per Cent. Pref.	3⅞ - 4⅛	5 9 0	Feb, Aug	3⅜	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 - 98	4 1 6	Jan, July	96	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅛ - 3⅜	6 0 0	Jan, July	3⅞	..
5	2/3	Chelsea Electric Supply Ord.	3⅛ - 4⅛	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 - 104	4 6 6	June, Dec	103	101½
10	5/0	City of London Electric Lighting Ord...	9 - 9½	6 6 0	Feb, Aug	9⅝	..
10	6.0	Do. 6 per Cent. Cum. Pref.	11 —12	5 0 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	121 —124	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 —99	4 11 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	£3 — 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	£3⅝ - 4⅛	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	7 — 8	6 5 0	Feb, Aug	7½	..
10	6 0	Do. 6 per Cent. Cum. Pref.....	10½ - 11½	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 —109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	94 - 97	4 12 6	May, Nov	95⅜	94
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜ - 5⅜	5 2 0	April, Oct	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	5 — 5½	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	£8 — 99	4 11 0	Feb, Aug	9⅛	..
5	5.0	Hove Electric Lighting Ord.	6⅞ - 7⅜	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ - 9¼	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅞ - 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	98 - 101	3 19 0	April, Oct	..	..
3	2.4⅜	London Electric Supply Ord.	1⅝ - 2	6 0 0	Mar, Sept	..	..
5	3.0	Do. 6 per Cent. Pref.	4⅜ - 5⅛	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	£2 —95	4 4 0	Jan, July	..	..
5	3.0	Metropolitan Electric Sup. Ord.	5⅜ - 6⅛	6 8 0	April, Oct	£⅜	5
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅞ - 5⅜	4 9 0	Jan, July	4⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 —107	4 4 0	June, Dec	105½	105
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	£8 - 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp.for P.D.1stMort.Db.	95 - £8%	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist.Elec.Ltg.Ord.(£9 paid)	9⅜—9⅝	4 15 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	99 - 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅛ - 6⅜	6 0 10	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5⅛ - 5⅜	4 15 3	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 - 18	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 —£9	4 11 10	Jan, July	..	..
10	6 0	Notting Hill Electric Ord.....	11 —12	7 10 0	March ..	..	..
5	4.6	Oxford Electric Ord.	£3 - 6½	5 12 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£5 - 97	4 2 6	Jan, July	..	..
5	5.0	St. James' & Pall Mall Elec. Ord.....	7⅜ - 8⅛	6 1 4	Feb, Aug	7⅜	..
5	3/6	Do. 7 per Cent. Pref.	6 — 7	5 0 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	£6 - 11	3 17 0	Jan, July	£6	..
5	..	Smithfield Markets Electric Sup. Ord...	⅜ - 1⅜	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 — 75	5 6 0	Feb, Aug	..	..
5	3.0	South London Electric Supply Ord.....	2 - 2⅜	6 0 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜ - ⅝	3 6 9	..	⅜	..
1	0.8⅜	Do. 7 per Cent. Cum. Pref.	1⅛ - 1⅜	5 7 0	Feb, Aug	1⅛	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 —103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅝ - 2⅛	8 18 0	April, Oct	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	2 - 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	£4 - 97	4 12 9	April, Oct	..	..
5	5.0	†Westminster Elec. Sup. Ord.	6⅛ - 9⅜	6 3 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 — 5⅛	4 2 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	£8 — £3	4 6 0	Jan, July	£8	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ - ⅝	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	13/16 - 15/16	5 7 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 - 98	5 2 0	April, Oct	95	£2
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 - £7	4 13 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14 —14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	£4½ - 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	£8 - 1·0	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2 - 2⅜	..	June, Dec	2⅜	..
10	6/0	† Do. 6 per Cent. Cum. Pref.....	6¼ - 7	8 10 6	Feb, Aug	6⅞	6 13/16
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 - 103	4 17 0	April, Oct	101½	100
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 —81	5 11 0	May, Nov	79½	78
St.	3%	†Central London Ordinary Stock..	71 —73	4 18 0	Feb, Aug	72	71
St.	4%	† Do. 4 per Cent. Pref. Stock	89 - 91	4 8 0	Feb, Aug	..	..
St.	..	Do. Deferred Stock	53 — 56	7 2 8	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	102 - 105	3 16 0	Jan, July	..	..
St.	4%	Charing X. Euston&Hmpstd Per.Db.Stk.	£1 —£4	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm.Pref.	4½ - 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 —101	3 19 0	April, Oct	..	..
St.	2½%	†City & South London Rly. Con. Ord. ...	45 - 47	4 15 9	Feb, Aug	46½	44½
St.	5%	† Do. 5 per Cent. Perp. Pref. (1891) ...	115 - 118	4 4 9	Feb, Aug	..	..
St.	5%	† Do. (1896)	113 - 116	4 6 0	Feb, Aug	115½	113½
St.	5%	† Do. (1901)	113 - 116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 - 105	3 16 0	May, Nov	104	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	12¾ - 13¾	4 7 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	12¾ - 13¾	4 7 0	Feb, Aug	..	..
10	0/11½	†Gt. Northern & City Rly. Pref. Ord. (4%)	1½ - 2	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 —7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 — 85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Lb. St.	93 - 101	4 9 0	April, Oct	98	..
10	9%	‡ Imperial Tramways Ord.....	11 - 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10½—11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 - £9	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 — 1½	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	£6 — 71	5 12 6	Jan, July	..	..
St.	5%	Lunes. Utd. Trams 5% Prior Lien Db. St.	£4 —97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.....	1½ - 1¾	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6⅞ - 7¼	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	£4 - 86	4 13 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	5⅜ - 5¾	5 14 8	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	£4 - 88	4 11 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 — 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 - 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	— —	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝ - ¾	5 3 0	Feb, Aug	£	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	£4 — 97	4 13 0	Jan, July	..	..
..	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾ - 1⅛	..	May	..	..
1	0/9⅜	Potteries Electric Traction Ord.	15/16 - ⅞	7 3 0	April, Oct	..	..
1	0.6	† Do. 5 per Cent. Cum. Pref.	½ - ⅝	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock	95 - £8	4 11 9	May, Nov	..	..
1	0/3	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅞—1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£0 —84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	£4 —£8	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London...	55 — 58	8 12 0	June, Dec	56	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 — 1½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2¼ - 3⅝	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	£7 —50	5 0 0	Jan, July	..	..
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅝ - ¾	..	..	..	..
1	0.7½	Do. 6% Cum. Pf.	¾ - 1	8 16 0	April, Oct	..	..
1	9/4⅝	Babcock & Wilcox Ord.....	£3⅝—£4	5 0 0	April, Oct	3¾	3⅝
1	0/7⅛	Do. Pref.....	1⅛ - 1⅜	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	£6⅜—7⅛	6 18 0	July, Feb	7⅛	..
5	3/0	Do. 6 per Cent. Pref.	£5⅝ - 6¼	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 —104	4 6 6	Jan, July	103½	..
St.	4½%	British Thom's'n-Houst'n 4½% 1st Mt.Db.	£7 - 91	4 19 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 — 1½	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	£9 — 64	6 5 0	Jan, July	..	..
2	..	Brush Electrical Engineering	⅛ - ⅜	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅞ - 1⅛	5 7 0	Mar, Sept	..	..
St.	4½	Do. 4½ per Cent. Perp. 1st Deb. Stock	£9 — 91	4 19 0	Mar, Sept	..	..
St.	4½	Do. Perpetual 2nd Deb. Stock	71 —74	6 0 9	Jan, July	..	..
5	10.0	Callender's Cable Con. Ord.	9⅜ - 10⅜	6 19 0	Jan, July	10⅛	10⅛
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼ - 5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105½—107½	4 3 6	Nov, May	105½	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅛—1⅜	5 12 6	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	95 —100	4 10 0	Feb. Aug	..	..
1	1/2⅝	Chadburn's (Ship) Telegraph Ord.	1¼ - 1½	8 0 0	March ..	1⅜	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅜	5 7 0	April, Oct	1	..
3	1/-	* Crompton & Co. (Nos. 1 to 56,000)	1¾ - 2⅜	7 1 0	Jan, July	2⅛	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	94 —97	5 3 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝—1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅜	4 16 0	Sept	1⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 - 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1⅜—1⅝	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼—2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 — 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 —92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½—1	10 0 0	Jan, July	⅜	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1½ - 2	..	May, Nov	1⅞	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 — 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜—⅝	..	Jan, July	⅜	⅛
2	..	Do. 7 per Cent. Cum. Pref.	1⅛—1⅜	..	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 — 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 — 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 — 95	4 4 0	Mar, Sept	..	..
£	10/0	Henley's Telegraph Works Ord.....	11½ - 12¾	6 0 0	Feb, Aug	12⅜	11⅞
5	2/3	Do. 4½ per Cent. Pref.	5 — 5½	4 2 0	Feb, Aug	5½	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½—107½	4 3 6	Mar, Sept	105⅝	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14⅝—15½	6 9 0	Feb, Aug	14⅞	14¼
10	4%	Do. 4 per Cent. Debs. (red.).....	97 —99	4 1 0	April. Oct	98	97
1	1/2⅜	Richardsons, Westgarth & Co., Ltd. Ord.	⅞—1	7 14 0	Nov	⅞	..
1	0/7⅛	Do. 6 per Cent. Cum. Pref.	⅝—¾	6 4 0	May, Nov	¾	..
St.	4½%	Jo. 4½ per Cent. Perp. Deb. Stock ...	93 —£6	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1½	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	31 —32	5 10 6	Mar, July	31½	..
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	£9¼—102½	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅝ - 2⅞	6 7 6	..	2⅝	2⅝
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛—1⅜	4 4 6	..	1⅜	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 6	..	..	111
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 —104	3 17 0	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	100 - 103	4 3 3	June, Dec	..	..
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9½—9¾	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	1½—1¾	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3¾—4¼	..	Apr, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 —80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 —3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 —88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	60 —62	6 3 0	F,My,Ag,N	6⅞	..
St.	30/0	Do. Preferred	105½—106½	5 12 6	F,My,Ag,N	106⅛	105½
St.	13⅞	Do. Deferred	17½—17¾	8 0 0	F,My,Ag,N	17⅝	16½
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 —94	4 4 6	Jn,Ap,Jy,O	93½	92¾
10	5/0	Cuba Submarine Ord.....	7 — 8	6 5 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞—16¾	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜—3⅝	5 10 6	April, Oct	3½	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 - 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100%-103%	4 7 3	Jan, July	..	..
20	6/6	Direct United States Cable	14¾—15	6 4 0	Ja,Ap,Jy,O	14⅞	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99½—101½	4 8 6	June, Dec	..	..
St.	25/0	Eastern Ordinary	132 —137	5 2 6	Ja,Ap,Jy,O	134½	132
St.	17/6	Do. 3½ per Cent. Pref. Stock	86 —88	3 19 6	Ja,Ap,Jy,O	87½	87½
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 16 6	May, Nov	..	..
10	2/6	Eastern Extension	17⅞ - 18	5 4 6	Ja,Ap,Jy,O	18⅛	12⅜
St.	4%	Do. 4 per Cent. Deb. Stock	102 —104	3 17 0	Feb, Aug	102⅜	102
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 —100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ..	9 ½%-10 1/4%	4 1 0	May, Nov	..	..
10	5.0	G.N. (of Copenhagen), with Coupon 71...	£4 —£6	6 19 0	Jan, July	34⅛	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99¼—101¼	4 8 6	June, Dec	..	..
25	£2/6	Indo-European	56 — 58	5 12 0	May, Nov	..	..
100	£1	Mackay Companies Common	£6 — £8	5 18 6	Jan, July	..	..
100	£1	Do. Preference	67 —£9	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅞—1	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Debs. (red.)	98 —100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 —10½	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅜ - 1⅝	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	1/16 - 3/16	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7¼ - 7⅝	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅞ - 7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 —102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	13 —13½	5 6 0	Mr,Jn,O.D	13⅜	13
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 —103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 —92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	101 —104	4 16 0	Mar, Sept	..	..
5	1.0	Chili Telephone	6¾—7¼	5 10 6	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	⅜—1/16	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾—1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	105½—106½	5 13 0	Feb, Aug	107	106½
St.	6%	Do. Def. Stock.....	105 —107	5 12 0	Feb, Aug	106	105
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11 —13	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛—5⅞	4 12 0	Feb, Aug	5⅞	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	96½—97½	3 12 0	June, Dec	96⅞	96½
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 —103	3 17 6	Jan, July	101⅝	101½
1	0/9⅜	Oriental	1⅛—1⅜	5 2 0	April, Oct	..	..
1	0/7⅛	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 —94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	98 —101	4 9 0	Jan, July	..	..
5	1/0	United River Plate.....	6¾—7⅛	6 18 0	July	6¾	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5½	4 11 0	June, Dec	5	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	8¾—4¾	6 6 3	Jan, July	..	..
10	6.2	Globe Telegraph & Trust.....	10½ - 10¾	5 2 6	Ja,Ap,Jy,O	10¾	10½
10	4/0	Do. 6 per Cent. Pref.....	13⅜—13⅝	4 8 0	Ja,Ap,Jy,O	13⅝	13½
10	6%	Submarine Cables Trust (Cert.).....	127 —130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. †, Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

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NOTES.

Internal Forces in Conductors Carrying Currents.

IT is not often that commercial experiments bring to light elementary facts requiring scientific explanation, for generally the elementary facts, at least of electricity and magnetism, have been fully studied in the laboratory, or effects have been indicated by theory and have been subsequently found by careful experiment. A recent exception, however, is the observation by CARL HERING that the charge in an electric resistance furnace cannot be heated above a certain point, depending upon the proportions of the furnace, owing to a tendency for the fluid to form into the shape of a trough, the direction of the trough being transverse to that of the current, thus reducing the cross-section until finally the circuit is broken. This effect, which he called the "pinch phenomenon," has aroused a good deal of interest, because it showed that conductors, when carrying currents, are possibly subject to certain forces tending to make them contract. That such should be the case is not difficult to understand if we regard the conductor as consisting of filaments. Since the days of AMPÈRE the attraction of two parallel conductors carrying currents in the same direction has been a familiar fact. In a conductor consisting of filaments these will tend to attract one another, and if the conductor is a liquid and the current density is sufficiently high, the contraction will be sufficient to break the circuit. The familiar conception of a magnetic line of force acting as an elastic band gives a mental picture in the same direction. Elsewhere we give an account of some interesting experiments by Mr. P. BARY upon this subject, showing that the effect may even account for the "singing arc," and in our next issue we hope to give an abstract of an article by Mr. E. F. NORTHRUP dealing with the subject from a somewhat different point of view.

Electric Cranes.

ELECTRIC cranes afford a good instance of the unexpected changes sometimes brought about by the applications of electricity. Less than 20 years ago Lord ARMSTRONG expressed the opinion that, as regards "safety, controllability and adaptability to various purposes, electricity had little chance of ever rising to the level of hydraulic power." But since that time there has been a marked change of ideas, and electrical engineering has invaded a well-established branch of engineering which used to be exclusively in the hands of hydraulic engineers. There can be no question of advance when such important docks as those at Hamburg, Rotterdam, Antwerp, Genoa and Glasgow adopt electric cranes in preference to the older form of operation. This advance, no doubt, is due to the advantages, among others, of flexibility, ease of working, and freedom from trouble during times of frost, which are all possessed by the electric crane. Probably, not the least important point is the fact that a public electricity supply is usually available, whereas plant for hydraulic supply must generally be put down for the special purpose. When, on the other hand, overhead travelling cranes are considered, there is a marked advantage in the electric drive over the older form of rope driving and square shafts. Although great progress has been made, it is noticeable that the literature on the subject is not extensive, and, moreover, it is very scattered. On this account, we do not doubt that our readers will appreciate the series of articles, of which the first appears in our present issue, due to Mr. H. H. BROUGHTON, who has given a great deal of attention to the subject.

Supply in Bulk.

ALTHOUGH the power load is essentially the kind of load which a power company desires to have, the ordinary light-

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ing load is not to be despised if it can be obtained at a suitable price; in fact, there is no doubt that a good deal of development is possible by cultivating this kind of supply, not only for the power company but for electrical applications generally in the smaller towns. There are many towns which are not sufficiently large to bear the comparatively heavy capital expenditure of a generating station, and the high cost per unit where the output is somewhat small. In such cases the power company is at a great advantage, and there is much to be said in favour of a supply in bulk. This point is evidently being realised at the present time in Yorkshire, for the Yorkshire Electric Power Co. is now supplying in bulk 11 electric light undertakings and is negotiating with several others. The latest example is Brighouse, in which the local electricity works is to be discarded, and a supply is to be taken for light and tramways at a charge of £6 per annum per kilowatt of maximum demand, and a further charge of ¼d. per unit, subject, however, to the proviso that the charge shall not exceed 1·25d. per unit.

Street Lighting.

A CONSIDERABLE amount of information on most subjects pertaining to electricity supply must have been collected during the last few years by means of series of questions sent round by municipal electrical engineers to their confrères in other towns. Most of this information never becomes public, and we were, therefore, very pleased to receive a copy of the tabulated answers, in reply to questions in regard to public lighting, issued by Mr. F. TEAGUE, city electrical engineer of Bath. We summarise briefly, in another column of our Notes, the contents of the tabulated replies. As might be expected, a considerable variation is shown between the statistics given for different towns. For example, the number of lamps trimmed and cleaned per day per man varies from 30 to an unexplained figure of 100. At the present time when the competition between electricity and gas for street lighting is so very keen, it is specially important that arc lamps used for public lighting should be maintained in as efficient a state as possible. Arc lamp columns have the advantage of being more artistic than any gas standards yet devised, but dirty or badly illuminated arc lamp globes are very conspicuous, and are more noticeable than broken gas mantles. Even when the lamps are properly adjusted as regards voltage, careless centring of the carbons or worn guides may cause a poor and unsteady light; and we are sure that in many cases much more might be done, both in the way of keeping the globes clean and in the more careful adjustment of the lamps. Moreover, too much attention cannot be paid to the maintenance of street lighting in as efficient a condition as possible, for it is then one of the best advertisements an electricity supply station can have.

Effect of Electricity on Plants.

THE Paper by Mr. J. H. PRIESTLEY, of which we give an abstract elsewhere, gives an interesting account of the work being carried out by Mr. NEWMAN on the lines of the late Prof. LEMSTROM. Generally speaking the results have been satisfactory, the increase on various crops ranging from 15 to 80 per cent., though certain plants seem unaffected; and the experiments have probably been on a sufficiently large scale to be of agricultural value. Apart from any practical interest—and we scarcely anticipate that the extended use of the method will give rise to a large power load, though it may lead to the further development of influence machines—the mode in which electricity has a stimulating effect is of considerable interest. One naturally thinks of electric osmosis, and of the production of nitrates in the atmosphere by the discharge, as possible explanations of the increased growth, but so far no definite conclusions have been reached.

Wireless Telegraphy in the Navy.

IT is interesting to note that wireless telegraphy in the British Navy has now so far developed that the Admiralty have thought well to establish a separate branch for its operation. As we give elsewhere particulars of the circular issued by the Admiralty in this connection, we need only say that the new branch will deal exclusively with wireless telegraph matters and will be quite distinct from the visual signalling branch, so that the newer form of signalling will no doubt develop untrammelled.

American Railway Electrification.—It is reported that the Southern Pacific Railway has prepared plans for the electrification of 136 miles of their line in Colorado, running over the Sierra Madre Mountains.

Personal.—It is announced that M. Becquerel has been appointed president of the Commission Technique Interministérielle, formed to report on the organisation of the wireless telegraph service.

Electric Lighting in Paris.—The *Westminster Gazette* reports that the arrangements, whereby the electric lighting companies of Paris are to be combined in one large corporation, have now been concluded, and, with the co-operation of the civic authorities and the assent of the Council of State, there is being formed what will be known as the Compagnie Parisienne de Distribution d'Electricité, which is expected to produce beneficial results to the shareholders and to more completely satisfy the needs of users. The new undertaking will be capitalised at 50,000,000fr. (£2,000,000). A couple of months will, it is believed, see the organisation entirely completed and in full work.

Electric Traction in America.—The *Railway and Engineering Review* reports an extensive project for the utilisation of hydro-electric power by the Chicago, Milwaukee & St. Paul Railway. The scheme contemplates the development of 180,000 H.P. from the river, a part of which will be used as motive power on the adjacent sections of the railroad. That portion of the line is one of recurring tunnels, the aggregate being 10,000 ft. in 150 miles of line. The electrification project, therefore, offers the advantage of dispensing with steam power in the tunnels as well as of concentrating great power at the heavy gradients. It is stated that definite plans have been formulated for the hydro-electric works, for which three dams will be built at available sites in the river. After the requirements of motive power for the road are supplied, a considerable surplus of electric power will be at hand to be used in the operation of saw mills and for other purposes tending to the industrial development of the territory.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Brest—Dakar	July 22, 1907 ..	—
Kotonou—Libreville	July 18, 1907 ..	—
Maranham—Ceara.....	Aug. 21, 1907 ..	Sept. 2, 1907
Medan—Olehleh.....	Aug. 21, 1907 ..	Sept. 2, 1907

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New Tramcar Indicator.—An ingenious device for automatically announcing streets and points of interest when passed by a car has recently been invented by Mr. P. J. Mann, and is described in the *Street Railway Journal*. The indicator is mounted in the centre of the car, where it can be seen by all the passengers. It gives the name of the street the car is approaching and also affords a large space that can be devoted to advertising. A great advantage is always to have the name of the next street before the passengers. This saves much work for the conductor and not a little annoyance to the passengers. The indicator is operated by a small motor controlled by a shoe placed just inside the rail at each block.

Production of Undamped Oscillations.—A recently patented invention, due to Dr. H. Manders, has for its object the modification of the Poulsen arc in such a way that the production of oscillations shall be free from the inconveniences caused by the hydrogen atmosphere. The inventor has discovered that hydrogen may be dispensed with, provided that the electrodes between which the arc is formed are composed of certain conducting materials. The electrodes must also have a definite disposition as regards the current flowing in the circuit in which they are placed. His experiments have shown that the best effects are produced when the material of the electrode forming the cathode is of lower atomic weight than that composing the electrode which forms the anode. The best material of which to form the cathode is aluminium or its alloys, especially the white alloy known as romanium. To form the anode either zinc, silver, cobalt, nickel, copper or iron is used, or alloys of these metals, either with one or several of the others, or with other metals possessing a higher atomic weight than the metal, or principal metal—if an alloy—of the cathode. The combination of aluminium, as cathode, with zinc, as anode, gives the best results, and with the other metals respectively mentioned above as anodes the efficiency is in the order there given.

Theory of Nernst and the P.D. at the Contact of Two Electrolytes.—Suppose any two solutions, L_1 and L_2, which have a common anion, and into which dip two electrodes of mercury covered with a mercurous salt, form a cell; then the difference of E.M.F. at the contact of the electrodes is

$$e = \frac{RT}{\epsilon p} \log \frac{\omega_1}{\omega_2},$$

the total E.M.F. of the cell being

$$E = \frac{RT}{\epsilon p} \log \frac{\omega_1}{\omega_2} + \frac{L_1}{L_2}.$$

With equal concentration the osmotic pressures ω_1 and ω become equal, and the final equation reduces to $E = L_1/L_2$ This gives a very useful method of measuring P.D.s between electrolytes of the same molecular concentration which possess a common anion. In a recent number of the *Comptes Rendus*, Messrs. Guyot and Lippmann give determinations on a number of sulphate solutions, the cation being in each case a monovalent element, such as sodium. By taking into account the degree of dissociation of the various salts very good agreement was obtained between the actual measurements and the calculated values. These results do not altogether agree with those previously obtained by Negbaur, but it is probable that this author has made assumptions requiring more detailed investigation.

Public Electric Lighting.—We have received from Mr. Francis Teague, electrical engineer to the Bath Corporation, a table of replies received from 41 municipal electrical engineers in reference to public lighting. As regards the number of lamps used, it is noticeable that incandescent lamps vary very much in favour with the different engineers. In many districts no incandescent lamps are used, or, at most, very few, whereas in certain towns the number is comparatively large. Thus, at Blackburn, Blackpool, Brighton, Derby and Fulham, the number of glow lamp groups, including Nernsts, amounts to 470, 695, 1,745, 800 and 483 respectively, these figures referring to standards. In passing to the particulars given of arc lamps, it is noticeable that a good many engineers seem reluctant to give the flame arc lamp a trial. Among the exceptions may be mentioned Hackney, where 105 flame arc lamps are being erected, and where it is found that only one extra trimmer will be required for these lamps, because of the better lamp routes that can be arranged, and because the lamps have magazines. In Hastings also 105 flame arc lamps have been fixed, replacing ordinary arcs, and are giving complete satisfaction. It is noticeable that ladders and towers are still very frequently used in trimming, and at Leith raising and lowering gear has been tried, but has been abandoned. On the other hand, at Hampstead such gear has been found to be a great advantage; for lamps, globes, &c., have received better attention, and there is a great saving in time. At Dublin, also, lowering gear has been found much cheaper than ladders. A number of particulars are given as to superintendents, the number and wages of trimmers and the number of arc lamps trimmed per day. Trimmers sometimes receive a bonus—for example, at Bath, Folkestone and Islington—if the lamps burn satisfactorily. There seems to be no recognised rule as to holidays for trimmers, as these vary from nothing up to 14 days. It is interesting to note that at Newport the trimmers also trim about 70 flame arc lamps for private consumers, and at Nottingham all trimming and repairing is carried out by contract by a local contractor, which is found to be cheaper than the usual method of handling the work by the electricity department itself.

Wireless Telegraph Notes.—The first introduction of wireless telegraphy on the stage is to be credited to Mr. Arthur Collins, of Drury Lane Theatre, London, who, in a new play by Messrs. Raleigh and Hamilton, entitled "The Sins of Society," will utilise the wireless telegraph in one of the chief scenes. Wireless telegraphy has very often figured in fiction, but this is the first time, to our knowledge, that it has been presented in the "legitimate" playhouse.

It is reported that the Admiralty have ordered all destroyers to be equipped with wireless telegraph apparatus. At least 80 boats will thus be fitted out in the dockyards, and installations will be supplied to those boats now under construction.

It was reported last week that Sir Wilfrid Laurier had intervened in the dispute between the Canadian Marconi Wireless Telegraph Co. and Mr. Templeman, the acting Minister of Marine. The Premier advises the company to accept provisionally the licence now offered, on condition that it would not prejudice them in connection with any future licences. He also stated that the Government were willing for the points at issue to be decided in the Courts. The Company are stated to have replied that they cannot agree to any conditions adversely affecting their patents or contracts.

It is stated that the Lords Commissioners of the Admiralty have issued a circular letter directing the officers commanding such vessels of the Navy as are equipped with wireless telegraph apparatus to send meteorological reports when they can conveniently communicate with certain of the wireless stations on shore.

The second Commission at the Hague Conference has been discussing the proposed new regulations relative to neutral States and their subjects. The first two articles have already been adopted. Article 3 forbids a belligerent to erect upon neutral territory wireless telegraphic or any other apparatus intended to enable the belligerent to communicate with his armed forces or fleet. Nor is the belligerent to be allowed to utilise any such apparatus which he may have erected on neutral territory before the outbreak of war. Articles 8 and 9 declare that a neutral state need not restrict the employment of telegraph and telephone wires and wireless telegraphy in their territory in the interest of belligerents, while at the same time enjoining uniform treatment of belligerents in the event of such restrictions. It is announced that Great Britain reserved her decision on articles 3 and 8.

It is reported that the wireless telegraph station at Dunnet Head, in Caithness, is now ready for the reception and transmission of messages by the Marconi system.

ARRANGEMENTS FOR THE WEEK.

SATURDAY, September 7th.

JUNIOR INSTITUTION OF ENGINEERS.

3 p.m. Visit to the Works of the Metropolitan Water Board, Hampton-on-Thames.

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ELECTRIC CRANES.*

BY H. H. BROUGHTON.

In an interesting Paper on "The Modern Equipment of Docks, with special reference to Hydraulic and Electric Appliances," read at the Engineering Conference of the Institution of Civil Engineers,† Mr. Walter Pitt reminds us that less than 20 years ago Lord Armstrong, speaking in a discussion at the Institution of Civil Engineers,‡ said he "felt satisfied that in point of safety, controllability, and adaptability to various purposes, electricity had little chance of ever rising to the level of hydraulic power." Hydraulic engineers have accumulated a large amount of valuable data, and appliances worked by hydraulic power have reached such a state of mechanical perfection that further improvements and economies can only be effected by adopting another motive power. The hydraulic and electric are the only two practicable systems of power transmission available for dock appliances. During the last 15 years considerable improvements in the design and construction of electric machinery have been effected. To quote from the *Engineer*: "In a few short years the electric motor has jumped from the sealing-wax and string stage into a convenient and trustworthy piece of mechanism." At the present time engineers are beginning to recognise the insuperable advantages of electric power transmission over the hydraulic system. On every hand we find installations being remodelled in favour of electric driving. Instances are furnished by the docks of Hamburg, Rotterdam, Antwerp, Cologne, Copenhagen, Genoa, Bremen, Barcelona, Amsterdam, Capetown, East London, Naples, Glasgow, Heysham, Middlesbrough and many others. A large number of dock-owners and railway companies in England are putting down electric installations, and new docks and works are, almost without exception, being fitted with electrically driven cranes, capstans, coal-hoists, lifts and tips.

The rapid development of the electric crane is in large measure due to the application of electric power to steel-works plant and machine tools.

Owing to the ever-increasing competition most engineers are nowadays compelled to reduce the cost of manufacture in order to maintain their position in the market, and a recognised means for attaining that end is by using suitable transporting and conveying plant of modern design.

Cranes can be divided broadly into two distinct classes, viz.: Fixed cranes and travelling cranes. The former can be subdivided into two types, namely, (*a*) constant radius and (*b*) variable radius. Travelling cranes can be subdivided into five distinct types, depending on the arrangement of the travelling carriage or bogie and the location of the track.

There are several designs for each type, and each design is particularly suited to a certain class of work. A summary of the various types is given in Table I.

In the early days of electric driving it was customary to convert square-shaft and rope-driven workshop cranes into electrically driven cranes by fixing a single motor on the crane, the hoisting, traversing and travelling motions being effected by means of open and crossed belts, or clutches, operated from the attendant's cabin or from the ground. The working speeds had to be kept at a low value, in order to prevent sudden and inconvenient jerking when the clutches operated. The construction was mechanically complicated on account of the several motions being derived from a single motor, and the efficiency was very low.

In order to take full advantage of the then new method of driving, it was quickly recognised that a separate motor for each motion would be required, and the first fully equipped multi-motor crane was put into service about 15 years ago.

Emboldened by their success, designers, with the help of the user, have from time to time introduced various improvements. Amongst these may be mentioned, (*a*) the independent auxiliary hoist fitted on heavy cranes for economically handling light loads, (*b*) the mechanical brake with electric release, (*c*) the rheostatic or electric brake, (*d*) series-parallel control of the motors driving the hoisting and travelling gears, (*e*) the auxiliary bogie, (*f*) the moving turn-table, (*g*) the electric turning tackle for forging, (*h*) the free-barrel system.

After enumerating the advantages of electrically driven cranes and a few remarks on hydraulic versus electric systems by way of introduction, we propose to discuss the electrical and mechanical arrangements which are common to all types of electric cranes. By so doing it is hoped that the reader will be better able to understand and appreciate the designs to follow, illustrating the construction and arrangement of the various types.

Advantages of Electrically Driven Cranes.—Amongst the advantages of electric cranes, compared with hydraulic and other cranes, are the following:—

(1) The power plant can be centralised, enabling the most favourable possible conditions to be chosen for the cheap generation of power in bulk. The station can be located where land is cheap, and where coal and water are cheapest and easiest to handle. Large generating units of high efficiency can be laid down.

(2) A high load factor can be secured, and works costs reduced by combining a lighting scheme with the power scheme.

(3) The high efficiency of electrical power transmission to all points, and the relatively low cost of power mains. The mains, moreover, require very little attention. The connections to cranes, coal-hoists, capstans, &c., can be readily made or unmade in any place required, and the whole scheme admits of almost indefinite extension without difficulty.

(4) High efficiency at full load and under varying loads, the power required being practically proportional to the work done whether the crane is working at full load or light load.

(5) The great flexibility of the system and range of speeds obtainable; the accuracy of speed regulation; the rapidity of all the crane movements; ease of starting up the cranes and comparatively noiseless working.

(6) With proper attention the machinery is perfectly reliable, and, unlike hydraulic machinery, remains unaffected by frost.

(7) The action of electrical machinery can be made in large measure automatic, so that mistakes or uneconomical handling on the part of the attendant are avoided.

(8) Breakdowns cannot, as a rule, affect more than one machine. The few parts likely to go wrong require but a small number of spares, and repairs can be quickly effected at low cost.

(9) The general adaptability of electricity is incomparably greater than that of any other known power.

(10) If required, power can usually be obtained in all large towns at a cost of less than 1d. per unit.

An idea of the inefficiency of the hydraulic system of power transmission, from the £ s. d. standpoint, will be gathered from the following particulars taken from a Paper on the Coal Shipping Appliances at the Bute Docks.* The

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† Minutes of *Proceedings* Inst. Civil Engineers, June, 1903.

‡ *Ibid.*, 1888, Vol. XCIV., p. 64.

* Minutes of *Proceedings* Inst. Mechanical Engineers, July, 1906.

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Table I.—*Summary of the Various Types of Electric Cranes.*

Class.	Type.	Construction.
Fixed	Constant radius ...	Revolving jib, single or double cantilever.
Ditto	Variable ditto ...	Ditto ditto ditto
Travelling	Constant ditto ...	Ditto ditto ditto
Ditto	Variable ditto ...	Ditto ditto ditto
Ditto	Gantry or Goliath	Jib or cantilever, with fixed radius and fixed turn-table.
Ditto	Ditto ditto	Ditto ditto variable ditto ditto
Ditto	Ditto ditto	Ditto ditto fixed radius and movable turn-table.
Ditto	Ditto ditto	Ditto ditto variable ditto ditto
Ditto	Ditto or bridge ..	With or without sin. or dbl. cantilever extensions, and one or more bogies.
Ditto	Ditto ditto	With fixed or movable turn-table.
Ditto	Cross girder.....	One, or more, bogies. Elevated runway.
Ditto	Ditto	Ditto ditto with turn-table.
Ditto	Ditto	Swing jib on fixed bogie turn table.
Ditto	Ditto	Ditto movable ditto
Ditto	Ditto	Revolving jib, single or double cantilever, constant radius, movable bogie.
Ditto	Ditto	Ditto ditto ditto variable ditto

motive power for working the whole of the hydraulic coal-hoists, cranes, capstans, gates, sluices, &c., at the docks is supplied by 13 hydraulic pumping engines. The indicated horse-power is as follows :—

No. 1 Engine..	..	80 I.H.P.	No. 8 Engine..	..	150 I.H.P.
2 ,, ..	..	80 ,,	9 ,, ..	..	80 ,,
3 ,, ..	..	80 ,,	10 ,, ..	..	150 ,,
4 ,, ..	..	80 ,,	11 ,, ..	..	225 ,,
5 ,, ..	..	125 ,,	12 ,, ..	..	225 ,,
6 ,, ..	..	125 ,,	13 ,, ..	..	225 ,,
7 ,, ..	..	150 ,,			

The pumping engines, in groups of two or three, are installed in six suitably situated power-houses. The total indicated horse-power of the engines is 1,775. The Author was unable to obtain any information as to the total cost per horse-power hour delivered at the cranes, or as to the load-factor of the plant, but from what he saw he believes that the former was unreasonably high and the latter abominably low.

All the published comparative tests of electric and hydraulic cranes working under exactly similar conditions show the superiority of the electric crane. Probably the most complete comparative tests that have yet been carried out were made during 1902-3 at Clydebank Dock, Glasgow, by Mr. G. H. Baxter, mechanical engineer to the Clyde Navigation. Mr. Pitt, in his paper previously referred to, gave a synopsis of the figures obtained, but, in view of the interest attaching to the results of the tests, and through the courtesy of Mr. Baxter, we give below detailed particulars of the tests.

Crane Tests.

The tests carried out on March 19 and 20, 1903, were made on a hydraulic and electric crane to ascertain :—

1. The rapidity of working of both types.
2. Their efficiencies.
3. The cost of power used in doing the same amount of work (viz., to raise 30 ft., slew 100 deg., and discharge into wagons 1,000 tons of cargo and 1,000 tons of ore, when working with loads varying from 1 to 3 tons for cargo and at 2½ and 3 tons for ore).

Particulars of Cranes.—The hydraulic crane tested was a compound 5 ton and 3 ton, with a rake of 41 ft. and a range of lift of 75 ft. The 3-ton hoisting ram which was used has a diameter of 11 in. and displaces 0·66 cub. ft. of water per foot of travel, or 0·11 cub. ft. per foot of hoist, the velocity ratio being 1 to 6. The slewing ram of 9 in. diameter travels 15½ in. and uses 0·57 cub. ft. of water in slewing through 100 degrees.

The crane was fitted with meters intended to accurately measure the quantity of water used, but, as it was found that these had a tendency to choke the exhaust and retard the speed of working, it was decided to measure the water used by the displacement of the rams and allow 5 per cent. for slip and leakage. Pressure gauges were fitted on the main pressure pipe at the hydrant connected to the crane, and also to the upper parts of the hoisting and slewing cylinders, and the pressure noted at each lift. The pressure in the hydraulic mains was maintained at 750 lb. per square inch.

The electric crane was suitable for a maximum load of 3 tons, with a rake of 41 ft. and a range of lift of 80 ft. The hoisting gear was single reduction and worked by a slow-speed series-wound motor of 50 B.H.P. output at 240 volts. A 10 H.P. motor was fitted for the slewing motion.

Throughout the trials the cranes worked satisfactorily, except at the 3-ton load, when the brake heated after a quarter of an hour's working; but it should be noted that lowering the loaded bucket 30 ft. at the number of cycles per hour performed at this test was considerably more than would occur in working minerals or general cargo, as the buckets could not be filled so fast.

The crane was equipped with Siemens volt and ampere meters, and also with Chamberlain and Hookham's integrating wattmeters, which were overhauled and calibrated before the tests were commenced.

In testing for rapidity of working, each crane was provided with two tipping buckets, one for the load and one for the empty bucket, and, for convenience, the tests were carried out to specific instructions in double cycles, working the cranes as rapidly as possible for two hours under each separate load of 1 ton, 2 tons, 2½ tons, and 3 tons, in such a way as to imitate as nearly as possible actual conditions of working, without being subjected to the delays so frequently experienced in discharging ore or general cargoes.

For this purpose a mean lift of 30 ft. and a slewing angle of 100 deg. was decided on, being the most convenient height for testing both cranes, and the angle of turning obtaining in general practice. The cycle of operations therefore consisted in :—

1. Lifting the load 30 ft.
2. Slewing the load ashore through 100 deg.
3. Lowering the load 10 ft., discharging the load into wagons.
4. Raising the empty bucket 10 ft.
5. Slewing the empty bucket aboard through 100 deg.
6. Lowering the empty bucket 30 ft.

*Comparative Cost of Hydraulic and Electric Power.**

Period.	Cost per Horse-power Hour.		Comparative Cost of Power.	
	Hydraulic.	Electric.	Hydraulic.	Electric.
	Pence.	Pence.	Per Cent.	Per Cent.
12 months ending 30th June, 1902	3·248	2·373	100	73·06
6 months ending 31st Dec., 1902	2·532	2·030	100	80·17

In making up the working costs, the capital expenditure and working costs were taken from the annual accounts, and embrace all the capital expended up to the end of 1902 on buildings, foundations, culvert, machinery, and plant, divided into separate parts as follows :—

Hydraulic Power.—1. The cost of all buildings, foundations, culverts, machinery, and plant used in its production up to the discharge branches of the accumulators, where the water is delivered into the mains.

* For the electric transmission a drop of 6 per cent. in voltage is calculated, for the hydraulic transmission a useful effect of 80 per cent.

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Table II.—*Results of Tests of 3-ton Hydraulic Crane worked as if Discharging General Cargo.*

Loads (W)	1 ton.	2 tons.	2½ tons.	3 tons.
Duration of trial ..... hours	2	2	2	2
Pressure in mains ..... lbs. per sq. in.	750	750	750	750
Ditto on ram, hoisting ..... ditto	240	400	480	560
Ditto ditto lowering ..... ditto	140	300	380	460
Ditto ditto slewing to windward ..... ditto	500	500	500	500
Ditto ditto ditto to leeward ..... ditto	350	350	350	350
	56	54	52	38
1. *Number of Cycles per Hour* :—				
Time raising load 30 ft. (T) ..... seconds	7·5	8·57	9·25	10
Speed of hoisting loads (S) $=\frac{30\times60}{T}$ ft. per min	240	210	194·6	180
Horse-power, by load (L.H.P.) $=W\times S$, 33,000	16·29	28·51	33	36 65
Horse-power, by water (W.H.P.) $=\frac{95\times750\times S}{33{,}000\times6}$	86·36	75·56	70	64·77
2. *Mechanical Efficiency* (hoisting only) % $=100\times$ L.H.P./W.H.P.	18·87	37·73	47·14	56·6
Cargo discharged per hour (allowing for empty bucket 0·35 × 10/30 tons)	1·116 × 56	2·116 × 54	2·616 × 52	3·116 × 38
	62·5	114	136	118·5
Water used per cycle, hoisting 30 ft. ..... cub ft.	3·3	3·3	3 3	3·3
Ditto slewing 100 deg. ..... ditto	0·57	0·57	0·57	0·57
Ditto hoisting 10 ft. ..... ditto	1·1	1·1	1·1	1·1
Ditto slewing 100 deg. ..... ditto	0·57	0·57	0·57	0·57
Ditto slip, 5 per cent ..... ditto	0·28	0·28	0·28	0·28
Total cubic feet	5·82	5·82	5·82	5·82
Water used per hour ..... cub. ft.	326·5	314·5	303	221·5
Cargo discharged per hour ..... tons	62·5	114	136	118·5
Water used per 1,000 tons of cargo ..... cub. ft.	5,224	2,759	2,228	1,869
3. *Cost of Hydraulic Power* used in discharging 1,000 tons of general cargo, at 110·45d. per 1,000 cub. ft. of water at 750 lb. per sq. in.	48/0	25/5	20/6	17/2

Table III.—*Results of Tests of 3 ton Electric Crane Worked as if Discharging General Cargo.*

Loads	1 ton.	2 tons.	2½ tons.	3 tons.
Duration of trial ..... hours	2	2	2	2
E.M.F. at motor terminals ..... volts	240	245	240	245
Current hoisting loads ..... amps.	95	110	125	140
Ditto empty bucket ..... do.	60	60	60	60
Ditto slewing to windward ..... do.	15	35	35	40
Ditto to leeward ..... do.	15	15	15	15
	60	53	48	43
1. *Number of Cycles per Hour*				
Work done by load hoisting 30 ft. ..... ft. lbs.	67,200	134,400	168,000	201,600
Time raising load 30 ft. ..... seconds	8·1	9·25	9·85	10·6
Speed of hoisting ..... ft. per min.	222·2	194·6	182·7	170
Horse-power developed by load (L.H.P.)	15·08	26·42	31	34·62
Horse-power expended, volts and amps./746 (E.H.P.)	30·56	36·12	40·21	46
2. *Combined Mechanical & Elec. Efficiency*, % $=100$ L.H.H./E.H.P.	49·34	73·14	77·1	75·3
Cargo discharged per hour (allowing for empty bucket 0·35 × 10/30 tons) ..... tons	67	112	125·5	134
Units used per hour	5	8·5	9·5	10·4
Units required for 1,000 tons of cargo	74·6	75·8	75·7	77·6
3. *Cost of Electric Power* used in discharging 1,000 tons of general cargo, at 2·558d. per unit	15/11	16/2	16/1½	16/6½

Table VII.—*Average Performance of 12 Hydraulic and 12 Electric Lifts and Hoists.*

	Prime Cost.	Annual Duty in 1,000 ft.-cwt.	Load Factor.	Energy Cost per 100,000 ft.-cwt.	Age in Years.	Maintenance Total (£) per 100,000 ft.-cwt.	Total Annual Cost.
Hydraulic	£320	58	0·23	£0·89	7	0·23	£129·6
Electric	£326	83	0·25	£0·13	3	0 18	£80·4

Table IV.—*Summarised Results of Tests of Hydraulic and Electric Cranes.**

Power Generation and Distribution.	3-ton Hydraulic Crane.				3-ton Electric Crane.			
Output of supply station	5,442,415 cub. ft. of water (750 lb. per sq. in.)				100,916 kw.-hours.			
Total cost of production and distribution	110·45d. per 1,000 cub. ft.				2·558d. per kw.-hour.			
Cost per horse-power-hour delivered at crane ...	2·532d.				2·030d.			
Power Consumption.	Load in Tons.				Load in Tons.			
	1	2	2½	3	1	2	2½	3
Cycles per hour	56	54	52	38	60	53	48	43
Efficiency, per cent.	18·87	37·73	47·14	56·6	49·34	73·14	77·1	75·3
Power cost of discharging 1,000 tons general cargo	480	25/5	20/6	17/2	15/11	16/2	16/1½	16/6½

* Period of observation 6 months.

Table V.—*Comparative Performance of Hydraulic and Electric Cranes Discharging Ore with 2½ and 3-ton Lifts.*

	Hydraulic Cranes.		Electric Cranes.	
	2½ tons.	3 ton.	2½	3 tons.
Number of cycles per hour	52	38	48	43
Ore discharged per cycle, tons	2·05	2·55	2·05	2·55
Ore discharged per hour, tons	106·6	96·9	98·4	109·6
Water used per hour, cub. ft.	303	221·5	...	...
Water used per 1,000 tons ore discharged, cub. ft.	2,845	2,283	...	...
Units used per hour	...	...	9·5	10·4
Units required per 1,000 tons ore	...	...	96·44	95
Hydraulic power costs per 1,000 tons ore discharged	26/2	21/0	...	...
Electric power costs ditto ditto	...	...	20/6	20/3

Table VI.—*Results of Tests of 3-ton Electric Crane Worked as if Discharging General Cargo.*

Loads	½ ton.	1 ton.	1½ tons.	2 tons.	2½ tons.	3 tons.
Duration of trial ..... hours	1½	4	3	4	4	1
Heaving loaded bucket ... volts × amps.	235 × 54	234 × 67	232 × 87	229 × 99·2	232 × 119	229 × 136
,, empty ,, ,, ,,	234 × 52·3	234 × 49·5	234 × 52·5	234 × 49·5	234 × 49·5	234 × 49·5
Slewing loaded ,, ,, ,,	243 × 14·5	244 × 14·5	245 × 14·5	243 × 14·5	249 × 14·5	248 × 14·5
,, empty ,, ,, ,,	240 × 14·5	239 × 14·5	239 × 14·5	239 × 14·5	240 × 14·5	238 × 14·5
Effic. tests. Hoisting only ,, ,,	...	231 × 67	...	230 × 99	230 × 118	234 × 132
Number of double cycles during test ...	35	110	81	102	96	23
1. Number of Single Cycles per Hour ...	56	55	54	51	48	46
Work done, load hoisting 40 ft. ... ft.-lb.	44,800	89,600	134,400	179,200	224,000	268,800
Time raising load 40 ft. ..... seconds	...	11	...	13·2	14·5	15·04
Speed of hoisting ..... ft. per min.	...	218	...	182	162	159
H.P. developed by load only (L.H.P.) ...	...	14·8	...	24·7	27·5	32·88
H.P. exp. ... volts × amps./746 (E.H.P.)	...	20·74	...	30·43	36·84	41·4
2. Comb. Mech. and Elec. Efficiency p.c.	...	71·36	...	81·17	78·48	78·21
100 × L.H.P./E.H.P.	·5875 × 76	1·0875 × 55	1·5875 × 54	2·0875 × 51	2·5875 × 48	3·0875 × 46
Cargo dis. per hr. (allowing for empty bucket 0·35 × 10/40 tons) .. .. tons	32·8	59·8	85·725	106·46	124·2	142
Units used during test. Heaving	4·6	18·4	17·5	24·6	27·7	8·3
,, ,, Slewing	1·8	5·7	4·4	5·6	5·5	1·4
,, ,, Total	6·4	24·1	21·9	30·2	33·2	9·7
,, per hour	5·12	6·025	7·3	7·55	8·3	9·7
Units required for 1,000 tons of cargo	156	100·7	85·13	70·9	66·8	68 3
3. Cost of Elec. Power Dis. 1,000 tons of Gen. Cargo at 2·558d. pr. unit, pence	399	257·6	217·7	181·3	170·8	174·7
Watt-hours per cycle	33/3	21/5¼	18/1¼	15/1¼	14/2¾	14/6¾
	91·4	109·54	135·18	148·04	172·91	210·87

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2. The cost of all materials and labour expended on piping, valves, pipe-subway, hydrants, and boxes, including cost of laying, setting, and jointing, and relaying quay, and of everything else used in the transmission and distribution of water through the pressure mains to the hydrants and back to the pumping station.

Electric Power.—1. The cost of all buildings, foundations, engines, dynamos, accessories and everything concerned in the production of electric power up to the terminals on the 'bus bars of the main switchboard.

2. The cost of switchboard, cables, pipes and other appliances required for transmitting and distributing electric power up to the terminals on the lamp poles, and to the connection boxes on the quay.

In making up the costs, duties and taxes have not been allowed for. Interest on all capital expended has been charged at the rate of 4 per cent. per annum, and all repairs have been charged against working costs. Depreciation has been calculated as follows :—

Buildings are estimated to last for	100 years.
Culvert and subway	100 ,,
Machinery, pumping engines, &c.	40 ,,
Boilers, piping and fittings	25 ,,
Engines and dynamos	25 ,,
Cables, pipes, &c.	15 ,,

The scrap value of these different items at the ends of the respective periods of their lives is deducted from the original capital expenditure, and the remainder divided by the years each is expected to last. The result gives the relative annual amounts to be written off for depreciation, so that at the ends of the corresponding periods the whole of the original capital expended on each item will have been repaid.

A further trial was carried out by Mr. Baxter, at Glasgow, on July 27, 28 and 29, 1903, on the 3-ton electric crane worked as if discharging general cargo with a lift of 40 ft. From the tabulated data given below it will be seen that the efficiencies are considerably higher, and the cost lower for discharging 1,000 tons. The cycle of operations consisted in :—

1. Lifting the load 40 ft.
2. Slewing the load ashore through 100 deg.
3. Lowering the load 10 ft. and discharging into wagons.
4. Raising the empty bucket 10 ft.
5. Slewing the empty bucket aboard through 100 deg.
6. Lowering the empty bucket 40 ft.

Electricity as a motive power for lifts and hoists is in every respect superior to hydraulic power. The summarised results given in Table VII. are taken from an exhaustive Paper on the subject by Mr. H. C. Crews,* to which the reader is referred for further information.

(*To be continued.*)

Decomposition of Cement by Sea-Water.—In a recent number of the *Annales des Ponts et Chaussées* M. Le Chatelier gives an account of the action of sea-water on cement. As a result of his researches he concludes that all hydraulic binding agents, without exception, are capable of being decomposed by sea-water, but that the rate of this action varies within wide limits. It becomes relatively slow when alumina is present only in small proportions. The addition of pozzuolana, especially of calcined clay and of trass of good quality, endows all hydraulic cements with considerably increased powers of resistance to the action of sea-water. The most essential condition to render cements immune from decomposition in the sea is to reduce to the utmost the volume of water employed in gauging the cement; and it is here that the effect of pozzuolana, quite independent of its chemical action, becomes of value.

* "Lifts and Hoists," by H. C. Crews, Minutes of *Proceedings*, Inst. Elec. Engineers, Vol. XXXVII., p. 245.

SUNDERLAND CORPORATION TRAMWAYS.

Although the fares over many of the stages have been reduced and increased pay has been given to the employés in general, the tramways manager of the Sunderland Corporation (Mr. A. R. Dayson) is able to issue a very satisfactory report on the year's working. The actual surplus balance carried to the appropriation account is £23,055. 14s. 8d.

This good result is enhanced by the fact that the repairs and maintenance expenses have been heavier than usual. Nearly the whole of the guard wires have been renewed, as have also many of the bracket arms. Great attention has been given to some of the section boxes, with a view to improving the feeding arrangements, and a considerable amount of repair work has been done on the permanent way. The Corporation own a number of double-deck cars each capable of carrying 66 passengers. In order to facilitate the cleaning of these, special cleaning gantries have been erected at the Monkwearmouth depot.

The total mileage of track owned by the Corporation is 1·97 miles of single track and 8·95 miles of double track. The population served by the tramways is 170,000.

Twenty people were prosecuted under the bye-laws. The most prevalent offence seems to be refusing to pay the fare. One person was prosecuted and fined for striking a match on the side of the car. There has been no serious accident during the year and the manager reports that the lifeguards have shown their efficiency on several occasions.

We give below an analysis of the expenditure under the various headings together with the costs in pence per car-mile for last year and for 1905-6 :—

	£ s. d.	Per car-mile. 1906-7.	1905-6.
Traffic Expenses.			
Superintendence	357 7 4	0·056d.	0·052d.
Wages	13,268 15 10	2·074d.	2·030d.
Cleaning and oiling cars	2,246 15 7	0·354d.	0·308d.
Cleaning track	299 18 4	0·046d.	0·054d.
Fuel, light and water	445 17 1	0·069d.	0·067d.
Ticket check	1,127 4 4	0·176d.	0·180d.
Uniforms and badges	641 3 6	0·100d.	0·083d.
Miscellaneous	30 7 3	0·004d.	0·011d.
Total Traffic Expenses	£18,417 9 3	2·879d.	2·785d.
General Expenses.			
Salaries	£1,076 15 7	0·168d.	0·164d.
Store expenses	99 6 6	0·015d.	0·015d.
Rents	237 7 4	0·037d.	0·047d.
Rates and taxes	2,703 8 4	0·422d.	0·424d.
Printing and stationery	171 13 2	0·026d.	0·034d.
Fuel, light and water	204 9 8	0·033d.	0·025d.
Law charges	206 18 5	0·034d.	—
Insurance	575 17 5	0·090d.	0·102d.
Miscellaneous	130 2 2	0·020d.	0·041d.
Total General Expenses	£5,405 18 7	0·845d.	0·852d.
General Repairs and Maintenance.			
Permanent way	£926 12 5	0·145d.	0·059d.
Electrical equipment of line	419 16 4	0·067d.	0·079d.
Buildings and fixtures	232 2 11	0·035d.	0·013d.
Workshop tools and plant	44 12 8	0·007d.	0·006d.
Cars	2,535 12 3	0·396d.	0·346d.
Total Repairs and Maintenance Expenses	£4,158 16 7	0·650d.	0·503d.
Power Expenses.			
Cost of current at 1 11/16 d. per B.T.U.	£12,840 4 8	2·005d.	2·021d.
TOTAL WORKING EXPENSES (*ex.* capital charges)	£40,882 9 1	6·379d.	6·161d.
Capital Charges, &c.			
Interest on capital	£8,750 16 5	1·367d.	1·455d.
Income tax	469 7 6	0·073d.	0·082d.
Total Capital Charges	£9,220 3 11	1·440d.	1·537d.
TOTAL EXPENSES (*inc.* capital charges)	£50,102 13 0	7·819d.	7·698d.
RECEIPTS (from all sources)	£73,098 7 8	11·423d.	10·907d.
Balance (placed to appropriation account)	£23,055 14 8	3·604d.	3·209d.

The credit side of the net revenue account shows an amount of £31,573. 12s. 1d. brought from the revenue account, together

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with a sum of £702. 6s. 6d. for bank interest. The total is £32,275. 18s. 7d. The balance carried to the appropriation account is allotted to several funds. £9,014 goes to repayment of loans, £6,258 to reserve and renewals fund and £7,123 to the borough fund in aid of rates. This account also shows two small amounts spent on car covers and the Wheat Sheaf offices.

The capital expenditure during the year has been £3,845. 7s. 10d. on car equipment. The total capital expenditure to March 31, 1907, is £289,690. 16s. 3d. We give below an analysis of this expenditure under the various headings:—

CAPITAL ACCOUNT.

	£	s.	d.		Per cent.
To balance in respect of old tramways	8,500	0	0	....	3·9
Purchase of company's undertaking..	35,000	0	0	....	12·0
Permanent way	133,054	10	2	....	45·8
Alteration to bridges & street widening	5,855	0	0	....	1·9
Electrical equipment	24,521	4	5	....	8·4
Land	1,500	0	0	....	0·4
Buildings and fixtures.....	30,588	10	5	....	10·5
Workshop tools and plant	2,129	3	5	....	0·6
Cars and equipment	43,785	5	2	....	15·0
Other rolling stock	1,060	0	0	....	0·4
Parliamentary expenses	3,585	0	0	....	1·1
Provisional orders	162	2	8	....	—
Total Capital Expenditure.....	**£289,690**	**16**	**3**		**100·00**

The traffic receipts were £72,054 as against £67,847 in 1905–6, an increase of £4,207. The passengers carried were 17,488,132 as against 16,103,482, an increase of 1,379,650, and the car-miles run were 1,535,425 as against 1,508,879, an increase of 26,546. The greatest number of passengers carried in any one month was in August, when the total amounted to 1,701,991, but the highest receipts per car-mile were 12·7d. in July. The total number of units used was 1,826,167 or 1·18 units per car-mile.

ELECTRIC TRANSMISSION SYSTEM OF THE YORK HAVEN WATER & POWER CO., U.S.A.*

The hydro-electric power station of the York Haven Water & Power Co. on the Susquehanna River at York Haven, Pa., is one of the largest in the State. Much property surrounds the power-station site, which is owned by the power company, the original intention having been to lease the ground to large manufacturing concerns who would buy electricity in bulk, the power company supplying it at a very low cost, much after the system which now obtains at Niagara Falls.

The power house when complete will be 478 ft. long and 51 ft. wide. Extending from the building to the falls is an immense granite wall over 3,500 ft. long and from 28 ft. to 34 ft. high. This wall is 6 ft. thick at the top and from 16 ft. to 20 ft. thick at the bottom. It encloses a race 500 ft. in width and having an average depth of about 20 ft. At the intersection of the wall is a large wing dam over 5,100 ft. long. This is built diagonally across a portion of the falls to Duffy Island and is constructed of heavy timber and granite.

To ensure a durable foundation for the power house and its massive machinery, blasting and excavating below the surface had to be resorted to and a firm mass of rock far below the river bed was reached. Upon this the power house is constructed. The walls are of masonry and vary in thickness from 10 ft. at the bottom to 3 ft. at the floor line. From this point up the structure is of brick and the walls are 2 ft. thick. Windows on all sides provide ample light and ventilation.

Just above the power house there is a small spillway with log booms extending diagonally across the race for deflecting the ice, &c., to the overflow. The wheel pits are 19 ft. deep and extend the entire width of the power house, opening to the forebay. They are protected by iron racks and are made accessible by lowering large head-gates of structural iron weighing about 11 tons. Each pit contains two 78·5 in. inward flow turbines hung from a spring bearing in the top of the draught tube. The turbines are level with the floor of the pit and are about 6 ft above low-water mark. The draught tubes are 10 ft. long and extend well under water, the effective head under normal conditions being about 21 ft. Float gauges on the switchboard gallery show at a glance the height of head and tail water. The turbines were built by the Poole Engineering Co., of Baltimore, and are rated at 550 H.P. each. They are of special design, the buckets being made of pressed steel and having cast gunmetal hubs and guide rims. The shafts extend from the turbines vertically to the mitre gears above the main floor and each is encased in a cast-iron tube which protects it from the action of the water and insures longevity both to the shafts and bearings which sustain them in line. The spring bearing is located just above the runner, the shaft being held in line by a truss bearing at the top. Each shaft has a large gear wheel fitted with wooden cogs which mesh with a bevelled pinion on the generator shaft. The gates of both turbines are operated by one rack with suitable gearing and hand wheel. At present there are installed 10 pairs of turbines for the 10 generators, as shown in Fig. 1.

The generators are three-phase inductor alternators rated at 875 k.v.a. and generating 60 cycle current at a potential of 2,400 volts, the normal speed of the generators being 200 revs. per min. The generators may be short-circuited without injury. They are easily synchronised and when thrown together anywhere near the synchronising point will pull into step with very little fluctuation. They do not get out of step very easily, staying together during severe lightning disturbances or loss of load by short-circuits. The generators and system throughout are delta-connected; 200,000 cir. mil rubber-covered cable leads run from the generators to the switchboard gallery, passing through the floor in porcelain tubes to the rear of the switches, where two potential transformers and two current transformers for the switchboard instruments are located. Short lengths of § in. copper rod, insulated with cambric and asbestos, lead to the switches. Each generator has two three-pole single-throw 500 ampere oil switches so as to enable it to be connected to either set of 'bus bars, the entire equipment from the generators to the sub-station feeders being in duplicate. Two 250 kw. 125 volt compound-wound exciters furnish the direct current for the generator fields, each machine being connected through bevel gears to a small turbine and regulated by hand. Each exciter has sufficient capacity to excite the entire equipment of alternators, besides supplying current for small motor equipments in use around the station.

The main switchboard, a view of which is given in Fig. 2, is very compact, and is made up of nine panels at present. Two panels control three generators each, and one panel controls four generators. The equipment of instrument switches, &c., for each generator panel is alike in every particular, and the switching equipment for one generator occupies a strip on the switchboard 12 in. wide. At the top of each of these strips is an incandescent lamp, which is illuminated as the generator comes up to speed and lights up the instruments. The instrument equipment for each generator consists of a 1,000 kw. polyphase indicating kilowattmeter, connected through a Y box, a 250 ampere generator ammeter and a 150 ampere field ammeter. At the bottom of the strip is a General Electric two-pole closed-circuit time-limit relay, having its two coils in series with the ammeter and wattmeter, so that a short-circuit or overload on any phase will operate both solenoids and indicate on the ammeter and wattmeter. Each generator is provided with a transparent numbered bull's-eye in the switchboard, which is lighted by a 52 volt lamp at the back of it. This lamp is in series with a similar lamp in a signal box hung over the centre of the generator room, and which serves as a signal to the machine man.

This box contains compartments numbered to correspond with the machines, also a "start," "stop," "raise" and "lower" signal and an "A" and "B" signal to correspond with the letters on the exciters. These signals are operated by small double-pole double-throw switches on the operating table in the centre of the switchboard gallery.

Each generator has two sets of synchronising receptacles and voltage receptacles. The main generator switches are closed by a large solenoid, taking about 50 amperes, and are held shut by a small magnet, whose armature is attached to a toggle joint. A small switch on the main board, with copper leaf contacts, operates the main switch and is held shut against a light spring by two magnets, the main switch being opened by a heavy spring. The generator switches are enclosed in slate compartments and are of very heavy construction.

The synchronising panel contains for each 'bus bar a Lincoln synchroniser, a lamp and voltmeter for the incoming machine, a Thomson horizontal edgewise open-scale voltmeter for regulating the voltage and a Bristol recording voltmeter. Each machine's field coils have in circuit with them an iron grid rheostat. Shafts having a hand wheel in line with the generator instruments connect to the blade contacts by chain and sprocket, the rheostats being arranged directly behind the switchboard in two tiers, as shown in Fig. 3. The shaft for each rheostat has a gear which may be thrown in mesh with a worm on a transverse shaft by pushing the hand wheel down. This transverse shaft is connected to a 1 H.P. slow-speed series-wound motor, which is thrown into circuit by a small two-pole double-throw switch on the small operating table. The field adjustment is made by hand, and then the shaft is depressed, all the fields being then regulated by the motor simul

* Abstracted from the *Electrical World*.

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taneously. The operating table contains a push-button switch for ringing a large bell to call the attention of the machine man to the signals, and is also supplied with a speaking tube for communication with the head machine-man.

There are two totalising panels, each having three 5,000 ampere ammeters, two Stanley single-phase watt-hour meters, a power-factor indicator and a frequency indicator. Vacant spaces on the switchboard provide for three more panels for controlling 10 additional generators similar to the ones now in use. One exciter panel has switches for the two exciters, each of which is provided with a Weston voltmeter, a hot-wire 2,500 ampere ammeter and an I.T.E. circuit-breaker in the negative lead, a rheostat in the shunt field and a shunt field switch. The main exciter switches are single-pole single-throw and the exciters may paralleled by means of a double-pole single-throw switch. The exciters may be run in series if desired, and this feature provides a simple means of rapidly charging a shunt field in case one machine should build up in a reverse direction, without opening any connections. The cables from the exciters are 2,500,000 cir. mils in cross-section. The switch-board is completed by a lighting panel controlling eight circuits for incandescent lamps throughout the station and transformer house and a small panel for controlling direct current for various motors throughout the building.

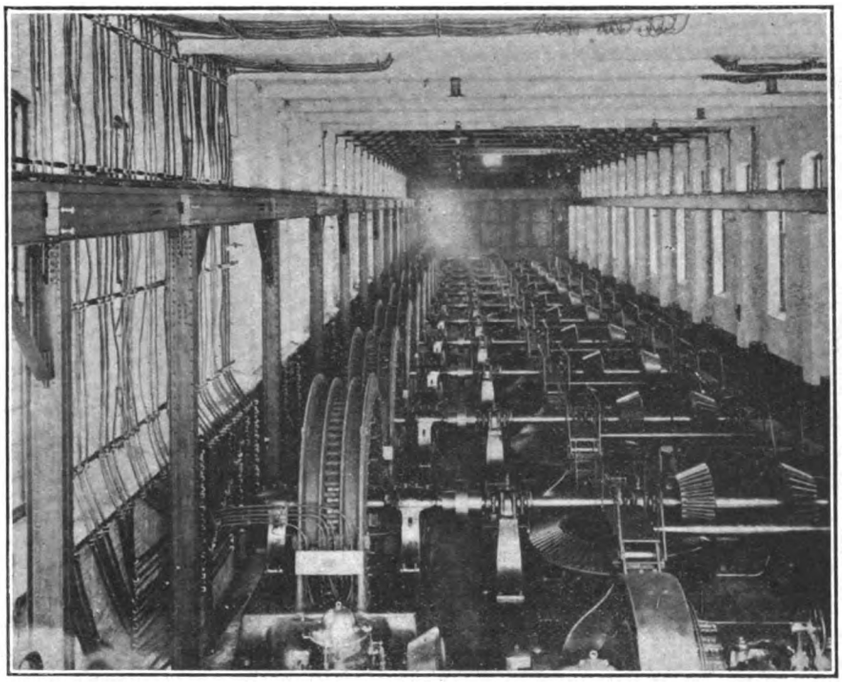

FIG. 1.—INTERIOR VIEW OF HYDRO-ELECTRIC STATION OF THE YORK HAVEN WATER AND POWER CO.

The 2,400 volt 'bus bars are suspended directly over the generator switches by channel iron hangers attached to the structural steel roof trusses. The 'bus bars are of bare copper strip 3 in. by $\frac{1}{8}$ in. in cross-section and rest on porcelain insulators bolted to the hangers. The 'bus bars are supported by barriers of slate, and starting with two strips increase until, at the end, nine strips are used in each bar. Large knife switches connect the 'bus bars to cables passing through the cable alley to the transformer house, where a similar set of switches connects the cables to 'bus bars feeding the step-up transformers.

The 'bus bars in the transformer house are insulated and run in a trench which passes under the large oil switches. There are two switches provided for each bank of transformers. At present each 'bus bar has two cables of 1,000,000 cir. mils connected in parallel. When the station is complete there will be four cables for each 'bus bar. There are three banks of transformers with three transformers to each bank. Each of these is of 1,400 kw. capacity, oil-insulated and water-cooled, and steps up the voltage from 2,300 to 23,000. By means of the large switches any bank of transformers may be put on either low-tension 'bus bar. These switches are three-pole single-throw and are now being replaced by large motor-operated remote-control automatic circuit-breaker switches. These latter will be controlled from a small board to be erected near the switches. The other switches will be removed to the new sub station now building outside the city of Harrisburg.

Each bank of transformers is provided with three ammeters on the low-tension side. The high-tension 'bus bars are of $\frac{5}{8}$ in. bare copper rods supported on regular line insulators and spaced 36 in. apart on supports of heavy wooden scaffolding. There are two sets of 'bus bars, and aluminum knife switches, which, of course, are not operated under load, permit any bank of transformers to be thrown on either high-tension 'bus bar. A similar equipment of knife switches allows any line to be put on either 'bus bar, so that two distinct systems may be operated, or the whole system may be operated in parallel. Each line is provided with three-pole high-tension oil circuit-breaker switches, and has ammeters with high-tension current transformers to indicate the load in amperes.

The lightning arresters and impedance coils are located in the transformer house and are of the air-gap type connected in series parallel with a water resistance in series. Similar arresters are located in the sub-stations and in the cable house across the river, except that the equipment at the York Haven transformer house has a high carbon resistance shunting about half the gaps and water resistance, and also has a high resistance between the three lines, thus making it a more sensitive equipment, and, as the high-tension lines are provided with circuit-breaking attachments in the transformer house only, the tendency is to concentrate all the high-tension troubles at this point and not in the sub-stations.

From the transformer house at York Haven there is a single wood pole line running to York, carrying two three-phase lines of No. 1 hard-drawn copper wire. The poles are spaced 50 to the mile and the lines are arranged in the form of an equilateral triangle with the apex at the bottom, and are spaced 36 in. apart. On a cross arm below are two telephone circuits with transpositions every third pole, the high-tension lines being transposed every 3 miles. The telephone line is remarkably free from noise and has given excellent service. Each pole is set 6 ft. in the ground and is 40 ft. long with a diameter at the top of 8 in. The top cross arm is 4 in. by 5 in. by 12 ft. long and the lower cross arm is 4 in. by 5 in. by 9 ft long. All the cross arms are well braced with angle braces and all corners are well guyed and anchored. Where the

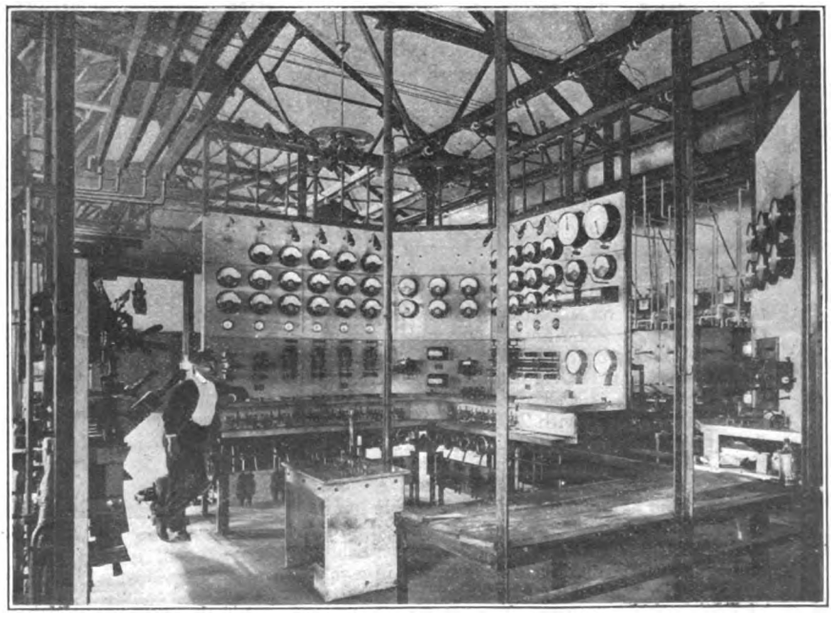

FIG. 2.—MAIN SWITCHBOARD.

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line changes direction double cross arms and double pins are used, so that the possibility of trouble is reduced to a minimum. Each circuit is capable of transmitting 5,000 H.P., thereby giving to the pole line a combined capacity of 10,000 H.P.

At the York sub-station the lines enter the building through 12 in. terra-cotta pipes slanting upwards toward the inside. The high-tension 'bus bars in the sub station are of ½ in. copper rod, and are supported on regular line insulators. The current passes

The sub-station at Steelton (Fig. 4) is similar to the sub-station at Middletown, with the exception that the transformers are each of 800 kw. capacity.

The company supplies about 650,000 to 750,000 kw.-hours of electrical energy to the Edison Electric Light Co. at York, Pa., per month, at a rate which averages about $65 per horse-power year. About 85 per cent. of all the manufacturing companies in York using electric power in any quantity are supplied by the York

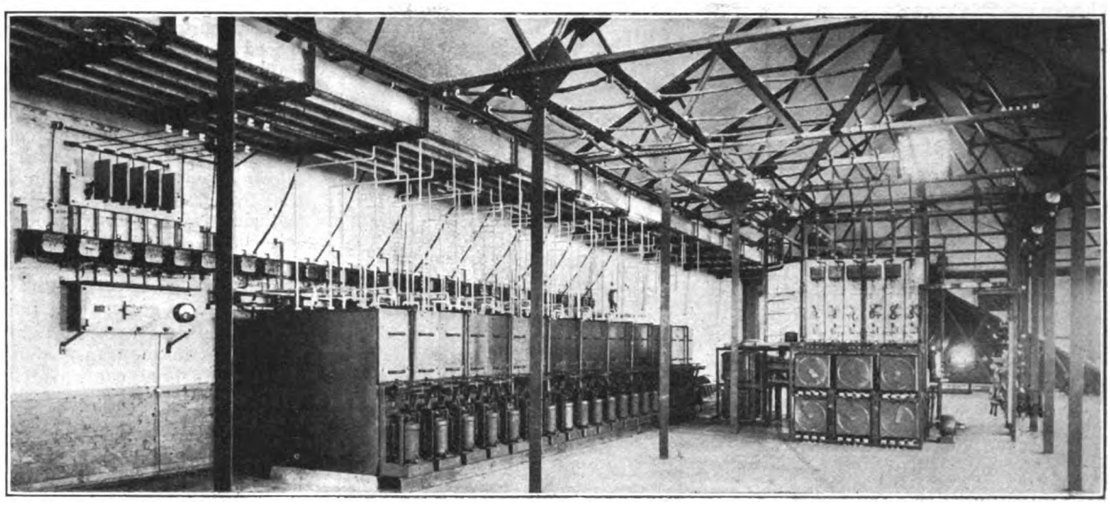

FIG. 3.—SWITCHBOARD GALLERY.

to the oil switches, which are similar to the ones in the transformer house at the power station, except that the circuit-breaker attachment has been removed, and taps to the aluminum knife switches are of heavy rubber-covered cable. These switches are operated with a special pole and may be opened or closed with perfect safety, while the attendant stands on the cement floor. There are two sets of high-tension 'bus bars in the sub-station which may be run separately or in parallel to either bank of transformers. Two banks of three transformers each step down the voltage from 23,000 to 2,400, and each transformer has a capacity of 800 kw. and is oil-insulated and water-cooled, the water being obtained from the city mains. The connections are such that either bank may be connected to the No. 1 or No. 2 set of low-tension 'bus bars through a 1,500 ampere oil switch, or they may be paralleled. The low-tension 'bus bars are insulated and run in a trench to a room under the switchboard gallery, passing thence to the ceiling, where they are supported by hangers directly under the switchboard. Taps are passed up through the floor through porcelain tubes to three-pole single-throw switches which are equipped with automatic circuit-breakers.

Located across the river from the power house, and some 6 miles up from York Haven, is Middletown, while 6 miles beyond this is Harrisburg. Between these two places are several extensive manufacturing plants, where the consumption of power is considerable. A terminal house was, therefore, built on the bank of the river directly opposite the power house from which circuits lead to Harrisburg, Middletown, Columbia, Marietta, Spring Grove, Steelton and Hanover. For these lines it was necessary to cross the Susquehanna river with 23,000 volts, and it was finally decided to use cable laid in the bed of the river. From the transformer house two three-phase power cables and one three-circuit telephone cable extend across the river to the cable house, about 3,500 ft. distant. Each high-tension power cable is composed of three stranded copper cables, rubber insulated, spiraled and enclosed in a solid rubber tube which is protected by jute and armoured with heavy steel wires, the latter being again covered with jute and impregnated with a waterproof compound. No lead covering whatever is used, and the finished cable is 3½ in. in diameter. From the cable house one three-phase line of No. 00 hard-drawn copper wire runs to the sub-station at Steelton, taps being taken off from this line for the Middletown sub-station. At the Middletown substation is a bank of transformers each of which has a capacity of 250 kw., a lightning arrester equipment and a two-panel switchboard.

Haven Water & Power Co. direct from the York sub-station, the connected load in York being about 6,500 H.P. Nothing less than 25 H.P. is connected to the company's lines in York, the Edison Company supplying such small customers. At Steelton there is a connected load of 500 kw., with an additional load of 1,500 kw. for the Pennsylvania Steel Co.'s plant. This latter is used 24 hours a day. The load contracted for in Harrisburg, chiefly by the Harrisburg Light, Heat & Power Co., which already has two steam stations operating in Harrisburg, is between 3,000 kw. and 4,000 kw. The load carried by the Middletown sub station is 600 kw.

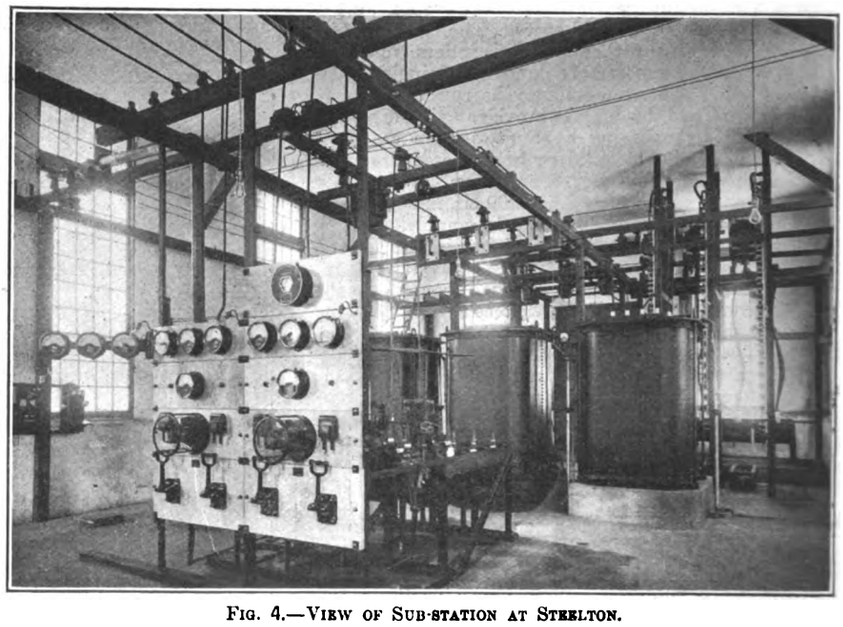

FIG. 4.—VIEW OF SUB-STATION AT STEELTON.

The rate for 10 hour power varies from 1½ to 2 cents per kilowatt-hour, and for 24 hour power the rate is 1 cent per kilowatt-hour. The load carried is, for the main part, motor load. As stated before, the system is 60 cycle, delta-connected from one end to the other. There are a number of synchronous motors connected to the lines, special inducements being made occasionally for such motor load, with the result that the power factor of the system ranges from 90 to 95 under regular conditions. A voltage regulation of 2 per cent. is constantly maintained.

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EFFECT OF ELECTRICITY UPON PLANTS.*

BY J. H. PRIESTLEY, B.SC.

Summary.—The Author gives the results of experiments with the overhead discharge system of electrification. This method has a distinct effect, usually favourable in character, upon the growth of plants Experiments with earth currents showed occasionally an increase in the rate of plant growth, but often there was no definite effect.

During the last two years several attempts have been made to apply electricity as a stimulus to plant growth. In some cases these experiments have been upon an unusually large scale, and those herein described are the work of Mr. J. E. Newman, who has carried them out at Bitton, near Bristol, and at Gloucester, in 1905, and at Bevington Hall, near Evesham, during 1906. I am indebted to Mr. Newman for keeping me so closely in touch with his work and for allowing me to embody his results in this Paper.

Historical.

The earliest work on this subject with which I am acquainted is that of the Scotch physician, Mowbray, in Edinburgh, and apparently about the same time Jallabert, in Geneva, carried out experiments upon the subject. The success met with apparently caused the Abbé Nollet to take up the subject in 1749. His experiments consisted in suspending iron plates upon steel chains hanging from a dry silk cord. Upon these insulated metal plates he kept animals and plants, the whole series of trays being charged from a somewhat cumbrous influence machine requiring the continuous efforts of three men to drive. Nollet found that maize and mustard thus electrified germinated in every case more rapidly than control plants.

The Abbé Bertholon in 1783 greatly enhanced the practical interest of the subject by suggesting that atmospheric electricity was an important factor in the environment of the plant. He applied his idea practically by constructing various types of an apparatus he called the electro-vegetometre. This consisted of a head of metallic points raised in the air in the manner of a lightning conductor and connected by a flexible conductor to a movable iron bar terminating in a series of discharge points just over the plants to be electrified. Atmospheric electricity was then collected by the upper end of the structure and discharged on to the plants from the lower end, the whole of the conducting structure being insulated by suitable wood supports. Bertholon states that the use of this apparatus was invariably accompanied with an improvement in the appearance of the vegetation and with an increase in the fertility of the plants, &c.

Grandeau in 1879 attempted to demonstrate the importance of atmospheric electricity by showing that when the plant was protected by means of a wire cage its development was greatly retarded. In Grandeau's work, and that of his pupil, Leclerc, the comparisons between the protected and control plants were not merely qualitative, but measurements of size, of gain in weight, and quantitative analysis of the plants were made. In this way they satisfied themselves that leaf and stem development was considerably retarded by the protection with a metallic network.

On the other hand, Ch. Naudin, about the same time, published experiments carried out in the same manner, in which the plants left exposed to the open air had not grown so well as the ones protected beneath a wire cage.

The application of atmospheric electricity to stimulate plant growth has been a fairly common practice in France since Bertholon's time, some modification of what is termed the Geomagnetifère system being adopted. By this system a lightning conductor is raised in an exposed position to collect atmospheric electricity, and this is connected with wires running through the earth under the plants it is desired to stimulate. With this method good results are claimed, though Lord Kelvin's suggestion is perhaps worthy of note—viz., that possibly the value of the treatment lies in the upturning of the earth necessary to plant the wire. M. Pinot de Moira has used the system for several years in his garden at Clifton, always with favourable results; he has also shown me rows of peas planted beneath a wire cage which were far less advanced than the control rows outside the cage. Recently a great deal of work has been carried on in France, at the station for Agricultural Chemistry established at Meudon, by Prof. Berthelot, who has tried the effect of the silent discharge, and particularly of atmospheric electricity upon plants. He compared the growth of plants at the top of a 28-metre tower with that of plants growing at the foot, and considered that greater growth at the higher level was largely due to the potential gradient in the atmosphere. His explanation of the action of the current is mentioned later.

Electricity has been applied in a different way by Barrat in France and Speschnew in Russia. In their experiments metal plates were sunk in the ground with a current passing through the soil between them, and apparently this stimulated the plants in this part of the soil to more vigorous growth than the plants on either side in the control plots. Speschnew obtained his current simply by using plates of different metals connected by a wire, the small earth-current thus obtained apparently proving amply sufficient to produce a marked result. Rawson and Le Baron* have used the same method at Arlington, Mass., quite recently. The plates of copper and zinc joined by a wire are sunk at either end of forcing beds in the greenhouses, and are said to be very efficacious in bringing on lettuce at an early time, in fact, they state that lettuce thus electrified was ready for market a week earlier than that in the control beds. The P.D. between the plates was about 0·5 volt, and the current flowing varied from 0·4 to 15 milliamps. approximately. The results obtained with this method at College will be described later.

In many cases electricity has been artificially generated and then used to increase the plant's growth, either by a system of discharge on to the plants from above or by being passed through the soil in which the plants are growing. Prof. S Lemstrom† used the method of overhead discharge in a great number of experiments which he conducted and which were often on a very large scale. He usually employed an influence machine of special construction driven by some continuous source of power. One pole of this machine was earthed, while the other was connected to a system of wires stretching over the plants and studded with fine discharge points. His results show a definite increase in yield in the case of many crops, whether the overhead wires were kept positively or negatively charged. The current was applied sometimes at night, sometimes in the daytime, with apparently equally satisfactory results. Lemstrom points out that precautions have to be taken in using his method of electrification, as in dry weather the electric discharge may easily be given for too long a time, when its effects are deleterious, also the treatment should vary according to the plants experimented upon—strawberries, for example, usually showing a very marked increase, whereas beans with the same treatment may often show considerable retardation in development.

At Clifton Laboratory Dr. E. H. Cook ‡ carried out experiments the results of which seem to point to an increased power of germination, either with the use of low-tension currents (up to 20 volts and current passing up to 100 milliamps.) or with high-tension discharge from a Wimshurst machine. Apart from the increase in rapidity of germination, Dr. Cook was unable to satisfy himself that the passage of the low-tension current through the soil made any difference to the plant. Using the overhead discharge from the Wimshurst influence machine (E.M.F. from 25,000 to 40,000 volts) or from an induction coil (E.M.F. approximately 45,000 volts) he obtained a continued increase in the rate of growth of the plant. S. Kinney, § in 1898, and Ahlfvengren, ‖ a year later, both found the germinating power of seeds apparently increased by an electric current passing through them. Kinney concluded that the optimum voltage for this current was about 3 volts. Ahlfvengren suggested that this optimum varied for different plants, and also, with changing conditions, varied for the same plant. Results such as these would explain the different action of the current upon two different species; for one of them the voltage supplied may be optimum, whilst for the other it may approach the maximum, when it might exert a deleterious influence on the plant. Lowenherz seems to have come to similar conclusions, and also found that the effect of the current on the plant is greatest during the period of germination. He is of opinion that the direction in which the current traverses the seed is of importance.

Practical Application of Electricity.

Experimental.

Bitton.—Mr. Newman was able during the winter of 1904 to instal a small trial apparatus with the overhead discharge system at the Golden Valley Nurseries, Bitton, near Bristol. The installation was completed by the spring, and, apart from occasional breakdowns, was running until the autumn. The breakdowns were accounted for by the fact that the machine used to generate the necessary electric power was simply a small influence machine of the Wimshurst type, hardly suited to continuous running, and that the oil engine first employed to drive it was scarcely powerful enough. The machine was working beneath a dust-free case in a small shed upon the grounds, and its two terminals were connected —one to the earth, the other to a system of wires running out over the grounds and through 7 out of the 15 glasshouses. In the open the total area of experimental and control plots was about 1,000 sq. yds. The wires ran at a height of some 16 in. above the tops of the plants, or above the rows of tomatoes in the glasshouses, and upon these wires at intervals were twisted short pieces of fine wire with the free ends pointing downwards and thus acting as discharge points. The wires were supported on ordinary telegraph-

* Abstract of a Paper read before the British Naturalists' Society.

* *The Electrician*, Vol. LVII., p. 305 (1906).

† Lemstrom's "Electricity in Agriculture and Horticulture," "The Electrician" Series, London.

‡ E. H. Cook, D.Sc., F.I.C. British Association, Bristol Meeting.

§ Hatch experimental station. Massachusetts Agricultural College, 1897.

‖ Ahlfvengren. Ofversigt af Kongl Vetenskaps-Akademien Forhandlingar, Stockholm, 1898, No. 8 (Ref. Bot. Centralblatt. Bd. 79, p. 53, 1899.)

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wire insulators, which proved satisfactory except in wet weather, when there was such a rapid leakage of the charge that there was practically no discharge on to the plants. From March 7 to July 26 the machine was running during 108 days for a period of 9·3 hours daily. Until May 20 the machine was running chiefly in the daytime, and after that date it was running principally at night. In all cases control plots were provided, which, apart from the electric treatment, were, as far as practicable, under identical conditions. The crops from the electrified and control plots were gathered and estimated separately, usually by weighing. The results of electrification in the case of the various crops were as follows:—

Cucumbers, 17 per cent. increase.
Strawberries (five-year plants), 36 per cent. increase.
Strawberries (one-year plants), 80 per cent. increase and more runners produced.
Broadbeans, 15 per cent. decrease, but ready for picking five days earlier.
Cabbages (spring), ready for picking 10 days earlier.
Celery, 2 per cent. increase.
Tomatoes, no difference.

One point requires special mention in the case of the cucumbers grown in the houses. On May 8 a spot disease of bacterial nature appeared in all the cucumber houses, and unquestionably made far more headway in the unelectrified houses.

Gloucester.—A somewhat similar installation was working during the same year over a vegetable garden in Gloucester. Here a somewhat higher voltage was given by the influence machine, and the discharging points were kept 5 ft. above the ground instead of 16 in. above the tops of the plants as at Bitton. With the crops under electrification:

Beet showed 33 per cent. increase;
Carrots showed 50 per cent. increase;
Turnips showed an increase—not determined quantitatively, because of the destructive ravages of slugs on both crops.

The amount of sugar in the beets was determined at the College.

The unelectrified yielded 7·7 per cent. total sugar.
The electrified ,, 8·8 per cent. ,, ,,

Considering the total increase in the root crop this suggests that this method of electrification may find a valuable field of application in the cultivation of the sugar beet.*

The results of some small trials with wheat that were made at Gloucester were very favourable, and arrangements were made by Mr. Newman to try the effect of the overhead discharge system upon wheat and barley on a larger scale.

Evesham.—Thanks to the interest taken in the work by Mr. R. Bomford, of Bevington Hall, near Evesham, Mr. Newman was enabled to use some 40 acres of this estate for experimental work in 1906, and experiments commenced on this ground in the spring of that year, and are still being continued. Some 20 acres were beneath the discharge field, and, as it was necessary for practical purposes to have the discharge wires at a considerable height, the very high-tension current required was obtained by means of an induction coil and valve rectifiers, upon the system devised and patented by Sir Oliver Lodge, who very kindly lent the necessary apparatus. It was very largely owing to the generosity of Sir Oliver Lodge, and the advice and help of Mr. Lionel Lodge, that Mr. Newman was able to successfully complete the necessary installation and to carry out the experiments.

As it was, however, owing to the late delivery of some of the apparatus, the work had to be carried on with a somewhat improvised generating station at the commencement on March 16. By the end of May, however, the installation was completed, and worked fairly continuously during the rest of the season, current being applied intermittently until July 10, by which date wheat had been in ear about a fortnight.

The overhead system of wires covered about 19½ acres of ground. The wires were mounted on insulators placed upon larch poles some 15 ft. high, which were placed in rows, the rows being separated by a distance of 102 yds., and the poles in a row being 71 yds. apart. Stout telegraph wire carried the current down each row, while thin galvanised-iron wires, placed some 12 yds. apart, were stretched between the rows and acted as the discharge wires. In this way 22 poles were sufficient to support the wire over the 19 acres.

This acreage was spread over two different fields. In one field some 12 acres of wheat were under treatment, in the other 6½ acres of barley and a ½-acre plot planted with potatoes, mangolds, &c. The wheat field was of 19 acres extent; the remaining 7 acres were sown with English (White Queen) wheat 1½ acres, and Canadian (Red Fife) on 5½. In the electrified part Canadian wheat occupied 3 acres, English 9 acres. The results on the barley field, including the small plot, had to be neglected owing to the great local variations produced by the very irregular manuring the field had previously undergone; the wheat field, however, as far as one could judge, had been very uniformly treated previously.

* See also Lemstrom, pp. 47 and 55.

The crops were gathered separately from the electrified and unelectrified plots, and the resultant yields were as under in bushels per acre:—

	Electrified.	Non-electrified.	Increase.
Canadian (Red Fife)	35½	25½	39 per cent.
English (White Queen)..	40	31	29 ,,

Moreover, the electrified wheat sold at prices some 7½ per cent. higher, several millers in baking tests finding that it produced a better baking flour.* No theoretical conclusions can be drawn from this fact, owing to the uncertainty existing as to what factors determine the strength of wheat, but it is interesting to note that greater strength is usually accompanied by increase in percentage of total nitrogen.

Mr. J. Kirkland, of the National School of Bakery, Borough Polytechnic, London, found the evidence from baking tests supported by the average of dry glutens from all his tests, thus:—

In the electrified ..... 11·15 per cent.
In the unelectrified ..... 10·35 ,,

The somewhat poor yield of wheat obtained from the unelectrified portion of the field is probably explained by a deficiency in lime, which has now been rectified. Further, the wheat was spring sown, and Red Fife, under this condition, does not usually yield good crops. The experiments are being repeated upon wheat during the present season, and strawberries are also under treatment once more.

Earth Currents.—At College further trial has been made of the method of Barrat and Speschnew (previously mentioned), in which plates of different metals are sunk in the ground and connected by a wire. Plates of copper and zinc were used with a copper wire soldered to them.

The results were inconclusive, though in most cases the plants where the current is passing have fared better. As an example of the strength of the currents used, with plates of area about 200 sq. in., 4 ft. apart, a current of 12 milliamps. was passing, the soil being very damp.

Physiological Action of the Current.

The chief aim in this Paper has been to give an account of these large-scale experiments with different methods, but it may be well to give an account of some of the theories advanced to explain the physiological action of the current and to describe the results of some further experimental work, though the results of the latter are negative in character.

It is obvious that the practical application of any method of electrification can only be empirical until the physiological effect of the current upon the plant is understood. One suggestion, frequently made, is that the passage of water up the plant is aided by the electric current. Lemström advanced this suggestion and referred to experiments in which he had found that if a negatively charged wire is placed over a capillary tube which dips into water the water climbs up the sides of the tube and collects in drops at a higher level. But if a positively charged pole is placed above the tube this did not happen and with a positively charged overhead wire system he obtained the best results.

J. Chundar Bose (in his work, "Plant Responses") explains the rise of sap on the assumption of a pumping action of the living cells throughout the course of the xylem, the pumping action being a form of response to stimulus. If this theory is correct, the electric current might be conceived as a stimulus giving rise to increased response, and therefore accelerating the flow of sap. The excitatory effects of kathode and anode are antagonistic, but with a current flowing through the soil there would always be a resultant excitation of the root, because the kathode effect is always greater than the effect due to the anode (as Bose shows). But in the case of overhead discharge with the wires overhead negative, the leaves and stem would, on this view, be more stimulated than the root, and the result should be a tendency to pump water downwards. On the whole, then, it is difficult to make out a case for the rise of sap being aided by electric stimulation, and there is no experimental demonstration of its occurrence in the plant. Bose would more probably attribute the effect of overhead discharge to direct stimulus of the growth responses in the plant.

The acceleration of germination noted by so many observers obviously involves some different factor; the only possible explanation seems to be that the current is used by the seed as a source of energy, this energy being directly used in the anabolic processes or in accelerating the katabolic processes of respiration.

Pollacci, in a recent Paper, has suggested that the effect of a current passing through a green leaf may be to render carbohydrate synthesis possible from carbon dioxide and water, even when the plant is in the dark. Bach has suggested that the electrolysis of carbonic acid might result in the formation of formaldehyde in the neighbourhood of the cathode, but he advanced no experimental results in support of this view. Euler, as the result of practical

* The tests were made by Watkins Bros., Hereford, and by D. W. Goodwin & Co., Kidderminster.

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investigation, found it impossible to obtain formaldehyde in this way. Waller has detected the presence of small E.M.F.s in a green leaf exposed to the light, but they are only found in a living tissue, and chloroplasts are necessary for their occurrence, no current being detected in a living petal exposed to the light. The experimental evidence that Pollacci brings forward is based chiefly upon the presence of starch in leaves kept in the dark with a current passing through them. Control leaves, also kept in the dark, contained no starch.

Before we were aware of Pollacci's work, Miss D. Johnson and I had investigated the same point, at first with results which seemed to confirm those of Pollacci. As the result of further experiment, however, it has never been possible to demonstrate starch in an electrified leaf if that leaf were quite free from starch at the commencement of the experiment. The presence of the starch in the earlier experiments seems to have been due to the inhibition of the normal transformation of starch into sugar, owing to the excessive strength of current used.

The experiments were made with elodea, with geranium and coleus leaves, and also with green filamentous algae, such as spirogya and cladophora, laid across platinum electrodes; the voltage used varied from 1 to 40 volts, above 40 the effect was usually fatal. With the object of ascertaining whether starch were produced by the action of the silent discharge in the dark, Mr. Newman kindly kept plants beneath the discharge points at Bitton during a continuous run of 27 hours, the leaves being afterwards picked and examined. No starch was found in them. I find myself, therefore, at present unable to accept Pollacci's conclusion that starch can be formed by a green plant in the dark if an electric current of suitable strength be passed through it.

It has also been suggested that the effect produced on the soil by the electric current may be beneficial to the plant. Electrolysis undoubtedly takes place, and Dr. Cook found the soil slightly acid near the anode and alkaline near the kathode in some of his experiments. Ewart (in his "Protoplasmic Streaming") suggests that the current increases the rate of solution and absorption of the insoluble food constituents present in the soil; but, as the amount of electrolysis proceeding is not likely to make the soil locally very acid, I do not see that this is likely to be the case.

Finally, there is the possibility that, in the case of the overhead discharge, oxides of nitrogen are formed by oxidation of either the nitrogen or ammonia present in the air. Samples of the soil from the electrified and unelectrified parts of the wheat field in the Evesham experiments were analysed at the College, the samples having been taken in the autumn after both crops had been gathered. They showed:—

Electrified	0·159 per cent. on dry weight.
Unelectrified	0·056 „ „

But it is impossible to draw conclusions from isolated analyses of this kind. However, following up this suggestion, it is intended to keep a continuous check upon the soils by analysis during the present season.

Berthelot considers that the clue to advantage of the electric discharge is to be found in an entrance of atmospheric nitrogen into the plant metabolism, but suggests that this is due, not only to the formation of oxide of nitrogen, but also to the combination of gaseous nitrogen with carbohydrates within the plant.

In conclusion, it remains for me to thank others for the help they have given me in various parts of this work; in particular, I wish to thank Miss D. Johnson for great help with the experimental work, Mr. Usher for many suggestions, and Miss A. A. Irving and Miss E. M. Rich for various analyses they have carried out for me.

MECHANICAL ACTION OF CURRENTS ON CONDUCTORS.*

BY P. BARY.

Summary.—In this article the author describes experiments made at the Ecole de Physique et de Chimie Industrielle, which show that when a current passes through a conductor certain mechanical forces are set up, causing a striction effect. He shows that molten metals are particularly affected, and discusses the movements produced in them by current and the internal E.M.F.s generated. He shows that these phenomena, when applied to gases, lead to a theoretical explanation of the singing arc. Oscillograms are obtained showing how the shape of the current curve affects the sound of the arc, and the article concludes with a discussion of the action of these forces on rarefied gases.

When a current passes through a liquid-conductor, phenomena arise which have scarcely been studied up to the present, and it is therefore proposed to give the results of some numerous and varied tests which have been made on the subject.

An electrical conductor carrying current is submitted to a series of centripetal forces, which tend to decrease its diameter, and a point is reached, if the conductor is liquid, when the connection is completely severed. The experiment can be carried out very easily by scooping out two cups, GG, in a block of wood (Fig. 1), and joining them by a narrow and shallow channel, *c*. Enough mercury is poured into the cups for the channel to contain a fine thread of it. As the current, which enters and leaves through the cups, is increased, the thread becomes finer and then breaks, giving a spark. The explanation of this is simple. The liquid thread is traversed by a number of elementary currents of the same sense and travelling in parallel directions along its whole length. According to Ampère's laws, these currents attract one another and give rise to an increased density, which, as the current is constant, can only follow by a diminution in section.

In the arrangement shown in Fig. 1, once the thread of mercury is broken capillarity prevents the mercury from resuming its original position. The experiment is therefore limited to a single break, and is better shown with the apparatus illustrated in Fig. 2. A flask, B, containing mercury, is connected by an indiarubber tube to a metallic tube, T, which terminates in a capillary. A thread of mercury flows from *a* and falls into the glass beaker. When a

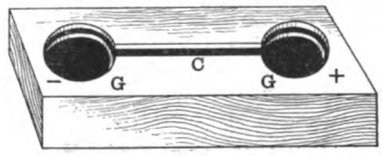

FIG. 1.

current is passed through this liquid thread it is quickly broken, the mercury then re-makes the circuit, which is broken afresh and so on. In the circuit containing this apparatus the current is therefore periodically interrupted with a frequency which may become very high if the circuit is of sufficiently low resistance and care is taken to increase the voltage, as the self-induction in the circuit becomes greater. As the breaks produced in the mercury thread are independent of the direction in which the current is flowing, this apparatus would work equally well on both direct and alternating currents. It was thought that the simplicity of its construction might make it convenient for use with the Ruhmkorff coil, but tests which have been undertaken with this end in view do not give good results. It seems that in an arrangement of this kind the break is not sharp enough to give the rapid variation of current necessary for obtaining the high voltages required from an induction coil. The modification due to Caldwell of the Wehnelt interrupter* is suitable for this work, and there is no doubt, in spite of the fact that Caldwell himself considered the effect to be due to the heating of the liquid at the orifice, that it is based on the same principle as the apparatus

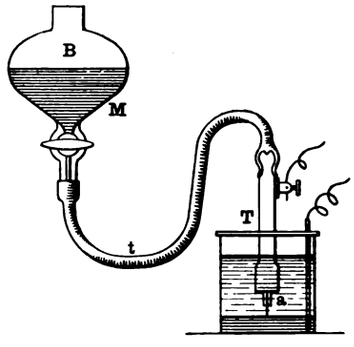

FIG. 2.

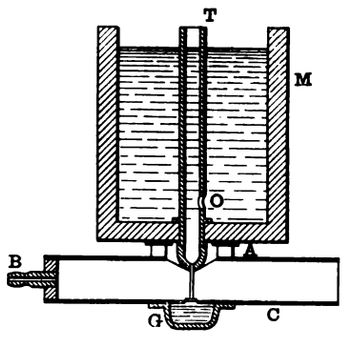

FIG. 3.

described above. It should be understood that the phenomenon is not due to the heat set free by the Joule effect; this would bring mercury to its boiling point and the bubbles of vapour produced would cause the rupture of the thread. The fact that the thread of mercury, whether it be formed in air or water, always requires nearly the same current to break it, although the cooling effect of the water prevents the temperature of the mercury from increasing more than a few degrees, leaves no doubt on this point. When a metal like tin, whose temperature of volatilisation is about 1,500°. or 1,600°C., is employed instead of mercury, it has been found that, provided it is molten, the temperature does not sensibly affect the result and the thread is broken when the metal is not even at a dark-red heat.

Electrical Pulverisation of Metals.—When the apparatus shown in Fig. 2 is in operation, it is noticed that at each break the spark produced vaporises a certain quantity of mercury. If the action

* Translation (slightly abbreviated) from *L'Eclairage Electrique.*

* *L'Industrie Electrique*, June 10, 1899. *The Electrician*, Vol. XLIII., pp. 294 and 596.

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takes place under water or alcohol the same phenomenon occurs and the liquid becomes black. The liquid, which then contains mercury dust in suspension, may be filtered without any metal being retained on the paper. Examination under the microscope shows that the mean diameter of the mercury globules is about two microns and these grains are of such dimensions that even the largest are agitated by pedesis. The same method may be applied to any other metal, only it must be maintained at a temperature higher than its melting point and be made to trickle through a tube in the form of a thread.

Experiments were specially carried out on tin. The apparatus employed (Fig. 3) consists of a cast-iron vessel, M, through the bottom of which a hole is drilled. An iron tube, T, terminating in a narrow tube, through which a continuous stream of tin from the vessel flows, is screwed into this. A wide tube, C, which is

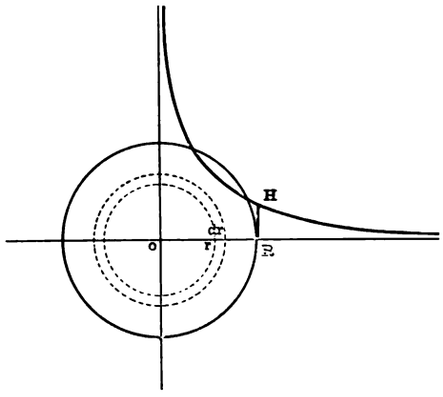

FIG. 4.

insulated electrically from the vessel M by an asbestos washer, A, receives the tin, which then falls into the dish G and flows away. Electrical connections are made to the upper reservoir and to the lower tube, so that the current has to pass through the tin thread. The same phenomenon occurs as with mercury. There is a large amount of pulverisation, and the dust obtained is carried away in a current of gas, which enters at B. When this operation is performed for the purpose of obtaining stannic acid, air is chosen as the gas. If metallic tin is desired, a neutral gas, such as carbon-dioxide, hydrogen or coal-gas, must be used. Water vapour and carbonic acid are sufficiently dissociated at the temperature of the spark to start the oxidisation of the metal. It is quite certain that lead, copper, or any metal whose melting point is not too high, could also be pulverised in this way, and for refractory metals the chief difficulty is the selection of a material with which to make the tube.

FIG. 5.

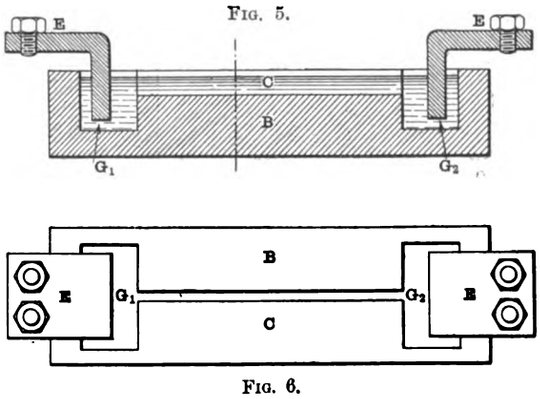

FIG. 6.

Movements Produced in a Liquid by the Passage of a Current.—All pressures which are exerted on each point of the section of a circular conductor are directed towards its centre, and a pressure exists at the point O (Fig. 4) which decreases from O to R, where it is nothing. If the conductor is a perfectly elastic solid variable tensions will be produced which will be greatest at the centre and which will all have a tendency to diminish the exterior diameter. But if the conductor is a liquid or gas, the differences of pressure put it in movement in such a way that equilibrium tends to be re-established.

To determine the pressures which may thus be produced at the centre of a cylindrical conductor, let there be a conductor of radius R (shown in section in Fig. 4). Each of the elements of the section is pressed towards the centre by a force, df, where $df = H l di$. All similar elements placed on the circumference of the circle of radius r help to make up a pressure dp at the centre, where

$$dp = df/2\pi rl = H di/2\pi r \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If the total current in the conductor is I, the current di, which traverses the circular ring of thickness dr, is given by $di = 2Irdi/R^2$; if the conductor has its section reduced at the point O, the value of H at a distance R from the centre will be $HR = 2I/R$. The value of H at any point in the interior of the conductor at a distance r from the centre is then $H = 2Ir/R^2$. By substituting the values of H and di in formula (1) we get

$$dp = \frac{2I^2}{\pi R^4} r dr$$

In the case considered of *an entirely circular cylinder*, the total pressure at the centre is given by the expression

$$p = \int_o^R \frac{2I^2}{\pi R^4} r dr = \frac{I^2}{\pi R^2} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

As the current is represented by a squared value in (2) the pressure (p) is independent of the direction of the current, and alternating currents, therefore, act in the same manner as continuous. In order to obtain an idea of the magnitude of these pressures let us calculate what it will be at the centre of a liquid cylinder 1 sq. cm. in cross-section and carrying a current of 1,000 *a*. According to formula (2)

$$p = (1{,}000 \times 10^{-1})^2 = 10{,}000 \text{ dynes per square centimetre,}$$

or in water pressure

$$h = 10{,}000/981 = 10{\cdot}2 \text{ cm. of water.}$$

In the case that has been chosen a difference of pressure equal to

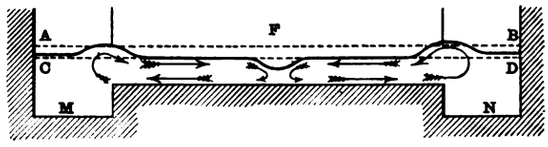

FIG. 7.

10 cm. of water may, therefore, be obtained between the surface of the mercury or of the molten tin and the axis of the cylinder. In a metal as fluid as mercury there is certainly no need for pressures as great as this to produce fairly rapid displacements.

The most characteristic experiments, by which the movements produced by the currents were determined, were made with an apparatus shown in section and plan in Figs. 5 and 6. A block, B of agglomerated magnesia contains a narrow channel (C) terminated by cups, G_1 and G_2, in which are placed two iron electrodes, EE. The whole is filled with molten tin. Fig. 7 shows the phenomenon observed when a current of from 1,000 to 1,500 amperes is passed through a channel 10 mm. wide and from 15 mm. to 25 mm. deep. The surface, which was horizontal, AB, before the passage of the current, falls along the length of the channel CD and hollows out at a point, F, which is generally near the middle. A movement is set up which can easily be observed by the scum on the surface of the molten metal. The waves show the direction of movement, so that what occurs at the surface can be observed, and it is supposed that, as the friction is much less below the surface, the currents there are practically nothing.

Experiments made with mercury give results similar to those obtained with molten tin, but, as the volatility of mercury prevents large currents from passing, the movements are much less rapid and for this reason the experiments are less striking. If, in the experiment of which the result is represented in Fig. 7, the current is increased

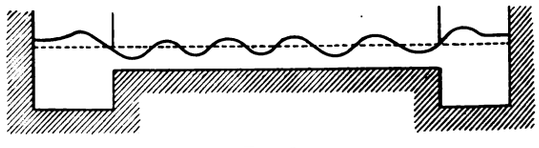

FIG. 8.

sufficiently, the depression F, which is indicated near the middle, is accentuated until a complete rupture is produced. A mean between these last two results is obtained when alternating currents are used and the contour of the surface allows the mean speed of displacement of the mercury under the influence of the current to be determined. Fig. 8 represents the effect observed. The surface assumes an undulating form of extreme regularity and with a distance l from one maximum to another, *i.e.*, the wave-length. This phenomenon may be explained in the following manner. Each time the alternating current increases in value positively or negatively the liquid conductor receives an impulse, which increases to a maximum and then falls to zero. During the time that the current is zero or only weak, the speed of the liquid decreases because of the friction and increases afresh when the current increases in the following half-period. The mass of the mercury receives a series of shocks at all these points and the frequency is double that of the alternating current generating them. The vibration thus produced is propagated throughout the

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mass, and the reflections which take place at the extremities give rise to the system of stationary waves observed at the surface. Calling N the number of maxima per second (*i.e.*, double the frequency n), l the length of the wave observed, and V its speed of propagation, we get

$$V = lN = 2l\omega.$$

V can then be experimentally determined. In the case cited above, calculation gives a speed of propagation of about 3 or 4 metres per sec.

Electromotive Forces Created by the Passage of the Current in Fluid Conductors.—The fact that a movement is produced in a liquid conductor by passing a current through it leads us to admit the existence of E.M.F.s. In fact, the power (P) absorbed between two electrodes is given by

$$P = RI^2 + p,$$

where R is the resistance between two electrodes, I the current strength, and p the power expended in keeping the liquid in motion. Dividing the two sides of the equation by I, we get

$$E = RI + \frac{p}{I}$$

where $\frac{p}{I}$ is the E.M.F. necessary to keep the liquid in motion ; e is therefore of opposite sign to E.

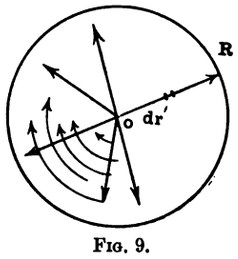

FIG. 9.

If a section is taken across a cylindrical conductor perpendicular to its axis *o* (Fig. 9), the lines of force produced by the current are circular and movements are radial. There is then an E.M.F. generated between the centre and the circumference of the conductor. At the other end of the diameter the E.M.F. produced will be the same, but at the middle, where the liquid is displaced in an inverse sense—*i.e.*, from the circumference to the centre—the E.M.F. will be in the opposite direction to that at the extremities. The sum of these E.M.F.s, which are in a direction at right-angles to the current, tends to deviate the lines of current, which, instead of being parallel, as in a solid cylindrical conductor, take a form approximately represented in Fig. 10. The arrows indicate the direction of the convection currents and the lines the course followed by the current itself. The figure clearly shows that the current maxima are situated at A, B, C and D, and that the apparent resistance of a system of this kind cannot be calculated simply from the value of the resistivity of the liquid employed and the dimensions of the canal. Resistances thus calculated would always be too small by a certain quantity varying with the current strength, the size of the conductor and the viscosity of the liquid. It appears quite certain, however, that in the case of measurements made on mercury standards where the tube is very narrow and the currents employed quite small, there is no appreciable movement in the mercury, and that in consequence this correction is negligible. When measuring the resistivity of the electrolytes in fairly wide tubes or even in tubes in which two electrodes are placed, the error

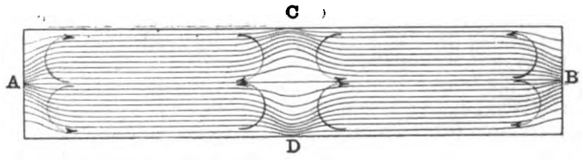

FIG. 10.

arising from this striction effect may be more important and should partly explain the large differences that exist between the various experimental results when differing arrangements are employed. It may also explain the variations of the internal resistance of cells with the current.

Effect of Striction in Gases, Theory of the Singing and Talking Arc.—The singing arc is obtained by placing a self-induction and a capacity across the terminals of an arc, which, when properly regulated, produces a sound of frequency, T, depending only on the electrical properties of the circuit. The relation is expressed by

$$T = 2\pi\sqrt{LC},$$

where L is the coefficient of self-induction and C the capacity. The arc cannot give any sounds except those in resonance with the electrical circuit, as the current in the principal circuit must follow the variations which are produced from the oscillatory discharge of the condenser. What has not been explained up to the present is the cause of the sound emitted—*i.e.*, the mechanism by which the fluctuations are produced—and how these variations, which are always extremely rapid, are transmitted to the gases of the arc and to the surrounding air. It has occurred to us that the arc may be considered as a fluid conductor, and the same phenomena may be observable, as with a liquid thread through which a current is flowing, but the intensity is increased owing to the viscosity of gases being greater than that of liquids.

M Hospitalier, under the name of the arcoscope,* applied the stroboscopic method to the study of alternating-current arcs. By working in a similar way with the singing arc and turning the screen at a speed proportional to the frequencies of the sound waves, maxima of sound and silence are observed at each period. The experiment was carried out in the following way.

The arc A was connected to a 180 volt battery of accumulators, P, through a resistance, R In parallel with it is a capacity, *c*, and self-induction, *s*. A lens, L, throws an image of the arc on a disc, D, which is pierced with radial slots and turns on its axis at a regulated speed. Lastly, a lens, L_2, receives the rays which pass through the slits and projects a magnified image of the arc on a screen, E. The disc is rotated by a variable-speed motor. When the speed of the disc is such that the passage of the slots across the luminous pencil is nearly synchronous with the current oscil-

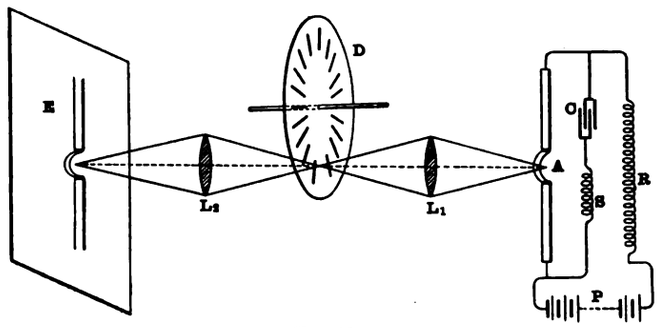

FIG. 11.

lations in the arc, all variations produced in the arc can be followed slowly on the screen. It is then that the variations of the light the value of which passes periodically through zero (*i.e.*, there is complete extinction every period) can be observed. In order to verify whether the curve of the current varies in the same way, a Blondel oscillograph was placed in circuit with the arc and the mirror was worked by hand. Fig. 12 shows some of the curves obtained in this way, varying according to the method by which the arc was regulated. When the sound given out is complicated by harmonics, curves of the nature of those shown at *a* and *b* are obtained. When the arc is well regulated and is giving out a pure sound, a curve, *c*, is obtained, which, as far as the eye can appreciate, is perfectly sinuous. It is only natural that these interruptions of the arc current should be attributed to the same cause as the ruptures of the liquid thread. After each interruption the current is re-established, for the carbons have not time to cool much, and a column of gas hot enough to allow a current to pass exists between them. The frequency is high—higher than that of ordinary alternating currents—where this phenomenon is produced twice every period. This explanation of the mechanism of the singing arc has the advantage of making intelligible why it only operates conveniently with minute regulation of current and length of arc. This regulation is necessary for the purpose of adjusting the dimensions of the gaseous strip in relation to the current strength, so that rupture by striction operates with sufficient rapidity. In a gaseous conductor like the arc, when there is not sufficient current to cause a break there is no less a striction effect, which results in a diminution in the section of the gaseous strip. When the current varies the tension increases or decreases and the bounding surface of the gaseous conducting strip, and of the air surrounding it, acts as an elastic membrane, which swells or subsides as the current decreases or increases. These movements, which may be very rapid, given that the inertia of this fictitious membrane and of the masses which it puts into play is very small, are then susceptible of transmitting the sounds produced to the surrounding air.

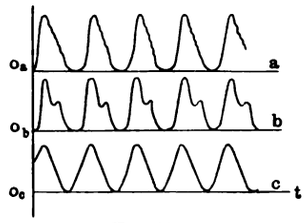

FIG. 12.

Effects of Striction in Rarefied Gases.—It results from the kinetic theory of gases that the internal friction is independent of the pressure. This theoretical deduction, made by Maxwell, was verified by him and by numerous other experimenters within wide limits. It is necessary, in fact, to descend to pressures of the order of 1 mm. of mercury and below for any great variation from this constant to be observed ; it then falls rapidly to zero as the pressure

* Described in *The Electrician*, Vol. LII., p. 299.

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becomes lower. The experiments were first made by Crookes,* and then by several scientists by studying the damping of an oscillating system as a function of the pressure of the surrounding gas. The mobilities that a rarefied gas may have and the feeble forces necessary to produce rapid movements in a gaseous column by striction may be judged when it is stated that the coefficient of internal pressure of a gas at atmospheric pressure is about 100 times less than that of mercury or water. In vacuum tubes the pressure may have any value between 2 mm. and $\frac{1}{1000}$ mm. of mercury; the fluidity of the gas may then be 1,000 or 10,000 times greater than that of the mercury which was used in the preceding experiments. The effects of striction in the rarefied gas tubes, and in particular the movements which result from it, are of great importance. It appears that it should be difficult to pass a continuous current through a vacuum tube, as the tendency would be for it to be interrupted directly it was switched on.

Numerous experiments have shown that the current traversing a rarefied gas tube, even at a constant voltage, is always discontinuous, and no other explanation of this phenomenon is known other than that given above. Exhaustive observations were made by Warren de la Rue† and more recently by M. Cantor,‡ who discovered that a similar tube emitted waves that affect a Branly coherer, but that it was not capable of generating a system of stationary waves, probably on account of the irregularity of the interruptions. It seems, however, that the deduction of the same author, in so far as it concerns the previously published experiments of Hertz,§ is not quite exact, for the result of this causes him to admit the continuity of the current in analogous conditions when they are, perhaps, not altogether the same. He attributes this to a fault in the method, but it should be possible to obtain a permanent current in a tube of these dimensions with a convenient current and pressure.

In mercury vapour lamps, which are now in fairly general use, different experimenters show that lamps operating under a continuous E.M.F. have an intermittent current passing through them.‖ This discontinuity explains the remark of M. Pellet,¶ who advises the insertion of a choking coil instead of a simple resistance in the circuit of the mercury vapour lamp, even with continuous current. Although no experiment has been made which allows it to be stated that this discontinuity is due to the phenomenon of electromagnetic striction, this explanation may be given as no other exists and it is nearly certain that phenomena of this kind do occur in vacuum tubes, and may even be fairly important on account of the great mobility of the gaseous molecules.

If striction is admitted as the cause of the discontinuity, it must be taken into account with the other effects by which it is accompanied—namely, the rapid displacement of the gaseous mass and the back E.M.F.s generated by these displacements. It is expected that with convenient current and pressure conditions, phenomena of the same order as those of Fig. 8 will be found, and it is proposed to verify the relation which may exist between the stratifications observed in vacuum tubes and the undulations which have been noticed at the surface of liquids carrying currents.

Conclusions.—The phenomena of electromagnetic striction, which have just been described are absolutely general and are applicable to all conductors carrying current. In solid conductors, the effect is rendered ineffective by the great cohesion of the molecules and by the small coefficient of compressibility. Whatever may be the magnitude of the effect, it must be admitted that it tends to increase the apparent value of the self-induction. In liquid conductors, on account of the greater mobility of the matter, there is always a tendency to break the circuit. This tendency is accompanied by a movement in the liquid, and when the current is alternating or discontinuous the movements give to the surface of the liquid a fluted form. In gases at normal pressures, the mobility being higher than in liquids, the effects of striction are markedly produced with quite small currents, and it is observed that the variation of section is proportional to the current even when the latter is very rapid (speaking arc). When the current strength and the dimensions of the gaseous envelope are conveniently chosen, a periodical rupture may be obtained (singing arc). In rarefied gases the effects seem to be considerably greater and explain the fact that current passing through a vacuum tube, even when the P.D. is continuous, is always discontinuous.

Manufacture of Aluminium.—*The Engineering and Mining Journal* states that, whilst the expiration of the Héroult patents has made the manufacture of aluminium free in Europe, the process in the United States is still subject to the Bradley patents, which do not expire until 1909.

* *Annales de Chimie et de Physique*, Vol. XIX,, 1881.
† Warren de la Rue, *Ann. de Chimie et de Phys.*, 1881, XXIV., p. 438.
‡ M. Cantor, *Wiedemann Annalen*, 67, 1899.
§ *Wiedemann Annalen*, 17, 1882.
‖ R. de Valbreuze, *Bull. Soc. int. des Electriciens*, December, 1903.
¶ *Bull. Soc. int. des Electriciens*, March, 1905.

THE EXPERIMENTAL DETERMINATION OF THE LOSSES IN MOTORS.*

BY C. F. SMITH.

(*Concluded from page 806.*)

Summary.—In this Paper, which is divided into two sections, dealing respectively with continuous and alternating-current motors, the author describes the methods in use for obtaining a separate determination of the iron and friction losses, and discusses the advantages and disadvantages of the various methods. Special attention is devoted in the Paper to the testing of alternating-current motors.

(2) Alternating-Current Induction Motors.

Comparatively little information has been published in this country on the experimental determination and separation of the losses in induction motors, although a considerable number of communications on the subject have appeared in various foreign journals. It may, therefore, serve a useful purpose to collect together some of the most important of the methods which have been suggested, and to point out to what extent they may be expected to give the desired results. With a view to assisting in the comparison of the various methods, several of them were tried under as nearly as possible identical conditions on a 5 H.P. 6-pole induction motor recently supplied to the Manchester School of Technology by Messrs. Siemens Bros. & Co., and the results are shown in the form of curves.

The various losses to be measured consist of: (*a*) Copper losses in stator and rotor conductors; (*b*) Friction and windage losses; (*c*) The stator iron magnetising losses; (*d*) Rotor eddy current losses; (*e*) Rotor hysteresis losses; (*f*) Pulsation losses due to the rapid changes in flux distribution in the teeth of the stator and rotor; (*g*) Additional losses which are due to increase of load.

(*a*) The resistance of the conductors employed in the calculation of the copper losses is usually measured by direct current. This is known not to give strictly correct values for the resistance of the stator conductors, particularly in the case of conductors of large section, owing to the distribution of an alternating current not being uniform throughout the section of the conductor.

(*b*) The variable element in these losses is usually due to change in friction of the bearings on account of change of temperature or unequal circulation of the oil. Change in load may be expected not to produce any variation in the losses of properly lubricated bearings.

(*c*) The stator magnetising losses consist of the usual two components due to hysteresis and eddy currents. They are dependent only on the induction (*i.e.*, on the terminal voltage) and on the frequency, and may therefore be taken to be independent of load.

(*d*) The rotor eddy-current losses in the teeth (exclusive of the tips which are affected by the pulsation losses, *f*) and the body of the stampings depend on the frequency of the alternating flux in the rotor. They will increase with the slip and practically disappear at synchronism and are consequently small at normal loads.

(*e*) The rotor hysteresis loss is practically constant in amount when estimated as power supplied to the stator. This power is, however, partly converted into useful output. The fact that the hysteresis of the rotor iron causes the pole induced in the rotor to lag behind the stator flux, which induces it, gives rise to a torque between the rotor and the rotating field. This torque, combined with the torque due to eddy currents in the rotor core when the slip is large, may be sufficient to produce a rotation of the rotor when open circuited. The special point to be noticed about this effect is that the hysteresis torque is practically independent of the speed of the rotor (unlike the torque due to the eddy currents, which is proportional to the slip) and depends only on the constant η; that is, on the area of the hysteresis loop formed by the rotating flux in the rotor iron. When the rotor is stationary, as assumed at first, the whole of the power supplied to the stator winding on account of rotor hysteresis will be converted into heat in the rotor. This power is given by the usual formula—

$$W = \eta B^{1.6} \quad \ldots\ldots\ldots \quad (1)$$

If the rotor rotates, useful work is done by the torque due to hysteresis. The power thus usefully exerted will be equal to the hysteresis torque multiplied by the angular velocity of the motor shaft, and we can re-write the expression for the hysteresis loss as

$$W = \eta B^{1.6}(S + np) \quad \ldots\ldots\ldots \quad (2)$$

where S = slip in cycles per second, n = revs. per second of rotor, p = number of pairs of poles.

The factor $\eta B^{1.6} np$ gives the power converted into mechanical energy, while the factor $\eta B^{1.6} S$ gives the portion transformed into heat in the rotor core due to molecular magnetic friction.

* Abstract of a Paper read before the Manchester Local Section of the Institution of Electrical Engineers.

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(*f*) The losses, which may be briefly called the "pulsation losses," are due to the very rapid changes of flux distribution which occur at the tips of the teeth of both stator and rotor. The intensity of the variation will be greater with open slots, but even with closed slots considerable variation has been found to occur. It is easy to see that the larger the air gap, the more evenly distributed will be the flux in the air gap and the smaller will be the losses due to the pulsation effect. Pulsation will occur in the teeth of both stator and rotor and give rise to both hysteresis and eddy currents in the teeth, the comparatively large value of which is due to the high frequency of the flux variation to which they are due.

Methods for Determination of Friction Losses.—(1) By auxiliary driving motor. This method is the well-known one for determining the losses in one machine by driving it by means of a motor and afterwards subtracting the copper and no-load losses of the motor from the total driving power to obtain the losses in the machine under test.

2. By decreasing stator volts. In the case of the induction motor, the stator volts are gradually reduced to the limit of stable running. A curve is then plotted showing the stator watts supplied on a base of terminal voltage (*see* Fig. 2). When continued, this curve cuts the axis corresponding to zero voltage at a height representing the watts required to overcome losses which are independent of the magnetic field—*i.e.*, the friction losses. Although it is possible with care to get fairly consistent results by this method when applied to the induction motors, there are several practical difficulties connected with the measurements. Firstly, although the speed of the motor remains practically constant over the greater part of the range of voltages, at the lowest readings the slip may be 10—15 per cent. or more. The actual friction losses would thus be those corresponding to a speed of about 10 per cent. below the normal. On the other hand, an increase in slip will increase the rotor iron losses, which will in consequence not decrease uniformly with the voltage. The two actions just mentioned will tend to neutralise one another, and this may account for the good agreement with the actual values often given by this test, while explaining the want of agreement found in other cases where the two errors compensate one another less completely. Another difficulty is the very low power factor at which the

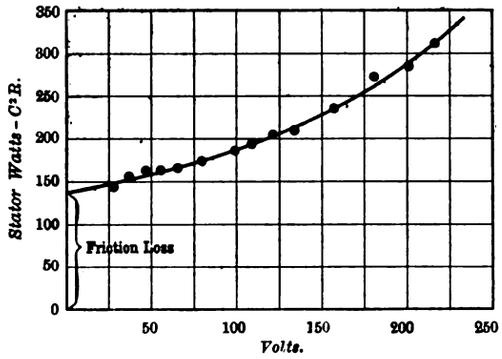

FIG. 2.—DETERMINATION OF FRICTION LOSSES.

readings have to be taken and the consequent liability to errors in the wattmeter readings. Since the current supplied, and consequently the copper losses, do not decrease towards a zero point at zero induction, the copper losses should be subtracted before the watt curve is plotted if accurate results are to be obtained.

3. Method of F. Blanc. $W = n3C_2^2 r_2 p/s$.

Where C_2 = rotor current per phase, r_2 = rotor resistance per phase, p = number of pairs of poles of stator winding, s = slip in cycles per second, n = revolutions per second of shaft.

When running light, W consists entirely of power spent in overcoming the frictional and other losses which oppose the rotation of the shaft. Consequently the determination of the no-load losses is thus reduced to a measurement of the slip and of the rotor current and resistance.

Except for the uncertainty of the resistance of brush contacts on slip rings and starting rheostat, this method is found to give in a fairly simple manner reliable and consistent results for the losses overcome by the rotor. It is, however, not correct to take these losses as being the true friction losses, and this method is only applicable to motors with wound rotors.

4. A method somewhat similar to the last in principle is that due to Dr. G. Benischke, which depends on the fact that for small values of the slip the total torque of the rotor varies in direct proportion to the slip. The slip of the motor is measured at no-load and at one or two loads slightly above no-load. A curve is then plotted on a base of torque—or, more conveniently, watts—with slip as ordinates (*see* Fig. 3). Joining the points thus obtained by a straight line, and continuing this line backwards to cut the horizontal axis at a point corresponding to zero slip, the distance of this point to the left of zero output will be the power exerted by the rotor in overcoming frictional and other resistances to its rotation.

The actual power measured in this case, as in the last, is really the friction + pulsation losses – the mechanically converted hysteresis loss.

This method is fairly easy to carry out if a convenient method of applying a small load to the motor is available. It is equally applicable to motors with wound and squirrel-cage rotors.

If the induction motor be run up to full speed in the usual way, and, when running light at full speed, if the rotor circuit be opened, the rotor will slow down and gradually come to rest. The retarding forces will be those due to friction and magnetic pulsation in the teeth, while the rotor hysteresis will tend to accelerate the rotor and prolong the time of coming to rest. During the early part of the retardation these will be the only forces to be considered. As the slip becomes large, eddy currents will be formed in the rotor core and conductors which will produce a diminution of the effective retarding forces. If a retardation curve is plotted with time measured horizontally, and speed vertically, from observations made on the motor while retarding as described, a tangent drawn to the curve near the point of maximum speed will make an angle α with the horizontal axis such that its tangent, ds/dt, is proportional to the losses $W_F + W_P - W_H$.

Now suppose that another retardation curve is taken with the stator open circuited. In this case retardation will be due to frictional losses only, and a tangent to the second curve ds'/dt at a point corresponding to the same speed as the first tangent will be proportional to the friction watts W_F.

As the height of the points from which both tangents are drawn are taken to be the same, the subtangents will be inversely proportional to the retarding watts in the two cases, and we have the relation

$$\text{ratio of subtangents} = \frac{W_F}{W_F + W_P - W_H}$$

from which the true friction watts are determined from the value of $(W_F + W_P - W_H)$ obtained in either of the tests described (Nos. 3 and 4).

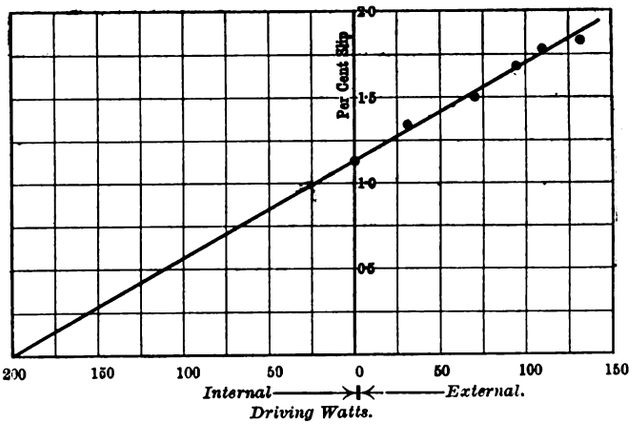

FIG. 3.—DETERMINATION OF LOSSES BY BENISCHKE'S METHOD.

In taking the two retardation curves, since only the ratio of the initial slopes of the curves is required, it is immaterial how the readings are taken, so long as the two curves are strictly comparable. Also only a few readings are required near the maximum speed. With motors of fairly large size, it would be sufficient to observe the times taken to retard by a certain amount after opening in one case the rotor and in the other case the stator circuit.

5. By opening rotor circuit. We may next refer to a very simple method which has been much used for measuring approximately the friction losses. The watts supplied to the stator of the motor when running light are observed. The rotor circuit is then opened and the watts are observed immediately after, before the motor has had time to slow down appreciably. The difference between the two wattmeter readings, after correction for the C^2R losses, is taken to be the friction losses of the motor. The power measured by this method is not the true friction watts, but is greater by the amount of the pulsation losses.

6. Retardation curves. Retardation methods for measuring losses, which are so well adapted for measurements on direct-current and synchronous alternating machines, have only a limited application in the case of induction motors. In order to obtain the relation between retarding watts and retardation, Bragstad and La Cour have suggested supplying the excitation losses entirely to the rotor in the form of direct current supplied to two of the slip rings while the motor is made to run synchronously. The machine then operates as a synchronous motor with rotating poles excited with continuous current, and the alternating supply provides the armature currents producing the driving power. The power supplied to the stator to maintain the rotation at any speed is then measured

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and compared with the slope of the retardation curve. After obtaining the constant in this manner, the friction losses are obtained from a retardation curve taken on the motor when retarding from full speed entirely without excitation.

The simplest method of employing the retardation method for determining the friction losses is to carry out the experiment with the induction motor coupled to a continuous-current motor, the two machines being allowed to retard together.

A method, which I believe is due to Mr. Cramp, by which very accurate values for the no-load friction coefficient may be obtained, is to wind a string round the shaft of the motor and pass the free end over a light pulley at a considerable height from the ground. Weights are then attached to the end of the string until by repeated trial the correct weight is found. This weight is such that when started downwards it is just able to maintain rotation of the motor shaft without acceleration. The uniformity of speed is ascertained by noting the time intervals taken by the weight to fall past two equally spaced marks. The friction torque is thus found directly in terms of the weight and radius at which the weight acts on the rotor shaft.

Methods for Determination of Iron Losses.—(1) By subtracting the friction and copper losses from the total no-load losses. The simplest method of determining the total iron losses is to determine the friction losses by any one of methods (2), (3) or (4) previously given, and to subtract these losses, together with the calculated copper losses, from the total no-load watts required to run the motor light. If either of methods (3) or (4) is used, the true friction losses should be obtained by retardation curves as described in (4), which incidentally gives the rotor losses as a separate item.

2. Motor driven by an auxiliary machine. By coupling the induction motor to a direct-current machine, so that it may be driven with open rotor circuit, a very complete separation of the no-load ron losses may be obtained.

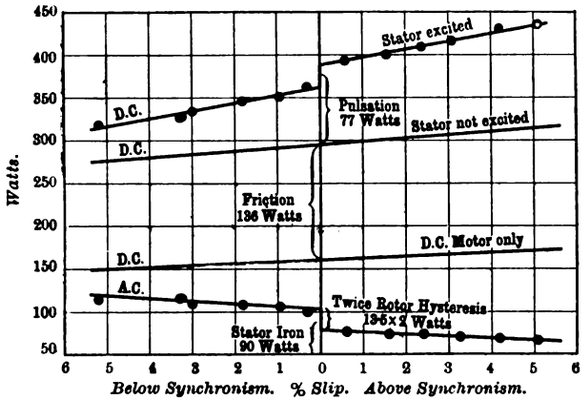

FIG. 4.—SEPARATION OF NO-LOAD IRON LOSSES.

When running below synchronism with the rotor circuit open, the iron losses in the rotor will increase with decrease of speed. Consequently, by gradually increasing the speed of the rotor up to synchronism by means of the continuous-current motor, the watts supplied to the stator of the induction motor will be found to diminish. At synchronism, the only losses in the rotor will be those due to magnetic pulsation in the teeth. At this point also the direction of the torque due to rotor hysteresis will be reversed. After passing the synchronous speed this effect no longer tends to drive the rotor, requiring power to be taken for this purpose from the stator. The rotor hysteresis is, on the contrary, supplied from the direct-current machine, and power is supplied to the mains owing to this cause. By making observations of the power supplied to the stator of the induction motor and of the power spent in driving the continuous-current machine, it thus becomes possible to measure separately the stator iron loss, rotor hysteresis loss, the pulsation losses and friction. The last-named is obtained by driving the direct-current motor first coupled to and then uncoupled from the unexcited induction motor. The experiment requires considerable care, but is not difficult to carry out if the ratio of alternating to continuous voltage supply can be kept absolutely constant. If the voltages have any relative variation, a continual change in the watts taken by the A.C. and D.C. machines occurs.

The curves shown in Fig. 4 will be understood from the particulars already given. The lowest curve is the A.C. wattmeter reading (corrected for C^2R), the other curves all being D.C. watts supplied to the driving motor.

It will be seen that the true friction is 136 watts, a value agreeing closely with that in Fig. 2, but considerably less than is given by the Benischke test (Fig. 3.)

3. Mr. W. Angermann has proposed an elaborate method for separating the iron losses. He starts by dividing the total iron losses into three groups, each group consisting of those losses which depend upon one factor which can be varied independently of the others.

These groups are: (1) Stator iron losses (exclusive of pulsation losses) which depend on the frequency of supply; (2) Rotor iron losses (exclusive of pulsation losses) which depend on the slip; (3) Pulsation losses in the teeth of stator and rotor which depend on the speed of the rotor.

By varying the frequency of the voltage applied to the stator, with the rotor circuit open, while maintaining the magnetic induction constant, a curve of watts (1) and (2) is obtained from the readings of a wattmeter in the stator circuit, and is plotted on a base of stator frequency which is also rotor slip.

A second test is made with the rotor circuit closed and motor running light. In this case, again, the frequency is varied and the induction kept constant. A curve of watts (1) and (3) is obtained from the readings, the rotor slip being assumed too small to produce iron losses.

Finally, a third set of readings is taken with the stator short-circuited and the rotor supplied with alternating current of the same voltage as those which would be generated at each speed by the voltages applied to the stator in the former two tests. For this purpose the ratio of transformation must have previously been taken. This test gives the losses (2) and (3).

By adding the ordinates of any two of the curves thus obtained, after correction for C^2R loss, and subtracting the ordinates of the third, each set of losses may be obtained separately. The friction losses must have been previously separated and the values of stator and rotor resistances accurately measured, since the copper losses will bear a large ratio to the total losses in the experiment.

The wide range of speeds, corresponding to values of the slip which would be never reached in actual working for which the various tests have to be carried out, the variations in the nature of the supply voltage and the number of incidental measurements—*e.g.*, transformation ratio, resistances, &c., combine to make the method anything but convenient in practice. Where complete separation of the losses is required, and careful measurement is possible, method (2) seems to be far preferable.

4. Retardation methods. The experiments of Bragstad and La Cour, in which the rotor is excited with direct current in order to provide the rotating field, have already been referred to. The iron losses were determined in two alternative methods. In one case the rotor was short-circuited and the motor run light from an alternator having constant excitation, but whose speed was varied from a maximum value downwards. A curve of watts on a base of speed was then obtained in the same manner as in the second measurement mentioned above in Angermann's test. The second method of obtaining the iron loss curves was by allowing the motor to retard with direct current supplied to the rotor of sufficient strength to produce the same alternating voltage at the stator terminals, as employed in the first test. The rotating field and iron losses were thus due to the rotation of a constant field formed by direct currents in the rotor. From the retardation curves, the iron and friction losses at any speed were calculated in the usual way, the predetermined constant being used. By plotting the iron loss curves (obtained from the total watts by subtraction of C^2R and friction losses) on a base of frequency, the losses proportional to frequency are separated and classed as "hysteresis"; while the losses varying with a higher power of the speed form the remainder, classified as "eddy-current" losses.

OBSERVATION OF ALTERNATE CURRENTS WITH THE STRING GALVANOMETER.*

BY GYÖZÖ ZEMPLÉN.

In 1903, W. Einthoven described an interesting instrument which may often be of service in the measurement of feeble electric currents. Particularly interesting are the later communications of Einthoven, in which he describes how the string galvanometer may be used for the observation of feeble alternating currents. If a note is made to sound into a telephone connected with the galvanometer, Einthoven tells us "in a white field the narrow black image of the string is expanded into a band several centimetres wide." The amplitude of the vibration string varies with the loudness of the sound. In his last communication (*Ann. der Physik*. 21, 687. 1906) Einthoven remarks that in observing alternating currents he obtained good results in the Wheatstone bridge arrangement, "substituting for the silvered quartz fibre a thin metallic wire between the poles of the electromagnet." The reason for this substitution and the resulting sensitiveness are not stated.

I work with a so-called "small" string galvanometer as constructed by Edelmann, possessing a smaller sensitiveness than the model described by Einthoven in his original communication. Its resistance was 3,800 ohms, and a continuous current of 1 milli-

* Translated from the *Physikalische Zeitschrift*, July 1, 1907.

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ampere gave in one adjustment of the string a deflection of 1 mm. in the microscope.

I then passed an alternate current of about 10^{-5} ampere through the galvanometer, using the municipal supply of 50 ~ and 100 volts with introduction of a suitable inductionless resistance. But on turning on the current the thin black string image abruptly disappeared, just as if the string had been torn. However, on breaking the current the image returned exactly to zero. On passing it again and observing accurately, two washy lines could be seen at −10 and +10, corresponding to the inversion points of the string. But in this form the instrument can hardly be used for practical purposes, for the very faint inversion points disappear completely at stronger currents.

For making the vibrating string visible I thought of dark-ground illumination, which could be easily carried out. It suffices to perforate the metal plate between the pole pieces and to illuminate the string from the side. But I soon found that even this was superfluous, for the string appears bright on a dark background as soon as the source of light lies, not in the axis of the microscope, but a little on one side of it. The proper adjustment is soon found at which the string stands out brightly from a background not too dark to allow the divisions of the eye-piece micrometer to remain visible. With this arrangement the image in the case of alternating-currents becomes a bright band on a dark background. Its margin is exceedingly well defined, and may be located to within 0·1 of a scale division. The sensitiveness was about the same as with continuous current. With the P.D. used a micro-ampere gave an ample tude of 1 scale-division, or a bright band 2 scale-divisions wide.

The amplitudes were strictly proportional to the currents, so that the galvanometer is suitable for measuring alternate currents of small intensity. But, of course, the sensitiveness also depends upon the frequency, and the string must be calibrated separately for different frequencies.

But as a null instrument it may be very serviceable, especially where, as in laboratories, the employment of a telephone is inconvenient. In particular, the instrument is suitable for comparing the sensitiveness for alternate currents of the same period—*e.g.*, of alternate currents produced by the same note in different telephones.

Given the possibility of directly observing the rapidly vibrating string, the utility of a string galvanometer, constructed by J. K. A. W. Salomonson, after Place's idea, and described in these columns, may be considerably increased. In this string galvanometer the magnetic field is produced by two thicker wires stretched on both sides of the string. By varying the connections of the field wires and the string the instrument is made into a universal apparatus, which may be used for measuring weak and strong continuous currents, weak alternate currents, and also as a wattmeter and electrometer.

For alternating currents the following connections are indicated; the current to be measured is sent in succession through the field wires and the string. The string gives a deflection in one sense only when the current traverses the two field wires in opposite directions. The sensitiveness is very small, say 2×10^{-4}, and decreases with the square of the current. But if the vibrating string is observed, we may employ the same connection for small alternate currents as that given by Salomonson for small continuous currents. A constant current of not more than 20 amperes is sent through the field wires, the alternate current is sent through the string, and the amplitude of the vibration is observed. The same connection gives in the case of continuous currents a sensitiveness of $2{\cdot}5 \times 10^{-9}$ amperes, and this sensitiveness may also be expected for alternate currents.

On the other hand, strong alternating currents up to 40 amperes may be measured by passing a constant direct current through the string and the alternate current to be measured through the field wires, which are connected in parallel for 20 amperes and upwards.

We may say, therefore, that by observing vibrations the utility of Place's instrument is increased.

PARLIAMENTARY RECORD FOR 1907.

At the close of each Parliamentary Session it has been our custom to publish a record of the proceedings and to give a brief digest of new Acts which affect the Electrical Engineering Industries. The most noticeable feature of the past year's work is the great falling off in the number of public and private Acts when compared with the previous year, and 1906 exhibited a marked decline from the standard of 1905. The main features of the past year's legislation are dealt with in our Leading Article, and we set out below a list of the public and private acts of 1907 dealing with electricity supply, electric traction, telegraphy, telephony, &c.

Public Acts.

Patents and Designs (Amendment) Act.	Limited Partnerships Act.
Patents and Designs (Consolidation) Act.	Employers' Liability Insurance Companies Act.
Companies Act.	Lights on Vehicles Act.
	Expiring Laws Continuance Act.

Provisional Order Confirmation Acts.

Electric Lighting.

Electric Lighting Provisional Orders (No. 1): Aston Manor, Chesham, Hipperholme, Lytham, Newark, Penrith, Pontefract, Stockport.

Electric Lighting Provisional Order (No. 2): Cork.

Electric Lighting Provisional Orders (No. 3): Castleford, Egham, Formby, Grimsby, Liversedge, Maldens and Coombe, Mansfield, Paignton, Selby, Stoke-upon-Trent.

Electric Lighting Provisional Order (No. 4): Arbroath.

Electric Lighting Provisional Orders (No. 5): Minehead and Dunster, Rhymney Valley, St. Albans.

Tramways.

Tramways Orders Confirmation: Audenshaw, Huddersfield, Leeds, Taunton, West Ham.

Confirmatory Acts under Private Legislation Procedure (Scotland) Act, 1899.

Dumbarton Burgh & County Tramways Order.	Portobello & Musselburgh Tramways (Port Seton Deviation) Order.
Dundee Corporation Order.	Portobello & Musselburgh Tramways (Levenhall Extension) Order.

Private Acts.

Aberdeen Corporation Electricity.	London United Tramways.
Birmingham Corporation.	Manchester Corpn. Tramways.
Brighouse Corporation.	Metropolitan Railway (Pension Fund).
Central London Railway.	Middlesbrough Corporation.
Coventry Corporation Water.	Middlesbrough, Stockton-on-Tees & Thornaby Tramways.
Devonport Corporation.	North-East London Railway.
Electric Supply Corporation.	North Metropolitan Electric Power Supply.
Folkestone, Sandgate & Hythe Tramways.	Oxford & District Tramways.
Glasgow Corporation.	Rawtenstall Corporation.
Grays & Tilbury Gas.	Richmond (Surrey) Elec. Supply.
Great Northern & City Railway.	Shanklin Gas.
King's Norton & Northfield Urban District Council.	Sheffield Corporation
Kingston-upon-Hull Corporation.	Sunderland Corporation.
London & North-Western Railway.	West Riding Tramways.
London County Council (Tramways and Improvements).	West Yorkshire Tramways.

Following is a list of the principal bills which were not proceeded with or were rejected in Committee:—

Public Bill.

Telegraph Construction (*withdrawn*).

Private Bills.

Administrative County of London and District Electric Power (*withdrawn*).
Barnsley, Wombwell and Wath Tramways (*not proceeded with*).
Cavehill and Whitewell Tramways (*not proceeded with*).
Channel Tunnel Railway (*withdrawn*).
London County Council (Electric Supply) (*preamble not proved*).
London Electric Supply (*withdrawn*).
Lower Thames Tunnel Railways (*withdrawn*).
Watford and Edgware Railway (*preamble not proved*).
York and District Tramways (*not proceeded with*).

Electrolytic Production of Copper.—The *Oesterreichische Zeitschrift für Bahnen und Hütte* gives an account of the methods employed at Medzianka for producing copper by electrolytic means. The produce of the mine is divided into rich ore with 50 per cent of copper, which is separated underground, and mixed ore with 16 to 20 per cent. containing calcite and limestone. The ore is crushed, mixed with 5 per cent. of damp brick earth and moulded into blocks, which are subjected to a partial roasting, with a free access of air, converting the copper into sulphate and oxide. The roasted ore is crushed fine and lixiviated in lead-lined tanks, with the spent liquor of the electrolytic baths, containing about 5 per cent. of free sulphuric acid. A liquor containing about 5 per cent. of copper and 1 per cent. of free sulphuric acid is obtained. After passage through a filter press, this is electrolysed in vats of about 35 cubic ft. capacity. Insoluble anodes of lead plates in cloth bags, and thin copper cathodes are used. A current of 1,000 amperes at 2·5 volts, corresponding to a density of about 1 ampere per square decimetre of cathode surface, is used, producing metallic copper, free sulphuric acid and oxygen. The deposited copper, about 1·1 gramme per ampere-hour, is nearly equal to the theoretical amount. The energy consumed per kilogramme of copper is 2·28 kw.-hours or 3½ H.P. hours. The liquor is exhausted in about 35 hours, when it is returned to the extraction vats for the treatment of fresh ore. The cathodes remain in the bath for about a month, when the deposit (1 in. to 1¼ in. thick) is removed.

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LEGISLATION IN 1907.

In comparing this year's Parliamentary Session with that of 1906, it will be noticed from the list, which we give elsewhere, of Public and Private Acts affecting the electrical industry that there is a pronounced falling off, not only in the number, but also in the importance of the measures passed. Apart from the Expiring Laws Continuance Act, which continues the Light Railways Act of 1896 for another year, the Telegraph (Money) Act is the only other Public Act of the past Session which has a direct electrical interest for our readers. The Telegraph Act authorises the Postmaster-General to raise £5,000,000 for the development and extension of the telephone system until the acquisition by the State in 1911 of the undertaking of the National Telephone Co. Of the amount proposed to be spent, £2,800,000 is for additional trunk lines, £1,800,000 is to be allocated to the London exchange system, and £1,000,000 is intended for the extension and improvement of provincial exchanges.

The question of the ratification of the Berlin Wireless Telegraph Convention of 1906 excited considerable interest in Parliamentary and scientific circles. Owing to opposition to the terms of the Convention, the Government in March appointed a Select Committee to consider and report upon the advisability of this country adhering to the Convention.

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After many sittings, and after hearing a number of witnesses, including representatives of Marconi's Wireless Telegraph Co. and officials of the Post Office, the Colonial Office and the Admiralty, the Committee decided, by five votes to four, to recommend the ratification of the Convention. As there was a majority of Government supporters on the Committee (including two members of the Government). so small a majority in the voting was unexpected. After the issue of the Committee's Report the Premier announced that it had been the intention of the Government to ratify the Convention in any event, and therefore, it is difficult to understand why the Committee was appointed and why so much time and energy should have been needlessly expended.

Though the legislation directly affecting the electrical industries is very limited, a number of Acts were passed which are likely to have considerable influence on the trade and commerce of this country. Among these may be mentioned the Limited Partnerships Act, the Patents and Designs (Amendment) and the Patents and Designs (Consolidation) Acts, the Employers' Liability Insurance Companies Act and the Companies Act. The Limited Partnerships Act introduces a principle hitherto unknown to the jurisprudence of this country—the principle of limited partnerships. The principle is well-known in both Germany and France: it is the Kommanditgesellschaft of Germany and the Société en Commandite of France. According to the law of this country, each of the partners of a firm has hitherto been the agent of the partnership to make contracts, incur obligations and dispose of partnership property to an unlimited extent; and each partner has been the unlimited agent of every partner in all matters connected with the partnership business, or which he represented as partnership business, and which was not in its nature beyond the scope of the partnership. Further, the partner's liability for the debts of his firm was not limited to his interest in the firm, but extended to the whole of his assets, including his private estate. On the other hand, the liability of shareholders in limited liability companies has been limited to their actual holdings in a company. By the terms of the new Act, however, "limited partnership" shall consist, in the case of a partnership carrying on the business of banking, of not more than 10 persons, and in the case of any other partnership, of not more than 20 persons, and must comprise one or more persons called "general partners," who shall be liable for all debts and obligations of the firm, and one or more persons to be called "limited partners," who shall at the time of entering such partnership contribute thereto a sum or sums, as capital or property, valued at a stated amount, and such "limited partners" shall not be liable for the debts and obligations of the firm beyond the amounts so contributed. A "limited partner" shall not, during the continuance of the partnership, either directly or indirectly, draw out or receive back any part of his contribution, and if he should do so he shall be liable for the debts and obligations of the firm up to the amount so drawn out or received back. Every limited partnership must be registered, or in default it is to be deemed a "general partnership." A "limited partner" shall not take part in the management of the partnership business and shall not have power to bind the firm. Should he take part in the management of the business he is to be liable for all debts and obligations of the firm incurred while he takes part in the management, as though he were a "general partner." A limited partnership is not dissolved by the death or bankruptcy of a "limited partner," and the lunacy of a "limited partner" is not to be ground for the dissolution of the partnership unless the lunatic's share cannot otherwise be ascertained. A company registered under the Companies Acts, provided its memorandum of association allows, may become a "limited partner." The provision made for winding up limited partnerships is somewhat similar to that for the liquidation of limited companies. The particulars required to be given on the registration of a limited partnership include a statement of the general nature of the business, the name of each of the partners, a description of every "limited partner," the sum contributed by him, and whether paid in cash or otherwise. Changes in the constitution of a limited liability partnership must also be registered, and default in complying with these requirements involves a fine not exceeding £1 per day during default. Notice of any transaction or arrangement under which any person ceases to be a "general partner," and becomes a "limited partner," or under which the share of a "limited partner" has been assigned, must be advertised without delay in the *London Gazette*, and until such notice is advertised the transaction is to have no effect. Making a false return is a misdemeanour, and the penalty is imprisonment with hard labour for not exceeding two years. The Registrar of Joint Stock Companies is made the Registrar of Limited Partnerships, and provision is made for the inspection of the files kept by the Registrar. It is doubtful whether the introduction of this principle into this country so late in the day, when nearly all businesses of any magnitude have been converted into limited liability companies, will be of much benefit to business men. It may, however, prove an advantage to a private firm or person to be able to obtain capital temporarily for, say, the development of a patent or the extension of a business in a particular direction. At present financiers and capitalists are loth to lend money to private firms, or to identify themselves as "sleeping partners," because of the risk not only of losing their capital but of being involved in liability for the general debts. This risk is removed by the new Act, and it is possible that comparatively small businesses will benefit, as they may be enabled to obtain money on easier terms.

We have already criticised the scope and draftsmanship of the Patents and Designs (Amendment) Act, and we can only repeat that we doubt whether the intentions of the framers—to benefit the "poor working-man inventor" at the expense of the "bloated Trust"—will be effected by the Act. Some of the provisions of the new Act are useful, but many of the clauses are contradictory and confusing. Principles from the German and American patent systems have been introduced in a half-hearted way, and it is very probable that means will be devised to circumvent the requirements of the Act as to the working of patents in this country. We question the wisdom of the new and very wide power conferred upon the Comptroller of Patents to refuse to grant an application for a patent, without right of appeal to either the Law Officers of the Crown or to the High Court.

The Employers' Liability Insurance Companies Act applies the provisions of the Life Assurance Companies

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Acts, 1870–1872, to companies carrying on the business of insuring employers against liability to pay compensation or damages to workmen injured in the course of their employment. Briefly, this is an Act to ensure that workmen who have been awarded compensation under the Workmen's Compensation Acts shall not be deprived of their compensation by the insolvency of the insuring company. The Companies Act introduces some useful amendments of the law relating to limited companies.

We hope that the President of the Board of Trade will find time in the next Session of Parliament to re-cast the legislation regarding electricity supply in this country. We have repeatedly pointed out the necessity for amendment of the existing Electric Lighting Acts, and Mr. LLOYD-GEORGE would find the electrical industry with him in any genuine attempt to revise and bring up to date the law relating to electricity supply, light railways, &c.

In regard to Private Bill legislation, the past Session presented few features of interest. Another unsuccessful attempt was made to solve the London electrical power problem. The original Bill of the London County Council was altered considerably after the March elections had changed the composition of the Council, but considerable opposition was aroused by the attempt of the new Council to obtain authority to lease their powers to a company. The Parliamentary Committee which considered their Bill found the preamble not proved, without waiting to take evidence in opposition to the scheme. Inasmuch as the existing County Council is not likely to promote another power Bill, and as the promoters of the Administrative County of London Bill have announced their intention not to submit a fresh Bill, it is probable that we have heard the last for some time to come of the London power problem. We have ranked ourselves amongst those who have considered that no additional powers were required, as the existing companies and municipal electricity undertakings in the metropolitan area cover the field. Great strides have been made during the past few years in the development of the London power load, and it is extremely doubtful whether any new enterprise would have a sufficiently tempting field to induce financiers to support such an undertaking. There is, however, much to be said in favour of the linking up of existing sources of electricity supply, and a Bill enabling the companies to do this and to work generally in co-operation was introduced, but it was withdrawn.

Among the miscellaneous Acts, the most interesting was that of the London and North-Western Railway Co., authorising the Company to construct a new electric railway between Euston and Watford. The new lines will be constructed in tubes from Euston to Loudoun-road, and from the latter station to Watford the line will be on the surface.

In the North-East London Railway Bill an unsuccessful attempt was made to obtain Parliamentary sanction to an increase in the interest to be paid during the construction period from 3 to 4 per cent. We regret this decision, as it would seem to indicate a want of flexibility in the standing orders of the House of Lords. Seeing that the Bank Rate has during the past year been as high as 6 per cent., it is not, we think, too much, under present industrial conditions, to pay 4 per cent. interest on the capital of an undertaking during the construction period. The Company, however, obtained an extension of time for constructing the line. The North Metropolitan Electric Power Supply Co.'s Bill was interesting from the fact that a House of Commons Committee inserted a special electrolysis clause, notwithstanding the opposition of the Board of Trade. At a later stage of the Bill, however, the clause was excised.

A clause introduced into all the tramway Bills of the Session, at the instance of the Postmaster-General, giving him the right to use the tramway poles for the support of telegraph wires, caused much discussion in tramway circles. The Municipal Tramways Association took the matter up, and after a conference the terms of the clause were agreed. Among the new tramway acts the most interesting was that of the Oxford and District Tramways Co., which authorises the construction of a system of tramways on the Dolter Surface Contact System.

In two or three instances local authorities (Sheffield, Glasgow, Coventry and King's Norton) made attempts to poach upon the "preserves of the electric power companies,' but in nearly all cases where the companies opposed and were able to show that they were giving a supply of electricity, the attacks of the local authorities were beaten off. The Richmond (Surrey) Electric Light and Power Co. promoted a bill in which an interesting point was involved. The Company had expended a large sum in erecting electricity works and in developing the undertaking, but doubts had been cast upon the validity of an agreement entered into many years ago between the predecessors in title of the Company and the Richmond Corporation. The Company, therefore, wished to settle these doubts by having the agreement confirmed by Act of Parliament. The Council, however, opposed the Bill, but despite this opposition the Company obtained substantially what they required.

The Coventry Corporation Act (in the miscellaneous group) increases the borrowing powers, extends the electricity supply area and confers other powers upon the Corporation, including this somewhat unusual clause: "That in calculating the amount which the Corporation may borrow under the Public Health Act, 1875, any sum borrowed (or to be borrowed) for the electric lighting undertaking shall not be reckoned." This is equal to an extension of the Corporation's borrowing powers by £186,000.

During the Committee stage of the Glasgow Corporation Bill a defect was discovered in the Private Legislation Procedure (Scotland) Act of 1899. It appears that under this Act there is no obligation on promoters of provisiona, orders to lodge estimates of cost with their drafts of orders and in the present instance Glasgow Corporation were severely criticised by a House of Commons Committee for the careless way in which they prepared their figures.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

La Construction des Machines Electriques. By JULIEN DELÉMONT. (Paris: Libraire Polytechnique.) 12fr. 50c.

The work before us treats in detail of the construction and manufacture of electric machines; it also deals, though rather briefly, with the design and organisation of works for the manufacture of such machines. There is ample evidence in its pages that the author has had a long experience in the subject with which he deals; his method of handling the subject is, moreover, very clear and entertaining. The illustra-

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tions are especially well chosen, and comprise numerous photographs of machines for the special purposes described in the text. Most of these photographs have heretofore never been included in any published work. The order of treatment consists in first describing the preparation of the core plates; then the various winding operations, the binding, balancing and finishing of the rotor, the construction of commutators, and, finally, the various processes involved in building the machine together. The book is well up-to-date, and the additional details required by the recent developments in high-speed machinery are given careful consideration. The construction of stationary transformers is included.

Nearly all the machines illustrated are of modern and up-to-date types, and it is a relief in turning over the pages to note the almost entire absence of illustrations of old-fashioned bipolar armatures and of fantastic and ancient alternators. The chapter on the manufacture of core plates impressed the reviewer as being especially clear. At the present stage of development of the manufacture of electrical machinery, these books dealing with special aspects of the question are becoming indispensable. It is no longer practicable in a single book to adequately cover the subject of the design, construction and operation of dynamo-electric machinery in general, or even of any particular class of such machines.

The Physical Laboratories of the University of Manchester. No. XIII. Manchester University Series. (Manchester: Sherrat & Hughes.) 5s. net.

This volume has been prepared by old students and assistants to commemorate the twenty-fifth anniversary of the election of Dr. A. Schuster, F.R.S., to a professorship in Owens College. For the first few years Dr. Schuster held the professorship of applied mathematics, and it was not until 1888 that he was appointed, after the death of Prof. Balfour Stewart, to the professorship of physics, for his work in connection with which subject he has received the highest honours. The present volume is divided into three sections. In the first of these is given a description of the equipment of the physics, electrical engineering and electrochemical departments of the Manchester University. The second section consists of biographical and bibliographical notes regarding the life and work of Dr. Schuster. The third section, which comprises half the volume, contains a record of the work of past students, demonstrators, &c., who have been connected with the physical laboratories or who have studied applied mathematics under Prof. Schuster. The book will be found especially interesting by all those who have been connected with Manchester University, or Owens College, as was its former title.

THE FREQUENCIES OF FLICKER AT WHICH VARIATIONS IN ILLUMINATION VANISH.*

BY A. E. KENNELLY AND S. E. WHITING.

Summary.—The series of experiments described by the authors was made on incandescent lamps burning on low-frequency alternating-current circuits. Two of the conclusions, among others, arrived at by the authors are that flickering ceases to be objectionable with ranges of less than 7·5 per cent., and the smallest range of flicker recognisable with certainty is 1·4 per cent., and this only at very low frequencies.

It is well known that arc lamps operating on 60 cycle alternating-current circuits, and subject, therefore, to 120 cycles of flicker per second, produce visible flickering of illumination on moving targets. It is also well known that arc lamps operating on 25 cycle alternating-current circuits produce visible flickering of illumination on stationary targets, and that incandescent lamps operating on such circuits also produce visible flickering in illumination under certain conditions. There is, however, considerable difference of opinion as to the conditions under which flickering appears or disappears in the illumination cast by incandescent lamps operating on low-frequency alternating-current circuits. It is the object of this Paper to describe some experiments made by the writers on this matter, and the results thereby indicated.

The measurements were made in a photometer room with dark walls, by employing a rotating sector-disc immediately in front of a steady and stationary incandescent lamp, thus producing an artificial flicker in its light. It is known that when different observers attempt to balance, in the ordinary photometer, a steady illumination against a flickering illumination, they make different estimates of the photometer setting. It was found on trial, however, that when several different observers simultaneously watched a stationary target illuminated by a beam of light which was artificially flickered through the intervention of a rotating sector disc, they substantially agreed upon the speed of rotation at which the flickering disappeared. This method of observation was, therefore, adopted in the tests here described.

The general arrangement of the apparatus used is indicated in plan by Fig. 1 and in side elevation by Fig. 2. BB, B'B' are the parallel bars of a photometer track, S a standard incandescent lamp, L the lamp under test. The small direct-current motor M carries a pair of superposed sector-discs, DD, on its shaft. The photometer carriage C contains a circular white paper screen, *n*, 3·6 cm. (1·4 in.) in diameter, with a central grease spot 1·1 cm. (0·43 in.) in diameter, viewed through a pair of inclined mirrors in the usual way. Fig. 3 shows a sector-disc with two 90 deg. windows. The apertures of these windows could be reduced down to mere slits at will by mounting the two sector-discs side by side on the motor shaft and changing their relative phases. The screw clamp P enabled them to be clamped in any desired phase relation. As indicated in Fig. 3, the window apertures are wide open. Each revolution of the disc DD will, therefore, produce two successive openings and closings of the sector shutters for equal periods of time, and two complete cycles of flicker. The first step in each series of measurements was to measure the horizontal intensity of the lamp L selected, by finding a balance of illumination on the Bunsen screen *n*, in the usual way, with the disc at rest and the window open. The standard lamp S was then removed, and the voltage kept steady at the terminals of the test lamp L.

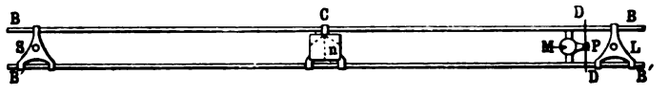

FIG. 1.—PLAN OF PHOTOMETER.

In the first series of measurements, the carriage C was moved to the left-hand end of the track in Fig. 1, at a distance of 5 metres from the lamp L, and the sector-disc DD set in rotation. By reducing the resistance in the circuit of the series motor M, its speed was steadily increased until the observer at the photometer carriage ceased to perceive a flicker, or estimated the illumination on the circular photometer screen *n* as steady. This observation was repeated with each of three observers in such a manner that each formed an independent estimate of the vanishing-flicker speed. The results obtained in this set of observations are recorded in Table I., which may be taken as a fair sample of a series of measurements.

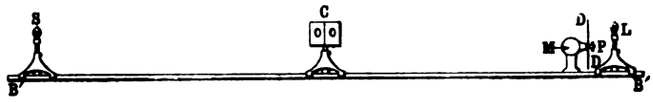

FIG. 2.—SIDE ELEVATION.

Table I.—*Vanishing-Flicker Speeds and Frequencies, at Various Illuminations on Photometer Screen, as viewed directly from a distance of* 50 *cm.*

Horizontal intensity of lamp L, c.p.	Dist. D between lamp L & screen *n*, metres.	D^2 (metres)^2	Illumin. on screen *n*, metre-candles.	Speed of motor *M* at vanishing flicker, r.p.m.	Mean vanishing flicker cycles per sec.	Observer.
33 04	4·0	16·0	2·065	842		K.
				740	25·6	W.
				720		C.
	3·0	9·0	3·67	870		K.
				840	27·4	W.
				760		C.
	2·5	6·25	5·29	840		K.
				920	29·3	W.
				880		C.
	2·0	4·0	8·26	980		K.
				940	32·0	W.
				960		C.
	1·5	2·25	14·69	1,090		K.
				1,040	35·2	W.
				1,040		C.
	1·0	1·0	33·04	1,110		K.
				1,100	36·8	W.
				1,100		C.
	0·5	0·25	132·2	1,290		K.
				1,390	44·1	W.
				1,290		C.

* Abstract of a Paper read at the Convention of the National Electric Light Association at Washington.

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The maximum variation between the vanishing-flicker speeds, as estimated by the three observers at any single illumination, is found in Table I. to be about 16 per cent.; while the average variation is 3·1 per cent. The series of mean vanishing-flicker frequencies is plotted in curve A, Fig. 4, where the ordinates are mean frequencies of flicker, and the abscissæ are maximum cyclic illuminations on the target, expressed in metre-candles. Additional scales are indicated for reading these illuminations in foot-candles or in metre-hefners.

On repeating the measurements with a stationary sheet of white paper 20·3 cm. by 13·3 cm. (8 in. by 5·25 in.) as a target, in place of the small white Bunsen carriage screen, supporting the target on the photometer bar perpendicularly to the beam of light passing through the sector-disc, and bringing the observer's eye to within a distance of about 35 cm. (14 in.) from the centre of the target, the rotation speeds and vanishing-flicker frequencies were found to be increased in the manner indicated by the curve B (Fig. 4); so that with the illumination of 200 metre-candles (227·5 metre-hefners or 18·6 foot-candles) the frequency of flicker at which the illumination appeared to become steady was over 53 cycles per second. The reason for the greater mean vanishing-flicker frequency with the larger white target is believed to be found in the increased surface area of retina undergoing flicker stimulation.

A screen of bright Turkey red colour about 25 cm. square (10 in. by 10 in.) was next used as a target, and the results obtained indicated on curve C, Fig. 4. The vanishing-flicker frequencies were a little lower with the red target than with the small white target formed by the Bunsen photometer screen. In other words, the total retinal stimulus from a target exposed to a given illumination intensity but absorbing all the light except red was markedly less than from a white target of similar size, and slightly less than from the small white circular disc of paper in the Bunsen photometer carriage. Other colours of target were tried, with the general result that the lighter and brighter the colour, the higher the vanishing-flicker frequency for a given illumination, and the nearer to that of a white target. No appreciable difference was found in the observed flicker frequency whether the sector-disc had two windows or four windows.

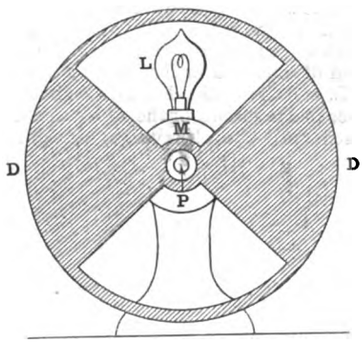

FIG. 3.—TWO-WINDOW SECTOR-DISC AND DRIVING MOTOR.

Considering the double-window sector-disc of Fig. 3, it was found that whether the windows were opened to their full angular width of 90 deg., or were nearly closed, the vanishing flicker speeds and frequencies for given maximum cyclic illumination on the target were substantially the same. Consequently, the vanishing flicker frequency does not seem to depend upon the mean illumination of the target nor upon the shape of the wave of cyclic illumination, but only upon the maximum and minimum illumination, or the limits of illumination in each cycle.

The range of flicker may be defined as the ratio of the difference between the cyclic maximum and minimum illuminations upon the target, to the maximum cyclic illumination. In all of the above-mentioned observations, the range of flicker was 100 per cent. In the case of the ordinary alternating-current carbon-arcs lamps the range of flicker is known to be large. With incandescent lamps operating on alternating-current circuits, the range of flicker depends upon the thermal capacity of the filament—that is, upon the specific heat of the filament and its mass per unit of surface. According to the observations of Mr. J. T. Morris,* on a 220 volt, 5 c.p. carbon incandescent lamp, with a filament of no doubt very small cross-section, the range of flicker was 63·9 per cent. of the mean illumination, which corresponds to 51·5 per cent. of the maximum, as here defined.

In order to reduce the range of flicker, the target was illuminated by two stationary incandescent lamps, side by side. One was placed behind the rotating sector-disc, so as to be cyclically obscured thereby. The other was left unobscured. By varying the sizes or candle-powers of these two lamps the range of flicker could be readily adjusted for different series of tests. The results are indicated in Fig. 4. Curve D corresponds to 44 per cent. flicker (or 56 per cent. of the total illumination kept steady), curve E to 33 per cent. flicker, curve F to 7·5 per cent. flicker, and curve G to 3·3 per cent. flicker. With ranges of less than 7·5 per cent. the flicker ceased to be disagreeable to the eye, especially as the frequency increased.

The lowest range of flicker which could be recognised with certainty was 1·4 per cent., and the most sensitive flicker frequency for making it apparent was a low frequency in the neighbourhood of 2·5 cycles per second. This is not far from the flicker frequency in the usual observations of mean horizontal candle-power with an incandescent lamp rotating about a vertical axis at 180 revs. per min., or 3 revs. per second, and ordinarily 2 cycles of flicker per revolution; that is, 6 flicker cycles per second. The curves D, E, F, G show that the vanishing-flicker frequency increases with the range of flicker, but in nothing like the same proportion.

Experiments with the open arc between vertical carbon electrodes and with alternating-current supply, showed that flickering on stationary targets with stationary eye, did not entirely disappear until the alternating-current frequency was 60 cycles per second. At this frequency the flicker frequency of the arc column would be 120 cycles per second, which is far in excess of any vanishing-flicker frequency with sector-disc interruption of incandescent lamps, as found in these tests. The anode glow will however, only have a flicker frequency of 60 cycles per second, or that of the supply current: since the anode will alternately change from one carbon to the other once in each alternating-current cycle. It would seem probable, therefore, that the light from an

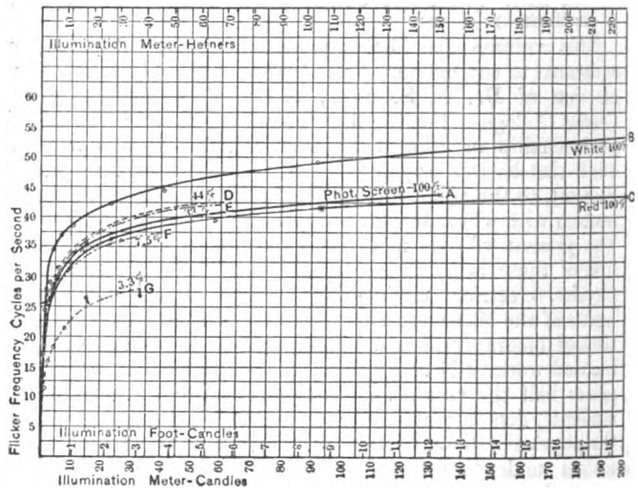

FIG. 4.—CURVES OF FREQUENCIES AT WHICH FLICKERING, IN DIFFERENT INTENSITIES OF ILLUMINATION, APPEARED TO VANISH.

alternating-current arc lamp possesses two flicker frequencies; namely, one equal to that of the current and affecting the light emitted by the tips of the electrodes, and the other of twice this frequency and affecting the light emitted by the vapour of the arc, or arc stream. The sensation of flicker due to a stationary illumination image on the retina might then be expected not to disappear entirely until both flickers exceeded the vanishing limit. If this reasoning is correct, the possibility is suggested of having less visible flickering with flaming arcs than with ordinary enclosed arcs at low alternating-current frequencies, because in the flaming arc the light emitted from the electrodes is relatively so much reduced with respect to the light emitted by the arc stream.

In an appendix the authors state that since preparing the Paper it has been discovered that if the curves of Fig. 4 are plotted on "semi-log" paper (co-ordinate paper with a logarithmic or slide-rule scale of abscissæ and an ordinary uniform scale of ordinates) the curves become a system of parallel straight lines, within the limits of observational error. This means that every time the illumination on the target is doubled the mean vanishing-flicker frequency increases by 3·3 cycles per second approximately. It also means that the observations conform substantially to the "Weber-Fechner law" of sensation and stimulus. According to that law the sensation y increases with stimulus of intensity x, according to the relation $y = k \log \frac{x}{x_0}$, where k is a numerical constant for each class of stimulus and sensation, while x_0 is the minimum appreciable stimulus in that class.

From an analysis of the tests, the authors conclude that (1) the sensation of flicker may be gauged in intensity by the vanishing-flicker frequency, or the frequency necessary to make the flicker disappear. (2) The law of flicker sensation in relation to flicker

* "Experiments on Carbon, Osmium and Tantalum Lamps, by J. T. Morris, *The Electrician*, p. 318, December 14, 1906.

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stimulus was similar, or at least substantially similar, to the law of steady luminous sensation with steady luminous stimulus, which is generally admitted to be in accordance with the Weber-Fechner law. (3) Constant ratios of increase in flickering illumination were accompanied by equal increments of vanishing-flicker frequency. Doubling the intensity of flickering illumination, everything else being unchanged, added approximately 3·3 cycles per second to the vanishing-flicker frequency, no matter what the size, colour or condition of the objects viewed; provided that their images on the retina were fixed (stationary objects and stationary eye). (4) The vanishing-flicker frequency plotted as ordinates, on uniform scale, to illumination as abscissæ, on a logarithmic scale, gives observation points falling approximately upon a straight line. Such straight lines in different series of observations with different targets and ranges of illumination appear to be parallel. (5) The vanishing-flicker frequency was 11 times the common logarithm of m times the illumination viewed by the eye, where m is a numerical constant depending upon the size, colour, quality and distance of the object illuminated, as well as on the range of flicker. With one exception, m was found approximately proportional to the flicker range, other things being equal.

MERCUROUS SULPHATE, CADMIUM SULPHATE AND THE CADMIUM CELL.*

BY G. A. HULETT.

Summary.—The author here describes a further series of experiments made on cadmium cells, and also gives the results of some experiments with regard to the ageing of standard cells.

Previous work† on standard cells developed a number of facts which indicated that there was some interaction between the cadmium sulphate solution and the mercurous sulphate of the depolariser, and now considerable experimental evidence on this question has been obtained. From the standpoint of the electrolytic dissociation theory we might expect mercurous sulphate to be less soluble in a cadmium sulphate solution than in water, since the two salts have a common ion. But the solubility was found to be about five times as great in a saturated cadmium sulphate solution as it was in water, and this fact suggested that the common ion might be ineffective in preventing hydrolysis of the mercurous sulphate. The solubility determinations indicated the presence of about a gramme of mercury in a litre of the saturated solution, but the solubility varied with the time the system had been rotated. This mercurous sulphate, which had been rotated with the cadmium sulphate solution and mercury, gave abnormal results when used as the depolariser of cells. The attempt to form mercurous sulphate directly in the cadmium sulphate solution by the electrolytic method also gave an abnormal product. These results were only to be understood after more information had been gained about the conditions of equilibrium of the system (mercurous sulphate, mercury, cadmium sulphate and solution). Accordingly, an apparatus was devised by which it was possible to rotate this system at a constant temperature and at any desired speed. By means of an adjustable anode of cadmium amalgam, cadmium sulphate and solution, it was possible to determine any change in the E.M.F. between the mercury and the solution of the rotated system, and thus it was possible to follow the changes of concentration of mercury in the solution.

On rotating the cathode system of the cadmium cell, it was found that the E.M.F. increased steadily for over two weeks and was only fairly constant on continued rotation. The experiment was repeated three times with fresh materials and, while the results varied somewhat, the maximum increase was about 0·00140 volts. After the system had been rotated for 30 days it was allowed to rest, but the E.M.F. did not remain constant, it decreased 0·00007 volts the first six hours, 0·00013 in 24 hours, and then more slowly as time passed. The system was therefore not in equilibrium.

The mercurous sulphate from this rotated system was used as the depolariser of two cadmium cells. For cell A49 the mercurous sulphate was first brought into a Gooch crucible and washed with a little fresh cadmium sulphate solution, while for cell A50 the depolariser direct from the rotated tube was used. These cells were set up June 11, 1906, and have since been maintained at 25 deg. The basis of all E.M.F. values given in this article are Clark cells with electrolytic mercurous sulphate as depolariser. Their value as determined by absolute measurements is 1·42040 volts at 25 deg.

The high preliminary value of these cells and the subsequent decrease are characteristic of cells which contain basic mercurous sulphate in the depolariser. The cells showed no tendency to stop at the normal value—1·01840. The results show that the rotated

* From the *Physical Review*.

† *The Electrician*, Sept. 14 and 21, 1906.

Cell.	June 12.	June 14.	June 17.	June 23.	June 26.	July 7.
A49	1·01863	1·01875	1·01868	1·01856	1·01855	1·01847
A50	64	64	64	60	55	47

Cell.	Aug. 14.	Oct. 22.	Dec. 19.	Jan. 3.	Feb. 26.
A49	1·01839	1·01827	1·01823	1·01817	1·01814
A50	38	29	26	20	15

system did not come to equilibrium even when rotated at constant temperature for a month, and unless the changes were due to the dissolved air or to some mechanical change in the materials of the system, they clearly indicate that slow chemical changes were taking place. It seemed possible that the oxygen of the air, dissolved in the cadmium sulphate solution, might have oxidised the mercurous sulphate to the more soluble mercuric compound, and if the rate of this oxidation was more rapid than the subsequent rate of reduction by the mercury, the observed results could be readily explained. This possibility had been considered* and reasons given for rejecting it, but, in view of the importance of the results obtained by rotating the cathode systems of standard cells, it has seemed advisable to further test the possibility of an effect due to the dissolved air. The test was carried out with apparatus similar to that used in the previous experiment. An adjustable cell (Fig. 1) was constructed from the materials which were to be tested in the rotating tubes. This cell was kept at 25 deg. and although the anode leg was frequently removed to test other systems, the cell has not varied over 0·00001 volts from its value of 1·01838 volts. The rotating tubes are represented by Fig. 2. The platinum contact wire was sealed through the bottom of the tube, extended 8 mm. up into the tube, where it was covered with a thin sheath of glass, except for 2 mm. of the end, which was exposed and thoroughly amalgamated. A small glass tube was

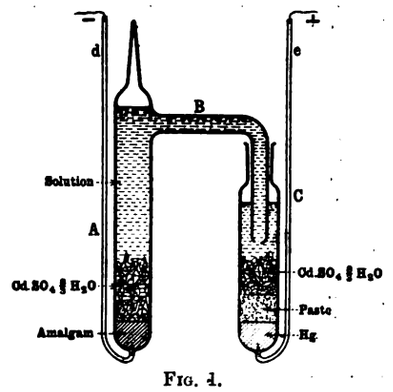

FIG. 1.
(one-third natural size.)

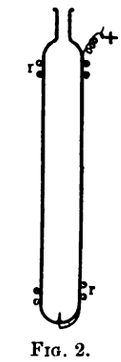

FIG. 2.
(one-sixth natural size.)

passed over the end of the platinum wire, which was outside of the tube, and then sealed to the large glass tube. This little glass tube was bent as indicated in the figure and served to protect and insulate the copper lead wire. Contact between the platinum and copper wires was made with a little mercury, and the rest of the little tube was filled with wax. The rotating tubes used were 20 mm. in diameter and 200 mm. long, each contained 7 cubic cm. of mercury, 4 cubic cm. of mercurous sulphate, 4 cubic cm. of powdered cadmium sulphate and about 50 cubic cm. of the saturated solution. These two systems were alike in all respects except that the air was rigorously excluded from tube No. 2, while tube No. 1 contained air and was frequently opened.

These tubes with their contents were rotated about their longer axis in the 25 deg. bath just as described for the first experiments. The temperature of 25 deg. was determined by certified $\frac{1}{10}$ deg. thermometers and the large 100 litre thermostat seldom varied 0·02 deg. from this temperature. Care was exercised to keep the bath covered so as to protect the rotating system from the action of light, since the black product formed by the action of light on mercurous sulphate increases the mercury concentration of the solution.

The materials used were distilled mercury, re-crystallised cadmium sulphate (the clear crystals only were used), and a saturated solution of these crystals. The mercurous sulphate was prepared chemically by adding an acid solution of mercurous nitrate to a 1 to 6 sulphuric acid solution. The sulphuric acid contained mercury and was rapidly stirred while the mercurous nitrate solution was added drop by drop. In the first experiments the gray electrolytic mercurous sulphate was used (l.c.), while here the chemically prepared sample was white, distinctly crystalline and coarse-grained. The preparation was brought into a Gooch crucible, washed with sulphuric acid

* *Phys. Rev.*, 23, 180.

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(D=1·15), with absolute alcohol to remove the acid, and finally with the saturated cadmium sulphate solution. Particular attention was given to these washings, because it had been found that sulphuric acid prevented the changes under consideration. The washed mercurous sulphate was mixed with an equal bulk of powdered cadmium sulphate crystals and brought into the rotating tube No. 1, which already contained the mercury and saturated solution. This tube was closed with a cork and a rubber cap and was rotated in the bath.

Tube No. 2 was first charged with the mercury and powdered cadmium sulphate and then evacuated and filled with pure hydrogen gas. The tube was evacuated and refilled with hydrogen several times in order to make sure that all the air had been removed from the tube and its contents. The saturated cadmium sulphate solution was brought into a vacuum and shaken until the dissolved air had been practically removed. Hydrogen gas was then allowed to bubble through the solution for three days. The mercurous sulphate was washed as before, except that the final washings were made with the hydrogen saturated solution, and care was taken to avoid drawing air through the sulphate. This sulphate was washed into tube No. 2 with some of the hydrogen saturated cadmium sulphate solution, a current of hydrogen prevented the entrance of air, and after the tube had been nearly filled with the solution it was evacuated and sealed off before the blow-pipe. The materials of this tube No. 2 may have retained some hydrogen, but they were free from oxygen, and when the tube was opened, after two weeks' rotation, the vacuum was still in evidence, so there could have been no leak.

The tubes were rotated together and at the same rate. After 33 hours, the rotation was stopped, tube No. 1 was brought to an upright position and measured with the anode leg of the adjustable cell.

3 minutes	after	stopping	rotation	E.M.F. was	..	1·01960 volts
6 ,,	,,	,,	,,	,,	..	51 ,,
13 ,,	,,	,,	,,	,,	..	40 ,,
45 ,,	,,	,,	,,	,,	..	30 ,,
60 ,,	,,	,,	,,	,,	..	29 ,,

The rotation was then continued and after four days the observations were,

2 minutes	after	stopping	rotation	E.M.F. was	..	1·02036 volts
5 ,,	,,	,,	,,	,,	..	17 ,,
10 ,,	,,	,,	,,	,,	..	08 ,,
20 hours		,,	,,	,,	..	1·01986 ,,
60 ,,	,,	,,	,,	,,	..	77 ,,

The rotation was then continued for six days, making a total of ten days, and tube No. 1 was again tested.

2 minutes	after	stopping	rotation	E.M.F. was	..	1·02035 volts
8 ,,	,,	,,	,,	,,	..	18 ,,
45 ,,	,,	,,	,,	,,	..	09 ,,
2 hours		,,	,,	,,	..	05 ,,
6 ,,	,,	,,	,,	,,	..	00 ,,
Adjustable cell					.....	1·01838 ,,

Evidently the system had about reached its maximum value and was nearly 0·00200 volt higher than the adjustable cell which had been made from the same materials. The increase in E.M.F. was somewhat greater than in the first experiments, but the maximum value obtained has no real significance, since it is not an equilibrium point; otherwise there would have been no change after the rotation was stopped. The significance of the decreasing E.M.F. will be considered later; here attention may well be called to some features of the experiment. The adjustable cell was compared with the standards before and after each series of measures on a rotated system, and since there was no variation of the adjustable cell greater than 0·00001 volt, it is certain that the anode tester remained constant and that the observed changes were all in the rotated system. Furthermore, after the solids had settled in the rotated tube some of the clear supernatant solution was removed and tested on a clean mercury electrode with the adjustable anode, and the value 1·02013 volts was observed. We may, therefore, be quite confident that the large values obtained for the E.M.F. were due solely to an increase in the mercury concentration of the rotated solution.

Tube No. 1 had about reached its maximum value, but was again rotated, and two days later, when both tubes had been rotated a total of 12 days, the hermetically sealed tube No. 2 was also tested with the anode leg of the adjustable cell.

The agreement between the two tubes is as good as between different measurements on tube No. 1, and since the systems were not in equilibrium the agreement in maximum values is better than was to be expected. The decreasing values depend for one thing on diffusion, and this rate of decrease varied at different times for the same system as may be seen from the various measurements on tube No. 1. The results obtained, therefore, give a decisive answer to the question at issue, and we may conclude that the dissolved air plays no rôle in these rotation experiments.

Since the dissolved oxygen did not cause the changes in the cathode system, there must have been some interaction between the materials of the rotated tubes which increased the mercury concentration of the solution. If this action was hydrolysis, as has been suggested, an explanation of the observed changes would be possible. Assuming that hydrolysis did take place, it followed that the presence of sulphuric acid, one of the products of hydrolysis, would minimise or prevent the changes. This conclusion was tested by the following experiment:—

Time from stopping rotation.	Tube No. 2. Air free.	Tube No 1. Air saturated.	Time from stopping rotation.	Tube No. 2. Air free.	Tube No. 1. Air saturated.
1½ min.	1·02040 v.	1·02060 v.	24 hours	1·01972 v.	1·020000 v.
2 ,,	23 v.	..	2 days	60 v.	1·01988 v.
5 ,,	11 v	50 v.	4 ,,	46 v.	64 v.
10 ,,	03 v.	42 v.	7 ,,	34 v.	40 v.
30 ,,	1·01997 v.	36 v.	14 ,,	12 v.	16 v.
60 ,,	91 v.	33 v.	21 ,,	00 v.	
3 hours	86 v.	22 v.	30 ,,	1·01800 v.	..
6 ,,	81 v.	17 v.			..

A saturated solution of cadmium sulphate was made tenth molecular in respect to sulphuric acid, and this acid solution was used in constructing an adjustable cell and in filling a rotating tube. Electrolytic mercurous sulphate was washed with alcohol and with the acid cadmium sulphate solution, and was then made to a paste in the usual way. The other materials, apparatus and method were the same as for the preceding experiments. The adjustable cell, due to the presence of acid, was lower than the cadmium cell (1·01825 volts at 25 deg.), but quite as constant. The cathode system in the tube was rotated, as previously described, at 4 revs. per min., and after 12 hours it was measured with the anode leg of the adjustable cell with results as follows:—

3 minutes	after	stopping	rotation	E.M.F. was	..	1·01812 volts
8 ,,	,,	,,	,,	,,	..	22 ,,
30 ,,	,,	,,	,,	,,	..	22 ,,
60 ,,	,,	,,	,,	,,	..	22 ,,
Adjustable cell					.....	24 ,,

After two days' rotation the following results were obtained:—

2 minutes	after	stopping	rotation	E.M.F. was	..	1·01815 volts
5 ,,	,,	,,	,,	,,	..	20 ,,
20 ,,	,,	,,	,,	,,	..	24 ,,
10 hours		,,	,,	,,	..	24 ,,
Adjustable cell					.....	25 ,,

The tube was then rotated two weeks:—

2 minutes	after	stopping	rotation	E.M.F. was	..	1·018200 volts
4 hours		,,	,,	,,	..	21 ,,
12 ,,	,,	,,	,,	,,	..	22 ,,
3 days		,,	,,	,,	..	25 ,,
4 ,,	,,	,,	,,	,,	..	23 ,,
Adjustable cell					.....	24 ,,

This system—mercurous sulphate, mercury, cadmium sulphate and acid solution of cadmium sulphate—came to equilibrium soon after it was brought together and there was then no further change. The system behaved exactly as did the cathode system of the Clark cell.* The effect of the sulphuric acid in eliminating the changes in the rotated system is in agreement with the view that the neutral cadmium sulphate solution hydrolysed the mercurous sulphate, but this is not by itself a proof of the point.

This experiment, with the previous ones, furnishes more evidence on the question of oxidation by dissolved air. The materials and solution in this last experiment were air saturated and frequently opened to the air, but the system came to equilibrium at once with the normal E.M.F. This would hardly have been the case if the dissolved air had been oxidising the mercurous sulphate. In the rotation experiment with the cathode system of the Clark cell the zinc sulphate solution was air saturated, but did not oxidise the mercurous sulphate because the system showed the normal value and did not change on continued rotation.

It will be seen that the experiment just described also gives some evidence on the question of the size of particles changing the solubility of the mercurous sulphate. A fine power has an abnormally great solubility, but the effect has not been observed until the powder contained a large number of particles with diameters less than 1 or 2 microns. Previous experiments have shown that mercurous sulphate which settled rapidly in a 1 to 6 sulphuric acid solution was sufficiently coarse-grained to avoid a measurable effect of the size of the particles on the solubility. But the mercurous sulphate might have been ground to a fine powder in the rotating tubes, and this would not only have increased the mercury concentration of the solution, but, on standing, the finer, more soluble crystals would have disappeared and the mercury concentration would then have decreased. The changes in E.M.F. observed on rotating the cathode system of the cadmium cell corresponded with this explanation, but when a little acid was added the system soon came to equilibrium, and the slow changes previously observed were entirely lacking. The same kind of mercurous sulphate and rate of rotation were used

* *Phys. Rev.*, 23, 181.

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in both cases, so the observed changes in the first experiment cannot be explained as due to finely divided particles or to grinding of the solids, since the presence of the acid in the last experiment could not have affected either of these factors.

The electrolytic mercurous sulphate and the same rate of rotation were used in the experiment with the cathode system of the Clark cell; the system came to equilibrium at once with no changes characteristic of the presence of finely divided particles, and the same conclusions may be drawn from that experiment. The method of rotating the tubes* was devised in order to avoid grinding the solid contents of the system, but at the same time it was necessary to ensure a thorough mixing of the cathode materials and this was satisfactorily accomplished by the method and apparatus employed.

The Ageing of Standard Cells.

In the method of constructing cells devised by Clark, Wright, and Thompson and Rayleigh, the mercurous sulphate was washed with water and thus contained the basic salt even if it had not been previously formed in making the mercurous sulphate. Such cells always had a high value and required a month or two of "ageing" before they reached a constant value. On the other hand, when the mercurous sulphate was properly prepared and washed so as to exclude the basic salt from the depolariser,† the cells had their constant value at once. Cells have been made with depolarisers which contained known amounts of the basic mercurous sulphate, and these cells had a high preliminary value, and then showed the characteristic decrease. Electrolytic mercurous sulphate was shaken with definite amounts of water and an excess of mercury; thus a definite amount of the basic salt was formed and mixed with the undissolved solid. This mixture was made to a paste in the usual way; cell A44 contained 1 per cent. of the basic salt in the depolariser, cell A45 3 per cent. and cell A46 10 per cent.; while the completely hydrolysed salt ($2(HgOH) . Hg_2SO_4$) was used for cell A41. These cells have been maintained constantly at 25 deg., and their records for over a year are as follows:—

Cell.	Jan. 13.	Jan. 26.	Feb. 7.	Mar. 13.	April 13.	May 12.	June 4.
A44	1·01878	1·01871	1·01868	1·01866	1·01865	1·01862	1·01860
A45	64	60	58	55	53	52	47
A46	98	90	86	80	74	69	62
A41	1·01768	760	767	774	776	772	770

Cell.	July 7.	Aug. 14.	Nov. 15.	Dec. 19.	Jan. 3.	Feb. 26.	..
A44	1·01857	1·01855	1·01853	1·01854	1·01850	1·01849	..
A45	47	47	45	57	46	46	..
A46	57	56	44	40	40	44	..
A41	764	756	747	741	736	732	..

The cells with 1 and 3 per cent. of basic salt have become fairly constant, while cell A46, with 10 per cent. of basic salt in the depolariser, had the highest preliminary value and has varied the most, while the cell with only the basic salt, A41, shows no sign of becoming constant. The depolarisers of cells A35 to A40 were made basic by mixing known amounts of the completely hydrolysed salt with the normal salt. The effect was not as great as in the experiments just described, but of the same general character. The higher values and more rapid rate of decrease were found in the case of the cells with the larger percentage of basic salt, and these cells were liable to go below the normal value.

On rotating the cathode system of the cadmium cell an increase in the E.M.F. was obtained, and when the system was allowed to rest the E.M.F. began to decrease, rapidly at first and then at a decreasing rate. The mercurous sulphate which had been rotated 30 days with the cadmium sulphate solution and mercury was used as the depolariser of cells A49 and A50, and these cells had a high value and then decreased and are now below normal value and still decreasing. The parallelism between all these facts is evident and indicates that a basic mercurous sulphate was formed in the rotation experiments. The fact that a little sulphuric acid prevented the changes in the cathode system is in agreement with this view, and on the whole it seems reasonable to conclude that a neutral cadmium sulphate solution interacts with the depolariser to form a basic mercurous sulphate. Hydrolysis would account for the facts established by the previous experiments, but the basic salt formed by the action of the cadmium sulphate solution is probably different from the one formed by the action of water, otherwise we would expect the cells with variable amounts of the basic salt (due to water) to show more agreement, since it would be a case of two solids saturating a solvent and enough of the basic salt to prevent any action of the cadmium sulphate solution. But whatever the nature of the new phase which formed on rotating the cathode system of the cadmium cell, the subsequent decreasing E.M.F. showed that the system had not attained equilibrium.

There evidently were two oppositely directed changes taking place; the one, assumed to be hydrolysis of the mercurous sulphate, increased the mercury concentration of the solution, while the other and much slower change was evidently a secondary action of the mercury on the soluble products of hydrolysis. This secondary action occurred only when the basic salt was or had been present, and it caused a decrease of the mercury concentration of the solution. Tube No. 1 attained the high value of 1·02060 volts and on standing decreased to 1·01900 volts in three weeks, but on examining the supernatant solution it was found to have still retained a high value, showing 1·02013 volts against a mercury electrode. This test was made by bringing some of the clear liquid on to a mercury electrode in a little tube like the part (C) of Fig. 1 and measuring the E.M.F. with the adjustable anode. When left in contact with the mercury electrode the clear liquid showed a slowly decreasing value and shaking it with the mercury seemed to have very little effect in hastening the action.

First reading	1·02013 volts	90 minutes	1·01989 volts
6 minutes	00 ,,	1 day	68 ,,
20 ,, ...	1·01938 ,,	3 days	51 ,,
10 days		1·01919 volts	

We may therefore conclude that both in the cells, which contained basic salt, and also in the rotated systems a slow secondary reaction took place and that this action was only at the surface of the mercury. The rate at which the mercury concentration of the solution above the paste decreased depended on the rate of diffusion of the solution through the paste and thus depended on the mechanical fineness of the solid materials of the cathode system. The hydrolysis, or whatever reaction formed the basic salt, could not have attained equilibrium until the secondary action was completed or had formed a new phase. If this view is correct it is probable that the maximum value was not observed in any of the rotation experiments. In the first experiment with the grey electrolytic mercurous sulphate there was a tendency for the mercury to become divided into fine globules, and thus the mercury surface was much increased and consequently the rate of the secondary reaction. In the experiment with the white chemically prepared mercurous sulphate there was no tendency of the mercury to become finely divided and the maximum value was higher than in the first experiment and attained in less time. Evidently variations in the materials and in the apparatus and method used will give quite different results, but the experiments seem to clearly show that in the cathode leg of the cadmium cell we have a system which is in unstable equilibrium.

The changes that have been observed in the E.M.F. of cadmium cells are, of course, small compared with those obtained in the rotation experiments. The F series of 10 cells, which were made February 15, 1904, showed an agreement among themselves of 1 part in 100,000 for nearly a year, but now they show variations of 5 parts in 100,000, and are from 10 to 15 parts lower than they were when made. The A series of October 21, 1905, showed the same excellent agreement for nearly a year.

Cell.	Oct. 26.	Dec. 14.	March 4.	June 4.	Oct. 2.	Dec. 19.	March 18
A1	1·01843	1·01843	1·01843	1·01842	1·01842	1·01841	1·01841
A2	42	43	43	42	46	44	43
A3	42	42	43	42	..	..	..
A4	43	43	43	42	42	42	42
A5	43	43	43	42	41	40	40½
A6	43	43	43	43	42	42	42

The paste in these (A) cells was about 2 cm. deep and the cells have remained undisturbed in the 25 deg. bath, but are not now in as good agreement as formerly, although they have not shown as great a decrease as was exhibited by the F series.

It is probable that cadmium cells, made with a fine-grained depolariser of good depth, would show less variations than have been shown by the F and A series, since there would be less chance for diffusion and consequently for the changes indicated in this article. A very fine-grained mercurous sulphate retains the sulphuric acid very tenaciously, and the presence of this acid in the cell also tends to retard the changes. But a standard cell which depends on the mechanical conditions of the solid materials and is in un table equilibrium must be less reproducible and less constant than cells which are free from these defects. In the experiment in which acid was added to the cathode materials of the cadmium cell it was found that the system soon came to equilibrium, and this has suggested that the cadmium cell should have a definite amount of sulphuric acid. A number of these acid cadmium cells have been constructed and are very constant, but as yet insufficient observations have been made on them to judge of their worth.

At the same time as the F and A cells were made, Clark cells were also made and with depolarisers made from the same samples of mercurous sulphate as served for the cadmium cells. These Clark cells are now in good agreement and have the same value as cells made in the last few months from fresh materials. This is in agreement with the results of the rotation experiments on the cathode systems of the Clark and cadmium cells.

* *Phys. Rev.*, 23, 177. † *Phys. Rev.*, 23, 172.

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The fact that these Clark cells which were made at various times with fresh materials are now in good agreement (± 0·00002 volt) is proof that they have not changed and that they form a reliable basis of E.M.F. The absolute value of these cells is 1·4204 volts at 25 deg., as determined by Dr. K. E. Guthe.*

The essential points to be observed in constructing these cells have been given.† The high temperature coefficient of the Clark cells has made it necessary to have very constant temperature baths. A large copper tank contained 100 litres of kerosene oil, and was electrically heated and controlled. A mercury-toluene regulator operated the relay, which in turn controlled the heating current. This regulator consisted of glass tubes joined together in the form of a gridiron, so as to be well distributed in the bath. The tubes were filled with toluene, except the outlet, which was filled with mercury. Contact with the relay circuit was made with a very fine platinum wire (0·05 mm.), and a condenser was used to prevent sparking. It was found that with the very fine contact wire there was no "fouling" of the mercury and no "drift" of the bath temperature. The heating coils were also in the form of a gridiron, made of glass rods and pianoforte wire, which was wound on the glass rods and then thoroughly shellacked. The resistance was 120 ohms and the heating current was only ½ ampere (an alternating current was used). The heating surface was large and well distributed in the bath, and only a very small amount of heat was needed, because the bath was well protected with non-conducting materials. The oil was stirred with a motor-driven paddle, and there were no differences of temperature in the various parts of the bath that could be detected with a Beckmann thermometer. The temperature was determined by certified 1/50 deg. thermometers, and these thermometers were checked at the transition point of sodium sulphate, 32·383 deg. An Otto Wolff potentiometer was used in the measurements, and its corrections were known and applied when necessary. The galvanometer gave 2 mm. deflection for 0·00001 volt. In making measurements it was found best to join all the anodes of all the cells together, and particular attention was given to the question of insulation. The measurements given are regarded as correct to 0·000005 volt.

ON THE MAGNETIC PROPERTIES OF HEUSLER'S ALLOYS.‡

BY J. C. McLENNAN.

Since the discovery by Heusler some three years ago that it was possible to prepare alloys of copper, manganese, and aluminium which possessed magnetic properties similar to and comparable in amount with those of cast iron, considerable attention has been paid by a number of investigators§ to this interesting phenomenon.

In order to prepare samples of the alloys a supply of manganese, copper and aluminium, sold as chemically pure and free from iron, was obtained from Messrs. Eimer & Amend of New York. The metals were melted in an ordinary coke furnace, such as is used in brass foundries, and poured into moulds just as in making brass castings. A graphite crucible was used for the purpose, and in the process the copper was first heated until it reached a molten state, after which the manganese was added to it. When this in turn was melted the aluminium was added, and the molten mass then stirred for a short time with a porcelain rod, after which the crucible was taken from the furnace and the melted metal poured into the moulds.

For a preliminary set of the alloys four castings were made. As Heusler had found that the most highly magnetic alloy contained manganese and aluminium in the proportion of their atomic weights, one casting was made with as nearly as possible this proportion of the two metals. A second was made with a larger proportion of aluminium and two others with smaller proportions of this constituent.

The percentages of the metals used in each of the four castings and the proportions of aluminium to manganese by weight and by atomic ratios are shown in Table I.

In each casting sufficient material was used to make two cylindrical rods about 20 cm. long and 8 mm. in diameter, as well as two rings about 7 cm. in diameter and 2·5 cm. in height. It was thought desirable to make the castings in the form of rings as well as rods, in order to investigate more fully the permeability of each specimen.

In the whole of the operation the greatest care was taken to keep the alloy free from iron in order that there might be none of this metal present to vitiate the results or to cast doubt upon their validity.

Table I.

No. of alloy.	Composition of alloys—Percentage·			Ratio of manganese to aluminium by weight.	Atomic ratio of aluminium to manganese.
	Aluminium.	Manganese.	Copper.		
I.	8·0	32·1	59·8	0·250	0·51
II.	9·7	25·6	64·6	0·378	0·77
III.	14·3	28·6	57·1	0·498	1·01
IV.	15·9	23·9	60·3	0·683	1·392

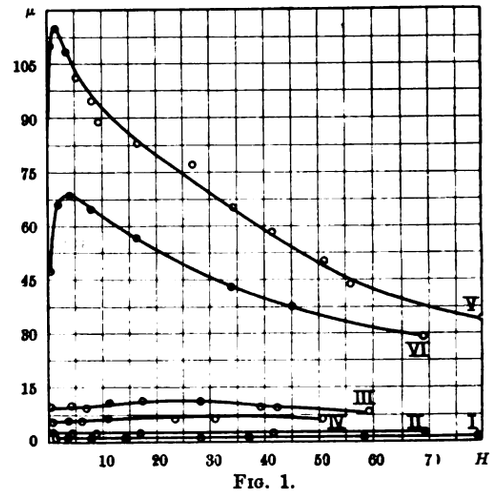

FIG. 1.

Investigations into the phenomenon of magnetostriction were made by Mr. Dawes, and also by Messrs. McTaggart and Robertson, and showed that:—

1. When a change was made in the field to which the bar was subjected an almost instantaneous change was made in the length. This change consisted in a lengthening as the field was increased, and shortening as it was decreased.

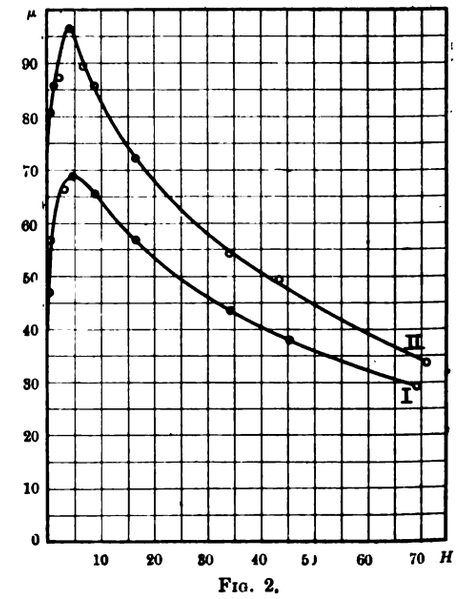

FIG. 2.

2. As the field was decreased there was a certain lag or hysteresis effect, so that the length did not have the same value for a given field as the field was approached from above or below.

3. In some cases when the specimen was left in a field for some time there was a continuous shortening. This effect when it existed was very marked in strong fields, so that the time for which the specimen was left in these fields had a comparatively great influence on the length. This effect was also observed by Austin in some

* *Bull.* Bur. Standards, 2, 33, 1906.

† *Phys. Rev.*, 22, 334-338.

‡ Abstracted from the *Physical Review*, June, 1907.

§ Fr. Heusler, W. Starck and E. Haupt, *Verh. der Phys. Ges.*, Vol. V., p. 219, 1903. Heusler, Starck and Haupt, *Über der ferromagnetischen Aigenschaften von Legierung unmagnetischer Metalle*, Marburg, 1904. Gumlick, *Ann. der Physik*, Vol. XVI., p. 535, 1905. Austin, *Verh. der Deut. Phys. Gesell.*, Vol. VI., p. 211, 1904. Fleming and Hadfield, *Proc.*, Roy. Soc., Vol. LXXVI., p. 271, 1905. E. Take, *Verh. der Deut. Phys. Gesell.*, Vol. VII., p. 133, 1905; *Ann. der Physik*, Vierte Folge, Vol. XX., p. 249. Hill, *Phys. Rev.*, Vol., XXI. p. 335, 1905; Vol. XXIII., p. 498, 1906. Guthe and Austin, *Bulletin of the Bureau of Standards*, Washington, Vol. II., No. 2, p. 297, August, 1906.

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experiments made by him with these alloys. It does not appear, however, to have been found by him in some measurements he has recently made, in collaboration with Guthe, with other samples of the alloys.

PERMEABILITY. (EXPERIMENTS BY MISS L. B. JOHNSON.)

A series of measurements was made by Miss L. B. Johnson on the permeability of the four alloys. Two rings had been made at each casting, and with these the experiments on permeability were carried out. The magnetisation was measured by the ballistic method, by reversing the magnetising force, and the arrangement of apparatus was similar to that used by Ewing and Klaasson.*

Table II.

Alloy.	*H*	*B*	μ	*H*	*B*	μ
I.	1·39	1·39	1·0	14·40	18 7	1·3
	2·82	4·01	1·4	28·22	37·8	1·3
	3·93	5·35	1·3	37·63	50·8	1·3
	7·52	10·7	1·4	86·45	78·9	1·3
II.	0·814	1·464	1·7	17·5	27·8	1·5
	1·66	2·92	1·7	42·5	68·8	1·6
	4·99	8·78	1·7	69·3	106·8	1·5
	8·55	13·17	1·5	..	..	..
III*a*.	0·68	6·442	9·3	17·1	201·0	11·6
	1·8	17·1	9·8	28·3	332·8	11·7
	4·4	46·1	10·3	36·9	364·0	9·8
	7·0	71·2	10·1	42·9	413·8	9·6
	11·9	129·8	10·8	59·3	483·1	8·1
III*b*.	0·99	4·596	4·6	11·24	70·17	6·2
	1·45	9·138	6·3	23·4	160·8	6·8
	2·04	11·42	5·5	30·81	221·5	7·1
	3·08	18 27	5·9	50·75	352·1	6·9
	6 01	34·26	5·7	..	..	..
IV*a*	0·2745	13·1	48·1	8·692	565·7	65·1
	0·5032	30·5	58·0	16·47	933·9	56·7
	1·464	96·1	65·6	34·31	1487·2	43·3
	2·379	157·2	66·1	45·29	1724·08	38·0
	4·575	314·5	68·7	69 54	2072·3	29·8
IV*b*.	0·0379	3·108	82·0	16·45	1,366·93	83·0
	0·147	13·67	92·9	27·14	2,113·44	77·8
	0·452	49·72	110 0	34·55	2,257·76	65·4
	1·192	136·75	114·7	41·77	2,424·24	58·0
	2·467	279·72	113·3	51·0	2,548·4	49·8
	3·331	360·52	108·2	55·93	2,586·4	44·4
	5 264	535·81	101·7	80·61	2,735·04	33·8
	7·81	739·70	94·7	92·13	2,735·04	24·6

The first set of measurements was made with the rings just as they were cast, and the results are given in Table II. The permeability curves are given in Fig. 1.

From these it will be seen that alloys IV*a*. and IV*b*. showed the highest permeability. Alloys I. and II. were but feebly magnetic, and alloys III*a*. and III*b*. only slightly so.

It had been expected that the permeabilities of the rings would give an indication of the relative permeabilities of the corresponding rods used in the measurements on magnetostriction. The very considerable difference in the permeability of the two rings Nos. IV*a*.

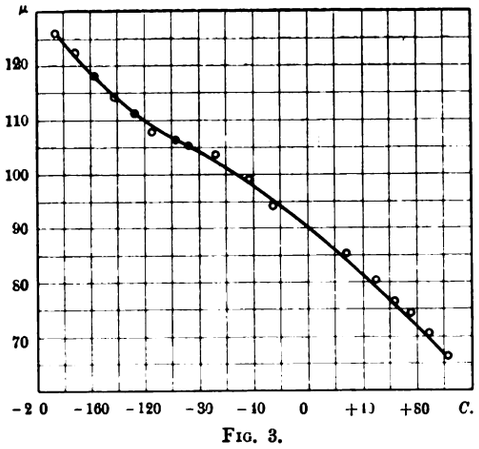

FIG. 3.

and IV*b*., which were made at the same casting, showed, however, that even different portions of the same casting did not exhibit the same magnetic properties, and that before any definite comparisons could be made it was necessary to make a chemical analysis of each of the specimens tested. This difference in magnetic properties was also very marked with alloy No. III. The rods of this casting gave the greatest elongation, while the rings, as the figures show, possessed but a small permeability. Guthe and Austin* have pointed out that the greatest elongation was obtained by them with rods which possessed the greatest permeability, and, as some experiments which are now being made on the permeability of the rods No. III. show that they possess a very much higher permeability than that exhibited by the rings, this conclusion is very probably correct.

In addition to the initial tests just described, some measurements were also made on the changes in the permeability produced by continued heating.

Increase in the permeability is shown by the numbers for alloy No. IV*a*. Curve I., Fig. 2, shows the permeability of the alloy in different fields when freshly cast, and curve II. its permeability in the same fields after it had been repeatedly heated up to 100°C. and cooled to the temperature of liquid air.

In the interval between which the results with alloy IV*a*. recorded in Fig. 2 were obtained, this specimen was examined under a constant magnetising force of 3·934 C.G.S. units for temperatures ranging from – 182°C. to 105°C. The temperatures were estimated from variations in the resistances of a platinum wire wound round the ring between the primary and secondary coils. The results of these measurements are given in Table III., and a curve representing them is given in Fig. 3 :—

Table III.—*Alloy No. IVa. H = 3·934 C.S.G. units.*

Temp.	B.	μ	Temp.	B.	μ
– 182·0	487·0	123·7	0	338·5	86·0
– 169·0	471·8	119·9	8·2	334·2	84·9
– 154·0	454·3	115·4	19·6	327·6	83·2
– 143·5	445·6	113·2	35·3	321·1	81·6
– 131·0	432·5	109·9	48·0	308·8	78·5
– 110· 5	410·6	104·3	63·1	297·0	75·5
– 53·0	375·7	95·4	69·0	288·3	73·2
– 46·0	364·8	92·7	76·4	281·8	71·6
– 36·0	358·2	91·0	91·6	266·5	67·7
– 13·5	342·9	87·1	105·0	521·21	63·8

The permeability, it will be seen, showed a steady increase as the temperature was lowered.

The results of these various tests, it will be seen, are in accordance with the observations of other investigators, who have found that the permeability of these alloys can be considerably increased by continued heating at moderate temperatures.

TESTS ON THREE-PHASE POWER PLANT FOR THE GREAT COBAR MINES.

The following is a brief description of the official tests of three Siemens-Browett Lindley steam alternators just constructed for

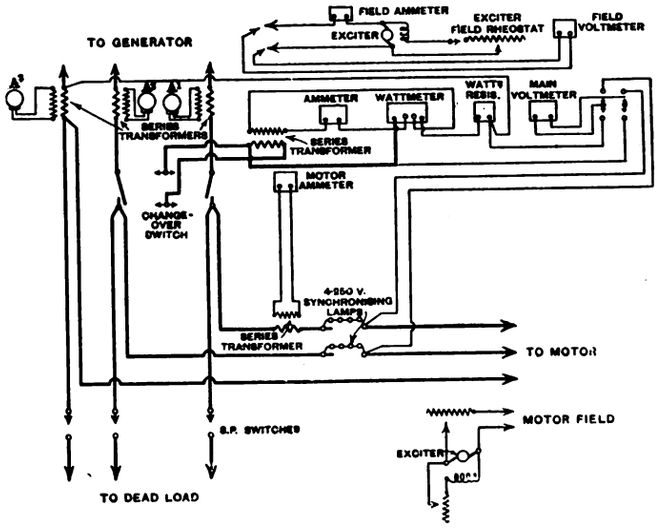

FIG. 1.—DIAGRAM OF CONNECTIONS.

the Great Cobar Copper Mines, Australia. They are interesting from an electrical point of view, as the sets were tested on a specified power factor of 0·85.

For the official tests two of the sets were connected as shown in Fig. 1. One set was run under steam as a generator, and the other acted as a synchronous motor working in parallel with a balanced water load. The pistons belonging to the engine of the second set were removed and the set run up to speed, to allow of its being

* *Phil. Trans.*, Vol. CLXXXIV., A, p. 987, 1893.

* *Loc. cit.*

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synchronised with the generator, by means of a 30 H.P. direct-current motor belted to the flywheel of the engine. The necessary current for this was supplied from the works power plant. The arrangement proved very flexible, as by varying the field on the synchronous motor it was possible to obtain any power factor on the generator from zero lagging to about 0·85 leading. The actual power-factor during the official tests was 0·85 lagging, for which the generators were designed.

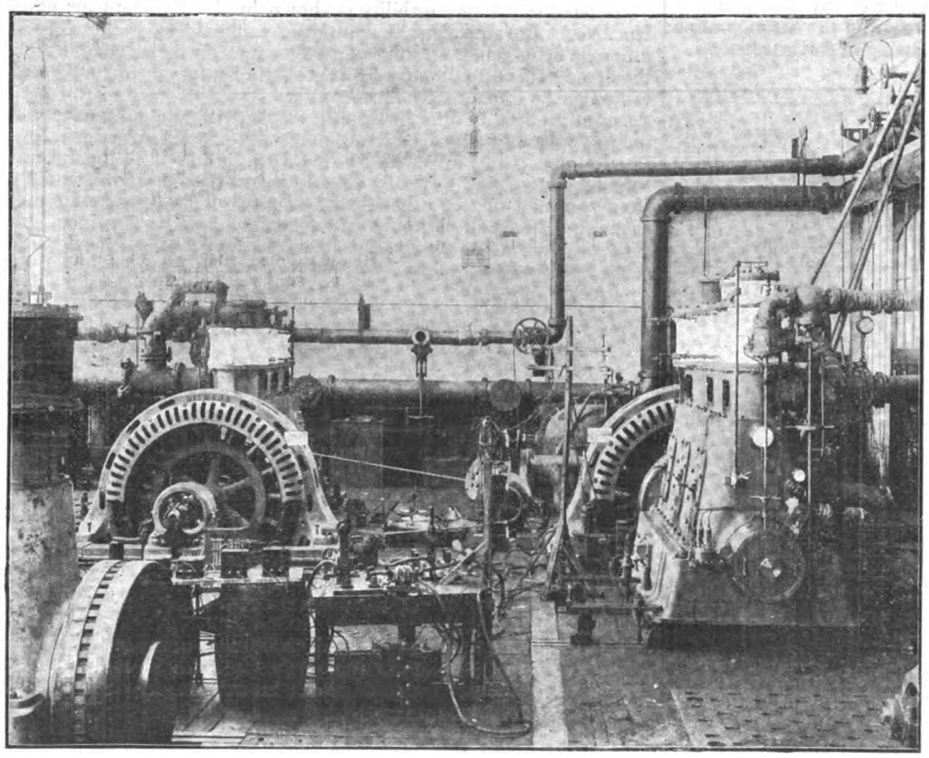


FIG. 2.

In cases where two generators of a similar type are to be tested, the adoption of this arrangement has the advantage over the use of choking coils that, once the connections are made, no time is lost in making adjustments to get the right power factor, since the only alteration required is to the series regulator in the field of the machine used as synchronous motor.

The instruments used in connection with the above tests were as follows:—Three ammeters for measuring the current in each phase of the generator. One Siemens table pattern indicating wattmeter connected as shown in the diagram to a special change-over switch to enable two readings to be made on the same instrument, so as to give the total power, by the well-known two-wattmeter method. A voltmeter was also connected in parallel with the wattmeter voltage coil to give a pressure reading across the two phases; this voltmeter was also connected to a small throw-over switch, so as to give readings on both generator and motor when paralleling. For paralleling the synchronous motor and generator, four 250 lamps in series across two of the connections between the machines were used.

The engines, manufactured by Messrs. Browett, Lindley & Co. (Ltd.), Patricroft, are of their well-known vertical triple-expansion enclosed type. The engines were run for six hours full load, and two hours overload, and exhausted into a surface condenser with an Edwards air pump delivering into a tank on an Avery weigh-bridge so that accurate steam consumption tests could be made. The steam supplied to the engines was passed through a Schmidt separately fired superheater, in order to obtain the specified temperature of 75°F. above that of saturated steam at 160 lb. pressure.

We give below a summary of the results of this test, the readings showing the great advantage of using variable expansion gear on the high-pressure cylinder, there being only a difference of ¾ lb. per kilowatt between 20 per cent. overload and half load.

Steam Consumption per Kilowatt-hour, Condensing.

Full load.	Three-quarter load.	Half load.	20% overload.
22·4 lb.	22·7 lb.	24·0 lb.	23·25 lb.

The governing results showed a rise of only 2½ per cent. permanent and 4½ per cent. momentary variation.

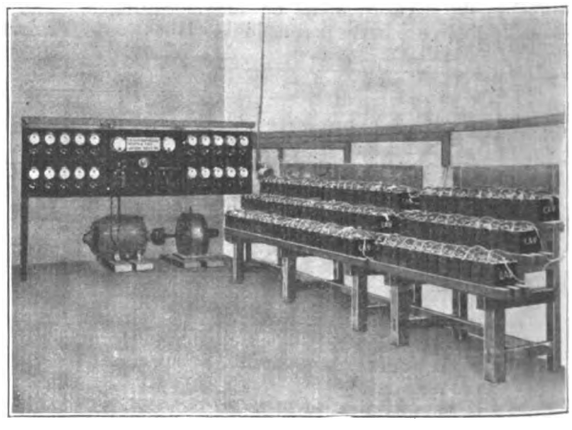
The Siemens three-phase alternators are of the rotating field type, the phases being star-connected. They have a continuous output of 300 kw. at a power factor of 0·85, and generate at 440 volts 50 cycles per second when running at a speed of 375 revs. per min. Each alternator stands on its own independent bedplate, the only connection with the engine being at the coupling, and the exciter is directly coupled to an extension of the alternator shaft. The poles are circular in section, and the pole shoes are laminated. The stator is of cast iron and of such design as to combine great stiffness with light weight, and particular care has been taken to ensure thorough ventilation. The armature core is built up of laminated stampings and the armature coils, after being placed in the open slots, are firmly held in position by wooden wedges. The coils are amply insulated and are protected against external injury by the shields on the frame, which cover them completely; some of these shields had been removed at the time the photograph (Fig. 2) was taken. The temperatures of the machine were exceedingly low after six hours' run, the highest on any part of the machine or winding being only 28°F. above the surrounding air.

The tests were conducted on Messrs. Browett, Lindley & Co.'s test plate at Patricroft, and the arrangements were carried out by their chief testing engineer, Mr. J. S. Colquhoun, and Mr. Woodward, of Messrs. Siemens' Stafford works.

ACCUMULATOR CHARGING PLANT.

We illustrate an accumulator-charging plant recently installed in the Daimler Co.'s works at Coventry by Messrs. C. A. Vandervell & Co., ignition battery specialists, of Warple Way, Acton Vale, London, W. The following brief particulars give some idea of the capacity of this installation.

The switchboard measures 11 ft. by 3 ft., and has mounted at the back of it a field rheostat for the dynamo, with hand-wheel in front. A reverse cut-out is fitted to prevent the accumulators discharging through the dynamo in the event of the latter accidentally stopping. The main ammeter and voltmeter are 9 in. in diameter and of the dead-beat moving-coil type, reading up to 175 amperes and 75 volts respectively, while there are 20 ammeters of 6 in. diameter for the charging circuit. The resistances are fitted in separate porcelain units for each step, and may be easily replaced. There are double-pole main switches and fuses, with a safety fuse to each circuit. The dynamo is capable of a normal output of 70 volts 160 amperes It is possible to charge at one time 275 "C.A.V." accumulators of 100 amperes 4 volts, the normal rate being 7 amperes, with a possible maximum of 10 amperes if necessary. The dynamo runs at 960 revs. per min., and is coupled direct to one of the Coventry Corporation's 15 H.P. motors.



THE DAIMLER CO.'S CHARGING PLANT BY C. A. VANDERVELL & CO.

It is claimed that, so far as motor factories or garages in Great Britain are concerned, this installation is unique.

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CORRESPONDENCE.

CORRESPONDENCE IN THE TECHNICAL PRESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Lately the correspondence columns in the English electrical technical papers have contained more than their usual amount of sarcasm and personal comment, whereas the American Press has been practically free from it. Though only relating to a small minority of electrical engineers, this failing has been demonstrated again and again by the letters published in the electrical Press, so that it might almost be thought that these columns merely formed a convenient dumping-ground for airing grievances. Personalities are always unnecessary, and not a few of the many American engineers who are readers of our technical papers must begin to think there is something radically wrong in the constitution of the English genus, and, therefore, conclude that all the species are alike.

The English nation has rightly acquired a reputation for open-mindedness and a sporting spirit. It would consequently be a pity if the only exception therefrom were found in a certain section of the electrical world, where there apparently prevailed a somewhat childish spirit of spleen and animosity. Dignity of thought and dignity of expression are rare qualities that only a few can possess, but it is always possible to keep clear of personal imputation or abuse, and if correspondents stated their conclusions in plain but simple English, without recourse to personal issues, their object would often be better subserved, and lucidity with economy of space would result.—I am, &c.,

W. E. MILLER.

Schenectady, U.S.A., Aug. 17.

[We think that Mr. Miller is scarcely fair to the English technical Press. At times personal matters no doubt do creep in, and doubtless they will continue to do so; but, generally speaking, the matters discussed in correspondence columns are of general interest. The American Press is certainly much freer from correspondence; we doubt, however, if that is in the general interest.—ED. *E.*]

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

Walsall Corporation invite applications for the appointment of electrical engineer for their electricity undertaking. Commencing salary £400 per annum, to be increased to £450 by additions of £25 for each two years of approved service. Applications to the town clerk (Mr. John R. Cooper), Council House, Walsall, by Sept. 9.

The Cleveland & Durham Electric Power (Ltd.) require three assistant sub-station attendants, technical training and experience of high tension distribution necessary. Commencing salary £1 per week. Applications to the Secretary, Hintons-buildings, Middlesbrough. See an advertisement.

Applications are invited for the position of chief lecturer in electrical engineering at the Bradford Technical College. Commencing salary £200 per annum. Particulars of duties and forms of application may be obtained from Prof. G. F. Charnock. Applications to the secretary of the Education committee (Mr. Thos. Garbutt), Education Office, Manor-road, Bradford, by Sept. 16. See also an advertisement.

Applications are invited for the post of instructor in electric wiring at Redhill Technical Institute. Salary 6s. per hour for one evening per week of two hours, plus third-class travelling expenses. Application to the secretary of the Surrey Education committee (Mr. Ramsay Nares), County Education Office, Kingston-upon-Thames, before Saturday, 14th inst. See advertisement.

The Electric Construction Co. require a reliable draughtsman with good experience in a.c. machines; also neat and accurate junior draughtsman for switch work. Applications to the Secretary of the Company, Dashwood House, 9, New Broad-street, London, E.C. See advertisement.

Bristol Merchant Venturers' Technical College require a temporary assistant teacher for physics. Salary £3 per week. Particulars from the Registrar. See an advertisement.

A laboratory assistant is wanted for the Pender Electrical Laboratory, University College, Gower-street, London, W.C. Wages, 35s. Applications to Prof. J. A. Fleming, F.R.S. See advertisement.

A teacher for a class in motor engineering is required at Woolwich Polytechnic. Particulars from the Clerk to the Governors (Mr. A. J. Naylor).

Mr. H. R. Kempe, M.Inst.C.E., M.I.E.E., principal staff engineer of the Postal Telegraph Department, has been promoted to the position of electrician to the Post Office Telegraph Department. Mr. Kempe, who is well known as the author of "Kempe's Handbook of Electrical Testing" and of the "Electrical Engineer's Pocket Book," was born in 1852. He is the youngest son of the late Prebendary Kempe, and has been in the engineering branch of the Post Office for 35 years. During this period he has been engaged in a great variety of work, including an investigation of conditions required for successful telephone working from London to Paris. Mr. Kempe designed the first submarine telephone cable laid between Dover and Calais and he has also designed and carried out various pneumatic tube systems for provincial towns.

Mr. G. Grace, B.Sc., of Doncaster, has been appointed principal of the Barrow-in-Furness Technical School at £350.

Mr. C. L. Cartwright has been appointed professor of mechanical engineering, and Mr. R. E. Michael temporary professor of civil engineering at the Madras College of Engineering.

Mr. H. D. Douglas, of the Leyton tramways department, has been appointed superintendent of the East London (Cape Colony) tramcars and carshed.

The position of general foreman of the Scarborough Tramways Co. (recently advertised in *The Electrician*) has been filled, and the company thanks applicants for their offers of service.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

University College, London.—The courses of instruction in mechanical, civil, municipal and electrical engineering begin on Tuesday, Oct. 1. The fee for the full three-year diploma course in engineering and the course for graduating B.Sc. in the faculty of engineering is 120 guineas. The college contains spacious mechanical and electrical engineering laboratories, workshops, drawing office, &c. Large extensions will be made in each of the engineering departments, the drawing office and the department of applied mathematics, &c. Particulars from the secretary (Mr. Walter W. Seton, M.A.), Gower-street, London, W.C.

King's College, London.—The Michaelmas term of the faculty of engineering and applied science commences on Wednesday, Oct. 2. A list of the teaching staff appears in an advertisement. Evening classes are held for civil, mechanical and electrical engineering, workshop practice, drawing, metallurgy, mathematics, physics and all science subjects. Prospectuses and further information can be obtained from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

University College, Bristol.—There are courses at this college for civil, mechanical, electrical and mining engineers and surveyors, and special facilities are offered in the way of college scholarships and engineering works scholarships. A diploma is awarded to students who pass the qualifying examinations, and the associateship of the college is conferred on students who obtain a first-class senior diploma. Applications for vacancies in October should be made to the registrar and secretary (Mr. James Rafter), from whom prospectuses, &c., may be obtained.

Battersea Polytechnic (Battersea, London, S.W.)—The next term commences on Sept. 23. There are technical day college courses in mechanical, electrical and chemical engineering at this Polytechnic. The day courses are in preparation for London University engineering degree under recognised teachers. There are also evening courses in preparation for the engineering degree and evening classes in all mechanical and electrical engineering subjects. The evening courses begin on Sept. 30. Prospectuses from the Secretary.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms.

Evening technical courses in all branches of electrical and mechanical engineering commence on Monday, 23rd inst. The

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laboratories are well equipped for both alternate (single and polyphase) and continuous-current work and for all kinds of electrical testing.

Particulars as to fees, &c., can be obtained at the Institute, St. John's-street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Hackney (London) Technical Institute.—The next session commences on Sept. 23. Evening lectures and laboratory courses are held in electrical engineering subjects, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses, &c., from the Principal, Dalston-lane, London, N.E.

Borough Polytechnic Institute.—A four years' course in electrical engineering is given at this Institute. There are also special courses in electric wiremen's work, the construction and design of electrical appliances and workshop fittings, &c. Detailed syllabus of courses can be obtained from the Institute, 103, Borough-road, London, S.E.

Sir John Cass Technical Institute (Aldgate, London, E.)—At this Institute there are evening classes in chemistry, metallurgy, physics and mathematics, designed to meet the requirements of those engaged in the chemical, metallurgical and electrical industries, &c. Facilities are given for special and advanced practical work in well-equipped laboratories, both in the afternoon and evening. The new session begins on 23rd inst. Details of the classes may be obtained at the offices of the institute, or from the principal, Mr. Charles A. Keane, M.Sc., Ph.D.

Tuition by Correspondence.—Prof. Andrew Jamieson, M.Inst.C.E., M.I.E.E., (16, Rosslyn-terrace, Kelvinside, Glasgow), prepares pupils, by correspondence, for all examinations in mechanical, electrical and engineering science. Prof. Jamieson's announcement appears on another page.

Aberdeen.—On the recommendation of the Tramways committee the Council have decided to procure a watering car for watering streets on the tramway routes. The cleansing department will pay the tramway department 7d. per car mile, with a minimum of 6,000 miles per annum.

The annual report of the city electrical engineer (Mr. J. Alex. Bell) states that a scheme for the extension of the generating station buildings is being prepared.

The new Act obtained by the Corporation extends the area of supply, authorises the supply of electricity in bulk and the hiring out of electric motors, &c. The Great North of Scotland Railway Co. completed their change over to the Corporation mains early in the year, and in addition electrically lighted Kittybrewster and Waterloo Stations. The new theatre and the new post office were coupled up in December and January respectively, and Rubislaw Quarries have, since the spring of the year, been entirely operated electrically. Satisfactory progress is being made with power consumers. Owing to the university quatercentenary celebrations, the department was called upon to undertake a large amount of exterior illumination work. Coloured lamps to the number of 4,860 were erected in Union-street and on the Town House alone, and two searchlights were fitted up. Many private consumers used electricity for exterior illuminations in connection with the celebrations. Additional lighting was required in all the public buildings used for meetings and entertainments during the week. The Strathcona Hall was fitted with 814 lamps. Extensions of mains had given an additional frontage of supply of 0·984 of a mile. Expenditure on repairs to the existing distributing system was approximately £140 above the average for the last three years. The Council has recently sanctioned the replacing of copper strip culverts in Union-street section by cables, which, it is expected, will reduce expenditure on repairs. Two brief interruptions of supply, to sections only, occurred during the past year. A 390 kw. set, originally in the Cotton-street works, has been moved from the main engine room to the temporary engine room to allow of the installation of the 750 kw. set on order. A 50 kw. set also from Cotton-street has been compounded and erected in the main engine room to deal with the early morning car load. A reversible booster for storage battery will be erected in the course of the next few weeks. Renewals to storage battery have been carried out, 20 cells being replated throughout, and 20 fitted with new positive plates. This expenditure has been borne out of revenue. Boiler and feed-pipe repairs have been heavier than usual. The output for private lighting was 309,836 units, and for power 279,702 units in excess of 1905-6. 10,574 units were sold for exterior illumination during the University celebration week, 2,591 being for private consumers. As a special rate of 1½d. per unit was charged for that lighting, the department benefited to the amount of £55 only. 131 private arc lamps and two public arc lamps have been added. There was an addition of 996 H.P. in motors during the 12 months. Reductions were made in costs per unit sold for coal and wages. An increase in repairs and maintenance had, however, counterbalanced that reduction, and the works costs remained the same as last year—namely, 0·51d. The total costs were down 0·02d., and the average price obtained per unit for all classes of supply had fallen from 2·22d. to 2d. The reduction of prices last year had affected their revenue to the amount of £4,179. Owing to the enhanced prices for coal and to the department being committed to an expenditure of some £8,000 on the renewals of the feeder and distributor system, Mr. Bell recommends that the existing charges be retained for the ensuing 12 months.

Accrington.—The Council have approved the arrangement whereby they shall pay the local tramways company £2,227 for the steam engines, tramcars, &c., of the company transferred, each side paying its own costs.

Altrincham.—At a meeting of the Council on Wednesday a resolution was passed agreeing to the calling of a conference of representatives of the Councils of Altrincham, Bowdon and Hale for the purpose of drawing up a scheme for the purchase of the undertakings of the Altrincham Electric Supply (Ltd.) and the Altrincham Gas Co. and the carrying on of same by a joint board of management elected by the three councils concerned. It was stated that three years ago the directors of the Electric Supply Co. offered to sell their undertaking for £99,000 and the gas undertaking was offered at £187,000.

Argentina.—The "Review of the River Plate" says Mr. M. Trebine has offered, on behalf of a syndicate, to establish gas and electricity works at Buenos Ayres, and to supply current for lighting at a maximum of 12 cents (gold) per unit and 7 cents for power for members of the company, 2 cents higher in both cases for non-members, and 2½ cents per unit for current for tramways. The City Director of Lighting has the proposal under consideration.

Bispham.—The Council have decided to apply for a provisional electric lighting order.

Bolton.—The charge for electric current for private lighting has been reduced from 4d. to 3½d. per unit.

Bradninch (Devon).—The Council have had under consideration the question of the introduction of electric lighting in the district, but before taking any definite steps in the matter it has been decided to ascertain the views of the ratepayers.

Bridgend.—The Council have decided to acquire the local generating station of the South Wales Electrical Power Distribution Co. for £5,000.

The chairman (Mr. R. C. GRIFFITHS) explained at the meeting last week that negotiations had been proceeding for some time. First of all the Council entered into an agreement with the company indemnifying them against any loss sustained in continuing to work the generating station at Bridgend. The station had cost £38,700 to erect and equip, and the Council had agreed to purchase it for £5,000. The Council had obtained favourable terms from the ground landlord for a reduced rent, and the committee of the Glamorgan County Asylums, the largest consumers of power from the station, had agreed to take energy for lighting at 3d. per unit, and for power at 1½d., against 1⅝d. paid to the company. The Council were advised that £1,500 would be sufficient for working capital, and an application was being made for permission to borrow £6,500.

Brighouse.—The steady development of power companies' operations is, perhaps, not fully realised. The Yorkshire Electric Power Co.'s supply has been available for something less than three years, yet the company has already made arrangements to supply 11 different electric light undertakings. The latest of these is Brighouse Corporation, who propose to take a bulk supply from the company for tramways, power and lighting, and to dispense with their present generating plant. It is anticipated that the cheapening of electric power under the new arrangement will greatly benefit the town of Brighouse.

At the meeting of the Corporation last week the General Purposes committee reported that the following were the best terms obtainable from the Power Co., and after discussion these were accepted:—

The company to give a supply of direct current for tramways and lighting at £6 per annum per kilowatt of maximum demand plus ½d. per unit for all units consumed, the maximum demand to be determined by adding the maximum readings on the tramway and lighting meters.

The charge made on this scale shall not exceed 1·25d. per unit for the whole supply.

The period of the agreement to be 14 years, with a revision of price at the end of 7 years, the 1·25d. per unit being the maximum price to be charged.

The Corporation to guarantee a minimum annual consumption in the first instance of 30,000 units per annum for lighting, and when the tramways take their load they are to be covered by an agreed further minimum quantity. (As it is impossible at present to say when the tramways will require a load, the company are not to be required before Sept. 1908, to give a supply of current either for lighting or power, unless the tramways come along). In that case the company are prepared to give the supply of energy to the trams, the minimum payment not to exceed in any case for lighting and power together the sum of £1,000 per annum.

The Corporation to provide the land and build the transforming sub-station, and also provide switchboard and balancer.

The company to put down all transforming plant and apparatus, supply all labour in the sub-station, and bear all loss of transforming, except the loss in the balancer.

Chili.—The "Diario Oficial" (Chili) for July 4 contains a decree authorising the Director-General of State railways to expend $1,634,000 (about £122,500) upon an electric light installation, railway construction, purchase of machinery, &c.

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Cockenzie (Haddington).—The Electric Works Development Co. have given notice of their intention to apply for a provisional electric lighting order.

Dorking.—The Council have sealed an agreement transferring their electric lighting order to Edmundson's Electricity Corpn., and a loan of £12,000 has been applied for.

Dublin.—The directors of the Dublin United Tramways Co. have issued a circular referring to the threatened strike of employés in the traffic department.

The directors state that they are glad to note that the men have resisted the attempt to mislead them into such a dangerous course, and that the good relations which have hitherto subsisted between the company and their employés remain undisturbed. It had been the intention of the directors for some time back to give the men in the traffic department a bonus out of the increased receipts arising from the Exhibition, and they think the men will appreciate it more if the distribution is made now rather than at the end of the season. Accordingly it has been decided to pay every driver and conductor who has been more than three months in the company's service an extra week's wages, which will be handed to them with their usual pay on the 6th inst.

Dundee.—Six new tramcars are to be purchased at a cost of about £8,700. On the recommendation of the city electrical engineer (Mr. H. Richardson) the centre-running trolley is to be adopted for the Downfield extension.

Messrs. Gourlay Bros. & Co. have again opened negotiations with the electricity department for the supply of power to their shipyard, and the Electricity committee have offered to give supply in bulk for not less than five years at 1d. per unit on condition that the minimum payment is £200 per annum; that for every increase of 3d. per ton in the average price of coal which the electricity department has to pay above the assumed standard of 10s. per ton for "Scotch steam singles," the price charged per unit shall be increased by 0·01d.; and that if any reduction be made generally to consumers of their class, and working under similar conditions, a proportionate reduction will be allowed to Messrs. Gourlay.

Electric Traction in the United States.—The Acting British Consul at Savannah (Mr. A. Harkness) reports that a number of street and inter-urban electric railways in the south-eastern states are projected, and an electric line from Columbus, on the Georgia side of the Chattahoochee River, to West Point, 34 miles in length, has been constructed. The water power of the river is used for generating current. The falls are capable of providing 100,000 H.P. There are three plants already in operation near Columbus. The surveys of the water power along the Chattahoochee are nearly completed, and plans have been prepared for a large power plant, four miles north of Columbus.

Engineering and Machinery Exhibition.—Sir Alex. B. W. Kennedy will perform the opening ceremony in connection with this exhibition at Olympia on Thursday 19th inst.

France.—A company has been formed for the construction of a tramway from Annecy, *via* St. Julien to Geneva. Electric power will be used if it is found practicable to utilise the waters of the Rhone. The "Journal des Transports" states that the only difficulty will be the construction of a bridge 25 metres long over the torrent of Usses. The cost of construction is estimated at 2,800,000 fr. (£112,000) and the line will be 40 km. (about 25 miles) in length.

Gas Engine Combine.—It is reported that negotiations are proceeding for the amalgamation of the undertakings of Crossley Bros., Manchester, and the National Gas Engine Co., Ashton-under-Lyne.

Inquest.—An inquest was recently held at Marley Hill, Durham, on Joseph Willey who was killed at Marley Hill Colliery on 21st ult.

Deceased was engaged in attending to an electric motor driving a pump, and evidence was given that after operating the switch at the switch-box he received a shock which caused death. The only live part connected with the switch box was a bar, which deceased might have caught with his hand when operating the switch. The jury found that deceased was accidently killed by his hand coming in contact with the bar of the switch box.

Italy.—In an instructive report on the trade of South Italy for 1906 Mr. Consul-General Neville-Rolfe states that the Italian Government has decided to take over the telephones, subject to coming to an arrangement with the various companies of which the Societa Generale Italiana di Telefoni ed Applicazioni Elettriche is the principal.

Naples can now communicate with Rome, Castellamare and some other neighbouring towns, but it is hoped that when the Government have taken the lines over there will be a great extension of the system. It is admitted that the service at Naples is well carried on by the company and that the rates are extremely low—£8 per annum without limit as to number of messages, and a day and night service throughout the year.

Leeds.—The question of the construction of a tramway along Whitehall-road to the city boundary, and of extending the system to the Farnley district, has been referred to the Tramways committee.

Leek.—The Electricity committee recommend the Council to apply for sanction to a loan of £6,850 for extensions of the electricity plant, cables, &c.

Light Railways.—The Llandilo & Lampeter Light Railway Order has been submitted to the Board of Trade for confirmation. Objections by Sept. 20.

The Board of Trade have confirmed the Derwent Valley Light Railway (Transfer, &c.) Order, 1907, transferring powers granted to the Escrick and Riccall Rural District Councils.

Malay States Imports.—The goods imported into the Federated Malay States during 1906 included electric and gas lighting material to the value of $148.353, or about £15,530 (compared with $37,796 in 1905); telegraph and telephone material $41,422, or £4,486 (against $27,627); and tramway and railway material, $618,027, or £66,953 (against $494,067).

Manchester.—On Wednesday the chairman of the Tramways committee (Ald. Wainwright) moved the adoption of a lengthy report of the Tramways committee on contract tickets, halfpenny stages, workpeople's and school children's fares.

Ald. WAINWRIGHT said that whilst the committee were anxious to do all they could to meet the demands from time to time made upon them, they found it necessary to move cautiously. The margin of profit per passenger was less than $\frac{1}{10}$d. The backbone of their financial position was the 1d. fare, representing 76 per cent. of the revenue, which they did not intend to touch.

The report was adopted.

Manchuria.—"Commercial Intelligence" states that the Chinese Merchants' Guild of Mukden, have invited offers for the erection and equipment of electricity supply works and a local Japanese concern has submitted an offer amounting to about £19,000. The outer wall of Mukden has a circumference of about 10 miles and roads traverse the city in all directions. It is proposed that arc lights shall be used for the principal avenues and buildings and incandescents for the suburbs. It is stated that the introduction of electric lighting is also planned at Kirin, and it is believed that other important cities of Manchuria will undertake similar enterprises in the early future.

Metropoli an District Railway.—The directors of this company, who are endeavouring to reduce working expenses, are considering a scheme for lessening the number of train attendants, of which there are at present from two to four on each train, in addition to the motorman.

It is proposed to abolish the mechanical operation of the centre doors, which will be adapted so as to permit them to be opened by the passengers and closed by platform porters. Trial cars fitted in this way have, it is stated, given satisfactory results.

Mexico.—The "Diario Oficial" (Mexico) for Aug. 1 contains a copy of a contract between the Cia Limitada de Tranvias Electricas de Mexico and the Government for the construction by the company of tramways in the City of Mexico.

Miners and Electricity.—At Houghton-le-Spring Police Court last week a man named Job was charged with a breach of the Mines Act at the Dorothea Pit, Philadelphia.

Mr. E. BELL, who prosecuted for the Lambton Collieries (Ltd.), said there were coal-cutting machines in the pit. Defendant had charge of one of these machines, and on the date named, current having failed, he opened the switch box, removed a portion which covered the terminals and introduced a piece of wire. The result was a "flare-up," which lit the whole of the pit, and it was a miracle there was not an explosion. The affair was, however, only found out after defendant had left the colliery.

Defendant pleaded he had erred in ignorance, and was fined 20*s.* and costs.

Mitchelstown (Cork).—The Council have decided to advertise for a loan for electricity supply at 4½ per cent.

Monmouth.—At the Council meeting on Tuesday it was reported that the borough electrical engineer (Mr. A. E. Wilkins) had tendered his resignation and the Electric Lighting committee had conditionally accepted it, the resignation to date from 10th inst. for the convenience of Mr. Wilkins, who has become a partner in a Dublin firm. It was decided to engage Mr. Blake, of Swansea, to visit Monmouth and superintend the electricity works, pending the appointment of another engineer.

Mountain Ash.—The Council have applied for sanction to a loan of £4,630 for the erection of electricity works.

Naval Wireless Telegraphists.—Among recent changes in naval ratings the Admiralty have approved the establishment of a separate branch for conducting wireless telegraphy in the fleet.

This branch is to be reserved exclusively for wireless telegraphy duties, and will be quite distinct from the visual signalling branch. It will work under the torpedo officer in the wireless room, and with the electrical party when not required in the wireless room. The ratings composing the wireless branch will be of the seaman class, rank and pay per day being as follows: Boy telegraphist 7d., ordinary telegraphist 1s. 3d., telegraphist 1s. 11d., leading telegraphist 2s. 1d., petty officer 3s.,

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and after six years 3s. 6d., chief petty officer 3s. 10d., and after three years 4s. 2d., and after six years 4s. 6d. Ultimately a limited number of warrant officers, commissioned warrant officers and lieutenants will be promoted from the telegraphists' ratings. Four telegraphists are to be allowed to all cruisers, scouts and flagships, and three to all battleships other than flagships. One petty officer telegraphist is to be allowed to every destroyer fitted with wireless apparatus except the "Swift" which will carry a telegraphist as well as the petty officer. It is ultimately intended to allow one warrant officer for wireless telegraphy duties to the senior flagship of the Channel, Atlantic, Mediterranean, and China fleets. All other flagships will carry one chief petty officer telegraphist. A pro rata reduction will be made in the signal ratings of these ships. Changes in complement are to be effected gradually as men become available. In order to place the telegraphist branch on a proper footing, 192 yeomen and leading signalmen are to be allowed to turn over to it as volunteers, as well as about 100 able seamen and marines. It is intended ultimately to fill the telegraph branch wholly from boys entered in the training ships in the ordinary way. The new regulations affecting the wireless telegraphy branch take effect as from Oct. 1 next.

Newcastle-on-Tyne.—The Fenham tramway extension was opened yesterday (Thursday).

New South Wales Tramways.—The annual report of the chief commissioner for the N.S W. Government railways and tramways (Mr. T. R. Johnson) states that on the tramways (128¾ miles), which are principally electric, the number of passenger journeys made during the year was 155,000,000, and the gross revenue was £908,701. The total capital expended is £3,669,524, and the return on this is about 5 per cent. per annum.

Parliamentary Intelligence.—*Royal Assent.*—On Aug. 28 the Royal Assent to the following new Acts of Parliament was read:—Patents & Designs (Amendment), Patents and Designs (Consolidation), Factory and Workshop, Lights on Vehicles, Expiring Laws Continuance, Dumbarton Burgh & County Tramways Order Confirmation. The full list of the past year's Acts appears on p. 835.

Personal.—As announced in our last issue, Mr. Alex. Wyllie has resigned his position as borough electrical engineer at Walsall on his appointment as city electrical engineer at Auckland, New Zealand. Mr. Wyllie sails for New Zealand on Oct. 3.

Presentations.—The office and works staff of the Twickenham & Teddington Electrical Supply Co. have presented a case of table silver to Mr. F. C. Lovett, on his marriage.

The Grimsby staff of the National Telephone Co. have presented a gold-mounted fountain pen to Mr. Wm. Cowburn, local manager, who is joining the electrical staff at Leeds. He is succeeded by Mr. Jones, Wakefield.

At Bath electricity works on Friday a marble timepiece was presented to Mr. L. A. Laing on the occasion of his marriage.

Provisional Order Revocation—The Board of Trade have revoked Beeston District Council's Electric Lighting Order (1902) as from Aug. 26.

Recent Will.—The will of the late Mr. Frederick Walters, a director of the Pacific & European and of the West Coast of America Telegraph Cos., who died June 15 last, aged 76 years, has been proved. The value of the estate is £31,235 gross, with net personalty £26,895.

Reigate.—The Council have decided to substitute electric for gas lighting in the main thoroughfares of the town.

Swansea.—The Electric Lighting committee have appointed a sub-committee to consider the advisability of organising an exhibition of electric light fittings, motors, &c., in the district.

Victoria Falls Power Scheme.—Sir Charles Metcalfe, Bart. (of Sir Douglas Fox & Partners), consulting engineer to the Rhodesia Railways, is reported to have stated to an interviewer on Saturday last that great progress had been made with the scheme for the electrification of the Rand. The Victoria Falls Power Co. had not only secured further valuable contracts since the flotation of the company, but had also been of consider able service to the Johannesburg Municipality in the difficulties they had encountered with regard to their municipal electrical scheme. As a result the prospects of the company were of the brightest.

Warrington.—An inquiry was held here on Tuesday into the application of the Council to borrow (among other sums) £3,000 for extensions of the electricity works.

Workhouse Lighting.—The Sanatorium committee of Belfast Guardians are considering plans and specifications for the electric lighting of buildings at a cost of £3,140.

Worthing.—It has been decided to charge private consumers, for lighting, 5d. per unit, with discounts, instead of 6d., with discounts, as at present. The charge for places of worship and religious institutions at 4½d. per unit, hotels and licensed houses, restaurants and clubs and boarding houses with minimum installation equivalent to 45 32 watt lamps, and public halls, public libraries and fire stations a flat rate of 4½d.

ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS

Coventry.—The electricity department's accounts for the year ended March 31 last show outstanding capital £158,243, increase £22,576.

Revenue was £25,925 (compared with £19,360 in previous year), including private lighting £9,947 (£8,449), power supply £14,596 (£8,974), public lighting £657 (£667), meter rents £585 (£526) and motor rents £1,162 (£720). Total expenses were £10,837 (£7,650) and gross profit £15,088 (£11,709). Capital charges were £9,973 (£9,369), leaving net profit £5,564 (£3,489). The average price received for current for all purposes was 1·57d. (1·84d.) per unit. Working expenses were 0·66d. (0·73d.) per unit, capital charges 0 60d. (0·89d.), gross profit 9·07 per cent. (8·33 per cent.) and net profit 3·26 per cent. (1·72 per cent.) on outstanding capital (deducting sinking fund). 4,649,624 units were generated and 3,950,785 (2,522,110) sold, 636,358 (545,971) for private lighting, 3,211,090 (1,906,508) for power and 103,337 (69,631) for street lighting. There are 951 (805) consumers, and the total maximum demand was 2,237 kw. (1,533 kw.). The capacity of the plant is 3,300 kw. (2,400 kw.).

Great Yarmouth.—The accounts of the electricity department for the year ended March last show capital expenditure £93,009, increase £3,279.

Income was £18,066 (compared with £17,327 in previous year), including sale of current for private lighting £10,425 (£10,368), for power £653 (£592), tramways £3,937 (£3,847), by contract £144 (£132), and for public lighting £2,409 (£1,909) and rental of meters, &c., £434 £453). Total expenditure was £10,225 (£8,363), including cost of fuel £4,178 (£3,940); gross profit was £7,776 (£8,900). Interest, sinking fund and income tax required £6,080 (£5,326), and discounts, rebate and bad debts £677 (£259), leaving net profit £1,054 (£3,393). 1,640,310 units were generated and 1,348,088 (1,239,649) sold, including 183,331 supplied to public lamps, 14,813 by contract, 605,042 to private consumers by meter, and 539,902 for the tramways. There are 181 arc and 55 incandescent lamps for public lighting. The total maximum supply demanded was 1,046 kw.

Greenock.—The accounts of the electricity department for the year ended June 29 give the total expenditure as £128,997. 3s. 2½d., an increase of £17,881. 13s. 4½d. during the year.

The revenue from the sale of current by meter was £13,011. 3s. 0½d., including £7,279. 0s. 1½d. from private lighting and £5,732. 3s. from power; public lighting produced £921. 15s., and the receipts from the Greenock & Port Glasgow Tramways Co. amounted to £4,821. 16s. 3d., meter and motor rental, &c., bringing the total to £19,642. 12s. 1½d. After paying expenses, there was a gross profit of £6,709. 12s. 7½d. Interest absorbed £2,652. 2s. 3d. and loan repayment instalments £4,072. 6s. 8d., £1,500 was transferred to the police department and the balance in hand is £286. 1s. 9½d. 3,631,345 units were generated (against 3,063,621 in 1906); 1,743,751 were sold to private consumers, 861,524 were supplied to the Tramways Co. and 76,530 to the public lamps. The total maximum supply demanded was 1,674 kw.

Newcastle-on-Tyne.—At the meeting of the Corporation on Wednesday, the chairman of the Tramways committee (Sir Joseph Baxter Ellis) moved the adoption of the accounts of the tramways department for the past year.

The amount carried to the appropriation account was £62,943. 17s. 6d., out of which £34,254. 10s. 4d. was contributed to sinking fund during the year; £12,000 was appropriated to relief of rates, and £15,105. 16s. 6d. was placed to reserve. The net profit for the year was £28,689. 7s. 2d.

The report and accounts were adopted.

Todmorden.—For the past year the receipts of the electricity department were £736, and the working expenses £859, leaving a deficit of £123, which is increased to £1,453 by sinking fund and interest charges. The capital outstanding is £19,037.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Aldershot District Council invite tenders for supply of cable (4,400 yds), bitumen (12 tons), troughing (1,100 yds.) and insulators (2,200) in connection with intended extension of mains. Conditions and specifications from the engineer (Mr. F. Garside), electricity works, Laburnum-road, Aldershot. Tenders must reach the clerk (Mr. W. E. Foster), Municipal-buildings, Aldershot, by 9.30 a.m. of Wednesday, Sept. 18 See also an advertisement.

Extension of Time.—The time for sending in tenders to the Town Clerk of *Kirkcaldy* for the construction and erection of steel dock gates and a swing bridge is extended until Oct. 7.

Extension of Time.—The time for sending in tenders for carrying out the City of *Winnipeg* hydro-electric development works at Pont du Bois is extended to Oct. 1.

London County Council invite tenders for the manufacture, delivery and erection of three electrically-driver boiler feed pumps, each of 9,000 gallons per hour capacity, at the tramways electricity station, East Greenwich. Tenders, upon official forms to be obtained from the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 11 a.m., Oct. 8.

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NOW READY.

"THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.—The 1907 Edition of the Big Blue Book, price 15s., or post free in the United Kingdom, 15s. 9d. The new and enlarged volume brings a great mass of statistical and technical data quite up to date, and the Directorial Division has been thoroughly revised and amplified.

All branches of Electrical Engineering and Industry are fully treated, and Electro-Financial matters have received every attention in the new volume, which aggregates more than 2,000 pages. The Directory Division is complete and thoroughly accurate, and has been revised up to Feb. 14, 1907. All mere lists of members of Societies and Institutions (so easily and cheaply available) are excluded, as quite unreliable for Manufacturers' and Dealers' purposes. The set of seven valuable Tables, &c., have been very carefully revised and extended, and remodelled into handy book form, making the 1907 Edition of this indispensable work the most complete book of the kind ever published.

The Committee of Management of the *Londonderry* District Lunatic Asylum invite tenders for supply, delivery and erection of a 22 kw. steam set with brush dynamo, pipe work, switchboard, connections, &c., for extension of plant at the Gransha Asylum. Tenders by 9 a.m., Sept. 20.

Dublin Lighting committee invite tenders for the supply of extra-high-pressure and low-pressure cables (*a*) delivered at their Fleet-street stores and (*b*) laid complete on site in Dublin. Tenders to the chairman of the Lighting committee, 3, Cork-hill, Dublin, by Sept. 9.

The *Postmaster-General* requires tenders by Sept. 9 for creosoting Norwegian, Swedish, Finland or Russian red fir telegraph poles. Forms from Mr. S. E. Hooley, Stores Department, G.P.O., 17-19, Bedford-street, London, W.C.

Maidstone Corporation want tenders by Oct. 7 for supply and erection of seven electric motors and centrifugal pumps, motor-driven air ejectors, cranes, switchboard, starting switches, &c., and a complete electric-light installation, for the sewage disposal works. Plans from Mr. G. R. Strachan, 9, Victoria-street, London, S.W.

Hastings Corporation want tenders by noon Sept 17 for six months' supply of best Welsh smokeless coal for the electricity works. Forms from the Borough Electrical Engineer.

Croydon Corporation require tenders by 11 a.m. Sept. 9 for trolley-wire and other overhead line material. Specifications from Tramways Manager.

Dover Electricity committee want tenders by Sept. 9 for supply of Welsh steam coal. Specifications, &c., from the Borough Electrical Engineer.

The Main Colliery Co., *Neath Abbey*, near Neath, want tenders by noon Sept. 21 for supply of electrical goods, steam tubing, paints, oils, &c. Forms of tender from the company.

Halifax Tramways and Electricity committee require tenders by Sept. 7 for 12 months' supply of pea slack coal. Particulars from the Borough Electrical Engineer.

The *Mersey Railway Co.* require tenders for supply of various stores, including incandescent lamps and fittings, electrical sundries, car fittings, indiarubber and gutta-percha, signal wire, iron piping, metals, oils, &c. Forms of tender from the Secretary, Worcester House, Walbrook, London, E.C.

South Shields Corporation invite tenders for a traction battery, stands and accessories, automatic reversible booster and switchboard. Tenders by noon Sept. 17.

Tenders will be received by the Deputy Postmaster-General, *Sydney*, at 2.30 p.m. of Oct. 22, for the supply of 11 tons of g.i. wire, 400 lb. per mile, 1,600 insulators (best white porcelain, large), 500 wall telephones and 100 party line telephones. Specifications, &c., from the General Post Offices, Sydney, Melbourne, Brisbane and Adelaide, or from the Australian Commonwealth Offices in London, 72, Victoria-street, S.W.

The General Direction of Canal and Waterworks at Trollhattan, *Sweden*, want tenders by Sept. 15 for the supply and erection of turbines of 10,000 H.P., and by Oct. 1 for three 350 kw. c.c. dynamos, a 4,800 ampere-hour battery, four three-phase alternators each of 11,000 k.v.a capacity, switchboards, &c.

Tenders will be received by the Chairman of the Tender Board, Control and Audit Office, *Cape Town*, until noon on Sept. 30, for supply of dry cells during 1908. Forms of tender from the Controller of Stores, G.P.O., Cape Town. Estimated requirements, 4,000.

The railway authorities at *Prague* (Bohemia) require tenders by Sept. 14 for supply of electrically-driven tools with motors varying from 5 to 12 h.p.

TENDERS RECEIVED AND ACCEPTED.

Eight tenders from British firms have been received by Dundee Corporation for the supply and laying of h.t. and l.t. mains, and these have been referred to the city electrical engineer (Mr. H. Richardson) for analysis and report.

Wimbledon Council have accepted the following tenders:—
G. & J. Weir, steam-driven air pump equipment, £400 (seven tenders); Everett, Edgcumbe & Co., 15 direct-reading voltmeters, £134. 13s. (13 tenders); Hy. Pooley & Son, adjustment of four weighing machines, £8 10s. per annum.

Ravensthorpe (Yorks.) Council have accepted the following tenders:—
British Thomson-Houston Co., meters; General Electric Co., cutouts; W. T. Garnett's Cable Co., cables; and W. Bradbury, erection of sub-station.

Eccles Council have accepted the following tenders:—
British Insulated & Helsby Cables, feeder cable, £215; Ferranti Limited, feeder switchboard, £71 10s.; Tudor Accumulator Co., milking booster, £38; W. & T. Avery, 10-ton weighbridge, £40.

Accrington Corporation have accepted the tender of R. P. Gerland & Co. for wiring and the supply of arc lamps for lighting the local tramway depot.

Blackburn Education committee have accepted the tender of the Electrical Power Storage Co. for a storage battery for the technical school.

Dundee Tramway committee have accepted the tender of the Brush Co. for tramcar bodies and top covers, and that of Dick, Kerr & Co. for trucks and equipment.

Darwen Electricity committee have accepted the tender of Babcock & Wilcox for supply and erection of superheaters.

Manchester Electricity committee have accepted the tender of the British Westinghouse Co. for a high-tension testing transformer.

Worcester Electricity committee recommend the acceptance of the tender of Stokes Bros. to extend the Cross distributing station for £67. 10s., including £5 for employing two shifts of men on the work.

Newcastle-on-Tyne Corporation have accepted the tender of Edgar Allen & Co. for the construction of tramway junction at Pilgrim-street and Market-street extension at £2,142. 10s.

BUSINESS NOTICES.

The headquarters of the publicity department of Bruce Peebles & Co. (Ltd.) has been transferred from London to the company's Edinburgh office, East Pilton Works, Edinburgh.

Mr. J. A. McLay, assistant turbine sales manager of the British Westinghouse Co, has been appointed agent in Great Britain of the Société Anonyme Westinghouse (Havre, France) for the Leblanc condensing apparatus He will take up his new duties at once at his London address, 2, Norfolk-street, Strand, W.C.

Mr. A. E. Wilkins, borough electrical engineer, Monmouth, has resigned that position, in order to enter into partnership with Mr. T. H. Burden, with whom he will carry on the business of electrical engineers and contractors in Dublin.

The offices and works of the Tandem Smelting Synd., are now at Merton Abbey, London, S.W.

BANKRUPTCIES, LIQUIDATIONS, &c.

The first meeting of creditors of W. A. Roderick, electrical engineer (lately trading as Aneurin Roderick & Co.), at Bridgend, and now of 12, Penmaen-street, Swansea, was held on Saturday at Cardiff. Liabilities expected to rank £277. 4s. 5d., assets £51. 4s. 7d., deficiency £225. 19s. 10d. Bankrupt commenced business as an electrical engineer in June, 1904, at Swansea, with free capital of £84. In June, 1905, he opened business at Bridgend. A year later he entered verbally into partnership with Louis Usher, who the debtor described as an exceptionally good workman, with £30 capital. The partnership was dissolved at the end of six months, debtor paying Usher £30 and taking over all assets and liabilities. Since then he has been trading on his own account.

Chas. Herbt. Montague Amias Vere (C. M. Vere & Co.), electrical engineer, 5, Park-parade, North Finchley, Middlesex, has been adjudicated bankrupt. The first meeting of creditors will take place on Sept. 11 at 14, Bedford-row, London, W.C., and the public examination on Sept. 12 at the Town Hall, Barnet.

A supplemental dividend of 1s. 2d. will be payable on Sept. 10 at 29, Manor-row, Bradford, in the failure of A. Blackburn and J. Walker (trading as Blackburn, Walker & Co.), electrical and mechanical engineers, Upper Lane Mills, Cleckheaton.

The Medical Electro-Thermic Generator Co. (Ltd.) is being wound up voluntarily, and Mr. H. W. Freshwater, 7 and 8, Railway Approach, London Bridge, S.E., has been appointed liquidator.

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Sales by Auction.—Messrs. John W. Morley & Co. have been instructed to sell by auction on the premises, 8, Pembroke-villas, Pembroke-road, Kensington, London, W., on Sept. 18 and 19, at noon, the surplus stock and miscellaneous plant and (finished and unfinished) high-class furniture, including electrical accessories and lamps, electric and gas light fittings, bells, &c. On view day prior to sale. Catalogues on the premises and from the auctioneers, 176, Earl's Court-road, S.W. Telephone Kensington 1720. See also an advertisement.

By order of the receiver of the Chiswick Ironworks & Erecting Co. Messrs. Hibbard & Whittingham will sell by auction on the premises (Railway-approach, Shepherd's Bush, and at the office, 196, Uxbridge-road, W.), on Sept. 25, at one o'clock, the nearly new plant and machinery, comprising powerful punching and shearing machine, drilling machine, cold metal saw, duplex lever hand-screwing punching machine, two 6 H.P. and one 1 H.P. electric motors, electric air blower for forge, air-pressure generating machine for pneumatic riveter and accumulator, electric installation in each department, &c. Catalogues of the receiver (Mr. H. Graham King, C.A.), 17 and 18, Telegraph-street, London, E.C.; of Messrs. B. A. Woolf & Co., solicitors, 28, Abchurch-lane, E.C.; and of the auctioneers, 17, Union-court, E.C. See also an advertisement.

Plant, &c., for Sale.—Messrs. Fielding & Platt, engineers, Gloucester, have for sale a second-hand 90 B.H.P. Fielding suction gas engine, electric lighting type. See advertisement.

Messrs. Matthews & Yates (Ltd.), Swinton, Manchester, have a few electric fans with open type motors for sale.

Premises to Let.—Mr. Adams, Gattens, Hockley, Essex, has conveniently situated offices to let, suitable for engineers, metal dealers, &c.

CATALOGUES, &c.

Electric Stoves.—The induced-draught stoves of Messrs. O. C. Hawkes (Ltd.), for the electrical heating of rooms and offices, are now too well known to need description at our hands. The extension of the electric heating load will be as much desired by central station engineers during the coming winter as in previous years. The circulation of Messrs. O C. Hawkes' latest electric stove catalogue should help considerably this desirable object, for the number of designs and types of stoves and radiators is complete enough to satisfy the simplest or the most artistic taste. Judging by prices, also, the demand should not be entirely confined to the aristocratic section of the electricity department consumers. The catalogue is of the standard size of the XL publications of O. C. Hawkes, and the illustrations are convincing and well reproduced. A feature of the list is a section dealing with a combination convector (or stove) with radiant-heat lamps.

Osram Lamps.—The economies of these lamps, which are already well known among electric installation contractors, are set out, from independent standpoints, by the "Daily Telegraph" and the "Standard," whose views are embodied in reprints from the journals in question. These reprints are being widely distributed by the General Electric Co., who have acquired the patents of the lamp and are making arrangements on an extensive scale for manufacture in this country.

Motors and Dynamos.—An attractive pamphlet on the subject of induction motors and alternators is being sent out by the British Electric Plant Co., Alloa, N.B. The company manufactures a standard range of a.c. machines, squirrel cage motors from 7½ H.P. to 70 H.P., two or three-phase 50 periods, and on any pressure up to 500 volts; also multiphase alternators of the revolving field type from 100 k.v.a. to 1,000 k.v.a. output (85 kw. to 850 kw.). The pamphlet is well printed and is put up in a tasteful cover.

Haulage Gears.—With a view to encouraging and assisting inquiries for electric haulage gears, Messrs. Mavor & Coulson, Mile End, Glasgow, are issuing a printed information sheet containing blanks which are to be filled in by inquiring colliery managers. Some 26 questions are asked on the sheet, and all appear eminently relevant to the subject of haulage machinery.

Printing Machine Control.—A budget of leaflets is to hand from Kohler Bros., 56, Ludgate-hill, London, E.C., dealing with the firm's special system of control for printing presses The feature of the system is the use of solenoid-operated switches controlled from a number of push-button stations.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Aug. 28 to Sept. 3, with the ports of destination:—

Aden, £26 (telegraph material). *Africa*—Beira, £903 (including £63 telegraph material); Benguella, £50 (telegraph material); Cape Town, £36; Chinde, £28; Durban, £747 (including £315 telegraph cable); Mombasa, £30 (telegraph material); Port Elizabeth, £390; Sekondi, £10 (telegraph material). *Argentina*—Buenos Ayres, £1,024; Rosario, £1,419 (including £37 telegraph material). *Australasia*—Adelaide, £112; Auckland, £43; Brisbane, £22; Christchurch, £305; Fremantle, £116; Lyttelton, £170 and 9 tons tram points and crossings; Melbourne, £1,744; Napier, £13; Sydney, £575 (including £100 telegraph material); Wellington, £664 (including £89 telegraph material). *Belgium*—Brussels, £125; Ghent, £150; Ostend, £62. *Brazil*—Bahia, £214; Rio Janeiro, £287. *British Guiana*—Demerara, £8. *Burma*—Rangoon, £17. *Canada* Montreal, £60; St. John (N.B.), £17; Toronto, £682. *Ceylon*—Colombo, £28 (telegraph material). *Chili*—Valparaiso, £55. *China*—Shanghai, £288. *France*—Boulogne, £198; Paris, £20. *Germany*—Bremen, £1,368; Dusseldorf, £19; Hamburg, £48. *Gibraltar*, £12. *Holland*—Amsterdam, £269; Rotterdam, £12. *Hong Kong*, £687. *India*—Bombay, £1,225; Calcutta, £514; Madras, £411. *Italy*—Genoa, £3,146. *Japan*—Kobe, £3,154 (including £1,034 telegraph cable); Nagasaki, £41; Osaka, £1,219; Yokohama, £3,744 (including £3,630 telegraph material). *Malta*, £107. *Mauritius*. £38. *North Atlantic*, £6,350 (submarine cable). *Russia*—Batoum, £75 (telegraph material); Odessa, £120. *St. Helena*, £10 (telegraph material). *Siam*—Bangkok, £123. *Straits Settlements*—Singapore, £370. *Sweden*—Stockholm, £240. *West Indies*—Trinidad, £15. Total, £34,155, against £23,864 in the corresponding week last year (Aug. 29 to Sept. 4).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

June 17, 1907.

13,926 JONES. Splicing sleeve or ear for jointing trolley wires, cables, &c.
13,930 STEVENS. Governors for engines of petrol-electric cars.
13,932 PIRDSCHUN & BARUCH. Automatic cut out specially for intense current.
13,940 FORSTER. Trolley-pole holders.*
13,943 PHILLIPS & HUTCHINS. Insulation of conductors and compounds therefor.*
13,983 LITTLE. Storage batteries.*
13,986 HADDAN. (Bergmann-Elek.-Werke A.-G., Germany). Manufacture of metallic filaments.*

June 18, 1907.

14,037 FROST-SMITH & STEVENS. Safety circuit-breaking device for petrol-electric cars.
14,059 GROB. Electric lighting and heating of vehicles. (Date applied for, 6/7/06.)*†
14,087 FORTUNY. Arc lamps for changing the luminous intensity in any given direction. (Date applied for, 19/6/06.)*†
14,099 B.T.-H. Co. (G.E. Co., U.S.) Resistances.
14,100 B.T.-H. Co. (G.E. Co., U.S.) Protective devices for electric conductor systems.
14,101 B.T.-H. Co. (Allgemeine Elek.-Ges., Germany.) Control of winding gear.

June 19, 1907.

14,130 BROOKS & ALSTON. Electric ignition apparatus.
14,150 MOORE & POWLES. Electrical signalling apparatus.
14,162 PLUMSTEAD and NEWTON & LAWRENCE. Apparatus for igniting gas electrically.

June 20, 1907.

14,203 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
14,221 MALSON. Electric fuses for use in blasting.*
14,238 BRITISH INSULATED & HELSBY CABLES and BARTLETT. Telegraph sounders.*
14,255 OPPERMANN. Secondary batteries.
14,262 BROWN. Telegraph apparatus.
14,263 STONEHAM. Automatic fire alarms.
14,265 COWPER-COLES. Insulating compounds and the like.
14,269 JOHNSON & TOOGOOD. Trolley poles.
14,286 MIETENS, KUSNETZOFF & TRECHCINSKI. Alternating-current generators and motors.
14,288 B.T.-H. Co. (G.E. Co., U.S.) Rheostats.
14,289 B.T.-H. Co. (Allgemeine Elektricitäts-Ges., Germany.) Control of electric motors.

June 21, 1907.

14,302 HARDING, PHILLIPS, JENKINS & BURNELL. Appliance for derailing trams on inclines, thereby preventing backward motion.
14,316 MUCKERSIE & M'CALLUM. Guards for tramway cars.
14,360 COSSOR, FLORY & DAVENPORT. Mercurial contact maker.
14,362 TIDDEMAN. Dynamo-electric machines.
14,368 LAKE. (C. M. Thompson Co., U.S.) Automatic telephone switches.*
14,372 SIEMENS & HALSKE A.-G. Electrolytic winning of zinc from solutions of zinc sulphate. (Date applied for, 29/8/06.)*†

June 22, 1907.

14,394 COPPOCK. Automatic starting and controlling devices for electric motors.
14,413 MARSHALL. Tension adjustment of electrical brush gear.
14,426 HENNING. Testing apparatus for plug fuses.*
14,428 GLOYSTEIN. Registering apparatus with electric transmission for steamships.

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14,440 Allgemeine Elektricitäts-Ges. Control of electric motors. (Date applied for, 23/6/06.)*†
14,451 Thompson. (Gesellschaft für Drahtlose Telegraphie m.b.H., Germany.) Production and detection of electric oscillations.*
14,461 Jackson & Jackson. Electric motors and similar machines.*

June 24, 1907.

14,552 Cowper-Coles. The generation of power.

June 25, 1907.

14,567 Eckstein, Heap & Mellis. Electrically operated switches.
14,572 Haywood and McKenzie & Holland. Switch for electrically detecting position of railway points.
14,594 Millard. Electric tramcars.
14,620 Siemens-Schuckertwerke G.m.b.H. Regulation of electric circuits. (Date applied for, 26/6/06.)*†
14,638 Taylor. Medical batteries.*
14,649 Wydts & Jeudi. Battery. (Date applied for 28/6/06.)*†
14,684 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.

June 26, 1907.

14,713 Hatfield & Lewis. Arc lamp electrodes.
14,725 Siemens Bros. Dynamo Works. (Siemens-Schuckertwerke G.m.b.H., Germany.) Electrical potential regulators.*
14,739 Gazzard & Miller. Brakes for tramway cars, &c.
14,752 & 14,753 Scott. Protective means for circuits. (Date applied for, 9/7/06.)*†
14,756 Ziegenberg. Secondary batteries. (Date applied for, 10/8/06.)*†
14,762 Ziegenberg. Secondary batteries. (Date applied for, 11/8/06.)

June 27, 1907.

14,797 Veritys Limited & Gott. Boxed switches, fuses and the like.*
14,802 van Haga. Magneto electric machines.*
14,818 Fischer. Return-current heaters for furnaces.
14,831 Thorpe. Prepaid hour meters for electricity.
14,838 Siemens Bros. Dynamo Works. (Siemens Schuckertwerke G.m.b.H., Germany.) Compounding alternate-current dynamos.*
14,839 Siemens Bros. Dynamo Works & Toplis. Switches.*
14,847 Gebrüder Siemens & Co. Electrodes for search lights. (Date applied for, 26/9/06.)*†
14,861 Leitner. Magnetic clutches.
14,876 Noeggerath. Dynamo-electric machines. (Date applied for, 30/6/06.)*†
14,877 Warwick Machinery Co. (G.E. Co., U.S.) Turbines.

June 29, 1907.

14,881 Somers & Crowley. New excitant for primary batteries.
14,905 Lewry. Brakes for tramway and similar vehicles.*
14,930 Lorrain. (Bölling, Germany.) Connecting together certain conductors of electricity.
14,935 Torda & Torda. Distribution of electric currents in the three-and-more wire systems.*
14,967 Goacher & Wragg. Apparatus for use in manufacture of earthenware conduits.
14,969 Pearson. Safety switch.
14,990 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control.
15,009 Felten & Guilleaume-Lahmeyerwerke A.G. Alternating-current electromagnets. (Date applied for, 2/4/07.)*†
15,012 Ross. Coils for electrical apparatus.
15,016 Tracey. Facilitating and checking code telegraphy.
15,017 Kuzel. Incandescence lamps with metal filaments.*
15,028 Ward & Cooper. Improved construction of electric lamp.

COMPLETE SPECIFICATIONS.

1906 Specifications.

11,657 B.T.-H. Co. (G.E. Co., U.S.) Electric heaters.
13,517 Brook & Hirst. Electromagnetically-controlled switches.
13,790 Stave. Automatic tell-tale indicators.
13 818 Newbery & British Prometheus Co. Actuating switches.
13,949 De Ferranti. Electric furnaces.
13,949A De Ferranti. Electric furnaces. (Date applied for, 18/6/06.)
14,259 Moscicki. Electric plant for producing chemical reactions. (Date applied for, 17/1/06.)
14,289 Oldbury Steel Conduits & Sutton. Conduit fittings.
14,501 Fynn. Dynamo-electric machines.
14,577 Statter. Circuit-breakers and makers.
14,589 Fricker. Switch apparatus.
14,615 Rothwell. Electric railways on the surface contact system.
14,737 Albion Motor Car Co. & Murray. Magneto-electric generators.
14,788 B.T.-H. Co. (G.E. Co., U.S.) Current-collecting devices.
14,816 Deutsche Gasglühlicht A.-G. (Auer-ges.). Metallic incandescence bodies for glow lamps. (Date applied for, 28/10/05.)
15,016 Tierney & Malone. Point-shifting arrangements for electric tramways.
15,154 de Ferranti. Turbines.
15,154A de Ferranti. Turbines. (Date applied for 3/7/06.)
15,159 Siemens Bros. & Co. & Turner. Method of sighting guns from a central station and apparatus therefor.
15,245 Robson & Clegg. Electric temperature-indicator bearings.
15,316 B.T.-H. Co. (G.E. Co., U.S.) Pneumatically-operated electric switches.
15,428 Jones. Switches.
15,512 Feuchtmeyer & Könitzer. Switch for strong and weak currents. (Rights not granted.)
15,587 Estler & Drake. Insulators for electric rail or tramways.
15,836 Stave. Indicators especially adaptable for railway and tramway service.
15,910 Marconi's Wireless Telegraph Co. & Priddle. Electric sparking mechanism for internal combustion engines.
15,989 Filney. Speed regulation of continuous-current motors.
16,011 Irwin. Instrument for observing and recording the instantaneous voltage across two points, the current flowing in, or the power given to a circuit.
16,087 Scherbius. Regulating the speed of asynchronous electric motors. (Date applied for, 18/7/05.)†
16,159 Rollet. Electric battery zinc.
16,425 Marks. (Boström.) Apparatus for laying electric conductors.
16,549 Kelly. Device for testing high-tension sparks.
17,293 Moule & Hasell. Automatic electric fire-alarm.
17,539 Haunz & A.B.P. Accumulator Co. Accumulators.
17,590 Patterson & Ramsay. Steam turbines.
17,670 Bassett. Emergency brake.
17,981 Wetter. (Elektrizitäts-A.G. vorm. Schuckert & Co.) Electrolytic production and separate collection of gases.
18,119 Lacy. Dynamos and motors.
18,120 Lacy. Electric motors.
18,291 Justice. (Melms & Pfenninger Ges.) Turbines.
18,365 Brook & Hirst. Metallic cases for motor starters, switches, &c.
18,486 Allgemeine Elektricitäts-Ges. Time and like switches for use with electric metering apparatus. (Date applied for, 19/8/05.)
18,487 B.T.-H. Co. (G.E. Co., U.S.) Electric conductors.
18,835 Wynne. Heating molten or semi-molten materials by electricity.
18,842 Kneen. Tramway and the like points.
19,120 B.T.-H. Co. (G.E. Co., U.S.) Electric motors.
19,548 B.T.-H. Co. (G.E. Co., U.S.) Electric transformers.
19,805 Artom. Receivers for wireless telegraphy.
19,861 Von Pindtershofen. Cable conduit for electric mains.
19,881 De Forest Wireless Telegraph Synd. (De Forest.) Wireless telegraph systems.
20,050 Allgemeine Elektricitäts-Ges. Regulating the voltage of alternating-current distribution systems. (Date applied for, 9/9/05.)
20,209 Lederer. Metallic glow-bodies for electrical apparatus.
20,733 Siemens Bros & Co. (Siemens & Halske A.-G.) Conversation counters in telephone installations.

1907 Specifications.

42 Cunningham. Time indicator for persons using the telephone.
99 Allgemeine Elektricitäts-Ges. Alternating-current commutating machines the magnet fields of which are excited by the armature. (Date applied for, 29/1/06.)
287 Siemens Bros. & Co. (Siemens & Halske A.-G.) Telephone installations having central and local exchanges worked by a central battery.
288 Siemens Bros. & Co. (Siemens & Halske A.-G.) Telephone exchanges.
414 Jumau. Electro-metallurgical production of pure copper. (Date applied for, 20/3/06.)†
543 A.-G. Brown, Boverie & Cie. Electric cut-outs. (Date applied for, 2/5/06.)†
1,080 Soc. des Procédés Gin pour la Metallurgie Electrique. Electric induction furnaces. (Date applied for, 7/3/06.)
1,141 Stratton & Claremont. Box for lead-cased cables.
1,201 Marks. (A.-G. fur Automatische Zund und Losch Apparate.) Igniting a gas or gaseous mixture by electric sparks.
1,242 Siemens-Schuckertwerke Ges. Alternating-current commutator motors. (Date applied for, 20/1/06.)
1,243 Siemens-Schuckertwerke Ges. Starting and regulation electric motors. (Date applied for, 3/2/06.)
1,362 Lake. (Clark.) Insulators for conductors.
1,662 Allgemeine Elektricitäts-Ges. Alternating-current commutat- electric machines. (Date applied for, 23/1/06.)
2,106 Frankcombe. Thermal electric contact-making devices.

COMPANIES' MEETINGS AND REPORTS.

BAKER STREET & WATERLOO RAILWAY CO.—Sir Geo. Gibb stated at the meeting on Wednesday that during the past half-year (the second half-year of full working) two new stations had been opened. The line showed a steady improvement in receipts. The number of passengers carried (including season-ticket holders) was 9,936,995. The passenger receipts amounted to £61,501, which worked out at an average of 1·49d. per passenger. The gross revenue was £63,451, an increase of £18,871 compared with the December half-year. The gross revenue per mile per week had increased from £469 in 1906 to £631 in 1907, which he thought was satisfactory. Working expenses (including £3,574 for rates and taxes) had amounted to £42,128. Out of that, £16,191 had been spent on train working, which worked out at an average of 2·67d. per car-mile. Traffic expenses had been £10,296, or 16·2 per cent. of gross revenue; while the lift expenses amounted to £4,125, or 6·5 per cent. of gross revenue. Total working expenses worked out at £495 per mile per week, which, considering the very full and frequent service run, was a low figure. The net result of the half-year's working was a credit balance of £6,744, which had been carried forward. The directors had given a good deal of consideration to the question of constructing the Paddington extension and had come to the conclusion that it would be wiser to defer the construction of that portion of the line. The company's powers for constructing the Paddington extension would not expire until 1909 as regarded purchase of lands, and not until 1911 as regarded completion of the works. The directors proposed to postpone commencement of the construction of the Paddington extension until after Sept. 30, 1908.

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CHARING CROSS, EUSTON & HAMPSTEAD RAILWAY CO.—Sir Geo. Gibb stated at the meeting on Wednesday that they might now practically regard the work of construction as finished. The railway had been admirably constructed and equipped with an evident determination to let the public have the best possible railway whatever it cost, relying that the public would sooner or later take advantage of the superior facilities provided. They had not as yet carried a large traffic, but of course the line was built to develop a new route, although part of it passed under streets where there was already a large movement of people, and from these he was glad to notice an increasing traffic.

GREAT NORTHERN, PICCADILLY & BROMPTON RAILWAY CO.—At the meeting on Wednesday, Sir Geo. Gibb in moving the adoption of the report (abstracted in our last issue) said that the total capital expenditure up to 30th June amounted to £6,747,715. The balance still to be credited to the contractors (the Underground Electric Railways Co.) on the share capital amounted to £592,400. The Holborn to Strand section was expected to be opened for traffic in Dec. next. They had now had the experience of a full half-year's working of the railway, and he was glad to say that they had found the whole of the construction work and equipment to be most satisfactory. They had carried 11,953,795 passengers, including the estimated journeys of season ticket holders. The passenger receipts had been £102,836, and the gross revenue £106,570, which worked out at £461 per mile per week. The average receipt per passenger carried had been 2d. The working expenses, including £6,063 for rates and taxes, amounted to £75,794, of which £30,152 (or 2·47d. per car-mile) was spent on train working, Traffic expenses amounted to £18,135 or 23·9 per cent. of the gross revenue. Lift expenses amounted to £9,252, or 12·2 per cent. of gross revenue. Total working expenses represented £328 per mile per week, and he thought they would be well satisfied if they were able to maintain that figure, and still more pleased if they could reduce it. The working cost averaged 1·51d. per passenger carried. The net result of the half-year's working after payment of the interest on all the debenture stock actually issued and sold to the public showed a deficit of £5,270, which the Underground Co. (under their guarantee) had paid. He thought they might say that the railway had made a fair start.

MERSEY RAILWAY CO.—Mr. Jas. Falconer stated at the meeting on Friday that there had again been a substantial increase in all classes of traffic. In the latter half of 1902 (the last six months of steam working) the total number of passengers carried, including season-ticket holders, was 3,357,000, while during the past half-year the number carried, including season-ticket holders, was 6,686,000. Since the line had been electrified the number of passengers had practically doubled. The improvement had been particularly marked in the season-ticket holders. The total revenue had increased from £29,470 in December, 1902, to £49,892 in the past half-year. With a view to meeting what was an obvious demand on the part of passengers travelling by their railway, the board inaugurated a service of motor omnibuses, in connection with the line. Anyone acquainted with Birkenhead and the neighbourhood would be aware that there was a considerable area not at present adequately served by the tramways of Birkenhead Corporation. Unfortunately, the Corporation, in the interests of their municipal enterprise, opposed the company's efforts, and the House of Lords, reversing the judgment of the Court of Appeal, had decided that they were not entitled to run these omnibuses as part of their business.

YORKSHIRE ELECTRIC POWER CO.—The directors' report for the half-year ended June 30 states that the progress of the company has been uniform, and the accounts show a satisfactory reduction in working expenses, whilst the sale of electrical energy is approximately double that of the corresponding half-year in 1906. During the past half-year agreements have been made for 600 kw., making a total of 3,122 kw. (4,163 H.P.). An important agreement has been made with Electrical Distribution of Yorkshire (Ltd.) to take a bulk supply of energy in all districts for which the distribution company shall hold electric lighting provisional orders within the area of the power company. A supply is already being given to the company in Gomersal, and it is expected that a supply will be given in other districts at an early date. An agreement for a short period has also been made to utilise the staff of the power company to manage and develop the distribution company, which will assist in rapidly building up an increasing demand upon the power company for electrical energy.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

DONCASTER ELECTRICAL CO. (LTD.) (94,732.)—Reg. Aug. 28, capital £500 in £5 shares (50 preference), to carry on the business of electricians, engineers, suppliers of electricity, &c. J. P. Child is first managing director.

JOHN E. GIBBS & MACLEAN (LTD.) (94,773.)—Reg. Aug. 31, capital £2,500 in £1 shares, to acquire the business of motor builders and repairers, electrical, mechanical and general engineers, &c., carried on as Gibbs & Maclean, and certain patents granted to J. E. Gibbs. First directors, A. M. Maclean and J. E. Gibbs (both permanent). Reg. office, Fawcett-street, York.

THOMAS GUNN (LTD.) (94,729.)—Reg. Aug. 27, capital £12,000 in 200 6 per cent. cumulative preference shares of £10 each and 10,000 ordinary shares of £1 each, to take over the business of a wholesale, retail and manufacturing ironmonger, electric-lighting engineer, &c., carried on by Thomas Gunn. First directors are T. Gunn (permanent managing), T. H. Gunn and A. Gunn. Reg. office, 34, Fore-street, London, E.C.

KEARNEY HIGH-SPEED RAILWAY CO. (LTD.) (94,746.)—Reg. Aug. 29, capital £11,000 in 10,000 ordinary shares of £1 each and 20,000 founders' shares of 1s. each, to adopt an agreement with E. W. C. Kearney for the acquisition of certain patents and rights to construct, alter, equip, purchase or otherwise acquire, maintain and work high-speed, light, service, tube and other railways and tramways, whether operated by electrical or other power, and particularly high-speed railways on the Kearney system. E. W. C. Kearney is managing director for 21 years. Reg. office, 17, Old Queen-street, Westminster, S.W.

McKENZIE, HOLLAND & WESTINGHOUSE POWER SIGNAL CO. (LTD.) (94,747)—Reg. Aug. 29, capital £20,000 in £1 shares, to carry on the business of contractors for power and automatic signalling, railway signal and interlocking apparatus makers, engineers, manufacturers of and dealers in pneumatic and electric tools and appliances, &c. 9,996 of the original shares are to be allotted to McKenzie & Holland, 9,996 to the Westinghouse Brake Co. First directors are G. Terrell and S. P. Wood (nominees of McKenzie & Holland), and J. W. Cloud and A. W. Rendell (nominees of Westinghouse Brake Co.). S. P. Wood is first managing director.

STATUTORY RETURNS.

COUNTY ELECTRIC TRACTION CO. (LTD.)—The capital in return to Dec. 31, 1906, is £3,000 in £1 shares, of which 1,050 have been taken up. 17s. 6d. per share has been called up and £537. 10s. has been received, leaving £381. 5s. in arrears. Mortgages and charges, nil.

EVERSHED & VIGNOLES (LTD.)—The capital in return to June 28 is £30,000 in £3,000 shares of £10 each, all of which have been taken up. £10 per share has been called up and paid on 2,700 and £6. 13s. 4d. per share on 300. Mortgages and charges, £14,000.

LISBON ELECTRIC TRAMWAYS (LTD.).—Return to July 3 gives capital as £1,250,000 in 750,000 ordinary and 500,000 preference shares of £1 each, of which 594,188 ordinary and 425,553 preference have been taken up. £1 per share has been called up on 94,188 ordinary and £94,189 has been received. £925,553 is considered as paid on 500,000 ordinary and 425,553 preference. Mortgages and charges, £500,000 debentures.

LLANGOLLEN & DISTRICT ELECTRIC LIGHT & POWER CO. (LTD.)—In return to June 22 capital is £6,000 in £1 shares, of which 1,764 have been taken up. £1 per share has been called up on 1,729 shares and 15s. per share on 25, and £1,744. 10s. has been received, leaving £3. 5s. in arrears. Mortgages and charges, £1,600.

MORTGAGES AND CHARGES.

CONDUIT & INSULATION CO. (LTD.)—Issue on Aug. 22 of a 5 per cent. debenture for £250, part of series created same date to secure £500, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. A debenture of even date, securing £500 and ranking pari passu with above as a charge on same property, has also been registered. Trustees, A. Holland and W. R Comings. No previous issue of same series.

CITY NOTES.

MEMORANDA (Sept. 5).—Bank rate 4½ per cent. (since Aug. 15, 1907). Price of silver 31 7/16—31 9/16d. per oz. Consols 81½—81⅝ for money, 81 11/16—81 13/16 for account; 2½ per cent. annuities 79⅝—80. Consols Pay Day, Oct. 3; Stocks and Shares Continuation Days, Sept. 11 and 25; Ticket Days, Sept. 12 and 26: Pay Days, Sept. 13 and 29; Mining Share Carry-over Day, Sept. 10.

ABERDEEN SUBURBAN TRAMWAYS CO.—At the meeting on Friday last the chairman (Mr. Geo. J. Walker) complained of the price which the company had to pay to the Corporation for electric energy. If, at the termination of the existing agreement, a very substantial reduction was not made the company must erect their own generating station.

BRITISH INSULATED & HELSBY CABLES (LTD.)—The directors have declared an interim dividend for the half-year ended June 30 at the rate of 8 per cent. per annum, less tax.

CHELSEA ELECTRICITY SUPPLY CO. (LTD.)—The directors have declared an interim dividend on the ordinary shares for the half-year to June 30 at the rate of 4 per cent., payable 16th inst.

MACKAY COMPANIES.—The regular quarterly dividend of 1 per cent. on the preferred and common shares in the Mackay Companies will be paid on Oct. 1. The transfer books will be closed Sept. 16 to 30 inclusive.

NEWCASTLE & DISTRICT ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend of 2 per cent.

NORTHAMPTON ELECTRIC LIGHT & POWER CO. (LTD.)—The directors announce the payment of an interim dividend of 2 per cent. on the ordinary "B" shares.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Sept. 18 a special settling day in and have ordered to be quoted £183,632 4½ per cent, debenture stock and provisional certificates (partly paid) for £116,368 4½ per cent. debenture stock of the *United River Plate Telephone Co. (Ltd.)* and have also granted a quotation to a further issue of £67,000 first mortgage 4 per cent. prior lien gold bonds of £100 each of the *Montreal Water & Power Co.*

UNITED ELECTRIC CAR CO. (LTD.)—For the year ended June 30 the directors have decided to pay a dividend of 5 per cent. on the ordinary shares (less tax), to carry £2,000 to general reserve, to write off £6,106 for depreciation (including reserve) and to carry forward £5,095.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Aug. 28	1,654	– 85	13	20,264	– 75
Airdrie	,, 28	233	+ 1	33	7,388	– 82
Anglo-Argentine	Sept. 2	15,621	+ 146	35	575,129	+ 56,949
Ashton-under-Lyne Corp	Aug. 31	380	+ 1	23	9,188	+ 859
Ayr Corporation	,, 31	365	+ 3	16	6,424	– 172
Baker St. & Waterloo Ry.	,, 31	2,005	+ 642	9	30,615	+ 8,825
Barnsley	,, 23	218	– 12	33	5,592	+ 43
Barrow	,, 28	309	– 16	33	8,595	– 131
Bath Electric Trams, Ltd.	,, 28	993	– 81	35	27,760	– 1,075
Birkenhead Corporation	Sept. 1	1,112	– 49	...	...	...
Birmingham Corporation	Aug. 31	6,083	...	22	132,695	...
Birmingham & Mid.	,, 16	801	...	32	26,091	...
Blackburn Corporation	,, 28	1,169	+ 129	¶22	25,193	+ 1,221
Blackpool Corporation	,, 29	2,175	– 294	21	31,855	– 2,253
Blackpool and Fleetwood	,, 31	1,310	– 533	9	13,825	– 2,955
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	Sept. 1	2,321	– 18	22	51,392	+ 2,639
Bournemouth Corporation	Aug. 28	2,564	+ 12	¶21	40,311	+ 591
Bradford Corporation	,, 31	4,736	– 115	22	101,525	+ 393
Brighton Corporation	Sept. 1	1,262	– 171	22	22,086	– 2,572
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	Aug. 30	5,376	...	8	39,167	– 1,050
Burnley Corporation	,, 31	1,251	– 30	22	26,272	+ 347
Burton Corporation	Sept. 1	300	– 32	22	6,645	– 357
Bury Corporation	Aug. 25	1,231	...	21	23,652	...
Calcutta Tramways Co.	,, 31	R45,522	+ R7,514	8	R376,166	+ R28,349
Camborne-Redruth	,, 31	148	+ 6	35	4,224	+ 56
Cardiff Corporation	,, 31	2,239	– 98	22	49,556	+ 1,771
Cavehill	,, 23	96	– 26	33	2,873	– 13
Central London Railway	,, 31	4,240	– 891	9	43,696	– 4,831
Charing C., Euston & H'stead	,, 31	2,345	...	9	22,710	...
Chatham & Dist. Lt. Rys.	,, 29	843	– 90	‡35	25,161	+ 2,021
City & South London Rly.	Sept. 1	2,838	+ 497	9	27,468	+ 5,757
City of Birmingham	Aug. 23	2,740	...	33	92,794	...
Colchester Corporation	,, 28	249	– 10	...	...	...
Cork Electric Trams Co.	,, 29	514	– 50	35	16,251	– 658
Croydon Corporation	,, 30	1,564	– 13	22	32,263	– 1,900
Devonport & Dist. Trams	,, 23	523	– 11	33	15,289	– 159
Dover Corporation	,, 31	322	– 50	22	5,533	– 833
Dublin & Lucan Railway	,, 30	163	+ 10	9	1,407	+ 84
Dublin United	,, 30	8,873	+ 961	‡9	67,185	+ 15,827
Dudley Stourbridge	,, 23	932	– 46	33	28,600	– 824
Dundee Corporation	,, 28	1,163	+ 19	15	17,256	+ 428
East Ham Council	,, 31	966	– 13	22	20,594	– 424
Exeter Corporation	,, 30	377	...	22	7,408	...
Falkirk and District	...	...	...	...	...	...
Gateshead & Dist. Trams	,, 23	1,032	– 20	33	33,475	+ 807
Glasgow Corporation	,, 31	17,428	– 91	13	237,125	+ 2,813
Glossop	,, 31	131	– 15	35	4,767	+ 34
Gravesend—Northfleet	,, 23	275	– 22	33	8,146	– 61
Great Northern & City Rly.	,, 31	1,498	– 33	9	14,209	+ 103
Gt. Northern, Piccadilly, &c.	,, 31	3,500	...	9	34,975	...
Greenock & Port Glasgow	,, 23	699	– 90	33	22,161	– 421
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 23	359	– 55	33	9,653	– 594
Hastings Elec. Trams Co.	,, 29	1,801	+ 372	9	12,508	+ 3,359
Hong Kong	Sept. 2	$7,874	+ $119	21	$270,206	+ $36,179
Huddersfield	Aug. 31	1,622	+ 29	22	35,785	+ 1,690
Hull Corporation	,, 31	2,364	+ 88	22	52,907	+ 2,591
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 23	153	– 1	22	3,214	+ 169
Ipswich Corporation	,, 31	527	– 57	22	9,658	– 787
Isle of Thanet Co.	,, 31	1,793	+ 30	48	27,051	– 692
Jarrow	,, 23	127	...	33	4,067	...
Keighley Corporation	,, 29	185	+ 15	9	1,495	+ 87
Kidderminster & District	,, 23	147	– 7	33	4,044	– 156
Kilmarnock Corporation	,, 31	148	– 15	15	2,586	– 53
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 29	1,294	+ 315	35	40,416	+ 9,918
Lancashire United	,, 28	1,479	+ 391	35	43,837	+ 11,193
Leamington	,, 23	192	– 5	33	5,325	– 742
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	,, 31	2,164	– 153	9	19,733	– 523
Leith Corporation	,, 31	499	– 75	‡16	8,650	+ 16
Lincoln Corporation	,, 31	134	+ 10	22	2,734	+ 64
Liverpool Overhead Rly.	Sept. 1	1,533	+ 35	9	15,366	+ 312
Liverpool Corporation	Aug. 24	11,027	– 97	34	370,826	+ 7,256
*London County Council	,, 24	30,718	+ 4 525	21	657,632	+ 103,123
London United	,, 30	8,217	+ 862	‡35	227,522	+ 7,457
Lowestoft	,, 31	459	+ 11	48	9,567	+ 943
Maidstone Corporation	,, 31	119	– 23	22	2,502	– 210
Manchester Corporation	,, 31	14,647	– 188	22	327,756	+ 24,089
Mersey Railway	,, 31	1,741	+ 116	9	16,401	+ 1,317
Merthyr	,, 23	225	+ 26	33	6,974	+ 359
Metropolitan Dist. Railway	Sept. 1	6,633	+ 66	9	65,448	+ 536
Metropolitan Elec. Trams	Aug. 23	5,152	+ 1,206	33	151,749	+ 33,766
Middleton	,, 23	450	– 64	33	11,826	– 290
Nelson Corporation	,, 31	149	– 14	23	3,410	+ 47
Newcastle-on-Tyne Corp.	,, 31	3,800	– 157	22	91,195	+ 335
Newport (Mon.)	,, 31	686	– 25	22	16,027	+ 1,578
Northampton Corporation	,, 30	478	– 24	‡22	9,885	– 498
Oldham, Ashton & Hyde	,, 23	718	+ 4	33	20,170	+ 921
Oldham Corporation	Sept. 1	2,167	+ 155	23	45,221	+ 2,781
Perth (N.B.) Corporation	Aug. 28	177	– 28	15	2,642	+ 23
Perth (W.A.) Elec. Trams	,, 30	1,346	– 71	35	49,533	– 1,666
Peterborough	,, 23	143	– 16	33	4,219	– 226
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	...	...	...	...	...	...
Potteries	,, 23	1,785	+ 96	33	62,211	+ 1,713
Preston Corporation	,, 21	816	+ 7	...	...	...
	,, 28	773	– 7			
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 29	633	– 120	‡22	13,150	+ 1,989
Rothesay	,, 23	506	– 13	33	7,822	– 615
Salford Corporation	Sept. 2	4,731	+ 119	22	104,737	+ 2,124
Sheerness	Aug. 21	83	– 4	33	1,948	– 72
Sheffield Corporation	Sept. 1	5,555	+ 32	23	128,119	+ 5,296
Singapore Trams	Aug. 31	$9,054	+ $1,139	22	$209,519	+ $10,594
Southampton	,, 28	1,211	+ 45	...	...	...

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 5 days. ‡ Minus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southend Corporation	Aug. 28	704	– 4	22	10,014	– 371
South Metropolitan	,, 23	939	+ 394	33	26,439	+ 4,727
Southport Tramways	,, 23	531	– 24	33	10,209	– 601
South Staffs	,, 23	901	+ 22	33	29,752	+ 1,985
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 11	1,851	+ 139	20	29,367	– 159
	,, 18	1,471	– 24			
Sunderland and District	,, 28	522	+ 69	35	15,784	+ 1,904
Swansea Trams	,, 23	1,694	+ 689	33	30,146	+ 1,725
Swindon Corporation	,, 28	189	– 4	...	...	...
Taunton	,, 23	55	– 2	33	1,461	– 99
Tynemouth and District	,, 23	390	– 48	33	8,353	– 759
Tyneside Trams Co.	,, 28	471	+ 22	35	16,246	+ 709
Victoria, Elec. Supply Co. of	July 28	672	+ 44	...	...	...
Wallasey District Council	Aug. 31	941	– 27	22	19,589	+ 349
Walsall Corporation	,, 31	556	+ 15	35	17,791	– 299
Warrington Corporation	,, 22	394	+ 20	21	7,990	+ 306
West Ham Corporation	,, 29	2,322	– 25	22	5,248	+ 1,198
Weston-super-Mare	,, 21	424	– 31	33	4,773	– 525
Wolverhampton Co.	,, 23	480	+ 16	33	15,144	+ 806
Wolverhampton Corpn.	,, 28	846	+ 1	6	5,421	+ 58
*Worcester	,, 23	380	– 1	33	9,428	– 266
Wrexham	,, 23	116	– 13	33	3,399	– 75
Yorkshire W.R. Trams	Sept. 1	1,269	+ 265	35	40,331	...
Yorkshire Woollen District	Aug. 23	963	– 9	33	31,913	+ 1,389

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., Sept. 4.	Rate % Yielded.	Dividend Due.	Business Week to Sept. 4. High-est.	Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8 1/16 – 8 5/16	4 16 3	Ap, Oct	8 1/4	8 1/8
5	2/9	Do. 5½ per Cent. Cum Pref.	5 11/16 – 5 13/16	4 8 8	Ja, Jul	6 1/8	6
St.	6%	Do. Permanent 6% Deb. Stock	131 – 134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 – 105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3 3/16 – 3 7/16	3 2 0	May ..	3 1/16	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4 3/4 – 5 1/8	4 18 6	My, Nv	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	98 – 100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 – 132	4 3 6	Mr, Spt	113	112
St.	5%	Do. Pref. Ord. Stock	110 – 114	4 7 6	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	103 – 106	4 14 6	Ja, Jul	105	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 – 103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	100 – 102	4 8 0	Ja, Jul	100½	100
5	3/0	Buenos Ayres & Belgrano Ord.	4 5/16 – 4 5/16	8 0 0	Ap, Oct	4 5/16	4 5/16
5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4 13/16 – 5 1/16	5 14 0	Ap, Oct	5	..
5	3/0	Do. "B"	4 13/16 – 5 1/16	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 – 115	4 7 0	Ja, Jul	108 3/4	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 – 103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 – 97	5 3 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 – 103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 – 105	5 14 6	Ap, Oct	102½	..
5	4/6	Calcutta Tramways (1 to 137,610)	7 3/8 – 7 7/8	5 2 6	Mr, Spt	7 1/2	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5 1/4	4 11 0	Ja, Jul	5 1/16	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 – 106	4 5 0	Ja, Jul	..	..
St.	..	Cape Electric Tram Shares	15/16 – 1	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 – 98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 – 87	5 15 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 – 93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 – 82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 – 1 1/4	4 0 0	July ..	..	..
100	0.7½	Do. 6 per Cent. Cum. Pref.	1 – 1 1/4	4 16 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb	95 – 98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 – 99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 – 103	4 7 6	Fb, Aug	..	..
St.	6%	Perth E. Trams. 1st Mt. Db. Stock	100 – 104	4 16 0	Ja, Jul	103½	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	118 – 123	3 19 0	..	119	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92¾ – 94¾	5 6 8	Ju, Dec	93 1/2	92 1/2
		ELECTRICITY SUPPLY.					
5	3/0	†Adelaide Elec. S'ply Co. 6% Cu. Pr.	4 1/2 – 5	6 0 0	Mr, Spt	..	..
10	4/8 3/8	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7 3/8 – 7 5/8	5 14 6	..	7 7/16	7 1/4
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 – 96	4 13 9	Ja, Jul	95 1/4	94 3/8
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6 3/4 – 7 1/4	5 3 3	Ap, Oct	..	..
5	2/3	Do. (80,001 to 100,000)	6 1/4 – 7 1/4	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 – 53	4 14 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2 1/4 – 2 3/4	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	89 1/2 – 92 1/2	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94 1/2 96 1/2	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 – 106	5 13 0	Ja, Jul	..	..
1	0/3 3/8	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 – 97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	3/4 – 3/4	3 6 9	April ..	3/4	..
1	1 2/3	Do. 6 per Cent. non-Cum. Pref.	7/8 – 1	6 0 0	May ..	7/8	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 – 98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 – 5 1/2	5 9 6	Ap, Oct	5 1/2	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 – 101 1/2	4 19 0	Ja, Jul	100	99

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

Shares	Last Dividend	Name.	Price Wed., Sept. 4.	Rate % Yield.	Dividend Due.	Business Week to Sept. 4. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord...	9⅜ – 10⅜	6 10 0	Mar, Sept.	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝ – 10⅜	4 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	10 – 10¼	5 14 9	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	99 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 – 100	4 10 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7⅜ – 8⅜	6 1 6	March....	7⅜	7⅜
5	3/6	Do. 7 per Cent. Pref.	7¼ – ⅞	4 5 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co 4% Guar. Db. Stock	99 – 102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3¾ – 4	5 11 3	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	7⅜ – 4½	5 9 0	Feb, Aug	4	3⅞
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 – 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3½ – 3⅝	6 0 0	Jan, July	..	..
5	2/3	Chelsea Electric Supply Ord.	3¼ – 4½	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 104	4 6 6	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord..	9 – 9¼	6 6 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11 – 12	5 0 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	121 – 124	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 – 99	4 11 0	Jan, July	99	97½
5	5%	County of Durham Elec. P.D. Ord.....	7⅜ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 4⅝	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10½ – 11½	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 – 109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	£4 – £7	4 12 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅛ – 4⅜	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	£6 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	£3 – 7½	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	5¼ – 5⅜	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½ – 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	£9 – 102	3 18 0	April, Oct	..	..
3	2/4½	London Electric Supply Ord.	1⅛ 2	6 0 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅜ – 5½	5 14 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	89 – 92	4 7 0	Jan, July	90	88½
5	3/0	Metropolitan Electric Sup. Ord.	5⅛ – 5⅜	6 1 6	April, Oct	5	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜ – 4⅝	4 5 6	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1 4 – 107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	88 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 – 98¾	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9 – 9¼	4 17 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	98 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	£8 – 6⅝	6 3 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 – 5¼	4 17 7	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 – 18	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 – 99	4 11 10	Jan, July	..	..
10	6/0	Notting Hill Electric Ord.....	11 – 12	7 10 0	March ..	..	..
5	4/6	Oxford Electric Ord.	5½ – 6	5 17 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£5 – 97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7⅜ – 7½	6 1 4	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6 – 7	5 0 0	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	£6 – £1	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	½ – 1½	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	2 – 2½	6 0 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅜ – ½	3 6 9	..	..	..
1	0/8½	† Do. 7 per Cent. Cum. Pref.....	1 – 1½	5 12 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 – 103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅞ – 2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	£4 – 97	4 12 9	April, Oct	..	..
5	5/0	†Westminster Elec. Sup. Ord.	8⅜ 9	6 2 6	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 2 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	£8 – £3	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ – ⅞	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	13/16 – 15/16	5 7 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 98	5 2 0	April, Oct	..	..
St.	4%	B'ham & Midland Trams 4½ 1st Db. Stk.	£4 – £7	4 13 0	Jan, July	14	..
10	9½	Bristol Tramways & Carriage Ord.	14 – 14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8½ – 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	£8 – £10	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2 – 2⅛	..	June, Dec	2⅛	2⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	6¼ – 6⅝	8 18 0	Feb, Aug	6⅜	..
St.	5%	Do. 5 per Cent. Perpetual Debs.	£10 – 103	4 17 0	April, Oct	10½	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	£8 – 81	5 11 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock.....	£1 – £3	4 18 0	Feb, Aug	72½	71½
St.	4%	Do. 4 per Cent. Pref. Stock	89 – 91	4 8 0	Feb, Aug	..	..
St.	..	Do. Deferred Stock	53 – 56	7 2 8	Feb	53½	..
100	4%	Do. 4 per Cent. Debs.	102 – 105	3 16 0	Jan, July	..	..
St.	4%	Charing X. Euston & Hmpstd Per. Db. Stk.	£1 – £4	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4½ – 5	5 0 0	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	£8 – 101	3 19 0	April, Oct	..	..
St.	2½%	City & South London Rly. Con. Ord. ...	46 – 48	4 18 0	Feb, Aug	48	47½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1896).....	113 – 116	4 6 0	Feb, Aug	..	..
St.	5%	Do. (1901).....	113 – 116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13½ – 14½	4 2 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	12⅝ – 13⅝	4 7 0	Feb, Aug	..	..
10	6/11½	Gt. Northern & City Rly. Pref. Ord. (4%)	1½ – 2	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	88 – 65	4 14 1	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ 1 b.St	98 – 101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	½ – 11	5 9 1	Mar, Sept	..	..
St.	4½	‡ Do. 4½ per Cent. Debs.	97 – 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1¼	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	94 – 97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.....	1⅛ – 1⅜	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6½ – 7⅛	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	84 – 86	4 13 0	Jan, July	..	..
10	5/0	London United Trams. 5% Cum. Pref. ...	5⅜ – 5⅝	5 14 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	£2 – 86	4 13 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	3/16 – 5/16	..	April....	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	3/16 – 5/16	5 3 0	Feb, Aug	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	94	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾ – 1⅛	—	May	..	..
1	0/6	Potteries Electric Traction Ord.	5/16 – 7/16	7 3 0	April Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅜ – 7/16	6 18 0	Feb, Aug	5	..
St.	4½	Do. 4½ per Cent. Deb. Stock	95 – 98	4 11 9	May, Nov	..	..
1	0/6	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref	1 – 1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	14 – 18	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	£5 – £8	8 12 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord. ...	1 – 1½	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	2¾ – 3⅜	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – 90	5 0 0	Jan, July	..	..

Shares	Last Dividend	Name.	Price Wed., Sept. 4.	Rate % Yield.	Dividend Due.	Business Week to Sept. 4. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅝ – ¾	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	1/16 – 1/8	8 16 0	April, Oct	..	..
1	2/4⅜	Babcock & Wilcox Ord.....	3¾ – 4	5 0 0	April, Oct	..	..
1	0/7⅜	Do. Pref.....	1⅛ – 1⅜	3 14 0	..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6¾ – 7½	6 18 0	July, Feb	7	..
5	3/0	Do. 6 per Cent. Pref.....	5⅝ – 6¼	4 18 0	Jan, July	5⅝	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 104	4 6 6	Jan, July	..	..
St.	4½%	†British Thoms'n-Houst'n 4½% 1st Mt. Db.	85 – 89	5 1 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	60 – 65	6 8 0	Jan, July	64	..
2	..	Brush Electrical Engineering	⅛ – ⅜	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜ – 1⅛	5 7 0	Mar, Sept	..	..
St.	4½%	† Do. 4½ per Cent. Perp. 1st Deb. Stock	86 – 89	5 1 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	71 – 74	6 0 9	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9⅜ – 10⅜	6 19 0	Jan, July	10⅛	9⅞
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ – 5⅜	4 7 0	Jan, July	5⅜	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105½ – 107½	4 3 6	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅛ – 1⅛	5 12 6	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	57 – 102	4 8 0	Feb, Aug	..	..
1	1/3½	Chadburn's (Ship) Telegraph Ord.	1⅛ – 1⅜	8 0 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	5 7 0	April, Oct	..	..
1	2/-	* Crompton & Co. (Nos. 1 to £6,000)	1⅜ – 2⅜	7 1 0	Jan, July	2	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	95 – 98	5 2 0	Jan, July	98	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝ – 1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1⅛ – 1⅜	9 8 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼ – 2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	¼ – 1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1½ – 2	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅛ – ⅜	..	Jan, July	..	..
2	..	Do. 7 per Cent. Cum. Pref.	1⅛ – 1⅜	..	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref....	8 – 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
5	5/0	†Henley's Telegraph Works Ord.....	11½ – 12½	6 8 6	Feb, Aug	11⅝	..
5	2/3	† Do. 4½ per Cent. Pref.	5 – 5½	4 2 0	Feb, Aug	5¼	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½ – 107½	4 3 6	Mar, Sept	106⅜	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14¾ – 15½	6 9 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Pref. (red.).....	97 – 99	4 1 0	April, Oct	..	..
1	1/3½	Richardsons, Westgarth & Co., Ltd. Ord.	13/16 – 15/16	7 14 0	Nov ...	⅞	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	13/16 – 15/16	6 4 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 – 96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	81 – 82	5 10 6	Mar, July	82	81
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	89½ – 102½	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅝ – 2⅞	6 7 6	..	2⅞	2⅝
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛ – 1⅜	4 4 6	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 – 112	4 9 6	..	111	110
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102 – 104	3 17 0	June, Dec	104	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	100 – 103	4 8 3	June, Dec	..	..
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9½ – 9¾	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	1¼ – 1½	..	Apr, Oct	1⅛	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅜ – 4⅛	..	Apr, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3¼	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 – 88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	60 – 62	6 3 0	F.My,Ag.N	61	..
St.	30/0	Do. Preferred	105½ – 106½	5 12 9	F.My,Ag.N	106	105
St.	1½	Do. Deferred	17⅛ – 17⅝	7 15 0	F.My,Ag.N	18⅛	17⅝
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	92 – 94	4 4 6	Jn,Ap,Jy,O	93½	93
10	5/0	Cuba Submarine Ord.....	£6 – 7½	6 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15½ – 16½	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	2⅝ – 3⅜	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 – 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝ – 103⅝	4 7 8	Jan, July	..	..
20	0/6	Direct United States Cable	14⅝ – 14¾	6 6 0	Ja,Ap,Jy,O	14⅝	14⅜
100	4½%	Direct West India Cable 4½% Bg. Db. (rd.)	99½ – 101½	4 8 6	June, Dec	..	..
St.	25/0	Eastern Ordinary	182 – 187	5 2 6	Ja,Ap,Jy,O	134⅜	134
St.	17/6	Do. 3½ per Cent. Pref. Stock	84½ – 88½	3 19 3	Ja,Ap,Jy,O	88	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 – 105	3 16 6	May, Nov	104½	..
10	9/6	Eastern Extension	15⅜ – 18	5 4 6	Ja,Ap,Jy,O	17⅜	17⅛
St.	4%	Do. 4 per Cent. Deb. Stock	102 – 104	3 17 0	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 – 100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	9⅜ – 10⅜	4 1 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71...	34 – 36	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99½ – 101½	4 8 6	June, Dec	..	..
25	£2/6	Indo-European	56 – 58	5 1 0	May, Nov	57⅛	56
100	£1	Mackay Companies Common	66 – 68	5 18 6	Jan, July	..	..
100	£1	Do. Preference	67 – 69	5 16 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜ – ½	..	April....	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 – 100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10⅜	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛ – 1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 – 100	4 0 0	Jan, July	..	..
10	..	West India & Panama	7/16 – 9/16	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅝	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6⅜ – 7⅛	..	May, Nov	7⅛	..
100	5%	*Do. 5 per Cent. Debs.	£9 – 10⅛	4 18 0	Jan, July	..	..
St.	3/0	Western Telegraph	13 – 13½	5 6 0	Mr,Jn,O,D	13⅜	13
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 – 103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 – 92	4 7 0	Jan, July	..	..
St.	5%	†Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	£9 – 102	4 18 0	Mar, Sept	..	..
5	1/0	Chili Telephone	6¾ – 7½	5 10 6	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1/16 – 1⅛	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	⅞ – 1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	103 – 107	5 12 0	Feb, Aug	107½	106½
St.	6½	Do. Def. Stock.....	105½ – 109½	5 12 6	Feb, Aug	109⅝	109
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11 – 13	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	16⅞	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛ – 5⅜	4 13 0	Feb, Aug	..	..
St.	3½	*Do. Deb. Stock 3½ per Cent. (red.) ...	96 – 98	3 11 6	June, Dec	96⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 – 103	3 17 6	Jan, July	102½	..
1	0/9⅜	Oriental	1⅛ – 1⅜	5 2 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜ – 1⅝	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 – 94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98 – 101	4 9 0	Jan, July	..	..
5	1/0	United River Plate.....	6¾ – 7½	6 18 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	2/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅜ – 4⅜	6 6 3	Jan, July	..	..
10	6/2	Globe Telegraph & Trust.....	10¼ – 10½	5 5 0	Ja,Ap,Jy,O	10⅝	10½
10	4/0	Do. 6 per Cent. Pref.....	13⅛ – 13⅜	4 8 0	Ja,Ap,Jy,O	13⅜	13⅛
10	6/2	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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NOTES.

The Motor Omnibus.

If we may judge by the report of the directors of the London General Omnibus Co., presented at the ordinary general meeting held last week, the electric tramway need have nothing to fear from the motor omnibus in localities where the traffic is dense, though the latter may be successful enough in localities where the heavy capital expenditure of a tramway would not be justified. The results obtained by the London General Omnibus Co. have been awaited with some interest, because of the vast experience and hitherto successful working of the company. For many years past the reports have been uniformly good, and although the margin of profit has been small, the dividends have been most satisfactory. On the present occasion, however, the dividend is nil, owing to a combination of adverse circumstances. For example, the weather has been so very bad during the past summer as to cause a serious reduction in the number of passengers. There has been a reduction in the traffic receipts of £59,678. Of this amount £22,400 was caused by the curtailment of the number of omnibus-miles run, as it appeared wiser to withdraw a certain number of omnibuses rather than to run them at a loss A decline in the average fare obtained accounted for a further loss of £16,000, and there was also a loss of £20,700 due to the smaller number of passengers per omnibus-mile.

The future, no doubt, will bring about a better state of things when the cutting of fares has been discontinued; but, as far as the motor omnibus is concerned, there appears to be no chance at present of this vehicle giving satisfactory financial results, under present London conditions. The remarks of the deputy-chairman were quite clear on this point when he stated in effect that not only were motor omnibuses unprofitable at the present time, but that they were likely to be so for some little time to come. Doubtless it is very largely a question of maintenance. That the cost of this item should increase from £52,000 to £82,000 and £101,000 in two successive half-years shows that the importance of maintenance has been somewhat overlooked by the promoters of the motor omnibus. Apparently, the same trouble is being experienced elsewhere, for at the meeting of the United German Street Tramways Associations at Mannheim the chairman expressed the opinion that motor omnibuses in Berlin were unprofitable, except in a few of the busiest streets, or in rural parts where no competition with railways existed. Those who are financially interested in electric tramways may, therefore, feel reassured, and need fear nothing at present from the competition of the motor omnibus so long as electric tramway projects are conceived, constructed, equipped and operated on sound commercial lines.

Manchester Corporation Electricity Supply.

One of the most interesting British electricity supply undertakings is that owned by the Manchester Corporation, which originally attracted considerable attention on account of its five-wire system of distribution. At the present time, two of its most interesting features are the complete shutting down of one generating station during the six summer months, thus tending to improve the costs of generation at the two newer and more efficient stations, and the installation of complete sub-stations on consumers' premises where a large power supply is required, as described in two of our recent issues. As will be seen from our analysis of the accounts, given on another page, the total number of units sold during the year ended March 31, 1907, was 47,564,903, or about 76 units per head of population. This total output is considerably larger than that of any other electricity undertaking in this country, but it

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may be noted that the total electricity consumption in Glasgow for the year ended May, 1907, was 51,307,054 units, or 65 units per head of population. In the latter case, however, the tramway supply, amounting to 24,974,056 units of the above amount, was generated independently by the Tramways Committee, so that the Manchester undertaking may still be regarded as our largest and most representative. The total costs of 0·73d. per unit, excluding capital charges, for a load-factor of 21·56 per cent., are not quite so good as those recorded in the case of one or two undertakings with smaller load factors; but account must be taken of the fact that the Stuart-street generating station does not yet contain its full equipment of plant, and, no doubt, better results will be obtained in the course of the next year or two.

Effect of the Tube Railways on Health.

THE ventilation of the underground electric railways of London has been freely discussed in the daily Press, and the effect of the atmosphere upon passengers has often been condemned as harmful. Special interest, therefore, attaches to the report of an investigation, carried out by Dr. G. A. SOPER, on the sanitary conditions of the New York subway, with particular reference to the effects of the air upon the health of the employés. Apparently the greatest evil arises from the presence of a considerable amount of iron-dust, due, of course, to the wear of the rails, wheels and brake blocks, and to a certain extent to the iron lining of the tube itself. Even this iron-dust, which is mixed with dust of a non-metallic nature whose presence is inevitable, did not seem to have any serious effect on the health of the employés. The most interesting conclusion arrived at, however, was that the somewhat unpleasant odour and heat of the subway were not injurious; on the other hand, the draughts and changes of temperature at the stations were considered to be of much more importance as regards their effect on health.

Municipal Telephones.

THERE has been much municipal shaking of hands over the final results of the sale of the telephones at Brighton and at Swansea to the Postmaster-General and to the National Telephone Co. respectively, for there has been a profit in both cases. True, the profit at Brighton might have been a considerable loss if there had not been a profit of £2,793 over the purchase of stock for the extinction of debt; but, as it is, there will be a sum of £631 for the happy ratepayers, even after deducting £1,878 which originally came as aid from the rates before the venture was self-supporting. Old ratepayers who have moved away will wish they were back again, and will think with misgiving of the high rate they once paid; whereas new ratepayers will be congratulating themselves upon arriving at the right time to benefit by the pecuniary tolls of their predecessors. At Swansea there will be a sum of at least £1,000 as profit, which has created so much surprise that former members of the Telephone Committee are receiving congratulations from the present members, which is a most unusual proceeding. Many hard things have been said of municipal telephony, but competition is a good thing, and we hope that with the change of hands the subscribers will find their service as good and as cheap as it was before.

Obituary.—We regret to record the death, on the 6th inst., of Mr. A. Bache, who for 14 years (1884-1898) held the post of secretary to the Institution of Mechanical Engineers.

Wireless Telegraphy—It is reported that the Admiralty have decided upon the erection and equipment of a wireless telegraph station at Corkbeg, near the mouth of Cork Harbour. This station is for the use of the Royal Naval Service, and is intended to supersede Roche Point station, which is considered to be not quite safely situated.

Engineering Exhibition at Olympia.—A series of lectures has been arranged for the forthcoming exhibition at Olympia. Among the subjects are "Gas Engines and Suction-Gas Plants," by Mr. H. Williams; "A New Method of Repairing Boilers," by Mr. H. Ruck Keene; "Submarine Telegraphy," by Mr. Charles Bright; "Ferro-Concrete," by Prof. H. Adams; and "Tool Steel," by Mr. P. Longmuir.

Dinner-hour Lectures to Workmen.—*Engineering* reports that recently Mr. Hans Renold distributed some 40 prizes to the employés of Messrs. Hans Renold, Ltd., of Manchester, for attending during the year a course of technical lectures delivered in the works during the dinner-hour. These lectures were undertaken by the works manager, Mr. Hellfristch, and occupied about half-an-hour on two or three days of the week. They dealt with such subjects as the theory of cutting-tools, the use of modern measuring instruments, the properties and treatment of material, electrical theory, &c. The average attendance was about 75.

German Electrical Commission.—The *Western Electrician* states that the commission of German electrical experts and railroad officials, appointed to tour the United States for the purpose of studying American city and interurban transportation facilities, sailed for New York from Genoa on August 12th. The commission will visit most of the United States, Canada and parts of Mexico in a trip that will last three months, and will inspect the high-voltage long-distance transmission lines. The second task of the commissioners is to examine the electrical transportation facilities of New York, Baltimore, Washington, Syracuse, Rochester and Chicago.

"The Principles of Electric Wave Telegraphy."—We have received a letter from Prof. R. A. Fessenden, in which he desires to call attention to the following sentence in his U.S. patent 706,736 (1902) in reference to the recent discussion in our columns on this subject:—"By employing a similarly tuned local circuit in resonance to the periodicity used at the sending station, said circuit consisting of a capacity in the form of a condenser and an inductance formed by the connecting wires placed in shunt across the spark-gap, an increased effect is also obtained on account of the oscillations being prolonged." Since this discussion has been closed we can only reproduce this sentence without comment, and must leave it to our readers to combine it with the letters which have already appeared in our correspondence columns.

Accidents caused in Germany by Various Systems of Lighting.—*L'Industrie Electrique* gives some interesting statistics of the accidents caused by various illuminants during 1906 in Germany. The following table only takes into account accidents which happened to people; those which caused fires and explosions, but no other serious injury, have been carefully excluded:—

Nature of accident.	Lighting gas.	Electricity.	Petroleum.	Alcohol.	Paraffin.	Acetylene.
Slight	112	42	199	119	53	24
Serious	149	46	218	140	62	34
Fatal	41	35	127	58	13	10

Calculation shows that 44·4 per cent. of the fatal accidents are caused by petroleum, 20·3 by paraffin, 14·3 by gas and only 12·2 by electricity. The greater part of the fatal accidents due to electricity were caused by carelessness, foolhardiness or drunkenness. Only two were actually due to leakage.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Brest—Dakar	July 22, 1907 ..	—
Kotonou—Libreville	July 18, 1907 ..	Sept. 10, 1907

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Electric Clocks in Vienna.—According to the *Pall Mall Gazette*, electric clocks, regulated from a central station, are being installed in various prominent positions throughout the city. In most instances they are fixed on the tall electric light poles at the intersections of the principal streets. Each clock has four dials, which have no figures for the hours, but, instead, black squares for the III., VI., IX. and XII., and black strokes for the intermediate hours. The new clocks will prove a great boon to the public, it having been always exceedingly difficult to ascertain the correct time, no two of the present public clocks synchronising.

Dynamo Firing.—With reference to the question of dynamo firing, it is stated in the *Engineer* that the Admiralty direct that the main and auxiliary circuits in His Majesty's ships so fitted are not to be cross-connected, but that the end of the auxiliary circuit is to be kept disconnected from the night sight switch-box and insulated. The terminal on the night sight switch-box should be covered with a cap. This procedure will enable the auxiliary circuit to be joined up and used if required, but, being kept disconnected, will, it is considered, prevent an earth or short-circuit on the circuit—main or auxiliary—in use affecting the other circuit. The work is to be carried out by the ships' staffs.

Engineering Standards Committee.—We have received from the Engineering Standards committee a copy of their standard specification for limit gauges for screw threads. In an appendix to this report are given allowances to compensate pitch errors and gauges for checking standard screw threads. In order to disseminate as far as possible the information as to how the interchangeability of screw threads may be secured, it has been arranged that this particular report shall be issued at the specially low price of 1s. net, in the hope that it may find its way into the hands of as large a number of engineers as possible. It has been further arranged to bind up together under the title of "Combined Reports on Screw Threads" the following reports:—"British Standard Screw Threads," "British Standard Nuts, Bolt Heads and Spanners" and "British Standard Systems of Limits for Screw Threads," the combined report being issued at the specially favourable price of 3s. 6d. net, or 3s. 9d. post free.

Petrol-Electric Locomotive on the Paris Metropolitan Railway.—According to the *Railway and Engineering Review* the engineers of the Metropolitan Underground Railway of Paris require some method of conveying the men engaged in the repair of the line; also for transport of material during the night, when the ordinary source of electrical energy is cut off from the track. A steam locomotive is obviously undesirable for this purpose. The use of an electric locomotive driven by storage batteries was considered, but was discarded on account of the probable cost of maintenance. Finally the adoption of a petrol-electric locomotive, in which the power supplied by an internal combustion engine was transmitted electrically to the wheels of the machine, was decided upon. The engine is a four-cylinder one, developing 32 H.P. at a normal speed of 1,500 revs. per min. and is direct coupled to a four-pole dynamo, the field magnets of which comprise four exciting coils with double winding, one series and the other of fine wire, through which passes the current from a small storage battery. The four electric motors, which are entirely enclosed, are of cast steel.

Electromagnetic Railway System.—The *Street Railway Journal* gives an account of a new electric railway system which is being exploited in America. It is said that electromagnets of alternate polarity are placed $2\frac{1}{2}$ ft. apart between the tracks, and the car carries another magnet whose poles span the distance between the track magnets. This car magnet is excited by a storage battery and is provided with a pole changer which alternates the current in the car magnet every time the car travels $2\frac{1}{2}$ ft. The mutual effect of the car and track magnets is thus to give a progressive magnetic pull to the car and produce motion. The air-gap is said to be 1 in. and the storage battery required is reported to be "small." On long-distance railways it is proposed to use a sectional third rail instead of storage batteries. No doubt a small model made up on this principle would run round an experimental track, but the major portion of the power required to propel the car must come from the storage battery, and, as the application is an uneconomical one, the battery would have to be very large. Other possible complications not explained are the hysteresis and eddy current losses in the car magnets and the troubles incidental to maintaining an air-gap of this size in the streets, especially in the presence of so much magnetism.

Working of Magnetic Separators.—According to the *Engineering and Mining Journal* the method of presenting the material to a magnetic separator is quite as important as the design and arrangement of the magnet. The usual method is to distribute the material in a thin sheet by means of a shaking tray, a travelling belt, or by spreading it over a magnetic drum. The rapidity with which it is passed into the magnetic field is a highly important consideration. For example, in testing a mixture of magnetite (strongly magnetic), rhodonite (feebly magnetic), and blende (very feebly magnetic) on a machine of high intensity, it was found that at a certain speed of the belt only the magnetite was attracted. At a reduced speed the rhodonite was partially attracted. A further reduction caused the rhodonite to be attracted, while the blende was still uninfluenced, and a still further reduction caused the blende also to be attracted. The size of the particles is also of importance. Theoretically, there should be no difference on this score, save that a closer adjustment of the distance between the magnets and the sheet of ore is possible with evenly sized particles, but in practice it is found that reasonably close sizing gives the best results in magnetic separation, and in well-designed mills this is arranged for, but the treatment of the very fine ore is a serious difficulty.

Submarine Signalling.—In our issue of January 25th we published an illustrated article on the "Submarine Bell System" of signalling in foggy weather at sea, a system based on the use of a microphone and telephone receiving apparatus. Since this article appeared, considerable progress has been made on both sides of the Atlantic with installations of the apparatus on important liners and on lightships, and over 210 steamships and 56 lightships are now equipped with this new aid to navigation in thick weather. A large number of the lightships so fitted out are located on the western seaboard of the Atlantic near the entrances to Quebec, Halifax, Yarmouth, Portland, Boston, New York, Norfolk, &c. On the north-west coast of Europe 17 bells have been installed, the only British ones being two at the mouth of the Mersey—the entrance to the port of Liverpool. Other European equipments are at Cherbourg, Boulogne, N. Hinder, W. Hinder, Maas, Schwonwen, Haaks, Elbe, Kiel, &c. As proof of the recognition of the value of the apparatus in official quarters we may state that the two new additions to the Cunard fleet—the "Lusitania" and the "Mauretania"—are provided with the complementary receiving apparatus (microphone and telephone transmitter), and that the two Royal yachts of King Edward and the German Emperor are similarly equipped. After lengthy preliminary trials of the system by the Trinity House officials, the Board of Trade have also sanctioned the use of the system upon the English lightships under their control, and four of these are now to be provided with the bell signalling apparatus. The new system of signalling at sea during fog is therefore in a fair position for receiving trial on a very extended scale, and it is anticipated that the claims made for it will be fully realised. As pointed out in the closing paragraph of our previous article, if these claims are justified the general adoption of the sytem by the mercantile marine and by the coast and harbour authorities of all countries ought to lead to the saving of numberless lives and of an immense amount of property at sea.

ARRANGEMENTS FOR THE WEEK.

TUESDAY, September 17th.

IRON AND STEEL INSTITUTE.

11.0 a.m. **Departure from London for the Meeting in Vienna.**

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ELECTRIC TRACTION ON RAILWAYS.*

IV.—RUNNING CURVES.

BY PHILIP DAWSON.

(*Continued from page 707.*)

Summary.—In this article the author first considers the construction and use of (1) the kilowatt-second curve of a motor, (2) the tractive-force speed curve, and (3) the time tractive-force curve from which these two are derived. The value of such curves is shown by a practical application to part of the London, Brighton and South Coast Railway. The effect of varying the gear ratio is then considered, and the derivation of the curve giving the load on the generating station for a given service. Polar curves are the most convenient for this purpose, as is shown by an actual example. Effect of revolving masses is then considered.

In the previous article we have considered the preliminary methods adopted in choosing the type of motor suitable for any given set of conditions.

This once effected it becomes necessary to determine more accurately whether the motor primarily selected is suitable for actually carrying out the work expected of it, and for this purpose the first thing required is a set of characteristic curves, taken from shop tests, of the motor under consideration. For the purposes of this article we will take as an example Messrs. Dick, Kerr & Co.'s "4A" railway motor, curve sheet of which is given below (Fig. 1).

It is assumed that the weight of train and corresponding number of motors (preliminarily fixed upon from the curves referred to in the last article) involves each motor being

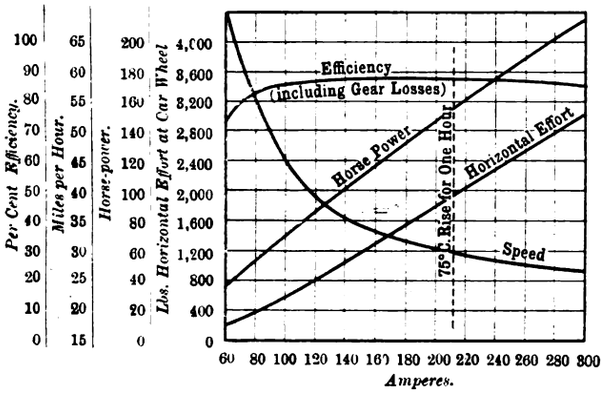

FIG. 1.—CHARACTERISTIC CURVE OF D.K. 4A RAILWAY MOTOR. 625 VOLTS.

Diameter of car wheel=42in. Gear ratio 43/22=1·95/1. Armature speed =M.P.H./0·0638. One turn armature. Brake test through gear.

called upon to deal with a load of 20 tons. It must, of course, be clearly understood that the train weight must include the electrical equipment, passengers, and all.

The curves which are required for our purpose are the time speed, the time distance, feet, lbs. and kilowatt curves.

In order to enable these four important curves to be plotted certain preliminary curves can be plotted direct from the motor characteristic curves, and these greatly expedite what is otherwise very tedious work, if anything like accurate results are required, and for railway work accurate results are essential.

Although in the following description four curves are referred to, there are really only three, but it is more convenient for reference to split one diagram in two parts and give each a number. The three curves are :—

1. A kilowatt speed curve.
2. A tractive-force speed curve.
3 Time tractive-force curve from which the time speed and time distance curve are directly resultant.

The motor having been decided upon, it is also assumed that the gear ratio has been fixed, and for the present investigation this is taken as 1 : 1·95, the diameter of the wheels being 42 in. The influence of gear ratio on the results and the method of constructing curves corresponding to different gear ratios will be gone into later in this article; for the present we will only discuss the gear ratio referred to above.

In examining the motor speed curve it will be noticed that the maximum current per motor is 300 amperes, and that this on the speed curve corresponds to approximately 27 miles per hour. It will also be seen that a horizontal effort of approximately 3,000 lb. corresponds to the current of 300 amperes, which we will take as the starting current. Therefore, as the tractive effort is practically constant for a given current, it will remain constant until the speed of 27 miles per hour has been reached, when the motor curve will be run on. Up to this time the current will have to be kept as nearly as possible constant in the case of the

FIG. 2. FIG. 4. FIG. 3.

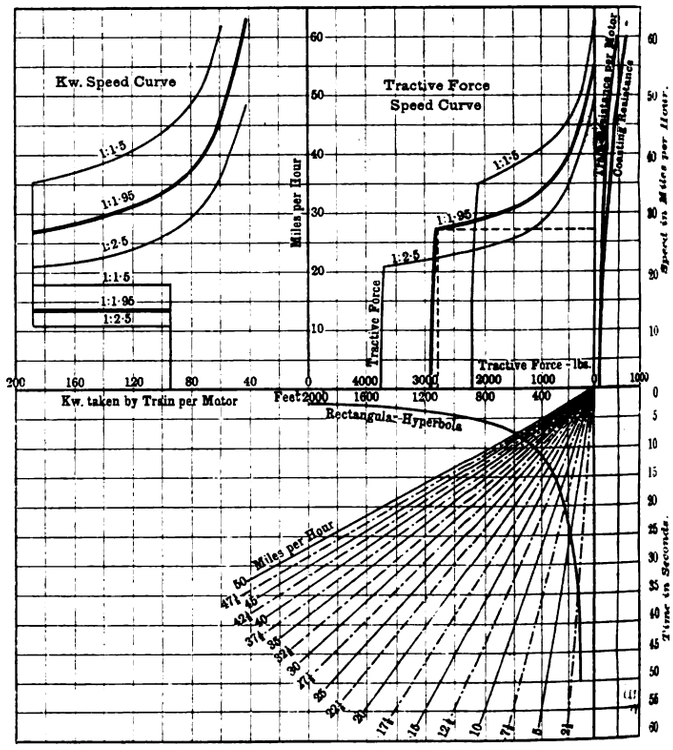

FIG. 5.

Figs. 2, 3, 4 and 5.—Operating Curves for D.K. 4A. Railway Motor for Gear Ratios 1 : 1·5, 1 : 1·95, 1 : 2·5. Train weight per Motor=20 Tons.

continuous-current motors now under consideration by running first in series and then in parallel, and by means of resistances, or in case of single-phase motors by means of varying transformer ratios, as will be seen later when these motors are dealt with. It will be assumed that we are dealing with a group of two motors which from zero to half-speed run in series, and from half-speed to 27 miles an hour run in parallel.

Therefore, from, say, 0 to 14 miles an hour the kilowatt input per motor will be 300 amperes multiplied by half the line voltage, or $\frac{300 \times 625}{2} = 93{\cdot}75$ kw., and from 14 to 27 miles an hour, as the motors are running in parallel, double the above amount, or 187·5 kw., as plotted on Fig. 2 on the curve marked with the gear ratio 1 : 1·95. From 27 miles an hour onward the motor curve will be run on and points on this curve can be obtained by transforming the amperes into kilowatts as taken from the speed current characteristic of the motor.

The next curve to be drawn is shown in Figs. 3 and 4, which, as mentioned before, represent only one curve. To the right of the axis of ordinates is plotted the train resistance curve as a function of speed in miles per hour and

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pounds per motor. The general question of train resistance formulæ (of which there are a very large number) will be considered later; for the purpose of the curve now under construction the following formula has been used:—

$R = 5{\cdot}5\,W + (0{\cdot}00086\,W + 0{\cdot}0465\,n + 0{\cdot}00346\,A)\,V^2$, in which

R = Total train resistance in pounds.
W = Weight train in tons of 2,240 lb.
$n+1$ = Number of cars in train.
A = Area of cross-section of train at right angles to direction of motors in square feet. For our case this area has been assumed at 93 sq. ft.
V = Speed or velocity in miles per hour.

From this the values of R (total train resistance in pounds) can be calculated for the various speeds and plotted as shown in Fig 3.

The values for a three-car train work out as follows:—

V = Speed in miles per hour.	R = Tractive resistance to be overcome per motor.
0 miles per hour	110 lb.
20 ,, ,, ...	150 ,,
30 ,, ,, ...	200 ,,
40 ,, ,, ...	266 ,,
50 ,, ,, ...	350 ,,
60 ,, ,, ...	460 ,,

It will also be necessary to plot the additional coasting resistance which will be encountered when current is cut off and the motors are being revolved by the momentum of the train. This cannot be obtained from the motor curves we have referred to, as it involves the friction in the motor bearings, driving gear and brushes. It can, however, be expressed and measured by the amount of energy which a traction motor takes to attain and be kept at a given speed without exerting any useful torque or tractive effort. In absence of data for the motor under consideration we will take 100 lb. per motor at a speed of 30 miles per hour, whilst for speeds greater or less than this the resistance will be taken to vary proportionally. This will enable us to draw the coasting resistance curve for one motor as shown in Fig. 3, the values of the abscissæ having been plotted from the train resistance as axis of ordinates.

Having drawn the train and coasting resistance curve per motor, we will now draw in the tractive force speed curve for the gear ratio, 1 : 1·95, which is derived from the curve of horizontal effort on the motor characteristic, the only difference being that the factors are horizontal effort and speed instead of tractive force and current.

It will at once be seen that in order to get the tractive effort available for acceleration purposes all we have to do in plotting the abscissæ (which express the tractive effort in pounds) is to measure off from the train resistance per motor line, instead of the vertical axis, and that then the abscissæ measured from the vertical axis will at once express the tractive force which is available at any given speed for acceleration purposes. As the total tractive effort of the motors is constant up to 27 miles per hour, the curve indicating the pull available for acceleration will up to that speed be parallel to the train resistance curve already plotted, the pull of 3,000 lb. as abscissæ being plotted, starting from the starting point of the curve of train resistance per motor. After 27 miles per hour, we plot the curve from the speed and horizontal effort curves obtained from the motor characteristic curve, a given tractive effort corresponding to each speed on the motor speed curve when referred back to the horizontal effort curve. And thus we obtain the curve plotted on Fig. 4 for the gear ratio 1 : 1·95 now under consideration.

Having plotted the curves on Figs. 2, 3 and 4, let us now consider the use which will be made of them and for this purpose let us examine what must be done in order to obtain a time speed curve from a tractive effort curve, and ascertain the relations which exist between them.

The fundamental equation connecting force and mass is expressed by $F = ma$ in which F = force in pounds of tractive effort per motor available for acceleration, m = mass to be dealt with per motor, or the total mass of the train divided by the total number of motors, and a = the acceleration produced by the force F.

Now $m = W/g$, in which W = weight dealt with per motor in pounds and g acceleration due to gravity in feet per second per second.

In our case, therefore, the weight to be dealt with per motor having been taken at 20 tons and $g = 32{\cdot}2$.

$$M = \frac{20 \times 2{,}240}{32{\cdot}2}.$$

But in our case the revolving masses of the armatures must be allowed for. This may be taken as adding 10 per cent. to the mass, or in other words we must multiply the above value for M by 1·1. Hence the real value of M which we have to consider becomes

$$\frac{20 \times 2{,}240}{32{\cdot}2} \times 1{\cdot}1 = 1{,}530 \text{ lb.}$$

In our time speed curve it is necessary to express the value of a, as a function of the time, and as will be shown, this can easily be done.

Thus, supposing we consider the variation of speed in increments of 5 miles per hour, and take two speeds, V_2 and V_1, which are separated from each other by 5 miles per hour, then we have $V_2 - V_1 = 5$ miles per hour $= 7{\cdot}33$ ft. per second, and if we call t the time in which the above increase of speed of 5 miles per hour has taken place then we have $\frac{V_1 - V_2}{t} = a$, or substituting in the equation $F = ma$, we get for the case we are considering

$$F = m\frac{V_2 - V_1}{t},$$

or

$$Ft = m(V_2 - V_1),$$

or, since $m = 1{,}530$, $Ft = 1{,}530 \times (V_2 - V_1) = 1{,}530 \times 7{\cdot}33$. Or, in other words, $F \times t$ = a constant, and the curve represented by this equation is therefore a rectangular hyperbola, which we can now plot in functions of F in pounds and t in seconds, as shown in Fig. 5. In the above discussion it is, of course, assumed that, during the change of speed $V_1 - V_2$, the acceleration remains constant, and the smaller the difference between V_1 and V_2 the more accurate the results will be, although for our purpose an interval of 5 miles per hour is quite accurate enough. We are now enabled to construct this hyperbola as shown in Fig. 5, in which 1 cm. on the squared paper in ordinates has been taken to represent five seconds and 1 cm. in abscissæ has been taken to represent an effort of 500 lb.

Therefore, for plotting the curve with the above scales, we get $F \times t = \frac{1{,}530 \times 7{\cdot}33}{500 \times 5}$, and by giving different values to F in pounds we can obtain t in seconds, and thus plot the hyperbola shown in Fig. 5.

We are now in a position to commence plotting a time speed curve for any given run on the assumption we have already made—*i.e.*, the weight of train per motor and type and gear ratio of motor. Also from the given time in which the run must be accomplished, we know the schedule speed, which in this case we will take as 20 miles per hour including 20 seconds stops at stations as shown in a previous article.

We will now start on the speed time curve shown in Fig. 6 dividing it into three parts as far as construction is concerned, *i.e.*, from 0 to 25 miles per hour, from 25 to 30 miles per hour, and from 30 to 55 miles per hour.

Starting from the vertical axes of ordinates, we measure off in the tractive-force-speed curve, Fig. 4, the average tractive force available for acceleration between 0 and 5

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miles per hour. This average pull in pounds being ascertained we consider on the hyperbola in Fig. 5 the ordinate in seconds corresponding to this effort, and this gives us the abscissa on the time speed curve corresponding to a speed of 5 miles per hour, and we proceed in a similar manner till we have reached a speed of 25 miles per hour. From 25 to 30 miles per hour the plotting of the time speed curve presents a little more difficulty as the tractive effort curve on Fig. 4 does not pass smoothly between these two points. We can, however, divide this portion into two curves, each of which will be separately considered, *i.e.*, between 25 and 27 miles per hour and between 27 and 30 miles per hour. From Fig. 4 we see that between 25 and 27 miles per hour the average accelerating force is as measured 2,830 lb., and on the hyberbola Fig. 5 we find that this force of 2,830 lb. corresponds to a period of 4 seconds. But as these 4 seconds correspond to an increase of 2 and not of 5 miles per hour, we must only take two-fifths of this time, or $\frac{2}{5} \times 4 = 1{\cdot}6$ seconds, which is the time taken for the speed to be increased by 2 miles per hour. The average abscissæ on the traction speed curve, Fig. 4,

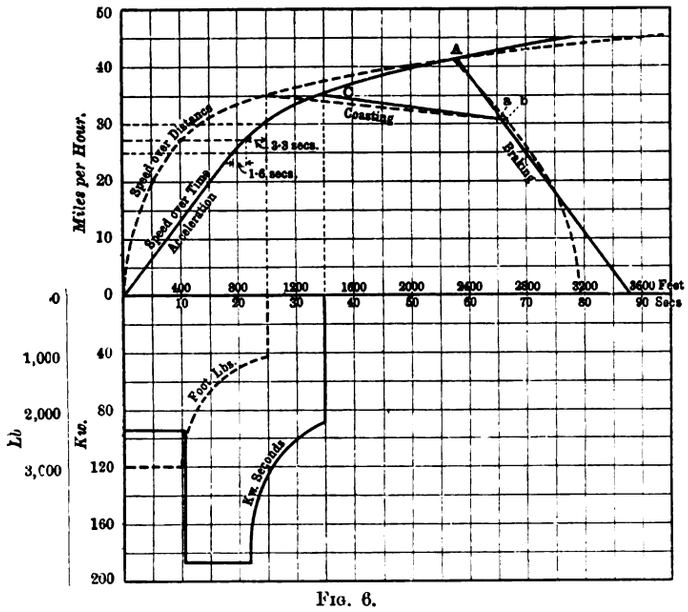

Fig. 6.

Speed time, speed distance curves for D.K. Motor 4A., Gear Ratio 1 : 1·95, with weight of train 20 tons per motor.

measured half-way between 27 and 30 miles an hour referred to the hyperbola gives a corresponding time of 5.5 seconds, but as the increase of speed has only been 3 miles instead of 5 miles per hour we must take as time $5{\cdot}5 \times \frac{3}{5} = 3{\cdot}3$ seconds. The remaining part of the time speed curve being regular is easily drawn in identically the same manner that the first portion was plotted between the speeds of 0 and 25 miles per hour.

We will now draw the braking portion of the curve, and for this purpose will assume a constant retardation due to breaking, which in the present case has been taken at 2 ft. per second per second. The point for ending this portion of the time speed curve is fixed as we have previously settled the average speed, and as we know the length of run (in this case taken as 0·6 miles) we also know that the running time will be 88 seconds.

The accelerating and the breaking curves intersect at A. The inclination of the coasting curve is a known quantity and is measured by Fig. 3. As these quantities are very small it may be advisable to draw another hyperbola with ordinates 10 times as great, but this can also be done by multiplying by 10 the abscissæ measured from the vertical axis on Fig. 3 to the coasting curve, seeing what time this effort corresponds to on the hyperbola Fig. 5, and dividing the time thus obtained by 10.

It is thus possible to construct the coasting curve, although its exact position—*i.e.*, at what speed coasting is commenced—has not been ascertained. It is now necessary to fix this point. For this purpose the easiest way will be to measure with a planometer the total area included between the acceleration and breaking curve.

It is known that the area enclosed by the time-speed curve expresses the total length of the run. Hence, if the total area measured is too large, all that is necessary is to subtract a triangle of such area as to leave the area enclosed by the acceleration, coasting and braking curves equal to the length of the run.

Thus, supposing the total area enclosed between the braking and acceleration curve measured 90 sq. cm., let us ascertain what will have to be the area of the triangle (*Aca* on Fig. 6) which must be taken off in order to realise the average speed which is required. The length of the required run is 0·6 miles=3,190 ft. Now the scale of ordinates on Fig. 6 is, −1 cm. = 5 miles per hour = 7·33 ft. per second, and the scale of the abscissæ is −1 cm. = five seconds: an area of 1 sq. cm. therefore represents 7·33 ft. per second multiplied by five seconds, or 36·65 ft. Therefore the area of 90 sq. cm. represents $90 \times 5 \times 7{\cdot}33 = 3{,}300$ ft. We have, therefore, to deduct 110 ft. or $-\frac{110}{5 \times 7{\cdot}33 \text{ sq. cm.}} = 3{\cdot}03 \text{sq.cm.}$

Thus the time speed curve is completed and we will now consider the method required in order to plot the time distance curve shown in dotted lines on Fig. 6. For this purpose it will be necessary to add some radiating lines to Fig. 5 expressing the distance run at varying speeds from, say, 5 to 50 miles per hour, in any given number of seconds. It will also be necessary to draw further radial lines halfway between each pair of radiating lines giving 5, 10, 15, up to 50 miles per hour speeds, because the distance run between speeds of 0 and 5 miles per hour is the same as that which would have been run had a constant speed of $2\frac{1}{2}$ miles per hour been maintained, assuming uniform increase in speed during the change of speed.

Having plotted these miles per hour lines on Fig. 5, we are now in a position to draw our time distance curve as shown in dotted lines in Fig. 6. Thus if we look at the speed time curve, Fig. 6, we see that it takes 3·8 seconds in order to get to a speed of 5 miles per hour, and the distance run will be the same as if an average speed throughout of $2\frac{1}{2}$ miles per hour had been maintained for the same time, which gives a distance run of 14 ft.

From 5 to 10 miles per hour the speed time curve shows that it takes again 3·8 seconds to realise this, the corresponding average speed being 7·5 miles per hour, and the distance run whilst the speed is going up from 5 to 10 miles per hour is 42 ft. The same reasoning shows that for 10 to 15 miles per hour the distance run is 72 ft. and so on. The point where coasting is to begin is given from the time speed curve, and this shows that coasting commences when a speed of 35 miles per hour has been reached.

The length of the run (0·6 mile, or 3,190 ft.) is known, hence we know when to start the braking curve for the speed distance curve, and the method of constructing this is identical with that for constructing the accelerating portion of the time distance curve. The speed at which braking is started is known from the speed curve and the coasting line can then be drawn in as it connects these two terminal points of the time distance curve.

We will now proceed with the construction of the kilowatt time curve, giving the total kilowatt seconds absorbed by the run before us. Comparing the speed time curve on Fig. 6 with the kilowatt speed curve Fig. 2, we see that for up to 14 miles an hour the input per motor is 93·5 kilowatts; and for our purpose we need only plot the kilowatt curve per motor. From 14 to 27 miles per hour, as the motors are then in parallel, the amount

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per motor will be double, or 187 kilowatts. From 27 to 35 miles per hour we are running on the motor curve, and the kilowatts corresponding to any given speed are taken from Fig. 2 from the curve corresponding to the gear ratio chosen—namely, 1 : 1·95. Having thus drawn the amount of electrical energy which the line has to supply per motor we will seek the amount of energy actually used in useful work—*i.e.*, in acceleration and in overcoming train resistance, this being expressed in feet and in pounds.

This curve shown dotted on Fig. 6 is derived in exactly a similar manner, but from the time distant curve on Fig. 6 and the tractive force curve on Fig. 4. In this case the force in pounds is not measured from the vertical axis but from the train resistance curve, as all the energy is required and not only that utilised for acceleration purposes. It will be seen that between 0 and 27 miles per hour this pull is constant, being equal to 3,000 lb.: for 27 miles an hour

In the present case the scales adopted having been :— 1 cm.=200 ft., 1 cm.=500 lb., 1 cm.=5 seconds, 1 cm. =20 kw., the area of the kilowatt seconds curve measured in square cms. being designated by A, we have

$$\text{Kilowatt seconds} = A \times 20 \times 5;$$

and for the foot-pound curves we have, the area of these in square cm. being expressed by B,

$$\text{Feet} \times \text{pounds} = B \times 200 \times 500;$$

and the efficiency thus measured and calculated for this case works out at 65 per cent., the difference between this and the motor efficiency (which works out, including gears at nearly 90 per cent.) being accounted for by the losses in the rheostats at starting.

The example we have taken has been for a run on the level without allowing for any effect of gradients or curves.

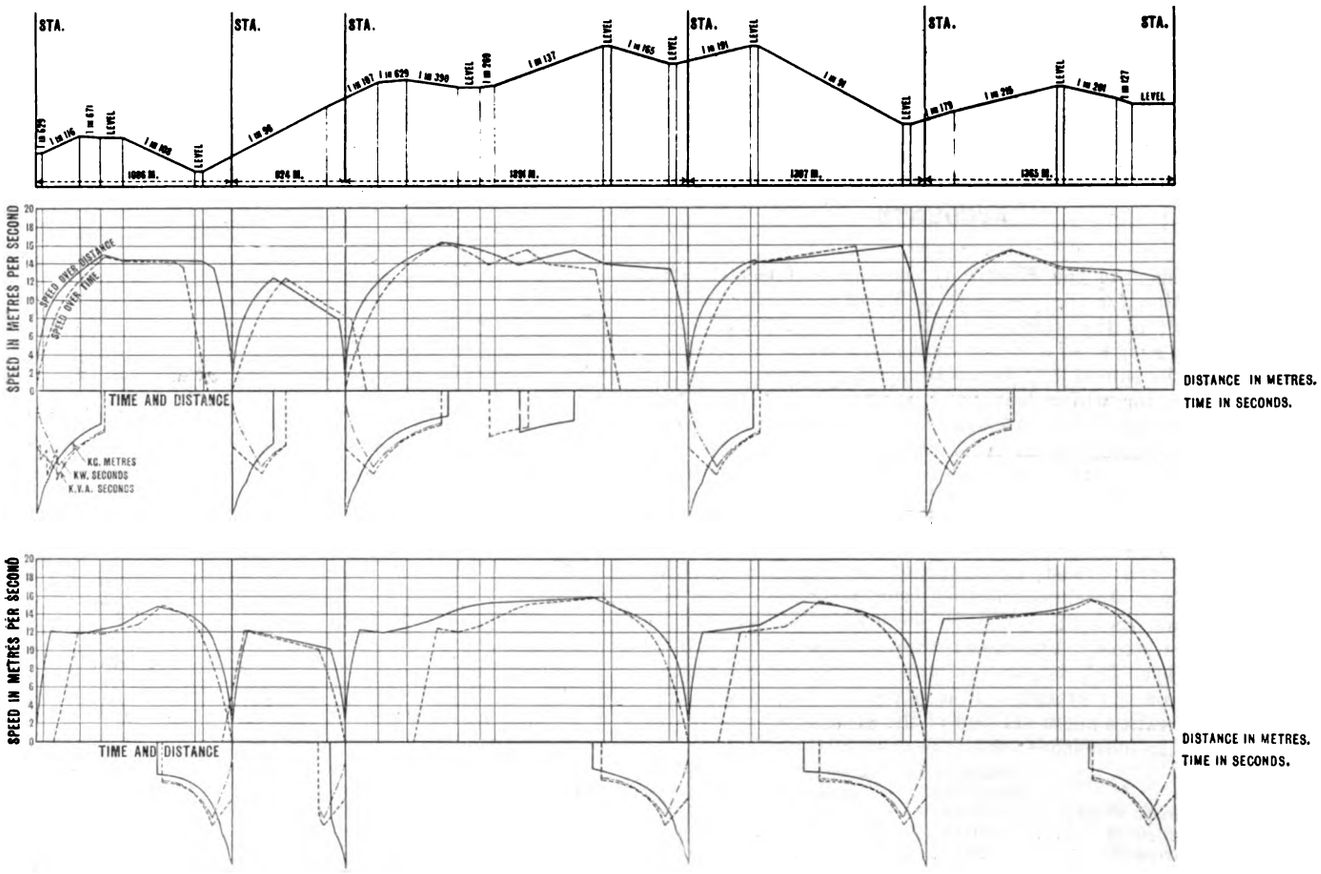

FIG. 7.—SPEED AND LOAD CURVES FOR RUNS IN BOTH DIRECTIONS, WITH THE PROFILE SHOWN FOR A TRAIN CONSISTING OF THREE CARS EQUIPPED WITH EIGHT W.E. 51 MOTORS.

Train weight=132 tons. Gear ratio=1 : 3·68. Scales: Distance, 1 cm.=400 metres; Time, 1 cm.=40 seconds; Speed, 1 cm.=8 metres per second; Tractive effort, 1 cm.=7,200 kg.; Kilowatts, 1 cm.=960 kw.; K.V.A., 1 cm.=960 K.V.A.

onward when we get on to the motor curve it decreases, until at 1,000 ft. it becomes zero as the current is cut off. The ratio of these two areas, the foot-pound and kilowatt curves, represents the efficiency of the system.

To effect this comparison the following must be considered :—

1 kw. second = 1,000 watt seconds.

$$= \frac{1,000}{746} \text{ H.P. seconds} = \frac{1,000}{746} \times 550 \text{ ft. lb., since 1 H.P.} =$$

550 ft. lb per second.

The ratio, therefore, giving the efficiency of the system is expressed thus :—

$$\text{Efficiency} = \frac{\text{Ft. lbs. as measured}}{\text{Total kw. seconds}} \times \frac{1,000 \times 550}{746}.$$

It may be advantageous at this point to consider what difference in the time and distance speed curve would have been caused by gradients and curves. For this purpose we will first examine the effect of a gradient.

Resistance in pounds per ton due to gradients is expressed by the gradient multiplied by 2,240; thus for a gradient of 1 in 50, which is equal to 2 per cent., or $\frac{2}{100}$, the amount to be added or subtracted in pounds per ton of weight to the figure for tractive effort taken for track resistance and acceleration would be 0·02 × 2,240 = 44·8 lbs. per ton.

This assumption is correct in the case of ordinary railways, in which under no consideration will a gradient of 1 in 20 be encountered. Therefore, when a gradient on the line is reached, the tractive force necessary to overcome the gradient has to be at once taken into consideration and

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added to or subtracted from, as the case may be, the values of R given by the formulæ we have already quoted.

$$R=5{\cdot}5W+(0{\cdot}00086W+0{\cdot}0465n+0{\cdot}00346A)V^2.$$

When the final speed-time, speed-distance, kilowatt-second and foot-pound curves have been determined, these must be worked out and should be plotted on the profile of the line as illustrated in the diagram (Fig. 7), which shows the time-speed and distance and kilowatt, kilovolt ampere and kilogram-metre curves worked out for the case of a short section of the L.B. & S.C. Railway; this diagram has, as will be noticed, in addition to those already treated, a kilovolt-ampere curve owing to the fact that alternating-current motors are being used, and this will be referred to at a later stage in the course of these articles. Current has in practice frequently to be kept on after the period of acceleration has terminated, and in order to render the reading of the curve more easy it is well to plot the speed-time and speed-distance curves in thicker and darker lines where current is being supplied to the motor, and in lighter and thinner lines where no current is on.

(To be continued.)

MANCHESTER CORPORATION ELECTRICITY ACCOUNTS.

The report of the Electricity committee of the Manchester Corporation for the year ending March 31, 1907, shows that the result of the year's working is a surplus of £26,267 as against a surplus of £16,219 in the year 1905-6. Out of this surplus the sum of £2,352 has been appropriated for extension of works for which borrowing powers cannot be obtained, and the balance, £23,915, has been carried to the reserve fund.

The city electrical engineer (Mr. S. L. Pearce) reports that during the year the whole of the existing plant has been kept in a high state of efficiency, and has given satisfactory results, both as regards reliability of supply and freedom from breakdowns. In consequence of the adoption of a report recommending the transference during the summer months to Stuart-street station of the Dickinson-street load, three motor-generators, each of 1,500 kw., were ordered and erected at Dickinson-street. For Stuart-street a 6,000 kw. turbo-alternator has been ordered, to cope with the anticipated increase in the load on that station. It is hoped that the new plant will be in operation about the end of the year.

The maximum loads for the year are given below:—

	Lighting and power load.	Traction load.	Combined simultaneous.
Dickinson-street	5,878 kw.	—	5,878 kw.
Bloom-street	5,130 kw.	2,491 kw.	7,419 kw.
Stuart-street	6,000 kw.	6,654 kw.	12,654 kw.

The total plant capacities of the three stations are now as follows:—

Dickinson-street	10,100 kw.*
Bloom-street	7,200 kw.
Stuart-street	16,500 kw.
Total	33,800 kw.

The whole of the distributing plant has operated satisfactorily during the past twelve months. The increased load on the several sub-stations, together with the more extended use of units of a larger capacity, have together substantially improved the "efficiency of conversion." Owing to an increased demand for lighting, power and traction a large amount of constructional work has been undertaken. Motor-generators having an aggregate capacity of 2,250 kw. have been added to the existing sub station plant and several sub-stations have been erected on the premises of large power consumers.

In connection with the tramway extension to Altrincham, feeders have been laid, and a large number of ducts have been put down for the purpose of linking up Stuart-street and Dickinson-street stations. An explosion which occurred on the Victoria-street mains last September, as the result of the failure of an old service joint, caused considerable damage and many claims were received for personal injuries. With this one exception the operation of the distributing network has been satisfactory.

We give below a table showing the total units sold and an analysis of the expenditure, with the total costs for each item, together with the cost per unit sold for last year and for 1905-6.

	1906-7.	1905-6.
Units sold for private lighting	12,254,563	11,248,739
Units sold for power	10,431,945	7,006,574
Units sold for tramways	24,786,457	22,267,858
Units sold for public lamps	91,938	94,613
Total units sold	47,564,903	40,617,784

The lighting, power and traction units show an increase of 18, 49 and 11 per cent. respectively, while the street lighting units decrease 3 per cent. The total percentage increase is 17.

COSTS PER UNIT SOLD.

		1906-7.	1905-6.
Generating Costs.			
Coal	£42,283 18 6	0·212d.	0·236d.
Oil, waste, &c.	4,676 0 2	0·026d.	0·029d.
Wages and salaries	15,730 5 3	0·078d.	0·092d.
Repairs and maintenance	15,127 2 7	0·076d.	0·076d.
Sundries	893 11 5	0·005d.	0·008d.
Total generating costs	£78,710 17 11	0·397d.	0·441d.
Distribution Costs.			
Wages and salaries	£13,182 0 11	0·066d.	0·087d.
Sundries	1,960 6 4	0·010d.	0·010d.
Repairs and maintenance	13,116 2 1	0·066d.	0·091d.
Total distribution costs	£28,258 9 4	0·142d.	0·188d.
TOTAL WORKS COSTS	**£106,969 7 3**	**0·539d.**	**0·629d.**
Management Costs, &c.			
Rents, rates and taxes	£27,100 11 5	0·137d.	0·144d.
Salaries, stationery and establishment charges	9,393 2 4	0·047d.	0·052d.
Insurance, legal charges, &c.	1,337 12 7	0·007d.	0·007d.
Total management expenses	£37,831 6 4	0·191d.	0·203d.
TOTAL COSTS (*ex* capital charges)	**£144,800 13 7**	**0·730d.**	**0·832d.**
Capital Charges, &c.			
Interest	£67,054 5 5	0·338d.	0·386d.
Sinking fund, &c.	104,044 13 1*	0·525d.	0·602d.
Instalment of loan repaid to Public Works Commissioners	5,473 16 2	0·028d.	0·032d.
Total capital charges	£176,572 14 8	0·891d.	1·020d.
TOTAL COSTS (*inc.* capital charges)	**£321,373 8 3**	**1·621d.**	**1·852d.**
INCOME (from all sources)	**£347,640 18 9**	**1·754d.**	**1·947d.**
Balance (carried to appropriation account)	**£26,267 10 6**	**0·133d.**	**0·095d.**

The costs of generation in the above table are averages for three stations. The following figures serve to show the difference in costs for the various stations, but it must be noted that they are the costs per unit *generated* and not units *sold*, and, therefore, do not compare directly with the table above, as the units sold only form 74·6 per cent. of the aggregate units generated.

Generating Costs. Cost per unit generated.	Dickinson-st.	Bloom-st.	Stuart-st.
Coal	0·237d.	0·175d.	0·137d.
Oil, waste, water and stores	0·030d.	0·018d.	0·022d.
Repairs and maintenance	0·106d.	0·061d.	0·044d.
Wages and salaries	0·123d.	0·071d.	0·039d.
Total	0·496d.	0·320d.	0·242d.

We also give a table comparing the coal consumption in pounds per unit during 1906-7 with that during 1905-6. Although it will be noticed that there is a reduction at all

* Including 2,000 kw. of sub-station plan Boiler capacity 7,000 kw.

* Including £40,000 carried to renewals suspense account.

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three stations, the increase in the price of fuel has counteracted any saving at both Dickinson-street and Bloom-street stations.

	Consumption in lbs. per unit. 1906-7.	1905-6.
Dickinson-street	4·51 lb.	4·64 lb.
Bloom-street	3·37 lb.	3·47 lb.
Stuart-street	2·77 lb.	3·22 lb.

The following tables give an analysis of the capital expenditure up to March 31, each station being dealt with separately:—

DICKINSON-STREET.

Account.	Total March 31, 1907.	£ per kw. for each station.	Per cent. of total.
Land	£47,545 12 8	4·47*	17·70
Buildings	52,555 12 8	5·00*	20·00
Machinery	166,083 15 5	15·62*	62·30
Total	£266,185 0 9	25·09*	100·00

BLOOM-STREET.

Land	£15,082 19 1	2·09	7·3
Buildings	57,948 3 3	8·04	29·1
Machinery	126,921 1 0	17·60	63·6
Total	£199,952 3 4	27·73	100·00

STUART-STREET.

Land	£9,981 18 0	0·65	2·10
Buildings	208,099 9 11	12·61	40·04
Machinery	300,700 19 2	18·18	57·86
Total	£518,782 7 1	31·44	100·00

STUART-STREET RAILWAY.

Land	£1,890 8 4	—	2.26
Viaducts and permanent way	79,490 0 2	—	96·74
Total	£81,380 8 6	—	100·00

The low capital costs at Dickinson-street of £25·09 per kw. are largely due to the inclusion of 2,000 kw. of sub-station plant, which has been housed in existing buildings and requires little or no expenditure in the shape of foundations. We understand that the comparatively high figure of £31·44 at Stuart-street is due firstly to the buildings which are prepared for a total of 35,000 kw. of plant, and secondly to the portion of the coal railway inside the depôt which has also been provided for the complete scheme. When the 6,000 kw. turbo-alternator is completed, the capital expenditure will fall to £24 per kw. and lower still, of course, on future extensions of plant.

The remaining items of capital expenditure are as follows:—

Account.	Total to March 31, 1907.	£ per kw.	Per cent. of total.
Generating stations as above	£1,069,006 11 9	31·46	45·39
Distributing stations	304,849 13 7	8·96	13·10
Mains	847,871 10 1	24 93	36·21
Meters	54,895 2 0	1·59	2·32
Motors	20,650 15 4	0 62	0·90
Instruments	3,709 0 8	0·11	0·16
Stores	30,532 0 0	0·90	1·65
Cottage property	3,992 14 2	0·12	0·17
Office furniture	2,287 11 0	0·07	0·10
Street lighting	578 3 5	—	—
TOTAL CAPITAL EXPENDITURE	£2,338,373 2 0	68·76	100·00

649 new consumers have been connected to the mains during the year, an increase of 39 on the corresponding figure for 1905-6. Extensions have been made to many existing consumers' premises. The new lamp connections are equivalent to 62,372 of 8 c.p. and the new motor connections to 124,762 8 c.p. lamps, or a combined total of 8,027 H.P. as against 4,810 H.P. in 1905-6.

The number of motors out on hire is 764, totalling 3,394 H.P., an increase of 1,057 H.P. over the number in 1905-6.

Niagara Falls.—Power obtained from the falls is being used for supplying current to 50 powerful searchlights, the light from these being thrown on to the water and giving a most brilliant and effective illumination of the falls. The total candle-power is stated to be 1,115,000,000. If the present experiment is a success the plant is to be purchased and operated by the American town of Niagara Falls, at a yearly cost of £600.

* These figures are calculated on a plant capacity of 10,100 kw., which includes 2,000 kw. of sub-station plant.

SOME FACTS AND PROBLEMS BEARING ON ELECTRIC TRUNK-LINE OPERATION.*

BY F. J. SPRAGUE.

Summary.—In this Paper the author makes a vigorous and detailed attack upon single-phase traction for trunk railways. The various parts of the electrical equipment are considered in turn. Conductors, when used for alternate currents, suffer loss of current capacity through impedance. Single-phase motors, although effective, are much heavier than continuous-current motors of the same capacity when considered on a thermal basis, and the weight of the complete single-phase equipment for a locomotive comes out to be about double. The differences between single-phase and continuous-current motors are given in some detail. Polyphase motors also are considered by the author to be unsuitable. After considering the pros and cons of electric braking, the author discusses the various systems of working conductors at present available, and describes an improved form of under-contact third-rail, designed by Mr. Wilgus and himself. Recent suggestions to use 15 cycles instead of 25 cycles show some advantages, but the total weight of single-phase apparatus on a car will remain much the same. After describing recent examples of locomotives, and considering some minor points, the author concludes that the field of the single-phase system is on roads with sparse traffic, and that where the traffic is dense a comparatively high-pressure continuous-current system is to be preferred.

Certain memorable opinions, recently uttered by Mr. E. H. Harriman and other leading magnates in the railway world, regarding the need of considerable developments and the present difficulties of operation of the steam railroads, are first referred to by the author, who considers that it is evident that the United States of America have entered on an era of unequalled expansion, and when planning for future developments the steam railroads must keep in view the possibility of a change in motive power and the adoption to an increasing extent of the use of electricity in some form. It is also especially to be noted that while fuel economy, not only in the matter of power generation, but also as affected by its own transportation (often a most serious matter), must be kept in view, capacity is of the first importance.

Increase of capacity, not only such as is possible and individual to electric application, but also such as is common to the larger developments of railroads, however operated, means of course economy in its highest sense, that is, saving in passenger and ton-mile operation, assuming that traffic increases at least in proportion to capital account, because of increased loads, reduced train crews, higher operating schedules, better distributed service, less dead time on sidings, less interruptions to schedule and greater freedom from accidents. I believe that this question of capacity will be a far greater controlling factor in the electrification of trunk lines than that of economy as narrowly measured by the cost of electrical horse power. I do not know of a single instance in which electricity has been adopted in which this feature has not been paramount, nor do I know of a road operated to-day which would sacrifice capacity to economy.

Increase of capacity is the keynote of all railroad development, however rated, for it makes possible an increase of revenue miles of freight or passenger traffic which can be carried on a given trackage or operative mileage of road, and results in a net comparative economy of cost per ton of freight or passenger moved. These improvements are all vital, no matter what the motive power, and they should ordinarily and naturally precede the application of electric power, for it is absolutely certain, except in specific instances, that if these have not been made before the use of electricity is considered, they must be taken up in connection with its introduction.

Electricity is no panacea for railroad ills, any more than freight and passenger rates arbitrarily determined without regard to cost of service is a panacea for the body politic. I know of no business in which universal averages as a guide for individual decision can be more unfortunately applied, and this is equally true no matter what branch of the railroad business is considered. Statistics in a way may demonstrate the desirability of wholesale electrification, but actually they do not afford the slightest reason for assuming that the possible saving in power is of sufficient importance to lead to general consideration of electric operation on extended lines with sparse traffic, no matter what systems may be developed.

This criticism, if it may be so called, was objected to on the score that railroads of this latter class, while not properly present subjects for electrification, were changing their character, and that in time density of traffic would be sufficient to warrant such adoption. This is precisely the point of my criticism. There are roads which can now properly consider the adoption of electricity. There are others which by no stretch of imagination can seriously consider it for many years to come. Why then dilute whatever advantages there are in the matter of economy—all of which are needed on even the best railroad—by consideration of such as are plainly out of present reach of electric equipment?

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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When taking up the question of the adoption of electricity, railway officials are met at the outset by an unfortunate and confusing condition of affairs, largely due to manufacturing rivalries, individual partisanship, professional dicta, and gratuitous advice. These are in no small measure responsible for an apparent division of the engineering world into two camps, alternating and direct current, as in the earlier days of electric lighting, a division which it seems to me is entirely unnecessary and misleading.

I do not intend to burden this Paper with statistics or abstruse mathematics—one can prove almost anything by them—but just here I will epitomise certain conclusions which I think will bear he test of time.

1. Of the two broad lines on which electrification can be considered, if increased economy, that is, reduction of operative expenses by replacing the steam locomotive with an electric one, with concentration of prime power and, perhaps, the use of water power, be deemed the dominant reason for change of motive power, then every wheel in an electrified division should be turned electrically; and the savings effected should pay not only a fair rate of depreciation of the total equipment, but a satisfactory rate of interest on the new capital expended—in fact, a better rate than if spent in some other way.

2. Increase of capacity, both in locomotive haulage, schedule speeds, motor car trains and terminal facilities, of a character im possible to steam service—all resulting in augmented traffic and increased use and capacity of the dead part of the systems, the tracks and roadbed—will ordinarily be the more potent influence in leading to the adoption of electric operation and will often warrant heavy capital expenditures.

3. Every large road is a problem which must be considered financially and technically on its own merits, and in most features other than those which without effort can be harmonised its decision will be of little practical concern to other roads.

4. The adoption of electricity will ordinarily begin with those divisions where traffic is comparatively dense, and, once adopted, the territory over which it can be extended will naturally increase.

5. Terminal properties in great cities, underground and tunnel sections, and heavy mountain sections, where duplication of tracks because of extra heavy construction cost is prohibitive, offer an immediate field for the serious consideration of electrification.

6. There cannot now be safely established any final standard, or any single system selected as the best for all roads. What is the best for one might easily be less advantageous for another, and there is no valid reason why any road should adopt something fitting to a less degree its particular requirements because of the action of some foreign road.

7. Extraordinary advances have been and are being made, and new discoveries are always possible. The limits of none of the systems now in use are clearly defined, and it would seem both natural and wise that the various manufacturing, technical and inventive activities should pursue every lead to its logical conclusion, for the best will be none too good.

It is not my intention in the present Paper to investigate railroad economies or to formulate any final conclusions in the matter of steam railway electrification, but rather briefly to analyse and make running comment upon various phases of the problem often discussed by engineers, to give some comparative facts as they have thus far developed, to describe sundry developments in electric locomotive construction, and to illustrate in some detail features specifically characteristic of the three typical initial equipments now commanding attention.

Motor Equipments.—In discussing the selection of any system, the first thing to investigate is the motor. The working conductor, with everything connected to it in transmission or generation, although essential, is tributary to the motor and its requirements. It is not sufficient that the source of power can be made of any desired size, although it is an essential feature; in any case such concentrated generating equipment must supply a number of motors. What is essential is that the new motor shall have not only certain mechanical advantages, to the extent of eliminating the evils of reciprocating parts and reducing the cost of upkeep, but above all it must have capacity, measured not alone by drawbar pull or speed, but by both, and it must be of sustained character, and this capacity, to accomplish more than the steam locomotive, must be greater than that of the latter. Such capacity should naturally be attained, first, by increase of capacity of the individual motor or locomotive, and then, when this increase has reached its limit, by combining motors or locomotives under a common control by the multiple-unit system.

Limitation of Design.—The designing of electric railway apparatus is handicapped by certain physical limitations which it is not in the power of the designer to change; for example, gauge of track, size and number of drivers, length of rigid wheel base, dead and total weights per wheel and axle, clearance of motors above the track, permissible speeds of parts, provision for accessibility and repairs, and capacity for heat radiation. The electric locomotive, when properly designed, provides a drawbar pull of constant character throughout the revolution of the driver, it increases to an extraordinary degree when necessary, and the capacity of the boiler supplied at the central station is ample. On all service, however high, continuous capacity of the motor is essential. Capacity being, therefore, the keynote of the equipment, I shall discuss at some length the characteristics of conductors and motors used with direct current and with alternating current. In so far as these comments relate to single-phase alternating-current operation, they will in some measure be based upon the only existing commercial development of this character now in the United States—that is, upon the series-wound, commutating, single-phase motor with compensated fields, operated at 25 cycles. Lowering the number of cycles to increase the capacity of the single-phase motor, as has been suggested although not yet developed in commercial practice, of course merits serious consideration, and I shall add some comments upon this proposed change.

Behaviour of Conductors.—Both motors and conductors when used for direct-current or for single-phase alternating-current, present certain differences of such inherent character that there seems no present likelihood of material change, and this conclusion is as sound in regard to the motor differences as it is in regard to conductors. When used for single-phase alternating currents, conductors offer, by reason of self-induction, an impedance or resistance to current materially greater than they present to direct currents. This impedance, and the consequent loss of energy at any particular potential delivery, depends upon the shape and material of the conductor, upon the frequency of alternation, the density of current and the power-factor. Under ordinary conditions a round copper conductor, say No. 0000 size has at 25 cycles an impedance of about 1·6. But with iron or steel conductors this impedance is increased many times, because the magnetisation of the iron and the self-induction drive the current toward the skin of the conductor, so that the body of it is useless, and it might as well be a shell of very much less weight. This effect in steel rails increases with the quality and with the cross-section of the rail. For example, according to the report of the test commission of the recent International Electrical Congress, on 50 lb. traffic rails the ratio of impedance to direct-current resistance at 25 cycles and 300 amperes is about 5·4, while on 80 lb. rail this ratio with the same current is 9·0, with the curious result that increasing the cross-section of the rail does not apparently increase its actual capacity for carrying single-phase currents. Quite the contrary, of course, is the fact in regard to direct currents, the conductivity increasing with the cross-section and quality.

Types of Motor.—Among the many types of motors proposed for railway service, four are now being exploited:—Polyphase alternating-current motor; single-phase alternating-current motor repulsion type; single-phase alternating-current motor series type; direct current. Of these, two, the direct-current and the three-phase motors, each have a continuous rate of energy-input, while the single-phase motor has an intermittent and variable rate. Moreover, there is combined in the single-phase motor two distinct functions, those of a motor and a transformer, and the latter cannot be entirely eliminated. The result is a reduction in both continuous and overload capacities. It is in this particular that the single-phase motor, despite a great amount of experimental development, has remained defective; and while not prohibitive to the extent of making it an unworkable machine, its defects are so inherent as to place it at a serious disadvantage in individual comparison with other types of motors. To attain the pre-eminence hoped for, the external advantages in current supply must be very marked. In fact, rated in the same manner and under like physical conditions, it is only about half as good as the direct-current motor. Or to put it another way, the weight of the complete single-phase electrical equipment on a car or locomotive, including transformers, motors and controlling apparatus, for continuous hard service, and with like physical limitations and ventilation, is about twice that required for direct-current apparatus. In addition to this there is, of course, a material increase in the mechanical equipment necessary to carry the electrical apparatus. The reason is simple—it is because of the heat generated on account of lower electrical efficiency, and the working the fields of the motors at a reduced magnetic flux. When considering locomotives, the net result is that the total weight of a single-phase alternating-current locomotive, with a service capacity equal to that of a direct-current locomotive of like armature speeds and permissible temperature rise (this temperature rise being the ultimate limitation of a motor for continuous service) will easily be from 30 to 50 tons more. An increase in the total weight of a train amounting to from 3 to 10 per cent. is, perhaps, not of itself of so much importance, because such a difference in net power demand can easily appear for various reasons; but a ratio of 2 to 1 in capacity for the limit of equipment possible to install within given allowable dimensions and number of units is a matter of vital importance. If an increased weight is permissible for any given capacity, there must be some ample compensation for it. Of course this is claimed to be the fact

the single-phase system, but another possible advantage which

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might prove important is the abolition of gearing and bearings, and simplification in motor and locomotive construction. Both advantages can hardly be hoped for.

Comparative Weights of Direct current and 25 cycle Single-phase Alternating-current Motors.—While testimony is practically universal that not only is any single-phase motor, whatever the number of alternations, more or less inefficient than a direct-current motor of like weight or capacity, the differences of efficiency, excluding the losses in the gearing, are variously estimated. The reason for the reduced efficiency of the single-phase motor (whatever the actual amount, which depends upon a number of factors) is inherent, and is due to the transformer action which, by increasing the losses, limits the output of the motor. There is an additional loss of considerable consequence. Electrical efficiency, it must be borne in mind, is the ratio between the real output and input. The net input is, however, not the product of current and potential, as in a direct-current motor, but is affected by the phase-relation, commonly known as the power-factor; and when this is below 100 per cent. it means that the actual watts input is less than the product of potential and current or volt-amperes. To put it another way, the actual current input is greater than would be required if the power-factor were unity. As ordinarily rated, efficiency does not take account of this fact, but the increase of current actually means an increased C^2R loss, hence greater heating, and a consequent further reduction of motor-capacity.

It is well, just here, to point out that an increase of 10 per cent. in the amount of current used on a direct-current system, because of improper gear-ratio, change of schedule, or careless handling of equipments by motormen, does not mean that this excess energy is dissipated in internal losses in the motors, for these may be increased only about 1 per cent. The situation in regard to the single-phase motor is, however, entirely different, for it is subject not only to increased power consumption with its proportionate losses because of careless operation, but it also has its individual increased internal loss, which is variously estimated to be much more than that found in properly designed direct-current motors of equal weight and like physical limitations. Much, indeed, has been stated and denied on this subject of the relative weights and capacities of direct-current and single-phase alternating-current equipments. On several occasions I have stated that, measured by equal physical limitations in speed and clearances, and for the same temperature rise with natural ventilation, the total weight for any given service would be twice as much with the alternating-current apparatus as with the direct-current

Valatin and others have indicated one measure of comparison between motors of different makes, types and capacities—the "weight-coefficient"—which for convenience may be expressed by the following equation:—

$$\text{Weight-coefficient} = \frac{\text{Nominal rated horse-power}}{\text{Revolutions} \times \text{weight in tons}}.$$

Let us investigate two motors, respectively for direct and alternating currents, which for convenience we will call X and Y, both standard modern machines.

Machine.	Type.	Voltage.	Air-gap.	1 hr. rating.	Weight.
X	D.C.	550	0·25	240 H.P.	5,474 lb.
Y	25-A.C.	225	0·10	125 H.P.	5,327 lb.

The weights are minus pinions, gear and gear cases. There is a difference of less than 3 per cent. in net weights, or about 2·5 per cent. in total weights. They can, therefore, be very properly compared. In passing, I would call attention to the air-gaps, that of the direct-current motor being nearly three times that of the alternating-current motor—a difference of vital importance as affecting allowable bearing wear, and the proper working of the armature circuits under practical operating conditions.

The accompanying curves (Fig. 1) show graphically, almost startlingly, the comparative speeds, capacities and weight-coefficients of these machines, all referred to the time required to rise 75 deg. in temperature when operating at full normal potential under varying loads and with natural ventilation. Inspection of these curves shows the following comparisons:—

Time for 75° rise.	Capacities.		Ratio of capacities. D.C. ÷ A.C.	Speeds.		Ratio of speeds. D.C. ÷ A.C.	Wt. coefts.		Ratio of wt. coefts. D.C. ÷ A.C.
	D.C.	A.C.		D.C.	A.C.		D.C.	A.C.	
39 min.	285	134	2·13	500	500	1·0	0·208	0·101	2·06
1 hr.	241	122	1·98	530	664	0·80	0·166	0·070	2·37
2 ,,	172	95	1·81	602	932	0·65	0·104	0 038	2·74
3 ,,	148	81	1·83	650	1,130	0·57	0·083	0·027	3·07
4 ,,	137	72	1·90	670	1,270	0·53	0·075	0·021	3·57
5 ,,	132	64	2·06	690	1,398	0·50	0·070	0·017	4·12

It is evident, therefore, that a pair of these alternating-current motors can handle only about one-half of the total load of the direct-current motors, with all the disadvantage of higher armature speed and smaller air-gaps; and considering the excess weight of the control apparatus, the net load over and above the electric equipment would be considerably less than one-half. This general comparison is not, so far as the relative characteristics are concerned, individual to this particular size of motor, but seems to be equally applicable through a wide range, and indifferently as to the make, or whether the alternating-current motor is of the series-compensated or the repulsion type. Furthermore, these differences are seemingly so inherent that there is little chance for improvement at 25 cycles.

Polyphase and Direct-current Motors.—These have similarly high weight efficiencies, the former having somewhat the advantage when compared with the ordinary type of direct-current motor.

The polyphase motor, however, is a normally constant-speed machine. It can, through a re-arrangement of fields, be run at two different speeds, but each is practically a constant one. Or with cascade operation and field changing combined there can be three running speeds. Polyphase motors have an enormous overload capacity, and the fact that they run at synchronous speeds with a very small slip, and if the frequency is unchanged will run upgrade nearly as fast as on a level, would indicate at first sight excessive loads on main and sub-stations. But with suitable provision for regulation at the central station, so that with excessive loads the

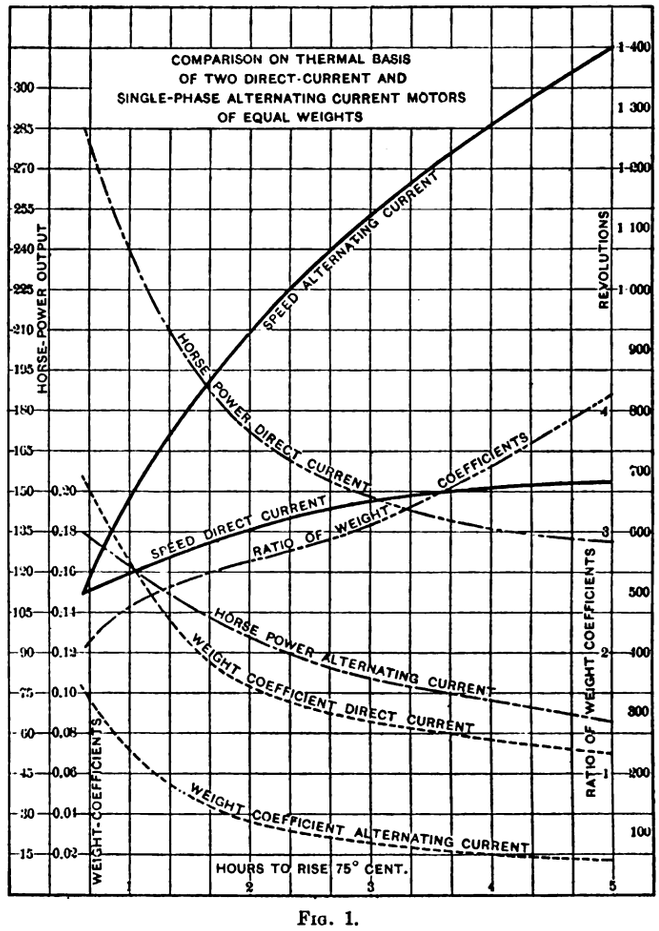

Fig. 1.

generators will drop in speed, there will, with such speed reduction, be not only a temporary cessation of drawing power by the locomotive, but there may actually be a return of energy to the line while slowing down. Multiple-unit grouping and operation is ordinarily impracticable because of the small slip. In spite of the splendid work done by the Ganz Company and the strong support of many Italian engineers, I feel that, all things considered, neither the motor characteristics nor the limitations of overhead construction are acceptable for such service and conditions as exist on our truck-line roads.

On the other hand, considered by itself, the direct-current motor, with its high average-weight efficiency, simplicity of construction, facility of control, automatic response in torque and speed to varying grades and curvatures, and great sustained capacity for enormous torque at low speed, besides the advantages of speed ranges obtained by motor grouping and the use of a single conductor and track return, offers a most effective machine to meet the conditions of railway service. During the last two years important developments have taken place in direct-current motor construction which materially change any preconceived conclusions as to its limitations. The introduction of the commutating pole has practically eliminated commutator troubles, such as sparking, undue

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heating and flashing over. This improvement makes possible the shunted field addition to the series parallel control of speed, the construction of motors for operation at much higher potentials, and the operation of two motors in series at double potential. An especially important development is used on the gearless locomotives built for the New York Central Railroad, in which the hitherto invariable practice of maintaining a fixity of relation between the armature, or rotating part, and the field magnet, or fixed part, has been abandoned; the armatures are mounted directly on the axle, the field magnets forming a part of the locomotive frame, supported by its springs and hence movable with regard to the armatures. In this construction, therefore, there are no armature or field bearings. This locomotive is of the simplest type possible, electrically and mechanically; and when operating under conditions for which it is properly applicable it has not only the highest weight efficiency, but the lowest cost of repairs of any direct-current machine, and much lower than is possible for any single-phase locomotive. It is structurally a natural high-potential machine on account of having but two poles. Since the capacity of electrical apparatus depends upon the speed at which, with any magnetic flux, the armature conductors move, this gearless type of locomotive, if used for the slow speed and heavy torque required on freight service, can only be constructed with reduced weight efficiency as compared with geared locomotives; but despite this handicap, there are so many special advantages that it can be seriously considered even for this service.

Difference between Direct-current and Single-phase Alternating-current Motors.—The present inherent differences between single-phase and direct-current motors may be briefly summed up as follows; (1) The input of current in one is continuous; in the other intermittent. (2) One has a single frame, the electrical and mechanical parts being integral; the other has a laminated frame contained within an independent case. Hence there is not equal rigidity or equal use of metal. (3) One has exposed and hence freely ventilated field coils; the other has field coils imbedded in the field magnets. (4) One has a large polar clearance, and consequently ample bearing wear; the other has an armature clearance of about only one-third as much, and hence limited bearing wear. (5) One is operated with a high magnetic flux, and consequently high torque for given armature-conductor current; the other has a weak field, and consequent lower armature torque. (6) One has a moderate-sized armature and commutator, and runs at a moderate speed; the other, with equal capacity, has a much larger diameter of armature and commutator, and runs at a much higher speed. (7) One permits of a low gear reduction, and consequently a large gear pitch; the other requires a higher gear reduction, and a weaker gear pitch. (8) The windings of one are subject to electrical strains of one character; in those of the other the strains are of rapidly variable and alternating character. (9) The mean torque of one is the corresponding maximum; the mean torque of the other is only about two-thirds of the maximum. (10) The torque of one is of continuous character; that of the other is variable and pulsating, and changes from nothing to the maximum 50 times a second. (11) One has two or four main poles only, two paths only in the armature, and two fixed sets of brushes; the other has 4 to 14 poles, as many paths in the armature, leading to unbalancing, and as many movable sets of commutator brushes. (12) One can maintain a high torque for a considerable time while standing still; the other is apt to burn out the coils which are short-circuited under the brushes. (13) In one, all armature-coil connections are made directly to the commutator; in the other, on the larger sizes resistances are introduced between the coils and every bar of the commutator, some of which are always in circuit, and the remainder always present. (14) In one, the sustained capacity for a given weight is within the reasonable requirements of construction; in the other, it is only about half as much. (15) Finally, the gearless type, with armature and field varying relatively to each other, is available for one, but this construction is denied to the other.

Consideration, then, of the characteristics peculiar to each class of motor indicates, not that the single-phase motor cannot be used, but that if adopted the weight or number and the cost of locomotives or motors required to do the work must be much greater; that the depreciation of that which is in motion will be much higher; and that there will always be an excess weight of fixed amount per unit which must be carried irrespective of the trailing or effective loads. We must, therefore, in many cases be led to the selection of the direct-current motor, that motor which has the higher weight-capacity, the greater endurance, and the lower cost per unit of power.

(To be continued.)

Reinforced Concrete.—The *Street Railway Journal* states that the reinforced concrete power house which the Stone & Webster Engineering Corpn., of Boston, has been building at Georgetown for the Seattle Electric Co. is completed. A Weber reinforced concrete stack is also to be built.

FORCES IN THE INTERIOR OF AN ELECTRIC CONDUCTOR.*

BY EDWIN F. NORTHRUP.

Summary.—The author describes experiments for showing the forces existing in the interior of conductors when traversed by a current, and considers their magnitude theoretically. These forces tend to make a liquid conductor restrict itself, causing the circuit to break if the current is sufficiently large. By suitably arranging the circuit the author adds pressures in series so that the forces may be utilised to give the measure of the current in terms of the pressure produced.

Some months ago my friend, Carl Hering, described to me a surprising and apparently new phenomenon which he had observed. He found, in passing a relatively large alternating current through a non-electrolytic liquid conductor contained in a trough, that the liquid contracted in cross-section and flowed up hill lengthwise of the trough, climbing up the electrodes. With a further increase of current he found that this contraction of cross-section became so great at one point that a deep depression was formed in the liquid with steeply-inclined sides like the letter V. This depression extended in the case of a liquid metal as deep as 6 in. With a current of constant value the condition was a stable one, but the liquid on the inclined surfaces showed great agitation. With a still greater increase of current, the depression reached the bottom of the trough, thereby rupturing the circuit; this, of course, resulted in the liquid flowing together again, and again breaking, a violent interrupter being thus formed. He thus concluded that there is a limit to the current which it is possible to pass through a liquid conductor and that this limit may be reached before the volatilisation limit. He suggested that the blowing of fuse wires and the action of the Caldwell interrupter may, perhaps, be aided by this phenomenon. Mr. Hering suggested the idea that this contraction was probably due to the elastic action of the lines of magnetic force which encircle the conductor, which lines, he said, acted on the conductor like stretched rubber bands, tending to compress it, especially at its weakest point.

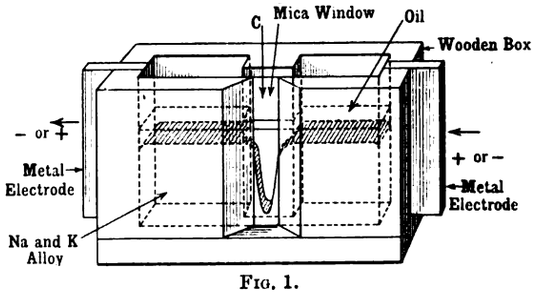

FIG. 1.

The phenomenon described appeared to the writer to have a considerable theoretical interest. The theory and the experiments described in the following are the results of the writer's analysis of the problem. In the development of the theory which follows he has been much assisted by the discussions which he had with Mr. Hering, who offered many useful suggestions.

Depression Obtained with a Small Current.—To show the phenomenon observed by Mr. Hering, the writer devised several laboratory experiments in which mercury was used as the liquid conductor. In a thick sheet of hard rubber, about 5 in. square, two square holes or depressions were cut. These depressions were about ¾ in. deep and 1¾ in. on a side. Their two adjacent sides were parallel and about ½ in. apart. A channel ¼ in. wide and ¾ in. deep was cut so as to connect the depressions. The depressions and channel were nearly filled with mercury. Electrodes of brass placed in the depressions enabled a storage battery current to be passed in the mercury from one depression to the other through the narrow channel.

It was found that about 800 amperes caused the mercury in the channel to depress lengthwise of the channel in the form of a V, about ½ in. below the general level of the mercury. A small increase in the current caused the angle of the depression to reach the bottom of the channel and rupture the circuit. The liquid would again flow together and again rupture, thus forming a slow and irregular interrupter.

The following experiment was then devised by which the forces at work could be shown in a more striking manner and with much smaller currents.

The apparatus shown in Fig. 1 was constructed. This is a box made of wood. The box is divided, as shown, into two rectangular compartments which are connected by a deep channel. One side of the channel was formed of a sheet of transparent mica, so that the

* Abstract of a Paper read before the American Physical Society, and published in the *Physical Review*.

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height of any liquid in the box could be observed from the side. In each end of the box were fastened brass electrodes.

The interior of this box, thus arranged, was filled to a depth of 2 in. with a liquid alloy of potassium and sodium. The remaining space was filled with kerosene oil. The liquid alloy used had a good electrical conductivity and a specific gravity but little greater than kerosene. Hence, if, when current is passed from one electrode to the other, in either direction, forces act to cause the liquid metal conductor to depress in the narrow channel, C, a great depression should be obtained with a feeble force. It is evident that, while the conductor may depress, the level of the oil would remain unchanged. The experiment fully realised the results anticipated. Less than 180 amperes, when passed in either direction from one electrode to the other, caused the V-shaped depression to extend at least 1¾ in. down. Regulating the current with a carbon rheostat enabled the depression to be held at any desired vertical depth. This proved that with a fixed current the depression formed in the liquid is stable. Fig. 1, drawn in perspective, shows the general appearance of what was observed.

By following Maxwell's reasoning it is easily seen that the strength of field about an infinitely long straight conductor is inversely as the distance from the axis of the conductor. Or if T_1, T_2 are the field intensities at distances r_1 r_2 from the axis, $T_1/T_2 = r_2/r_1$. The strength of field surrounding a conductor in the electromagnetic system is $T = 2I/r$, I being the current.

The field intensity within a conductor may be found by considering the conductor built up of concentric cylindrical shells, each

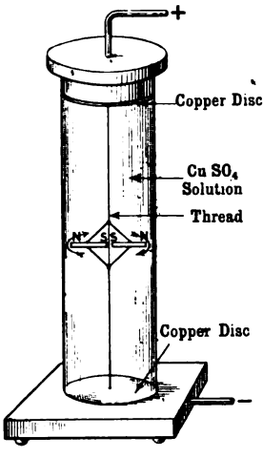

Fig. 2.

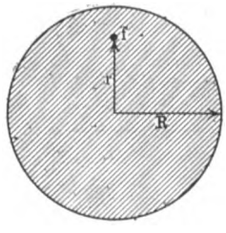

Fig. 3.

carrying current at the same density. If I is the current carried by the conductor, R the radius of the conductor and r the radius of any of the shells, then T_r, the intensity at a distance from the axis is given by

$$T_r = \frac{2Ir}{R} \cdot \frac{1}{R} = \frac{2Ir}{R^2} \quad \ldots \ldots \quad (1)$$

Experiment to Show the Action of the Field in the Interior of a Conductor.—Since in the interior of a solid cylindrical conductor the field intensity increases from zero at the axis to a maximum at the circumference, a condition exists the reverse of that on the outside of the conductor, where the intensity of the field decreases with the distance from the axis. To show this difference the following experiment was arranged.

A glass tube 14 in. long and 3 in. inside diameter was fastened in a vertical position on a wooden base. In the top and bottom ends of the tube, copper discs were fitted. To each of these a lead wire was fastened, one passing out of the top and one out of the bottom of the tube. Between the top and bottom discs a silk thread was tightly stretched and located on the axis of the tube. At the centre of the cylinder two small magnets were placed with their south poles pointing to the axis and their north poles to the circumference.

The magnets were fastened together by a light wire frame and supported by the thread in such a manner that they might move freely in a horizontal plane about the vertical thread as an axis. The arrangement described is made clear by referring to the diagram (Fig. 2). The glass cylinder was filled quite full with a strong solution of copper sulphate. A moderate current could be passed through the solution between the copper discs without generating gas.

As was expected, the magnets began to rotate as soon as current was sent through the liquid. When the current passed from the top to the bottom, the rotation was clockwise. Reversing the current reversed the rotation. With 5 amperes of current, the magnets made about two complete revolutions a minute. This result is demanded by the distribution of the field intensity in the interior of a conductor. For, call m and $-m$ the pole strengths of one of the magnets, T_1 the intensity of the field where m is located at the distance r_1 from the axis and T_2 the intensity of the field where $-m$ is located at the distance r_2 from the axis. Then the couple acting to turn one of the magnets in a horizontal plane about the axis of the conductor is

$$P = mr_1T_1 - mr_2T_2.$$

We have found $T_1 = 2Ir_1/R^2$ and $T_2 = 2Ir_2/R^2$, R being the radius of the conductor. Hence, $P = 2Im\frac{r_1^2 - r_2^2}{R^2}$, is the couple acting upon one magnet, while twice this couple acts to turn the two magnets, if these are alike and similarly located in respect to the axis.

Physical View of the Pressure in the Interior of a Conductor.—Let Fig. 3 be a cross-sectional view of the liquid column of Fig. 2. Let f represent the section of a small wire, which extends throughout the length of the liquid column and parallel to its axis.

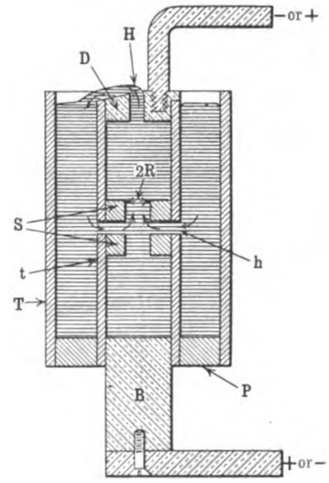

Fig. 4.

If the liquid column has a radius R and carries a current I, the wire, if located at a distance r from the axis of the liquid conductor, will be in a field of magnetic force of intensity $T_r = 2Ir/R^2$.

If current is passing in the same direction through the liquid conductor and the wire f, the wire will experience a force which will tend to move it across the circular lines of force in a direction to bring it toward and parallel to the axis of the liquid conductor. If the wire is free to move and the current-density in it is greater than the current-density in the liquid conductor, it will so move until it coincides with the axis of the liquid column.

This was proved experimentally as follows: In the apparatus shown in Fig. 2 a fine manganin wire of high resistance was placed in the liquid column. One end of the wire was fastened to the upper copper disc near its circumference and the other end to the corresponding point of the lower copper disc. The wire was slightly longer than the distance between the discs, and hence hung loose between them. It was arranged to have it hang near the circumference of the liquid column. When current passed through the liquid column a current in the same direction and of greater current density also passed through the wire. On making the circuit the loose wire was instantly urged from the circumference, and formed a bow which bent toward the axis of the liquid column.

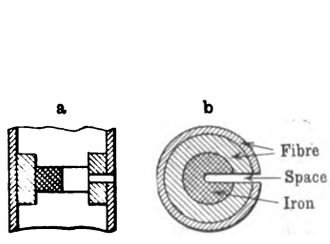

Fig. 5.

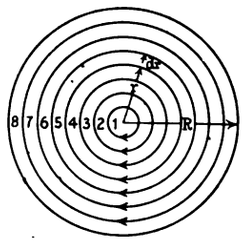

Fig. 6.

In place now of an actual wire in the inside of the liquid column we may picture this liquid column as being made up of a great many filaments parallel to the column. Each filament will be a conductor which carries a current proportional to the total current and to its own cross-section. All the imaginary conducting filaments, except the one coinciding with the axis, will be in a field of magnetic force, the intensity of the field in which any filament lies being proportional to its distance from the axis. All the filaments, except the one on the axis, will experience a force which, if free to act, will urge them toward the axis of the conducting liquid column.

From this conception, it is evident that, if the conducting liquid column have elastic walls, it will contract so as to diminish in cross-

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section and in consequence increase in length. If the column cannot increase in length, it will tend to contract. In other words, there will be a pressure at the centre greater than the pressure near the surface. This pressure is hydrostatic. Its existence and magnitude are shown by the following experiment :—

Experiment to Show Pressure in the Interior of a Conductor.—An apparatus was constructed which is shown in section in Fig. 4. T is the tube of fibre, and t another tube of fibre having an internal diameter of 2·54 cm; B and D are brass plugs tightly fitted in the ends of the inside tube. Heavy copper terminals enable these plugs to be joined to a battery of large current capacity. At the centre of the tube, t, was placed a fibre ring to reduce the cross-section of the tube at one place. The hole in the fibre ring had a diameter 2R or a radius of 0·635 cm.

Through the sides of the tube and fibre ring several small holes, h, were drilled radially to the axis. The bottom of the annular space between the tubes T and t was closed by a fibre piece P. The two tubes were then filled with mercury to the level shown in the cut. According to the conception given above, when current is passing through the mercury column in the tube, t, a hydrostatic pressure should exist in it, which is greatest along its axis. Hence, as the mobile conductor has no other escape than the hole, H, provided in the plug, D, it should rise in this hole from the pressure at the axis, more being at the same time drawn in at the holes, h. Sufficient pressure should raise the mercury in the hole H until it overflows the upper surface of the plug D, and falls back into the well from whence it came. Thus, a continuous stream of mercury should flow by the path, through the holes h, up the tube t and the hole H, into the well and thence again to the holes h.

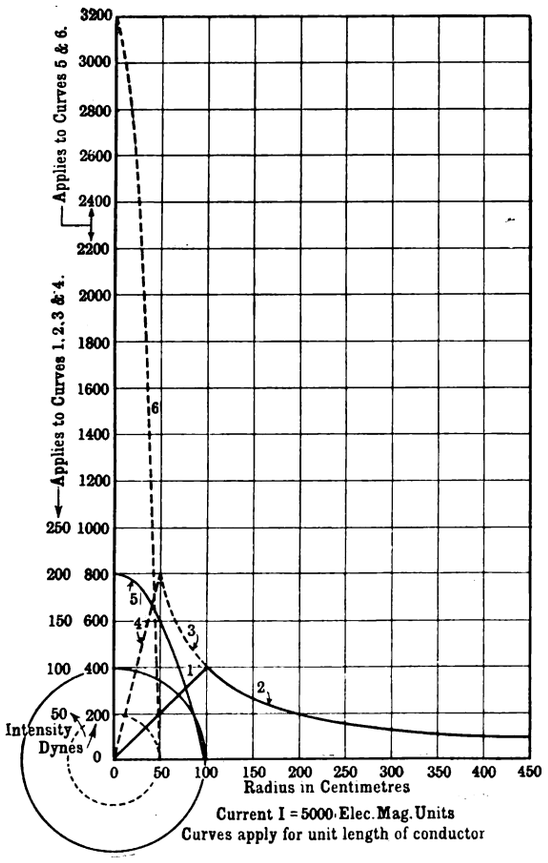
Applies to Curves 5 & 6.
Applies to Curves 1, 2, 3 & 4.
Intensity, Dynes
Radius in Centimetres
Current I = 5000 Elec. Mag. Units
Curves apply for unit length of conductor

FIG. 7.

In trying this experiment, these results were amply realised. With about 1,800 amperes, the mercury flowed in a continuous and rapid stream, as described.

To test the magnitude of the pressure, a glass tube was tightly fitted in the hole H, and the mercury column was found to stand, with 1,800 amperes, $\frac{5}{10}$ in. in the tube above the general level of the mercury in the well.

So large a current soon heated the mercury and it was not found practicable to keep it on more than a minute or two at a time. It is scarcely necessary to remark that the flow and the rise of the mercury is independent of the direction of the current.

It was thought that iron might be used to increase the induction and so get the mercury to flow continuously with less current. The previous experiment was modified as follows.

A disc of soft iron was inserted in the narrow portion of the tube t in the manner shown in Fig. 5, a being a vertical section and b a horizontal section of the middle portion of the tube t and its fittings. A slot was cut in the iron disc parallel to its axis. This slot was 1·6 mm. wide and extended in radially to the centre of the disc. The iron disc was located in the narrow portion of the tube t so that the end of the slot registered with one of the holes, h, Fig. 4. It is evident that the intensity of the magnetic field in the space of this narrow slot should be greatly increased by the presence of the iron, also that the conducting mercury filaments in the slot should be urged with increased force toward the axis with a resulting greater hydrostatic pressure at the axis.

In trying the experiment, it was found that the force previously obtained was about doubled and that with 1,800 amperes the mercury would rise in the glass tube about 1¼ in. With 900 amperes and with the tube removed, the mercury would flow continuously, the heating being now reduced so that the current could be kept on for many minutes.

Law of the Pressure in the Interior of a Conductor.—This can be found by considering any of the cylindrical shells represented in Fig. 6. Taking first any of the annular spaces, its area is $2\pi r dr$, and assuming uniform current density, the current it carries is $di = 2Ir dr/R^2$ This current is in a field T_r such that $T_r = 2Ir/R^2$. Thus, calling dF the force with which the element carrying the current di, and of length l, tends to move radially toward the axis, we have

$$dF = l di T_r = 4I^2 l r^2 dr/R^4.$$

It should be noted that the force dF is distributed so as to act normally on a surface the area of which is $2\pi rl$. Hence, calling dg the force per unit of area, or the force intensity acting radially inward, we have

$$dF/2\pi rl = dg = 2I^2 r dr/\pi R^4.$$

This is the intensity of the pressure at distance r from the axis,

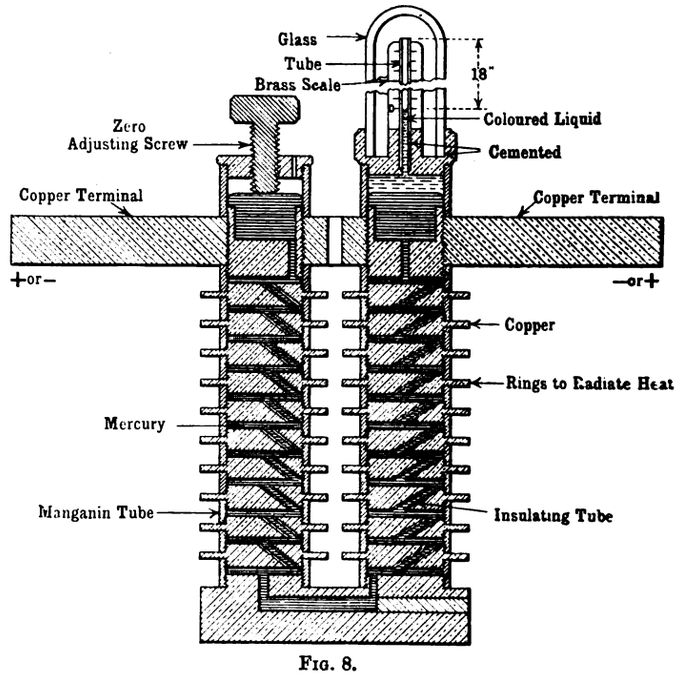

FIG. 8.

due to the current in a single annular space of radial depth, dr. It is necessary in order to obtain the total intensity g at the distance r from the axis to take the sum of the force intensities, or

$$g = \frac{2I^2}{\pi R^4}\int_r^R r dr = \frac{I^2}{\pi R^4}(R^2 - r^2). \quad . \quad . \quad . \quad . \quad (2)$$

If I_1 is the current per unit of cross-section, or the current density in the conductor, $I^2 = I_1^2 \pi^2 R^4$, and we obtain as another expression for the pressure

$$g = \pi I_1^2 (R^2 - r^2). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The pressure at the centre, where $r = 0$, is, therefore, equal to the area of the cross-section of the conductor multiplied by the square of the current density.

Gravitational Analogy.—It is interesting to compare the forces produced by an electric current in a conductor of circular cross-section with the forces produced by gravity in the interior of an infinitely long cylinder of the same radius and section as the electric conductor. By so doing the author shows that the hydrostatic pressure in the interior of a conductor at any distance r from the axis when carrying I electromagnetic units of current is $1{\cdot}513 \times 10^{-}$ times the pressure in this conductor, having G grammes of matter per unit length, due to gravitational attraction alone. It also appears that the attraction due to the electric current, which would

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act on a unit length of a unit current, is of the same nature and in the same direction as the gravitational attraction which would act on a gramme of a matter, but 3,928 times as great, the number of units of current per unit of cross-section of the conductor being equal to the number of grammes of matter per unit of cross-section in a unit of length of the cylinder.

Graphs.—The leading features respecting the forces discussed above are summarised in the curves shown in Fig. 7. The curves in full line apply to the cylindrical conductor which is shown in cross-section in full line. The curves in broken line and the curve 2 apply to the conductor shown in broken line, having one-half the diameter of the first conductor. In both cases the larger and smaller conductor are supposed to carry the same current. Curve 1 gives the intensity of the field in the interior of the conductor, curve 2 the intensity of the field exterior to the conductor. Curve 5 expresses the pressure in dynes per square centimetre. This pressure is a maximum at the centre and zero at the circumference. At one-quarter of the distance from the centre to the circumference the pressure has diminished but 6¼ per cent., a fact having importance in certain practical constructions.

When the conductor is diminished in diameter to one-half, its area is one-fourth and the current density is increased four times,

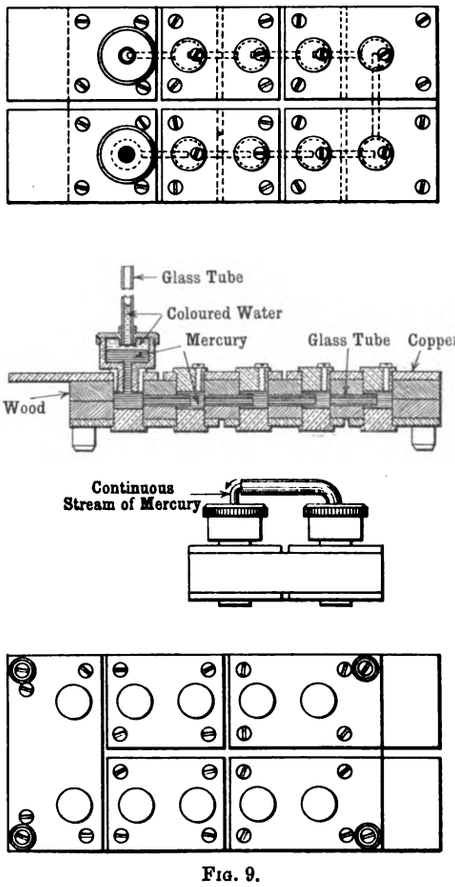

FIG. 9.

hence it follows from equation 3 that the pressure at the centre is increased four times. This is shown by curve 6. The intensity of the field in the inside of the conductor is doubled, curve 4. On the outside of the conductor the intensity of the field is not altered beyond the radius of the larger conductor, curve 2; but in the space outside the smaller and inside the larger there is a field the intensity of which is given by curve 3.

From what has been given, the following deductions are easily made.

Suppose a conductor to have originally a radius R. Imagine the conductor to contract in cross-section until its radius becomes aR, a being a number less than unity. Further, assume the conductor to always carry the same total current I and to preserve a circular cross-section. Let a portion of the length of the conductor be called l. Then the total number of lines of force in the interior of a length l, of the conductor is given by the expression

$$N = \frac{2Il}{(aR)^2}\int_0^{aR} r\,dr = lI. \quad . \quad . \quad . \quad . \quad (4)$$

Hence, we conclude that however the conductor may change in diameter, the total number of lines of force in its interior remains the same, provided the current is always the same, and that per unit length of the conductor the total number of lines of force in the conductor is numerically equal to the current in electromagnetic measure.

An inspection of curves 2 and 3 shows that when the conductor contracts from a radius R to a radius aR, the current remaining the same, lines of force are developed. These all lie in the medium around the conductor and their number per length l of the conductor is given by the expression

$$N_0 = 2Il\int_{aR}^{R}\frac{dr}{r} = 2Il\log_e\frac{1}{a}. \quad . \quad . \quad . \quad . \quad (5)$$

From this, it follows that the total number of lines exterior to the conductor is increased when the conductor diminishes in diameter, and as the number inside the conductor remains the same we conclude that the coefficient of self-induction of a small wire is greater than that of a large wire.

It may be further concluded that, if the current be maintained constant, when the conductor diminishes in diameter, electromagnetic energy is stored up in the medium around the conductor.

It may be shown that the electromagnetic energy in the interior of a length, l, of the conductor is given by the expression

$$E = \frac{lI^2}{R^4}\int_0^R r^3 dr = \frac{lI^2}{4}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Thus the energy stored in the conductor, as well as the number of lines of force, is independent of the diameter of the conductor. When the conductor contracts from radius R to radius aR, the energy added to the medium is stored in the space occupied by the conductor previous to its contraction less the space occupied by the conductor after its contraction. The energy so added per length l of the conductor is given by the expression

$$E_0 = I^2 l\int_{aR}^{R}\frac{dr}{r} = lI^2\log_e\frac{1}{a}. \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The above expressions (4), (5), (6) and (7) are given without proof, for they may be readily obtained from the facts stated above, and the energy relations given by Maxwell.

Adding Pressures in Series.—The writer soon perceived that to obtain forces of sufficient magnitude to be useful in practical applications means should be devised whereby the internal pressure at one point in a conductor might be added to that in another point and so on. This result may be obtained as follows: A cylindrical conductor is constructed, which consists of alternate strata of solid and liquid, as copper and mercury. This heterogeneous conductor is tightly encased in a tube of insulating or high-resistance material. In each of the solid portions of the conductor small tubes of insulating material are placed in a manner to connect the axis of one liquid layer with the circumference of the next liquid layer. This forms a continuous passage, which goes in steps from the axis to the circumference of each liquid portion. A tube from one end of this conductor connects with a reservoir of the liquid, and another tube of glass is raised from the other end of the conductor which connects with the end liquid layer, and in which the liquid may rise. Heavy copper terminals lead the current, which may be direct or alternating, in, and out of, the compound conductor. When the electric current flows, the pressures produced at the axes of the liquid portions of the conductor add in series and the liquid may be thus raised to useful heights in the glass tube. Fig. 8 shows in section such a contrivance which it is evident might serve as a direct or alternating-current ammeter of large capacity. A construction similar to that described was made and operated, and is a useful alternating-current ammeter.

Fig. 9 shows another embodiment of the same principle. This apparatus was constructed, and the calculated height of about 22 cm. to which the coloured water would rise in the tube with 600 amperes was practically attained.

It should be noted that the hydrostatic pressure obtained is independent of the axial length of the liquid strata, while the heat developed by the current is directly as this length. With this consideration in mind, the axial lengths of the liquid portions of the apparatus shown in Fig. 9 were afterwards reduced to 1·6 mm. each. The pressure was not lessened and the efficiency or cool running was greatly improved. The theoretical pressure or height of mercury that may be obtained in any particular case may be deduced easily from the curves (Fig. 7), or calculated from the expression

$$g_s = n\mathrm{A}I_1^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

which is derived from equation (3), when $r=0$, $\pi R^2 = A$, the cross-section I_1 = the current density, and n = the number of times the pressures at the axis are added in series.

If C is the current-density per square centimetre expressed in amperes and g_p is the pressure in pounds per square centimetre, and A is the cross-section in square centimetres the expression (8) takes the form

$$g_p = n\mathrm{A}C^2/44{,}479{,}100. \quad . \quad . \quad . \quad . \quad (9)$$

In the apparatus shown in Fig. 9, $n=10$, $A=1{\cdot}2$, $C^2=250{,}000$, which corresponds to nearly 600 amperes in the conductor. Whence

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we get $g_p = 0{\cdot}067$ lb. per square centimetre or 0·432 lb. per square inch. This pressure should give a rise of 0·88 in. of mercury or about 11·9 in. of water. The rise obtained with 600 amperes in the apparatus of Fig. 9 was about 9 in., but this lessened height is due to the fact that the mercury itself had to raise some to produce the rise in the water. The point to note, however, is that with 600 amperes, the apparatus runs cool. Hence we can conclude that with a heterogeneous conductor of $\frac{1}{2}$ in. diameter and made up of 1,000 cells, or mercury sections of, say, 1 mm. length each, we could obtain with 800 amperes the large pressure of 43·2 lb. per square inch, and this without iron in the circuit. This pressure would sustain a column of mercury over 7 ft. high.

Some Final Remarks.—One is naturally led to inquire if the recognition of this force that exists in the interior of electric conductors and the establishment of its laws of action is likely to result in new and useful applications. It is quite certain that this force, which depends only on the square of the current and linear dimensions, may be used as an accurate measure of the current, either direct or alternating. As the forces can be enhanced by a proper disposition of iron in the heterogeneous circuit, motors without brushes or slip rings may be made operative And remembering that power is the product of current and E.M.F., it is not impossible, even if large operative currents are required, that fair efficiencies may be obtained.

Further thought along an engineering line may bring about developments of a unique and useful character.

THE SUBSTITUTION OF THE ELECTRIC MOTOR FOR THE STEAM LOCOMOTIVE.

In our issues of March 1 and 8, 1907, we gave an abstract of a Paper on the above subject, by Messrs. Stillwell and Putnam, which was read at a meeting of the American Institute of Electrical Engineers. We give below the appendix which was added to that Paper, and also an abstract of certain parts of the discussion which subsequently took place :—

APPENDIX.

Power-House Output and Load Factor.—The report of the Interstate Commerce Commission gives the total revenue traffic for the entire United States for the year ending June 30, 1905, as 1,038,441,430 train-miles, of which 459,827,029 is passenger train mileage, 546,424,405 freight train mileage, and the unclassified balance, 32,189,996, we have assumed to be mail and express train mileage. Including the mail and express trains with the passenger train service, there is an average of 6·2 passenger and 6·9 freight trains per mile of line per day, or approximately seven trains each way per day. Using average weights of equipments, as stated in our Paper, and average hauls of goods and passengers, and making allowances for switching, &c., the traffic amounts to 3,000,000 ton-miles per mile of line per annum, of which 600,000 ton-miles are in passenger service and 2,400,000 ton-miles in freight service. In electric operation these figures will be reduced by the weight of engine tenders and a part of the weights on pony trucks.

To supply electric power for the operation of the steam roads, we have assumed that power houses would be located at average intervals of 300 miles. This requires a transmission of 150 miles, and for this purpose we have employed in our calculations 60,000 volts. As stated in our Paper, both the distance of transmission and the voltage employed are within current practice in plants now in commercial operation in this country, under conditions and for purposes identical with those contemplated in our Paper.

In our calculations we have assumed that passenger trains are geared for a maximum speed of 50 miles per hour and freight trains 25 miles per hour, on a tangent and level track. We have assumed that the average run of passenger trains is 10 miles and freight trains 15 miles between stops. With the gear ratios used this gives an average speed of 40·5 and 23 miles per hour respectively. At these speeds the average load on each power station supplying 300 miles of line is 1·98 passenger trains and 3·84 freight trains, an average of 5·82 trains of both kinds. With equal intervals between passenger and freight trains respectively, the average load on the power house is 2,100 kw., the load-factor is 0·97 and the maximum momentary peak is estimated to be 3,000 kw. This method of operation is shown in Fig. 1.

The schedule speeds above mentioned include momentary stops only. As trains are now operated, the average passenger train, owing to stops and delays of various kinds, does not average more than 30 miles an hour, and through and local freight trains probably do not average more than 12 miles an hour. In Fig. 2 we have illustrated the result at the power house if trains are operated at these modified average speeds. The average load remains practically the same as before, while the load-factor is reduced to 0·82 and the estimated maximum momentary peak is increased to 4,700 kw. Our estimate of the total power-house capacity for all the railroads of the United States is 2,100,000 kw., which is approximately 3,000 kw. for each 300-mile section. This is nearly 50 per cent. in excess of the average load. The generators proposed for this power-house equipment have a momentary overload output of 100 per cent. and can carry an overload of 50 per cent.

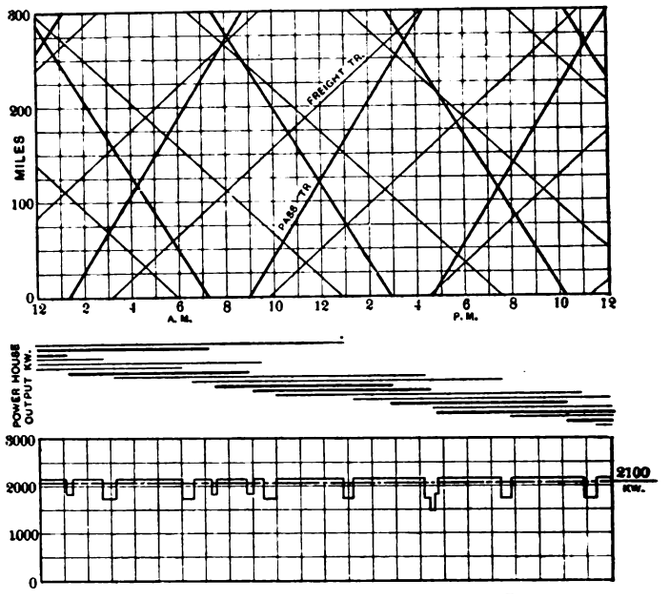

FIG. 1.—POWER-HOUSE LOAD, MAXIMUM AVERAGE SPEEDS.

Passenger trains, 226 tons, 40·5 miles per hour 273 kw. Freight trains, 937 tons, 23·0 miles per hour 351 kw. Transmission efficiency 90 per cent. Average trains on section 5·8. Average power-house load 2,100 kw. Load-factor 0·968 Estimated momentary peak 2,970 kw. 85 per cent. efficiency.

for several hours. It is evident, therefore, that the average power plant provided, after deducting 20 per cent. for reserve, is ample to take care of ordinary variations in traffic.

It is manifestly impossible for railroads to operate their passenger and freight trains on equal headway. Some roads as a matter of convenience despatch freight trains "in fleets," and cattle and some produce trains must arrive at their destinations at fixed times of the day. This method of operation is desirable and practicable in steam operation and obviously is objectionable

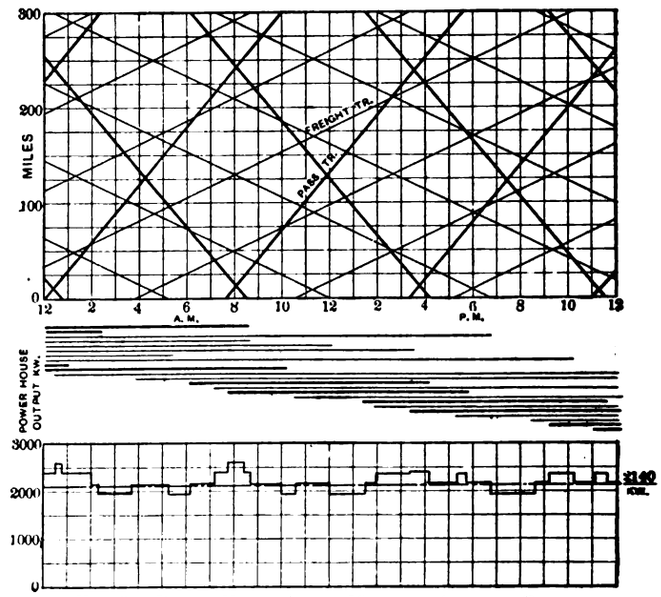

FIG. 2.—POWER-HOUSE LOAD, MINIMUM AVERAGE SPEEDS.

Passenger trains, 226 tons, 30 miles per hour 210 kw. Freight trains, 937 tons, 12 miles per hour 187 kw. Transmission efficiency, 90 per cent. Average trains on section 10·0. Average power-house load 2,140 kw. Load-factor 0·823. Estimated momentary peak 4·720 kw. 85 per cent. efficiency.

in electric operation, as power-house capacity must be provided for the maximum number of trains on the division. On the other hand, on those roads where traffic is most congested the track facilities can best be utilised by equal spacing of trains. When this question becomes important, therefore, the natural tendency is towards an approximately equal distribution. As the generators

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included in our estimates have a continuous overload capacity of 25 per cent., 50 per cent. for several hours and 100 per cent. momentarily, and as we have provided an excess of nearly 50 per cent. over average demands, the power-house capacity provided appears ample for any reasonable variation in the method of operating trains. In this connection we wish to call attention to the fact that under average conditions freight trains require 25 hours to traverse the length of line supplied from a single power house; hence, if trains are despatched in "fleets," a second fleet will begin to draw upon the power house as the first fleet passes off, the power-house load remaining practically constant.

Resistance Due to Grades.—In many cases we have found, so far as power-house requirements are concerned, that the additional resistance, due to grades and curves, can be practically neglected in the electric operation of trains. Unlike the steam locomotive, the electric motor, under certain conditions, operates at higher efficiency on grades and curves than when running free on a straight and level track. This is due to the fact that the motor and gear ratio are properly selected to obtain the highest average efficiency in operation. The effect of this selection throws the load in continuous operation on level track below the point of maximum efficiency. In ascending a grade the speed is reduced, and within reasonable limits this reduction implies an increase in motor efficiency. Again, the reduction in speed due to grade, results in a reduction in rolling friction and train resistance. These gains are not offset in descending grades unless, in addition to gravity, power be used to attain a speed exceeding the maximum limit which we have assumed—namely, 50 miles an hour in passenger service and 25 miles an hour in freight service. Theoretically, as long as the grade does not introduce a

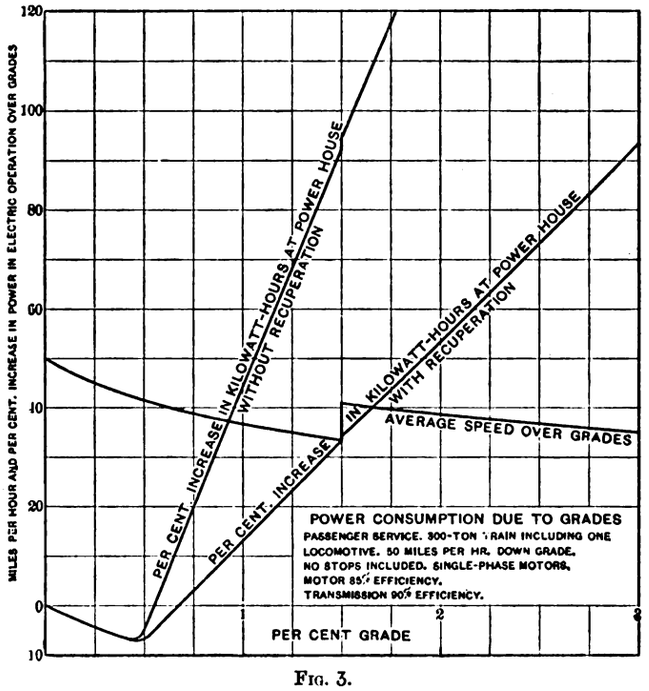
MILES PER HOUR AND PER CENT. INCREASE IN POWER IN ELECTRIC OPERATION OVER GRADES
120
100
80
60
40
20
0
10
PER CENT. INCREASE IN KILOWATT-HOURS AT POWER HOUSE WITHOUT RECUPERATION
PER CENT. INCREASE IN KILOWATT-HOURS AT POWER HOUSE WITH RECUPERATION
AVERAGE SPEED OVER GRADES
POWER CONSUMPTION DUE TO GRADES
PASSENGER SERVICE. 300-TON TRAIN INCLUDING ONE LOCOMOTIVE. 50 MILES PER HR. DOWN GRADE. NO STOPS INCLUDED. SINGLE-PHASE MOTORS. MOTOR 85% EFFICIENCY. TRANSMISSION 90% EFFICIENCY.
1
2
3
PER CENT GRADE

FIG. 3.

resistance in excess of that of the train friction independent of the grade, the energy expended in lifting the train will be recovered in overcoming train friction in going down grade. If the ascending and descending speeds are equal, the energy consumption will be the same per ton-mile as on a straight and level track of the same length. If the ascending speed is reduced, as it is in the case of the series motor, the total watt-hour consumption will also be reduced. In Figs. 3 and 4 we have plotted the effect of grades upon power consumption in both passenger and freight service. In order to keep this discussion distinct from the question of motor and transmission efficiencies, we have assumed a motor efficiency of 85 per cent. in all cases and 90 per cent. transmission efficiency. All power calculations are carried back to the power house, and that portion of the recuperated energy which cannot be utilised by the train auxiliaries has been returned to the power house at 90 per cent. efficiency. Extra electric locomotives are added as needed With the train weights employed, it will be noted from an inspection of these curves that the power consumption over grades is less than it is over straight and level track in passenger service for all grades less than 0·55 per cent., and in freight service less than 0·35 per cent. Comparatively few lines are absolutely level, but, on the other hand, the aggregate mileage on grades exceeding 0·5 per cent. is relatively small. It is believed, therefore, that the general result as to power consumption will be very close to that required over straight and level track. Nevertheless, as stated in our Paper, we have added to our calculations of energy required 10 per cent. in the case of passenger service and 15 per cent. in case of freight service, to cover contingencies, including switching, "double headers," and the additional resistance due to grades and curves.

In some recent calculations, in which we went into the subject in great detail, the foregoing conclusions were corroborated. In one case, in express service, the detailed calculations of runs over the road showed a consumption of power of 53 watt-hours per ton-mile, while 52·8 watt-hours per ton-mile was obtained by using an average run on a straight and level track. In the local service over the same line the figures were 84·2 watt-hours in the detailed calculations and 86 watt-hours for an average run on a straight and level track. These results were obtained from calculations relative to the electrification of the suburban portion of a steam railroad over 30 miles in length, a large percentage of its tracks being on grades and curves. There were maximum grades of 1·47, 1·55 and 2·32 per cent. and curves of 6° 22′ and 8° 30′. Numerous other calculations and road tests have verified these results.

Recuperation.—In making our calculations as to power consumption, we have made no deduction for the electrical return of power to the line. In the case of the higher grades this becomes a matter of importance, as shown by Figs. 3 and 4. Where the force of gravity due to grade exceeds the amount that can be utilised

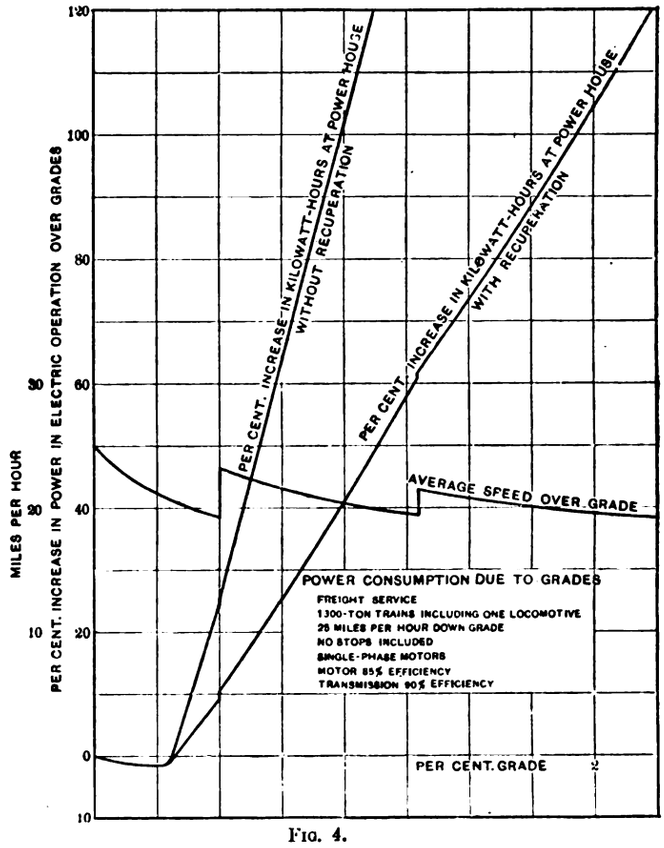

FIG. 4.

mechanically in overcoming train friction, recuperation reduces the increase in power consumption due to the grade by approximately 60 per cent. over a grade of 1·5 per cent., so that even in freight service over mountain grades the power required will not exceed that consumed on a level track by more than from 40 to 60 per cent. With recuperation the power consumption, or what is its equivalent, the coal consumption, is not doubled until we reach grades of over 3 per cent. in passenger service and 2 per cent. in freight service. These grades are considerably in excess of any used on our trunk-line railroads. The ability to recuperate energy is important on lines that have heavy grades. In addition to the saving in power the saving in wear and tear from mechanical braking is of as great, and perhaps even greater, importance. The energy represented by the difference between the curves shown on Figs. 3 and 4, representing the power required at the power house with and without recuperation, increased by the energy losses absorbed by the motor and transmission lines, must be absorbed by the brake shoes and wheels when mechanical braking is used.

DISCUSSION.

Mr. B. G. LAMME said that the strongest reason which could be given for the lower frequency was the greater output that could be got from a given motor. For instance, with a first-class motor, built for 25 cycles, the operation might be above question, and the machine might be considered perfect in every way; but take that same machine and operate it on

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15 cycles, and the induction could be raised from 25 to 40 per cent., which meant that 25 to 40 per cent. higher voltage could be applied with the same motor speed, and 25 to 40 per cent. greater output was obtained from the same motor, or 25 to 40 per cent. greater tractive effort could be developed. That in itself was a controlling feature in the question. They had verified it by actual test. For instance, they had taken a 100 H.P. 25 cycle motor, and obtained from it 125 H.P. at 15 cycles. This motor had good efficiency, good power factor, and good commutation on both frequencies at the above ratings. It was therefore not a question whether the 25 cycle motor would work, for it would work successfully, but it was a question how much more could be got out of it by going to the lower frequency. It might be questioned that if 15 cycles was better than 25 cycles, why was not a still lower frequency recommended? The answer was that at 15 cycles the machine was practically saturated, which fixed the output. At still lower frequency there would be a gain in efficiency and power factor, but not much in output; and there would be loss in other things, such as the speed of turbo-generators and weight of transformers. So there was some point at which a compromise could be made; and it was his opinion, and had been for a long time, that this compromise was considerably below 25 cycles and should be about 15 cycles. In discussing this question of 15 cycles they were asked—Where was it in use? He would call attention to the fact that quite a number of European companies had adopted 15 cycles for railway work. The Valtellina plant, put in by the Ganz Company, with three-phase motors, used 15 cycles; and he felt safe in saying that a great deal of the success and good operation of that plant was due to the choice of this frequency. The Oerlikon Company of Switzerland had gone into the single-phase work extensively, with 15 cycles as a standard. The Siemens-Schuckert Company, of Germany, was also manufacturing series railway motors for 15 cycles. The Allgemeine Company, of Berlin, was the principal company which was adhering to 25 cycles, and that was largely due to their type of motor. They had a so-called "series repulsion" motor, in which the characteristics of the motor apparently showed to better advantage if the frequency was not too low. It was not directly due to the high frequency that they got better results, but to the fact that the motor should preferably run below the nominal synchronous speed, and this condition was obtained to better advantage by keeping up the frequency.

Mr. W. B. POTTER declared that, compared with a direct-current motor, a 25 cycle motor of corresponding service capacity would weigh approximately 25 per cent. more; while at 15 cycles, the single-phase motor would weigh probably not more than 10 per cent in excess of the direct-current motor. The efficiency and power factor of the single-phase motor on either 25 or 15 cycles would be approximately the same. While the motors and the reactance of line and track were benefited by a lower frequency, there was the increased cost of the generators and transformers to be taken into account. Messrs. Stillwell and Lamme had both spoken of the effect of a lower frequency upon the maximum available tractive effort. They would appreciate that, owing to the characteristics of an alternating current, the average tractive effort of the single-phase motor was approximately 50 per cent. of the maximum at the top of the current wave, and with a motor rigidly mounted the wheels would begin to slip at about one-half the tractive effort which would be given by a direct-current motor under the same conditions of track and weight on drivers. With the motor mounted on springs in the usual manner, there was introduced some degree of flexibility, and the impulse due to the top of the wave was absorbed by the springs so that the average torque was considerably higher than the theoretical 50 per cent. Under similar conditions of track with equal weight on drivers and the same method of mounting, tests had been made which indicated that, in comparison with the same motor on direct current, the maximum available tractive effort at 25 cycles was from 80 to 90 per cent., and on 15 cycles from 70 to 80 per cent. The maximum available tractive effort was not generally important, except in locomotive operation, where the maximum draw-bar pull was, in a sense, the measure of the locomotive's value for starting a train, and during acceleration. On motor cars there was usually an excess of weight on the drivers over that required for acceleration, so that the maximum tractive effort was a matter of less importance. It was, incidentally, an interesting fact that after the wheels had commenced slipping the direct-current motor showed a much greater reduction in tractive effort than the single-phase motor. The torque being maintained uniformly with a direct-current motor, the wheels rotated rapidly, reducing the coefficient of friction with the rail to something like 20 or 30 per cent. of the maximum adhesion. With the alternating-current motor, both on 25 and 15 cycles, although the initial slip was at a lower maximum, the draw-bar pull was only reduced to 80 or 90 per cent. of the maximum adhesion. This appeared to be due to the fluctuating character of the torque, which at its minimum allowed the wheel to secure a slight grip on the rail after the wheel began to slip. When the wheel was slipping its rotation was not uniform, but fluctuated, corresponding with the frequency. While of interest, this higher tractive effort, after the wheels commenced to slip, was of little practical value. Mr. Sprague had referred to higher voltage direct-current motors. With respect to motors suitable for operation on higher voltage direct current and also on 600 volts, he (the speaker) would mention the marked improvement in the motor that had been obtained by the addition of a commutating pole. As an illustration, a motor having commutating poles and designed for operation on 600 volts could be run at full load on 1,000 volts so far as commutation was concerned, and, further, such a motor, when the current was momentarily interrupted or there was a momentary rise in voltage, would not flash over, as sometimes happened with motors not having commutating poles. A commutating-pole motor designed for 1,200 volts, and operated at that potential, would be superior to the ordinary 600 volt motor, both with respect to commutation and liability to flash over. He felt that the addition of the commutating pole to the direct-current railway motor, in its effect on commutation, was comparable to the improvement made by the substitution of the carbon brush in place of the copper brush. The carbon brush reduced the sparking and flashing to a permissible degree, and the commutating pole by neutralising the cause had finally eliminated defective commutation.

Mr. C. L. DE MURALT thought that the greater advantage of the electric locomotive lay in the fact that it could utilise its weight very much better than could the steam locomotive; and if the actual values of tractive effort taken from the curves were compared with the weights of the corresponding locomotives it would be found that the direct-current and the single-phase alternating-current locomotives were capable at low speeds of exerting a very much greater tractive effort proportional to their weight than could the steam locomotives, and even at high speeds their proportional performance was better than that of the steam locomotive. An additional, and perhaps even more important, advantage of these electric locomotives over their steam competitors lay in the fact that the electric locomotive could readily respond to almost any kind of overload demand. As a matter of fact, a prolonged grade for instance, might seriously decrease the usefulness of a given steam locomotive, due to the impossibility of forcing the latter's boiler for any considerable length of time above rated capacity, while the electric locomotive would slow down, of course, but would, with the assistance of the power house, carry great overloads for any reasonable length of time. The three-phase alternating-current locomotive not only accommodated itself to such increased demands on its hauling power, but it did so without any great drop in speed, and automatically adjusted its power to the demand. If at 1,500 H.P. normal output the motors of a given three-phase locomotive had a 2 per cent. slip, then at five times the normal tractive effort the slip would be approximately 10 per cent., and the speed would drop from 68·5 to 63 miles per hour. Three-phase induction motors of this size (750 H.P.) could be built with a maximum torque of six to seven times full-load torque with very good electric qualities. And, notwithstanding the objection sometimes urged that the design must be very liberal for such service, it remained a fact that the three-phase motor could do what the others could not do, and its intrinsic lighter weight per horse-power, its higher efficiency, its more economical distributed winding and the absence of the commutator kept down the cost of the three-phase locomotive within the limits governed by competition.

Mr. N. W. STORER remarked that the single-phase locomotive seemed to offer the greatest possibilities. With it they could not only operate up to what might be called the normal speed of a locomotive, but far beyond that. High speeds became simply a question of applying higher voltages from the transformer to the terminals of the motor. The same locomotive could be operated just as well at 10, 15, 20 or 25 per cent. above what might be called its normal voltage as the direct-current locomotive could be operated at its normal voltage. The question of commutation in the single-phase motor was not so much one of voltage as one of induction in the field, one of current which the motor was carrying, or, in other words, of the tractive effort which it was exerting. Every time a single-phase motor was designed for heavy work, the question of frequency arose, and it always worked out much better for 15 cycles, for this reason: at least 30 per cent. greater output could be got from motors at 15 cycles than from motors of the same size operated at 25 cycles. That meant that at the limit there must be 30 per cent. more motors if the motor was to operate on 25 cycles than would be needed on 15 cycles. That not only increased the cost of motors very much, but increased the cost of all mechanical parts; the motor trucks must be heavier than trail trucks—the entire equipment must necessarily be heavier. The question of efficiency alone was bound to influence the matter very largely. The 15 cycle motor approached closely the efficiency reached by the direct-current motor, and there was so little difference that it could hardly be detected. In power factor it came very close to the direct-current motor. It was above 90 per cent. throughout the entire range of loads in most sizes—it was practically unity. The saving in cost of locomotives which might be effected by using 15 cycles instead of 25 cycles was mentioned in the Paper, and he was bound to say that the difference which was shown was entirely inadequate to cover what in their opinion it would be. He should say that the difference would be at least £1,000, rather than £200. That made a difference which seemed to him to be overwhelmingly in favour of the 15 cycles; it was due largely to the number of motors. In regard to the lighting of the cars, he believed that satisfactory lighting could be obtained with 15 cycles, by using a low-voltage lamp having a heavy filament. A lamp designed to operate on a 15 cycle circuit would give just as good light and as perfect illumination as the ordinary incandescent lamp on a 25 cycle circuit. It would be entirely satisfactory for the lighting of cars. The many other questions which came up in connection with railway installations would, of course, influence the choice of frequency very largely, but as he had said in the beginning, it was simply a matter of dollars and cents that would determine whether 15 or 25 cycles was going to be adopted for railway work.

Mr. W. J. SLICHTER, considering an inter-urban road in which the amount of motive power was small compared with that considered for a large steam road as discussed by Messrs. Stillwell and Putnam, said that the relative costs of the various parts of an installation were fairly represented as follows:—

	25 cycles.	15 cycles.
Generating station	34·4 per cent.	38·0 per cent.
Sub-stations	1·8 ,,	2·1 ,,
Low-tension construction	14·8 ,,	14·8 ,,
Low-tension copper	12·0 ,,	11·0 ,,
High-tension line	5·4 ,,	5·4 ,,
Bonding	7·0 ,,	7·0 ,,
Equipments and cars	24·6 ,,	23·0 ,,
	100·0	101·3

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For this inter-urban road, then, a 15 cycle installation would be more expensive. But turning to a road which approximated steam railroad conditions, the cost of the equipment formed a much larger proportion of the total cost, while the increase in the cost of the power station was not so great on account of the larger size of the units. This transferred the balance to the other side, and the figures were similar to those given in the Paper. This showed that as they approached heavy railroad work the greater would be the need for the lower frequency.

Mr. L. B. STILLWELL, in reply, said that it was evident that the great majority of engineers present would admit that the question of frequency was settled decisively by the testimony they had had in favour of 15 cycles. The testimony of Mr. Lamme, the inventor of the single-phase motor, of Mr. Storer, of Mr. Slichter and other men who had been active in their development and practical application, to his mind, was conclusive as regarded the performance of the motor, and they had testified that the difference in favour of 15 cycles, as measured at the draw-bar, was approximately one-third. When this fact was taken into consideration, in view of the general perspective of the problem, which they had endeavoured to establish by considering the electrification of their railroads as a whole, it seemed to him there was only one conclusion to draw. In their estimates they had calculated that the expenditure for electrical equipment of rolling stock, if the 25-cycle system were used, would approximate £90,000,000. Mr. Storer had stated that the difference in favour of 15 cycles would be at least £1,000 per locomotive, but his figure for the entire locomotive was considerably higher than that which they had assumed in their estimates, and therefore they might scale this £1,000 down to about £800. Applying this to 24,000 locomotives, the difference in favour of 15 cycles was £19,200,000, which was ten times the difference in cost of the power-house equipment which was adversely affected by a reduction of frequency.

Mr. F. J. SPRAGUE (by letter) stated that capacity was the keynote of an equipment, and capacity was not measured alone by that of conductors, but ultimately also by motor equipments; and the entire testimony of that evening bore out his criticism, that the 25-cycle motor as constructed to-day did not under like conditions approach the capacity of the direct-current motor. It was proposed to increase this capacity by lowering the frequency. This, also, in itself was not a novel proposition, for it had been discussed for a number of years. It involved a good many questions, some of them going back to the central station. It might be advisable in the end to adopt for alternating-current operation this periodicity, and he ventured 6months ago to predict that the largest 25-cycle railroad enterprise now arried on would adopt a lower frequency. He was quite sure that many of the critics of the direct-current development were not as familiar as they might be with what had been done in that line within the last year or two, especially in commutating-pole construction and gearless motors. The former, one of his early babies, and now a vital feature in single-phase alternating-current motors, had been reduced to practice with direct-current motors with such success that he fully confirmed Mr. Potter's statement as to its efficiency. To his personal knowledge, four-pole motors of this type, varying from 40 H.P. to 240 H.P. normal hour capacity, would operate, so far as commutation was concerned, at excess voltages of 75 or 100 per cent. with entire freedom from all commutator disturbance. This improvement alone was one of the most remarkable in electric motor construction in recent years; and directly dependent upon it was the possibility of a return to his earlier methods of varying speed and torque of a motor by varying the field-magnet strength, a principle now in common use in variable speed shunt motors, and which was equally applicable to series machines. This addition of a shunt to the series field had an important bearing upon the comparisons made by Mr. Muralt. The series motor was no longer a machine with a fixed curve, but one with a very wide range of speed and torque control. On the matter of standardisation, perhaps he could add a few words. To a certain extent some things took care of themselves. The height of a trolley wire was dictated by the necessity of a clear height above a man on a freight car, and was about 22 ft. There could, of course, be considerable variation from this without in any way interfering with actual operation. The location of the third-rail, with centre 28·25 in. from the gauge line, and with a working surface from 2·75 in. to 3 in. above the rail had been practically accepted.

Mr. C. TOWNLEY (by letter) stated with respect to the advantage of 15 cycles or any other modification of a standard frequency that might be suggested, the burden of proof obviously lay with those advocating the change; to receive serious consideration, reasons for the change must be weighty and the evidence supporting them fairly conclusive. In the present instance, the arguments advanced in favour of 15 cycles were essentially two—first, the lower frequency permitted a lighter and more compact motor; and, secondly, the induction in the line and track were reduced. Of these two reasons, the first was advanced as the controlling one. Every other consideration was confessedly adverse. It was, therefore, pertinent to inquire, in fact, they must know, to consider the subject intelligently, how much smaller, lighter and cheaper the lower-frequency motor was to be. In undertaking to procure this information, however, they were at once confronted with embarrassment. There being no 15 cycle equipments in existence in this country, it was not surprising that the Westinghouse engineers hesitated definitely to predict what would be their relative weight, cost, &c., when they should have been constructed to meet the necessary widely varying specifications that would certainly be forthcoming as soon as the electrification of steam roads was fairly under way.

Mr. R. D. MERSHON (by letter) said that it seemed to him that they should go slowly in the matter of adopting a standard frequency for traction work. The reasons for caution in this matter were pretty well set forth in the Paper, but there was one of the considerations touched upon which would, he believed, before long have considerably more weight than at present. This consideration was that of the use of induction motors for traction purposes, especially motors whose speed characteristics might be varied by a change in the number of poles. In the case of such method of speed control, a higher frequency than 15 cycles was desirable as giving greater flexibility in the range of speed. It seemed to him it would be much better to wait until the lines of development of traction work were more clearly defined than at present before adopting, as standard, a frequency lower than 25 cycles.

Mr. W. S. MURRAY (by letter) said that upon the belief that the two departments in which the greatest economies to be derived in electric *versus* steam operated trains were fuel and locomotive repairs, it had been his effort during the past 18 months to secure absolutely reliable data in these two departments of cost concerning the steam-operated trains of the New York Division of the New York, New Haven and Hartford Railroad Co., and his investigation led him to the two following conclusions: (1) For a mixed freight and passenger service the same gross draw-bar could be produced by the single-phase method of traction for 60 per cent. of the coal required by the steam method of traction. (2) Locomotive repairs were between three and four times as great for steam as for electric locomotives.

Messrs. L. B. STILLWELL and H. S. PUTNAM (by letter) stated that the Paper and the discussion had established the fact that the increase in cost of the power-house equipment consequent upon the suggested reduction in frequency was far more than offset by the reduction in cost of electric equipment of rolling stock consequent upon the adoption of 15 cycles. The question whether 24,000 electric locomotives would do the work of approximately twice that number of steam locomotives now owned by the railroad companies was certainly open to discussion. If the actual number required were greater than the number assumed, the argument in favour of the lower frequency was strengthened. In their Paper they expressed the opinion that work equivalent to that now done by approximately 48,000 steam locomotives could be performed by electric locomotives numbering from one-half to two-thirds of that figure, and in showing that the change to the lower frequency would effect a saving in first cost of aggregate equipment they used the smaller figure in order to be entirely fair to the higher frequency. Adhering to the figure 24,000 as representing the aggregate of electric locomotives required, and taking Mr. Storer's figure of £800 as representing the difference in cost per locomotive, it appeared that while the adoption of the lower frequency would involve an increase of about £2,000,000 in cost of power house and sub-station equipment, it would save £19,200,000 in cost of rolling stock equipment: both of these figures having reference to the equipment of the entire existing railroad systems of the United States. The point made by Mr. Storer, therefore, greatly strengthened the argument in favour of the lower frequency. As regarded the necessity of standardisation in order to avoid confusion and loss as the zones of electrification of their railway systems were extended, the following considerations, not specifically mentioned in the Paper or in the discussion, and apparently overlooked by some who had discussed their Paper, might be referred to: (1) The effect of consolidations. The doctrine of special treatment of individual cases of electrification now presented to the electrical engineer, if adopted, would lead to needless expense and great inconvenience in operation in cases where properties equipped with different systems might be consolidated at some future date. The same was true in case of a transfer or sale of a section of line by one railroad property to another. (2) In emergency, in case of accidents blocking the line, their steam railways not infrequently sent their trains to destinations by using lines belonging to neighbouring railways under different management. If one line was to use the 1,200 volt direct-current system, and another the alterna ting-current system, such accommodation would be impossible. (3) At junction points and terminals the use of different systems in permitting interchange of rolling stock was in many cases practically prohibitive. Every terminal in the city of Chicago was in use by two or more trunk-line railways, and, in such a case as this, obviously, uniformity of systems, frequency, &c., was essential. It was pointed out that the existence of a certain number of 25-cycle generating plants, sometimes owned by the railway, and possibly available as a source of power supply for emergencies, was a consideration of weight in some instances. The answer to this was that undoubtedly in each specific case of contemplated electric installation the problem should be carefully studied with reference to local as well as to more general considerations, and it was not impossible that in some cases the weight of local considerations might justify departure from the general standard. This obvious fact, however, did not argue against the general adoption of a standard. So far as it had weight, undoubtedly it argued in favour of 25 cycles, but it in no way supported the position, which some had taken in opposition to their contention, that a standard should be promptly agreed upon.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"Standard Polyphase Apparatus and Systems." By Maurice A. Oudin. 5th edition. (London: Sampson Low, Marston & Co.) 12s. 6d. net.

"Electric Light & Power." By E. E. Brooks, B.Sc., and W. H. M. James, A.M.I.E.E. (London: Methuen & Co.) 4s. 6d.

"Science Abstracts," August, 1907. Vol. X. Part 8. Section A, Physics; section B, Electrical Engineering. (London: E. & F. N. Spon.) 1s. 6d. each.

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With the number of THE ELECTRICIAN for Sept. 14, 1906, was issued the first of a series of "Industrial Supplements," to be published from time to time with THE ELECTRICIAN. The fourteenth monthly issue of the Supplement will be published (Gratis) with THE ELECTRICIAN for Sept. 20.

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MUNICIPAL TRADING.

FROM time to time a good deal has been said, more particularly by irresponsible politicians, in favour of the indefinite extension of municipal trading. In this connection the report issued by the Committee of the National Civic Federation, which recently visited England and other countries, to inquire into the advantages of municipal ownership, is of some interest. The Committee appears to have been unusually representative in character, the members being engaged in responsible positions in large business concerns, or as college professors, or as labour leaders and journalists, the chairman being Mr. M. E. INGALLS, chairman of the board of directors of Big Four Railroad. With members holding many different shades of opinion, and probably with preconceived ideas, there has naturally been some difficulty in obtaining a final report; indeed, the preliminary reports, which appear to have run to about 1,000,000 words in length, were drawn up in a partisan spirit, and were, therefore, not of great value. Finally, however, the Committee has been successful in drawing up a practically unanimous report, which is by no means in favour of wholesale municipalisation. This result is, perhaps, rather unexpected, as it might have been supposed that the spirit of municipalisation would have flourished in a country

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where socialistic ideas have been prevalent; but we can only conclude that the business instinct of the American is too strong to give way to any foolish partiality for municipalisation in preference to private enterprise. Also, as is pointed out in the report, there is a good deal of dissimilarity between the United States and this country, and it does not follow that because municipalisation has met with a good deal of success over here that it should also be successful there; in fact, so far, municipalisation has not been successful in the United States, which, we think, is due to two causes, viz., the disinclination of American citizens to engage in work which is not pecuniarily requited, and to the fact that a great deal of corruption exists in the public life of many of the towns of the Republic. Fortunately, in this country municipal government is comparatively free from this influence, and thus successful municipal enterprise is much more feasible.

In dealing with what are termed public utilities, the report states that three courses are open. Such utilities must either be controlled and regulated by the Government, or they must be left to the free will of those by whom they are handled, or they must be operated by the public. As the policy of leaving a free hand to private individuals is out of the question, it becomes a case either of regulation or of municipalisation. The report, therefore, expresses the opinion that a public utility which concerns the health of the citizens should not be left to individuals, since the temptation to make a profit might produce disastrous results; that undertakings in which the sanitary motive largely enters should be operated by the public; but that municipal ownership should not be extended to revenue-producing industries which do not involve the public health, public safety, public transportation or the permanent occupation of streets or land; and that municipal operation should not be undertaken solely for profit. Among the conclusions reached as regards management, the Committee consider that no municipal operation is likely to be highly successful that does not provide for an executive manager with full responsibility, holding his position during good behaviour; that exclusion of political influence and personal favouritism from the management of the undertaking is essential; and that the finances of the undertaking should be separate from those of other City undertakings.

Mr. C. L. EDGAR, who is president of the Edison Electric & Illuminating Co. at Boston, and Mr. W. H. CLARKE, who is general manager of the Foreign Department of the General Electric Co., took exception to the conclusions to a small extent. Among other opinions expressed, they apparently consider that the conditions of private and public operation in any given instance are not likely to be the same, and that consequently the financial results will generally differ; and they dissent from the conclusion that a public utility involving the public health should not be left to individuals, since this view has not been supported by the investigation, privately-operated water systems having been found to be as properly managed as those in public hands.

Generally speaking, we think that the report bears out the opinion very largely held in this country, that, although municipalisation has advantages where no questions of profit are involved, municipal trading pure and simple, where in competition with private enterprise, can only be harmful to public interests.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Long Distance Electric Power Transmission. By R. W. HUTCHINSON, JR. (London: E. & F. N. Spon.) 12s. 6d. net.

This is a distinctly American book. Not only does the author accentuate this feature by speaking of "American turbines," "American induction motors," "American converters," types of "American insulators," and so on, but he has completely excluded any reference to power transmission plants in Europe and to the scientific literature available on this side of the Atlantic, whilst he gives exhaustive references to the American literature on the subject. At the end of each chapter there is a very full list of books and articles bearing on the subject treated in that chapter. This is an excellent feature of his work and will be the more appreciated by the reader as the author's own treatment is necessarily very brief, since he attempts to cover in some 340 pages of fairly wide print the enormous subject of electric power transmission from the hydraulic works down to the motor on the customer's premises.

An exhaustive treatise on American practice would be very valuable to English readers. The Americans have done in this direction such admirable work, both as regards magnitude of plant and ingenuity of design, that we can learn much from them, but the author does not help us to learn. For the expert his book contains not enough detail of a scientific character and not the right kind of illustrations, whilst the beginner will be puzzled by the highly technical terms which are used without explanation. There is also a want of critical spirit which leads the author to make or repeat statements which an expert can hardly credit. Thus we read that a large alternator has 97·5 per cent. efficiency (p. 114), that up to an output of 800 kw. the alternators generally used are of the revolving armature type (p. 109), that "discharges of low potential" pass through 50 megohm tubes and spark gaps to ground (p. 151), and so on.

One third of the book is devoted to hydraulics, and this is the best part. The author gives us the fundamental principles of the flow of water through pipes and flumes, the measurement of water by weir and float, something about impounding reservoirs and dams, the construction of pipe lines, and something about turbines and turbine governors. Nothing is said about the scientific principles underlying the working of turbines and the different types are shown by what may be termed catalogue illustrations. The description attached to these is very meagre. Some pictures are given of the "Pelton," "Risdon" and "Doble" wheels, which look very much alike, and nothing is said in the letterpress as to the features in which these wheels differ from each other. The electrical part of the book begins with p. 109, under the title "Generators, Switches and Protective Devices." The fixed armature type of generator is treated very briefly, but the inductor alternator is described at some length. In contrasting this type with that more generally used, the author says: "The advantages claimed for the inductor generator are, that the iron is worked through only half a cycle, which makes the iron losses quite small, if the machine is worked at low magnetic densities, freedom from moving wire," &c. It does not seem to have occurred to the author that working the iron through only half a cycle (whatever that may mean) is associated with getting only half the E.M.F., so that the ratio of iron loss to output is not improved.

The description of time-limit relays is very unsatisfactory. We get on page 139 a catalogue picture of the mechanism, and on the previous page a diagram of connections which is very incomplete, whilst the description of the relay which fills the next two pages is, owing to the absence of illustrations, quite incomprehensible.

The next chapter, treating of the laws of electric transmission of energy, is equally unsatisfactory. What, for instance, is the reader to make of the following: "Denoting instantaneous values by (′): when the current lags by the angle ϕ . . . . . $E' = E \sin \alpha$, and for convenience $\alpha = 2\pi ft$." Apart from the fundamental error of putting an angle as equal to a length, where is the convenience of doing so? There are also

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some serious printers' errors. On page 163 the author talks of leakage when he means linkage, and on the next page the coefficient of self-induction is given as $L=dt/dI$. The experienced reader knows, of course, that this is simply a printer's error, the factor e having been omitted, and even a beginner would not be puzzled by such an error if the formula for L had been deduced from first principles; but when such expressions are given without reference to scientific principles, merely in the style adopted in some engineering pocket-books, one expects them to be absolutely correct.

Where the author treats of the pole line he seems to be on more familiar ground, and some useful information about height and strength of poles, stresses, wind pressure, method of bracing cross-arms, preserving wood, erecting steel poles and cost of these, length of span and other details is given. Ryan's curves showing losses by brush discharge are also useful additions to this chapter. In the chapter on transformers some general remarks are made as to iron losses, and some formulæ are given in the pocket-book style, but no definite figures. Scott's test at slow cycles is explained so briefly and the illustration of connections is so imperfect that only a person already acquainted with this test is able to understand what the author means. Brevity, but, alas, not clearness, is, in fact, the characteristic of the book. As an example may be quoted what the author says about measuring the efficiency of transformers by the stray-power method, first published by Dr. Sumpner, but not credited to him by the author. "Stray-power methods for determining efficiency are quite accurate, and permit of the individual determination of the losses. The core losses are found from wattmeter measurements in the primary circuit, the secondary being open circuited." Then follow some sentences about the use of "static interrupters" to prevent dangerous rise of pressure, but what these things are and how they are connected is not revealed.

We next come to motors, with more catalogue pictures and such curves of their performance as are found in all the publications of the large American manufacturers. When dealing with converters and the cause of hunting, the author is at times quite obscure. Thus, on page 299 we read: "(3) Hunting caused by absence of armature reaction. Lack of armature reaction in a converter is the result of an equilibrium between two equal and opposite forces."

The last two chapters of the book are devoted to information about the cost of plant, some general remarks on the limits of distance to which power may be carried (but here again we miss definite information) and an account of the distinctive features of the plant installed by four large power-transmission companies in America.

Les Alternateurs à Collecteur Monophasés et Polyphasés et les Dynamos à Courant Continu à Deux Paires de Balais. By C. JACQUIN. (Paris: Gauthier-Villars.) 3fr. 50c.

This little volume of 140 pages contains a very readable and simple account of single-phase commutator motors, self-exciting alternators, and the peculiar type of continuous-current machine devised by E. Rosenberg. The treatment is non-mathematical throughout, although in places the analytical theory is developed in long foot-notes. The great interest which is now being taken in single-phase commutator motors renders the publication of a little work like the present very opportune, and its simple and easy style should secure for it many readers. The author wisely refrains from attempting to go into the history of the subject, and merely contents himself with an account of some of those types of motors and generators which are of actual commercial importance. A great deal of space is devoted to the work of Latour; whether intentionally or not the author seems to do but scant justice to Winter and Eichberg, who are mentioned only casually, as it were. The title of the book appears to us to be somewhat too ambitious, as polyphase alternators provided with commutators are dismissed in six pages. A serious defect of the book is the absence of an index.

Notions Générales sur la Télégraphie Sans Fil. By R. DE VALBREUZE. (Paris: "L'Eclairage Electrique.") 170 pp. 7fr. 50c.

In the clear and concise manner of the educated Frenchman, M. de Valbreuze puts before his readers the main facts of wireless telegraphy as now practised. He does not pretend to enter into great detail, and still less into mathematical discussions, but explains in a simple and straightforward way the methods by which the actual work is at the present day being carried out. As the author does not assume any technical knowledge on the part of his readers, beyond a general acquaintance with the principal laws of physics, he necessarily occupies several chapters in discussing vibratory motion, the ether, and various types of radiation. It seems a pity that almost half the book should have been sacrificed to elementary descriptions which may be found in any modern text-book of physics, and only the small space of 66 pages devoted to telegraphy proper, particularly as the author is so well qualified to give fuller information on the subject. The book is well illustrated and should be useful as a text-book in technical classes where the elements of wireless telegraphy are taught and to engineers who desire to keep themselves *au fait* with the progress of the art.

A SUGGESTION FOR THE IMPROVEMENT OF THE SMALL POWER LOAD.

BY H. S. HATFIELD.

There are two ways in which a supply undertaking can increase its sale of current: the first, by getting new customers; the second, by persuading the present consumers to take more current. The second should be the easier and the more profitable. The private lighting consumer at present avails himself to but a very small extent of the offer of cheap power. The supply must be separately metered, and it is necessary either to install a separate service for the purpose or to use a sub-meter.

The cost of a separate service is the great bar to the extension of the use of heating and power appliances by the lighting consumer. He has to spend several pounds on what is, from his point of view, an experiment, and the money so spent is irrecoverable. Many, if not most, supply authorities are prevented, for various reasons, from bearing the cost of the wiring; even if they were able to do so, the capital sunk would be irrecoverable, and the next tenant might not wish to make use of the service. The sub-meter system is free from this objection; the meter or meters may be removed at any time and employed elsewhere. No supply authority is legally barred from supplying meters.

The writer is not aware that any extensive experience of such a system is on record; indeed, it is only quite recently that the introduction of radiators and cooking utensils, at reasonable prices, and, it must be admitted, the pinch of lean years have aroused engineers to consider the lighting consumer worthy of their attention as a power user. But even where great efforts have been made, progress has been very slow. A sub-meter system might very possibly hasten it considerably. The following objections to the sub-meter system have been, or might be, raised:—

1. Want of flexibility. The power appliances can only be used near the meter. If, for instance, a radiator or other appliance is to be moved from room to room, a meter must be supplied at each point; this leads to excessive cost.

2. Cost. The cheapest full-sized reliable meter cannot be obtained under about 28s., and a certain expense would attend its installation; if three or four such meters were to be installed, the expense would almost equal that of separate wiring, though the capital would not be irrecoverable. But the next objection is now obvious.

3. Unsightliness. The average electricity meter is hardly a drawing-room ornament.

4. Less accuracy of metering, due to addition of casual errors in main and sub-meters, and increased chance of uncertainty in the final account, introduced by any one meter failing.

5. The difficulty of application in the case of customers supplied on the demand-indicator system.

The writer remains convinced that a sub-meter system, nevertheless, offers the only opportunity of gaining the very desirable end in view—namely, a wide and free use of small power appliances. The instrument illustrated herewith is designed to obviate some of the objections above mentioned.

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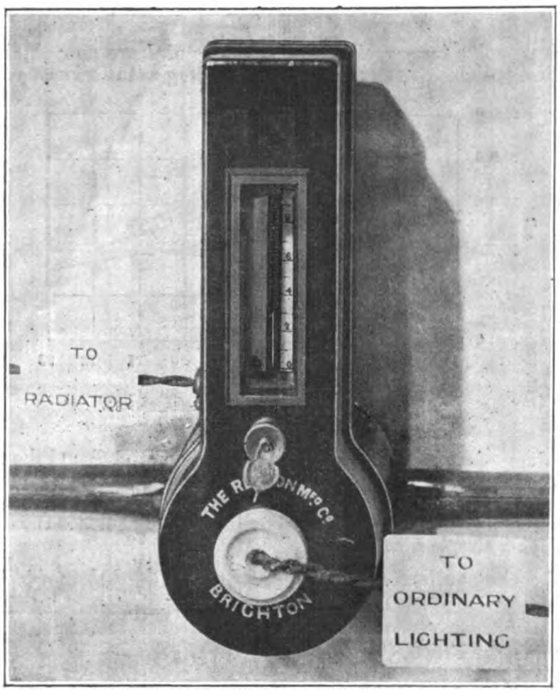
It is a miniature mercury electrolytic meter, with a scale of 100 divisions, with one B.O.T. unit (or more, if desired) per scale division. Most engineers acquainted with the facts are now convinced that, by an improved electrolyte, the mercury electrolytic meter has been rendered permanent chemically and in its calibration. The meter fits over the ordinary two-pin wall plug, and is fixed to the base or skirting. On the lid being placed in position, the wall plug may be employed in the ordinary manner. The meter registers either (1) the current consumed by a tapping taken from the plug and connected to another plug or direct to a radiator, &c., or (2) the current consumed by an appliance plugged in on the lid of the meter. In the latter case, the distance apart of the pins may be altered, so that an ordinary plug cannot be used, but a special power plug supplied with the meter must be employed. In the first method, the meter does not register the current taken from the lid, but only that from the tapping. The dimensions are 9 in. by 3½ in. by 2¾ in., the case is inconspicuous and well finished, and the cost is 10s. A similar meter (even smaller, 2½ in. by 2½ in. by 7¼ in.) with terminals for use in the ordinary manner can also be made at the same price.



It is, therefore, not an expensive matter to fix such a meter at several points wherever a consumer may wish to employ his appliance. It is not large enough to be seriously unsightly, and no noticeable damage is done to walls or woodwork in fixing it. It may be removed at any time and employed elsewhere. An ultra-incredulous person, who has no faith in new-fangled contrivances, may be given a trial of a small radiator, kettle or motor without depriving him of the ordinary use of the wall plug on which the meter is fixed. He is able to read the meter as often as he pleases without trouble, and follow the cost of the apparatus in action. A little active co-operation between the supply authorities and the retailer of electrical appliances should thus not be without advantage to both.

The writer believes that the increased accuracy and reliability of this type of meter should suffice to render the objection in this respect negligible.

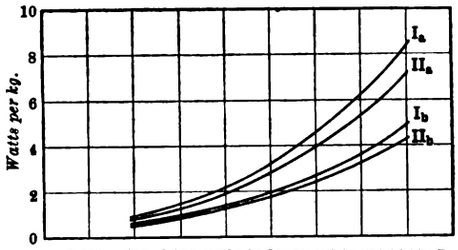
The demand-indicator difficulty is not so easily disposed of. The only solution seems to be a certain degree of liberality on the part of the supply authority, the latter agreeing to deduct the known demand of the customer's radiator, &c., from the recorded demand. Perhaps a special and slightly higher power price might be fixed for the sub-meter system. There would then remain some inducement to the consumer to install separate wiring.

THE DESIGN OF TRANSFORMERS AS INFLUENCED BY THE EMPLOYMENT OF ALLOY-SHEETS.*

BY DR. ROBERT POHL.

Summary.—The author proves, by means of a comparative design for minimum cost and fixed temperature rise, that the use of alloy-sheets for smaller sizes of transformers leads not only to increased efficiency, but also to reduced cost and weight of active material, provided the design is carried out with due regard to the properties and the price of the new material. The main points of difference in the design of alloy-sheet transformers and iron-sheet transformers are deduced.

A comparative design of a 50 kw. 50 cycle single-phase transformer based on the magnetic properties of alloy-sheets and iron-



I_a 0·5 mm. thickness 75 periods. I_b 0·5 mm. thickness 50 periods. II_a 0·35 mm. thickness 75 periods. II_b 0·35 mm. thickness 50 periods.

FIG. 1.—LOSS IN ALLOY SHEETS.

sheets respectively, as shown in the curves Figs. 1, 2, 3 and 4 (Capito and Klein Benrath), is carried out and use is made of the method of calculation for minimum cost as published by H. Bohle

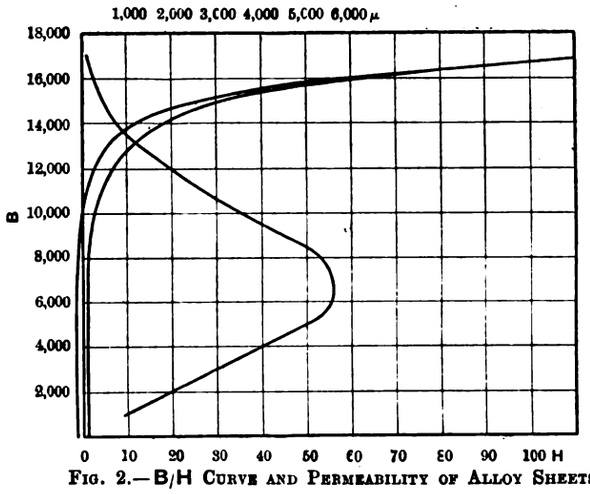
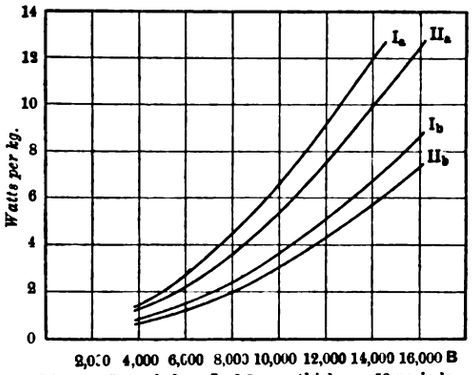


FIG. 2.—B/H CURVE AND PERMEABILITY OF ALLOY SHEETS.

and the author (*E.T.Z.*, 1905, p. 897), to which the reader is referred as to the details of calculation.

From Figs. 1 and 3 it is at once evident that the most favourable thickness of stampings is much greater for alloy sheets, so that in



I_a 0·5 mm. thickness 75 periods. I_b 0·5 mm. thickness 50 periods. II_a 0·35 mm. thickness 75 periods. II_b 0·35 mm thickness 50 periods.

FIG. 3.—LOSS IN IRON SHEETS.

the following design 0·5 mm. is used, whereas iron stampings of 0·35 mm. thickness are employed. The curves No. I. C, Fig. 4, and No. II. C, Fig. 3, are therefore applicable, and may be transformed

* Abstracted from the *Elektrotechnische Zeitschrift*.

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into the K_2 curves, Fig. 5. The method of calculation contains the copper-loss constant K_1 = loss per kilogramme copper/s^2 = 2·6 [s = current-density in amperes/sq. mm.]; the iron-loss constant K_2 = loss per kilogramme iron/B^2 (to be suitably chosen from Fig. 5 according to the expected B); and the ratio of weights K_3 = weight of iron/weight of copper, which for minimum cost must

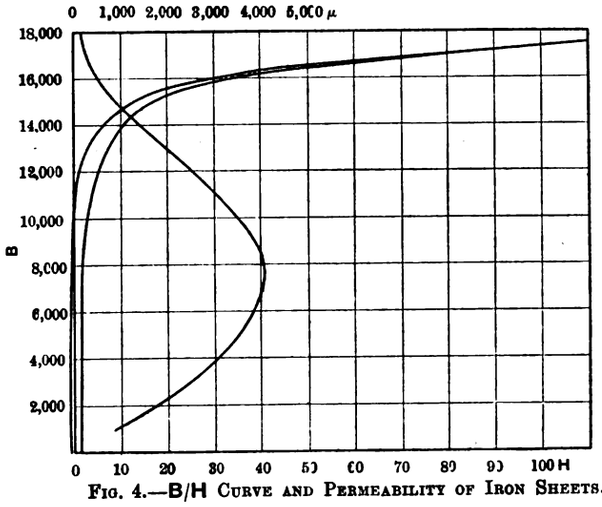

FIG. 4.—B/H CURVE AND PERMEABILITY OF IRON SHEETS.

be in the inverse ratio of the prices, K_3 = price per kilogramme of insulated copper/price per kilogramme of stampings, or, in other words, the total cost for the copper should equal the total cost of stampings. Introducing the actual prices, it will be found that for the iron-sheet transformer K_3 = 3, whereas for alloy stampings we obtain K_3 = 2. This difference greatly affects the whole design.

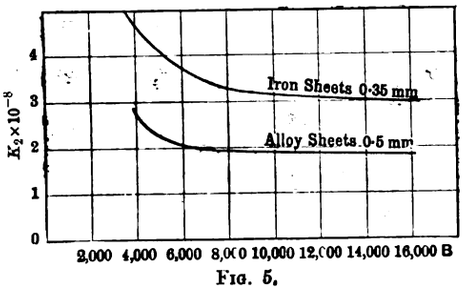

FIG. 5.

The transformer is of the type shown in Fig. 6, and the space factors are assumed to be

$$f_i = \frac{\text{actual cross-section of sheets}}{d^2\frac{\pi}{4}} = 0{\cdot}67$$

$$f_c = \frac{\text{actual cross-section of copper}}{d_1 h} = 0{\cdot}35$$

We further take $K_2 = 3{\cdot}36 \times 10^{-8}$ for iron and $K_2 = 1{\cdot}9 \times 10^{-8}$ for alloy, corresponding to B = 8,000 and B = 10,000 respectively. Even

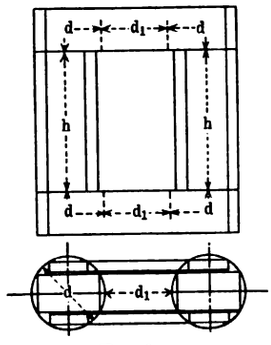

FIG. 6.

if the densities finally arrived at should differ considerably from these assumed values, the error thus introduced will be very small.

In order to obtain the same specific cooling surface—22·5 $\frac{\text{sq. cms.}}{\text{watt}}$—in both cases we have to calculate the transformer for three different efficiency values. Plotting, then, the results including the specific cooling surface, we shall be able to compare the properties and cost of the two transformers having equal temperature rise. As the alloy transformer will work with higher density, its dimensions, and consequently for equal temperature rise, its losses, will be smaller. We, therefore, calculate it for η 97½, 97¾ and 98 per cent., whilst for the iron-sheet transformer we assume η = 97, 97¼ and 97½, from which the values of W_c = total watts lost are obtained. Taking further, c = frequency = 50 and $p_i = p = 0{\cdot}5$ (percentage loss in iron and copper respectively), we form the factors

$$a = \frac{5{\cdot}7 \times 10^8 \times \text{K.V.A.}}{c f_i f_c}, \quad \beta = \frac{K_3 W_c}{{\cdot}012 f_i}\sqrt{\frac{p_c \times p_i}{K_1 K_2 K_3}}, \quad \gamma = \frac{W_c}{{\cdot}028 f_c}\sqrt{\frac{p_c \times p_i}{K_1 K_2 K_3}}$$

and obtain

For iron sheets η =	97	97¼	97½ per cent.
	$a = 24{\cdot}4 \times 10^8$	$24{\cdot}4 \times 10^8$	$24{\cdot}4 \times 10^8$
	$\beta = 5{\cdot}45 \times 10^8$	$5{\cdot}10 \times 10^8$	$4{\cdot}55 \times 10^8$
	$\gamma = 1{\cdot}5 \times 10^8$	$1{\cdot}38 \times 10^8$	$1{\cdot}25 \times 10^8$
For alloy sheets η =	97½	97¾	98 per cent.
	$a = 24{\cdot}4 \times 10^8$	$24{\cdot}4 \times 10^8$	$24{\cdot}4 \times 10^8$
	$\beta = 4{\cdot}95 \times 10^8$	$4{\cdot}36 \times 10^8$	$3{\cdot}96 \times 10^8$
	$\gamma = 2{\cdot}03 \times 10^8$	$1{\cdot}83 \times 10^8$	$1{\cdot}62 \times 10^8$

With the aid of the equations

$$d_1 = 2d\left(\frac{\gamma}{a}d - 1\right), \quad sB = \frac{\beta - \frac{a}{d_1}}{2\frac{\gamma}{a}d^1}, \quad h = \frac{a}{sB\,d_1 d^2},$$

which we solve for several assumed values of d, we now obtain the cheapest possible transformers, corresponding to the highest possible

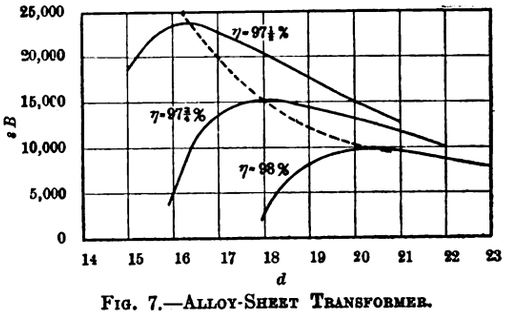

FIG. 7.—ALLOY-SHEET TRANSFORMER.

sB-values—*i.e.*, the peaks of the curves (Figs. 7 and 8) and the corresponding values of d, d_1 and h. Thus we are enabled to plot the latter dimensions and the specific cooling surface as functions of the efficiency (Figs. 9 and 10). For the cooling surface the author employs a simple formula:—

$$\text{Total cooling surface} = \underbrace{2C_t d(h + d_1 + 2d)}_{\text{iron}} + \underbrace{2\pi\left[(d+d_1)h + \left(d + \frac{d_1}{2}\right)d_1\right]}_{\text{copper}}$$

in which, for Fig. 6, $C_t = 4{\cdot}4$.

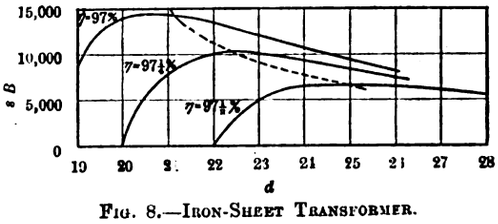

FIG. 8.—IRON-SHEET TRANSFORMER.

Selecting from Figs. 9 and 10 the dimensions corresponding to 22·5 sq. cm./watts, we now have the final comparison:—

Most favourable transformer for 22·5 sq. cms./ watt cooling surface.

	With iron stampings.	With alloy stampings.
η =	97·3 per cent.	97·8 per cent.
d =	23·0 cm.	19·0 cm.
d_1 =	12·5 cm.	12·5 cm.
h =	39·5 cm.	39·0 cm.
s =	1·35 amps./sq. mm.	1·32 amps./sq. mm.
B =	7,000	10,600
Weight of copper =	141·5 kg.	120·5 kg.
Weight of iron =	424·5 kg.	241·0 kg.
Total weight =	566·0 kg.	361·5 kg.
Cost of active material about	£28. 6s.	£24. 2s.

In regard to the no-load current, the alloy-sheet transformer is somewhat inferior, whilst as to drop and leakage there exists no material difference between the two designs.

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An interesting comparison can further be obtained by plotting the copper weight, which is proportional to the total cost of active material as a function of the efficiency. It appears that the saving in the alloy-sheet transformer would be very great indeed if it could be worked with as low an efficiency as the iron transformer. This, however, is not permissible, unless more efficient cooling methods

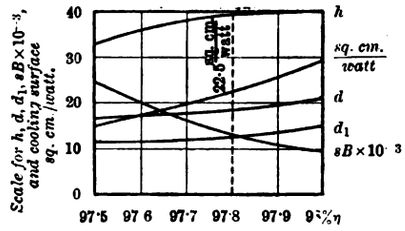

FIG. 9.—ALLOY SHEET TRANSFORMER: PEAK VALUES.

are employed. On the other hand, for equal cost of active material, the alloy-sheet transformer is superior in its efficiency and temperature rise.

In conclusion, it may be pointed out that these results apply mainly to smaller sizes of transformers, whereas in the larger and magnetically more saturated types, as in most rotating machines,

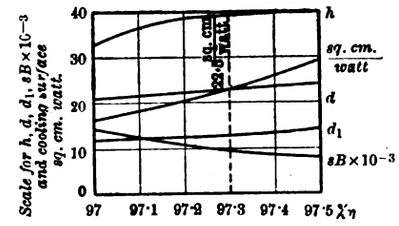

FIG. 10.—IRON SHEET TRANSFORMER: PEAK VALUES.

the high price of the alloy-sheets cannot be compensated for by the employment of higher densities; it is to be hoped that the makers will succeed in further reducing the price of the new material, and in improving upon its permeability at high densities, so as to make its employment for all classes of electric machines a commercial possibility.

GENERAL THEORY OF ALTERNATE-CURRENT MOTORS.*

BY H. GÖRGES.

Summary.—The author explains the action of single and polyphase alternate-current motors by resolving the magnetic flux through the rotor into two components, displaced relatively to each other by 90 electrical degrees. The rotor winding is similarly split up into two components, whose magnetic axes coincide with those of the fluxes. The rotor currents are divided into free, externally influenced, and forced currents, and the classification of motors is based on the nature of the rotor currents. The theory is applied to the following four principal types: The induction, the series, the series-short-circuit, and the repulsion motor.

The early study of the single-phase induction motor led to the development of two theories regarding its action. One of these was based on the decomposition of an alternating magnetic flux into two oppositely rotating fluxes, while in the other the flux was considered to be resolved into a main flux and a cross flux. Only the second of these two theories has been applied to commutator motors.

The theory of the various types of alternate-current motors may be considered from a perfectly general standpoint. For the sake of simplicity we shall suppose, in what follows, that the motor is a two-pole one, and that the stator winding gives rise to a horizontal magnetic flux through the rotor, the positive direction of the flux being from left to right. The horizontal direction will, as usual, be spoken of as the x-axis, and the vertical direction as the y-axis (the positive sense of the latter being from below upwards). A *counter-clockwise* direction of rotation will be reckoned *positive*.

In all forms of alternate-current motors the magnetic flux may be resolved into an x-component and a y-component, the two components having the same frequency—viz., that of the alternating current supplied to the motor. The resolution and composition of magnetic fluxes according to the parallelogram law is, strictly speaking, only correct on the assumption of a sine distribution of the flux in space. In some cases it is desirable to produce fluxes along both the x-axis and the y-axis; if a phase difference (in time) exists between the two components a rotating field will result, and in order to favour the production of such a field the stator is constructed in the form of a continuous laminated ring, without polar projections. In other cases the production of a cross-flux is undesirable, and in order to suppress it a special compensating winding, like that used in series motors, is provided. In such cases the stator may be furnished with polar projections.

Let the magnetic flux components through the rotor along the two axes be denoted by Φ_x and Φ_y respectively. Considering a single coil on the rotor, let us first suppose its axis to coincide with the x axis. The variation of Φ_x will induce a transformer E.M.F. E'_x in the coil, while the rotation of the coil in the y-component of the flux will give rise to a rotation E.M.F. E''_x. Suppose, next, the axis of the coil to coincide with the y-axis. Then the variation of Φ_y gives rise to a transformer E.M.F. E'_y, and the rotation of the coil in the flux along the x-axis to a rotation E.M.F. E''_y. In any intermediate position of the coil all four E.M.F's are present. But we may replace the coil in any such position by two others, having their axes

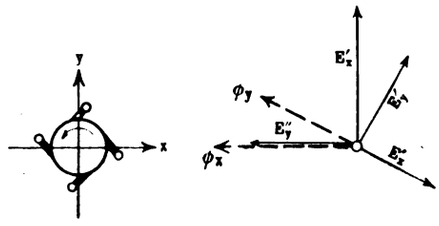

FIG. 1.—POSITIVE DIRECTION OF ROTATION.

along the two axes of reference. If N denote the number of turns in the coil, and γ the angle which its axis makes with the x-axis, then the number of turns to be assigned to the x-component of the coil is $N_x = N \cos\gamma$, and the number of turns to be assigned to the y-component is $N_y = N \sin\gamma$.* The x-component of the coil is the seat of the two E.M.F s.—

$$\left.\begin{aligned} E'_x &= \epsilon n N_x \Phi_x \\ E''_x &= v.\epsilon n N_x \Phi_y \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (1)$$

And the y-component of the coil the seat of the E.M.F.s.—

$$\left.\begin{aligned} E'_y &= \epsilon n N_y \Phi_y \\ E''_y &= v\epsilon n N_y \Phi_x \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (2)$$

where ϵ denotes a constant depending on the type of winding, n the frequency, v the ratio $\frac{\text{actual speed}}{\text{synchronous speed}}$. The phases of these E.M.F.s are given by the diagrams of Figs. 1 and 2, Fig. 1 referring to a positive and Fig. 2 to a negative direction of rotation.

The question now arises as to the effect of these E.M.F.s on the phase and magnitude of the current flowing through the rotor winding. Three cases may be considered. In the first case, the rotor

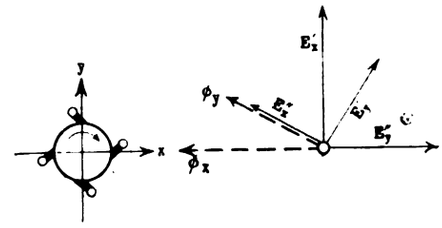

FIG. 2.—NEGATIVE DIRECTION OF ROTATION.

windings are short-circuited on themselves, so that the currents circulating in them are due entirely to the induced E.M.F.s, and are proportional to, and co-phasal with, their resultant. Such currents may be spoken of as *free currents*. In the second case, an E.M.F. from an external source is impressed on the rotor windings, in addition to the induced E.M.F s. The currents may in this case be described as *externally influenced*. In the last case, currents of definite magnitude are introduced into the rotor windings; such currents may be termed *forced currents*.

An example of free currents is afforded by the short-circuited rotor winding of an induction motor; such a winding being equivalent to a commutator winding having two sets of independently short-circuited brushes, one set along the x-axis, the other along the y-axis. The commutator windings devised by Heyland for the purpose of compensating the wattless currents, and so improving the power-factor of induction motors, furnish one example of externally

* Abstracted from the *Elektrotechnische Zeitschrift*. Paper read before the fifteenth annual meeting of the Verband Deutscher Elektrotechniker in Hamburg.

* The assumption is here made that the flux due to each coil is distributed in space according to the simple sine law; it is only on this assumption that the above decomposition is legitimate.

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influenced currents. To the same class belong certain windings due to Winter and Eichberg, Latour, Fynn, and Arnold and La Cour. As an example of forced currents, we may consider the currents flowing through the armature of a series motor, which must be equal or proportional to the current in the field winding.

Since in general there are two induced E.M.F.s present in each component of a coil, it follows at once that a more or less perfect balance of these is possible. The necessary conditions for balance of the E.M.F.s in the x-component of the coil are (1) that Φ_x and Φ_y be in quadrature with each other as regards time (*see* Fig. 3), Φ_y being 90 deg. behind Φ_x if the rotation is positive, and 90 deg. in advance of Φ_x if the rotation is negative; (2) that $\Phi_x = v$. Φ_y. Similar conditions hold for the y-component of the coil. An important difference between a short-circuited coil in a stationary transformer and one in the rotor of a motor may here be pointed out. In a transformer, the short-circuit of a coil necessarily involves the reduction of the flux through the coil to a very small value. In a motor, on the other hand, the flux through a short-circuited coil may be considerable, owing to the fact that the transformer and rotation E.M.F.s may compensate each other.

Assuming the two flux components and rotor currents to be known, the torque may be calculated. This may be regarded as made up of two components, one of which is due to the action of the x-field on the y-component of the rotor winding, and the other to the action of the y-field on the x-component of the winding. The first is positive, the second negative (*see* Figs. 4 and 5). We may thus write:

$$\left.\begin{aligned} T_1 &= -\delta \Phi_x N_y I_y \cos(\Phi_x I_y) \\ T_2 &= +\delta \Phi_y N_x I_x \cos(\Phi_y I_x) \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where T_1, T_2 are the two components of the torque, δ a constant depending on the type of winding, I_x and I_y the currents flowing

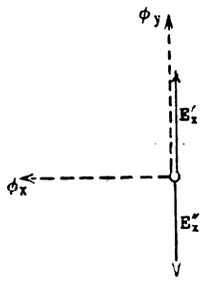

FIG. 3.

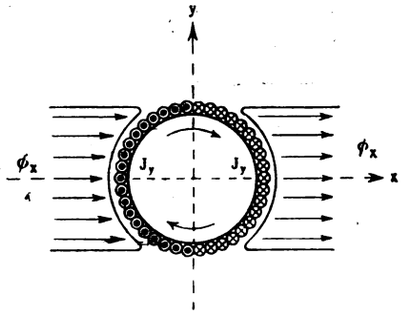

FIG. 4.

between the x brushes and y-brushes respectively, and $\cos(\Phi_x I_y)$ the cosine of the phase-difference in time between Φ_x and I_y. The resultant torque T is given by

$$T = T_1 + T_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In order to find the direction of the torque, we consider its direction at a standstill. If the torque vanishes in this latter case (as it does, *e.g.*, in a single-phase induction motor), the motor may be started in either direction.

In accordance with what has been said above, we may adopt the following classification of alternate-current motors :—

I_x.	I_y.	Type of motor.
..	forced	Series motor
free	forced	Series—short-circuit motor of Latour, Winter and Eichberg
free	free	Induction or multiple short-circuit motor
I free along an oblique axis		Single short-circuit or repulsion motor

In the case of the repulsion motor, we may suppose the winding resolved into an x- and a y-component, and the two connected in series and short-circuited.

The principle of resolving rotor fluxes and currents into x- and y-components may be applied to the various types of motor enumerated, and the corresponding vector diagrams may be constructed. In dealing with induction motors, we suppose the rotor winding to be replaced by a commutator winding provided with two sets of independently short-circuited brushes, one set being arranged along the x-axis and the other along the y-axis.

The use of *externally influenced* currents may be applied to the purposes of phase compensation or speed regulation. Thus, in the case of single-phase motors the former may be obtained by impressing on the brushes along the y-axis a small voltage which is proportional to, and co-phasal with, the P.D. across the stator, since such a voltage will be approximately in quadrature with E'_y and E''_y. This is practically the method of phase compensation devised by Heyland. On the other hand, in order to obtain speed regulation, a variable voltage co-phasal with the P.D. across the stator may be impressed on the x-axis, such a voltage being practically co-phasal with E'_x and E''_x, and hence bringing about a change in E''_x—*i.e.*, a change of speed.

Induction motors are characterised by the fact that Φ_x and Φ_y are practically in time-quadrature, and that their speed changes but little with load. In motors having short-circuited rotors traversed by *free currents* the speed is in the neighbourhood of synchronism. If, on the other hand, by the application of an external P.D. the rotor currents become *externally influenced*, the speed may be made to be either above or below synchronism.

In the series motor, in which the rotor currents are *forced*, Φ_x and Φ_y are co-phasal. The E.M.F. E'_x induced in the stator winding is co-phasal with E'_y, both being in time-quadrature with Φ_x or Φ_y, while E''_y is in phase opposition to Φ_x or Φ_y. E'_y may be wiped out by a suitably arranged compensating winding.

If a series-wound motor be provided with a short-circuited set of brushes along the x-axis, it becomes the series short-circuit motor of Latour, Winter and Eichberg, and the characteristics of the new motor are entirely different. Φ_x and Φ_y are now nearly in time-quadrature, and—as in induction motors—E'_x and E''_x are nearly in phase opposition, and nearly balance each other. Hence $\Phi_x = v\Phi_y$, in accordance with (1).

Again, along the y axis we have the rotation E.M.F. E''_y, which is proportional to $v\Phi_x$, and co-phasal with Φ_x, and which is therefore in phase opposition to E'_y. The two E.M.F.s will balance each other if $v\Phi_x = \Phi_y$. But since, as we have seen, $\Phi_x = v\Phi_y$, compensation of the E.M.F.s E''_y and E'_y will take place when $v = 1$—*i.e.*, at synchronism—and the P.D. across the y-brushes will decrease with increase of speed until synchronism is reached, when the resultant flux becomes a rotating one of constant magnitude.

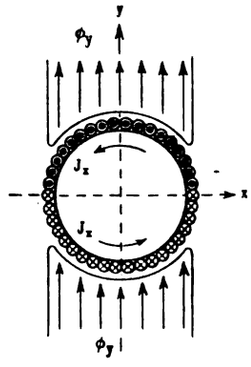

FIG. 5.

Lastly, considering the single-short-circuit or repulsion motor, we may show that if γ is the angle made by the short-circuit axis with the stator or x-axis, then

$$\text{for } v = 1,\ \Phi_y = \Phi_x,$$
$$\text{for } v = 0,\ \Phi_y/\Phi_x = 1/\tan\gamma,$$

and for $\gamma = 45$ deg. and any value of v whatsoever, $\Phi_y = \Phi_x$. If we trace out the changes in the relative phases of Φ_x and Φ_y with varying values of v when $\gamma = 45$ deg., we shall find that at standstill Φ_x and Φ_y are in phase opposition; that as the speed increases, Φ_x becomes gradually retarded in phase, reaching a quadrature relation with Φ_y at synchronism, and becoming coincident with Φ_y when the speed is infinite.

DISCUSSION.

In the discussion which followed the reading of the above Paper Dr. EICHBERG gave a brief sketch of the present state of single-phase railway motors. Practically two types only are in use: the series motor and the Winter-Eichberg one. As constructed by the Westinghouse Company, the series motor is provided with a compensating winding, which is intended to wipe out the armature cross-field; the armature itself is provided with resistance connectors between the winding and the commutator. In the form constructed by the Siemens-Schuckert Works the resistance connectors are so arranged as to increase the torque. This arrangement Eichberg does not regard as of any practical importance, as in his opinion the total increase of torque thereby obtainable is extremely small. As regards the Winter-Eichberg type, the earliest motors (1903) were constructed with high-voltage stators. This construction has now been abandoned, not because it presents insurmountable difficulties, but because exceptional care has to be used in order to render the construction thoroughly reliable. The *entire* current is transformed in the newer types of motor. The power transformer adds about 20 per cent. to the weight of the electrical equipment, but this increase represents only a small fraction of the total weight of the car. The Winter-Eichberg motor possesses the advantage over the series motor that, whereas the latter has not been built for voltages exceeding 300, the former may be built for 500, 600 or 850 volts, the consequent reduction of the working current resulting in a cheapening of the switch gear. A peculiarity of the Winter-Eichberg system is the use of a special exciting transformer.

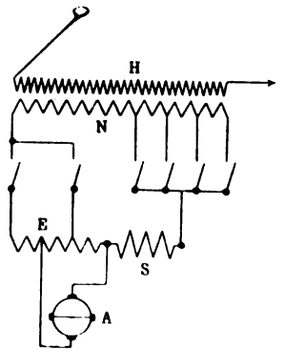

FIG. 6.

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The actual connections as used at the present time are shown in Fig. 6, where H denotes the high-voltage winding of the power transformer, N its low-voltage winding, E the exciting transformer, which is connected in series with the stator winding S, and A the armature. Regulation is effected simultaneously by the power and the exciting transformer. By the use of the exciting transformer, starting may be effected with a field so weak that the short-circuit currents under the brushes due to transformer action are kept within bounds, and resistance connectors between the armature winding and commutator become unnecessary. Such resistance connectors, which are an absolute necessity in all series motors, constitute a source of danger, as when the motor has to exert a large starting torque and the starting is comparatively slow, the resistance connectors may be destroyed by the excessive currents flowing in the short-circuited coils.

Mr. HEYLAND questioned the advantages claimed by Dr. Eichberg for the exciting transformer, pointing out that a similar arrangement was applicable to the series motor, but that a weakening of the field at starting necessarily reduced the starting torque unless the armature current were abnormally large.

Mr. RICHTER gave a diagram (Fig. 7) of the switching arrangements of a reversible series motor as used by the Siemens-Schuckert Works.

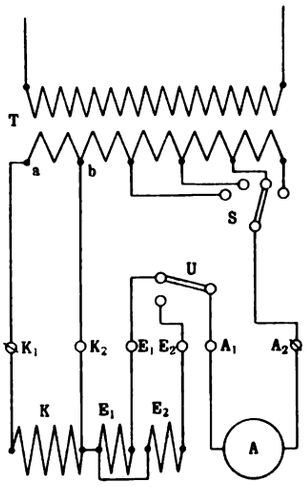

FIG. 7.

K is the compensating winding, E_1 and E_2 the series winding, U the reversing switch, A the armature, and S the starting switch. The compensating winding K is supplied at a constant voltage from two fixed points, *a* and *b*, in the secondary of the transformer T.

REPORT ON TEST OF 1,000 kw. B.T.-H. TURBO-ALTERNATOR SET.

Below are given the results of an official test made at the contractor's works on a 1,000 kw. Curtis steam turbine supplied to the Lancashire United Tramways (Ltd.) by the British Thomson-Houston Co. (Ltd.), of Rugby. The tests were carried out under the supervision of Prof. E. Wilson, of King's College, London, and Mr. J. R. Salter, engineer and manager to the Lancashire United Tramways (Ltd.).

The turbo-alternator set consisted of a vertical Curtis steam turbine, mounted on a sub base condenser, running at a speed of 1,500 revs. per min., driving a two-phase alternator capable of giving a continuous output of 1,000 kw. (1,250 k.v.a.) with 80 per cent. power factor, the pressure being 7,500 volts and the frequency 50. The steam consumption tests were made by measuring the amount of water discharged into the hot well, the power taken by the air and circulating pumps being excluded. The test was run in the following order: Half-load for two hours, full load for six hours, 1¼ load for one hour, after which the voltage regulation and insulation tests were taken. In Table I. is given a summary of the electrical readings obtained during the run, whilst Table II. gives the steam-consumption figures. Fig. 1 shows the turbine set mounted on its

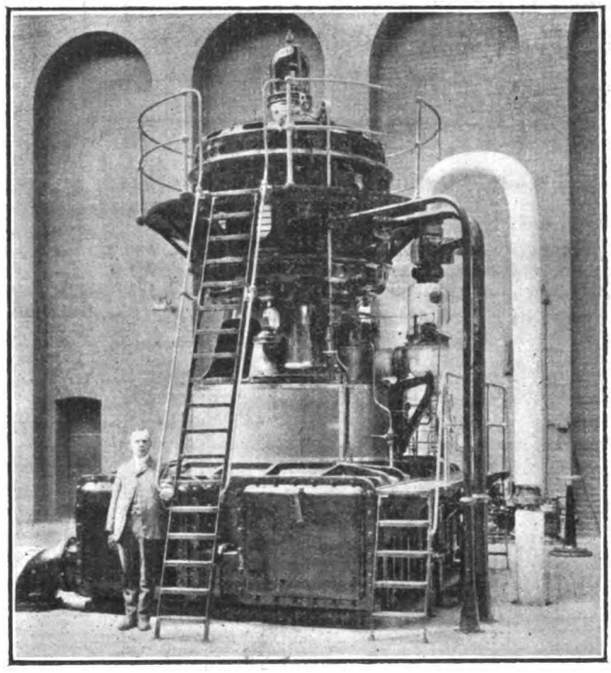

FIG. 1.—1,000 KW. CURTIS B.T.-H. TURBO-ALTERNATOR.

sub-base condenser, with electrically driven air pumps, as erected in the power station of the Lancashire United Tramways Co. at Atherton.

Steam Consumption.—The specification provided that the test for steam consumption should be made under the following conditions:—(1) A steam pressure of 150 lb. per square inch at the stop valve; (2) a vacuum of 28 in. with the circulating water at a temperature not exceeding 80°F., and when the power absorbed by air and circulating pump motors does not exceed 52 kw.

The guarantees were as follows: 1¼ load, 20 lb.; full load, 19·3 lb.; half load, 21·8 lb. The full load figures were subject to a penalty or bonus of £50 for every 1 per cent. variation.

In each of the tests the rate of consumption in pounds of steam per hour has been obtained from the log sheets between the times

Table I.

—	Load. Average volts per phase.	Average amperes. Phase 1.	Average amperes. Phase 2.	Average kw. from watt-hour meters. Phase 1.	Average kw. from watt-hour meters. Phase 2.	Average k.v.a. Phase 1.	Average k.v.a. Phase 2.	Excitation. Volts across field coil. Start of test.	Volts across field coil. End of test.	Average amperes.	Kilowatts in field coil. Start of test.	Kilowatts in field coil. End of test.	Kilowatts at 110 volts.
Half load	7,500	33·7	33·5	..	..	252	251	60·5	66·5	69·5	4·17	4·65	7·65
Full load	7,500	66·7	66·4	506	505	500	498	71·0	75·0	75·0	5·31	5·63	8.25
1¼ load	7,500	85·4	85·0	643	638	640	637	79·5	81·0	79·4	6·29	6·45	8.73

Table II.

Time.	Load.	Steam. Press. in lb. per sq. in.	Steam. Temp. Fahr.	Steam. Suph't. Fahr.	Exhaust vacuum.	Barometer.	Temperature of circulating water. In.	Temperature of circulating water. Out.	Lb. of steam per hour.	Total kilowatt hours.	Kilowatt hours due to field coil.	Net kilowatt hours.	Lb. of steam per kw. hour.
7:30 to 8:30 p.m.	Half	153	384	18	28·65	29·60	35	47	9,650	503	4·65	498·4	19·4
9:36 p.m. to 2:6 a.m..	Full	153	389	22	28·82	29·66	35	51	17,100	1,011	5·63	1,005·4	17·0
2:30 a.m to 3:30 a.m.	Full	153	466	100	28·88	29·72	35	51	15,940	1,011	5·63	1,005·4	15 9
4 to 5 a.m.	1¼	148	508	145	28 77	29·72	35	54	19,390	1,281	6·45	1,274·6	15·2

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set out in Table II., the test being made by measuring the amount of water discharged into two tanks. The 30 cwt. platform weighing machines used during the test have been certified as accurate by the

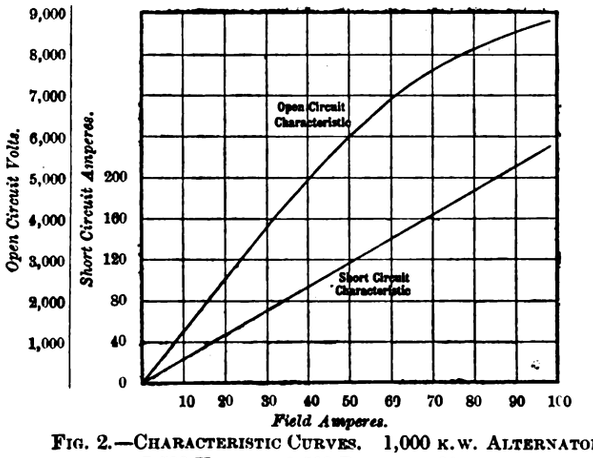

FIG. 2.—CHARACTERISTIC CURVES. 1,000 K.W. ALTERNATOR. 7,500 VOLTS AT 1,500 REVS. PER MINUTE.

Government inspector of weights and measures, and all electrical measuring instruments were calibrated by the Board of Trade after the test. Correcting the test results at full load to specification conditions as regards (1) steam pressure, (2) superheat (3) vacuum,

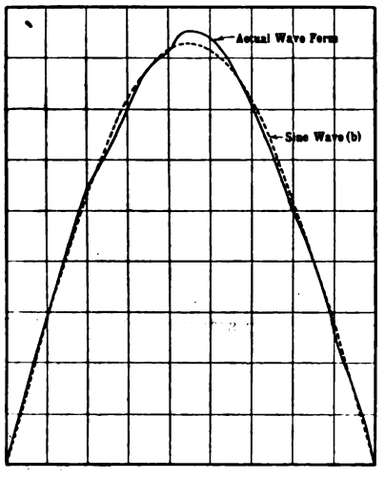

FIG. 3.—HALF-LOAD TEST.

and allowing for excitation losses and lubricating pump (9·8 kw.), the full-load figures work out to 18·5 lb. per kilowatt-hour. This is 4 per cent. better than the guarantee, which thus entitles the contractors to a bonus of £200.

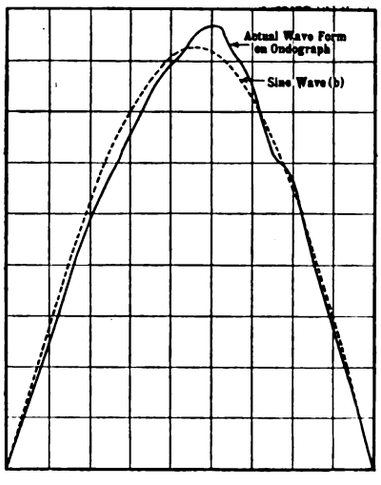

FIG. 4.—FULL-LOAD TEST.

Temperature Rise.—The specification allows a rise of 75°F. in temperature after a 10 hours' run at full non-inductive load. When the rise was calculated from the air temperature 15 ft. from the centre of the turbine, the highest value given, near the steam pipe, was 39·2°C., whereas it was 31·2°C. if the air temperature was measured at the intake to the stator; in either case the rise is within the specification limits. The temperature rises have been checked by resistance measurements, and agree closely.

Voltage Regulation.—The percentage variation from 7,500 volts at full non-inductive load was 5·75, as against the specified limit of 6 per cent. The short-circuit characteristic (Fig. 2) has enabled an approximate idea to be formed as to what the regulation will be on inductive loads. It will be seen that the field coil, according to theory, will have to be supplied with the full 110 volts for the requisite excitation of about 115 amperes when the generator is hot.

Figs. 3, 4 and 5 give the wave forms obtained by an ondograph, and the equivalent sine curve has been superposed thereon; that is, the curve marked (*b*) in each of the figures which would give the same reading on the same voltmeter that the actual curve gave.

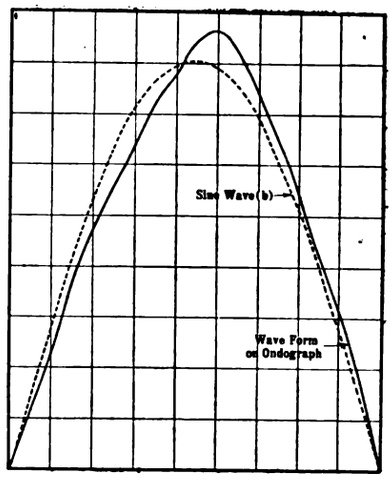

FIG. 5.—25 PER CENT. OVERLOAD TEST.

The deviation from a sine curve is not beyond the limit given in the specification and is satisfactory. The deviation becomes more pronounced as the load is increased, on account of the increased armature reaction.

SUMPNER'S ALTERNATING-CURRENT WATTMETERS.

The instruments here described and illustrated are of a special shunt-magnet type, designed by Dr. W. E. Sumpner and manufactured by the General Electric Co. In their construction a strong

FIG. 1.

magnetic field is produced by an iron-cored electromagnet, having a narrow air-gap much the same as in the permanent magnet type for continuous current. The sensitiveness thus secured makes it possible to use a strong spring to control the deflection of the

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moving-coil system, whilst external magnetic fields have no influence on the readings. Iron-cored electromagnets have previously been tried in such instruments, but, as is well known, the effects arising from varying permeability and hysteresis in the core have rendered such instruments inaccurate. By taking advantage of the properties of the shunt-magnet, Dr. Sumpner has shown how to use iron in such a way that variations in the magnetic reluctance of the core do not affect the accuracy of the instrument readings. The magnetism of the shunt-magnet is caused and controlled by the applied voltage, and the relationship between the two is not affected by any change in the reluctance of the magnetic circuit, when certain conditions are fulfilled. A change in the magnetic reluctance affects the ratio of the magnetism to the magnetising current, but does not alter the relationship of the magnetism to the magnetising voltage, provided that the resistance of the windings is so small that product of this resistance and the magnetising current is a negligible the fraction of the whole voltage applied to the coil. The strength of the magnetic field in the air-gap is governed by the applied voltage in accordance with a precise mathematical law, but the field and the voltage are not in phase with one another, and a special quadrature transformer has to be used to supply the moving coil with a suitable current, in order to make the instrument indications a true measure of the power or voltage tested.

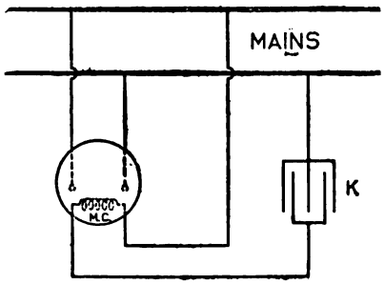

FIG. 2.

For the wattmeter this transformer consists of two fixed coils, the primary of which is traversed by the main current, while the secondary is joined up through a resistance to the moving coil. The two coils of this transformer have a constant coefficient of mutual induction, and the resistance used in the secondary circuit is such as to make that circuit essentially non-inductive. For the voltmeter, the transformer consists simply of a condenser, joined up in series with the moving coil, and applied, like the electromagnet, to the voltage to be measured. It is claimed that changes of frequency or wave form have no measurable effect on the indications of the voltmeter, and the readings of the wattmeter are quite accurate on circuits of high power factor for all voltages, current, frequencies and wave forms. The error in the reading is said to be less than 1 per cent. of the scale length, however low the power factor of the circuit may be. The error of the wattmeter for loads of power factor greater than 0·7 is quite negligible.

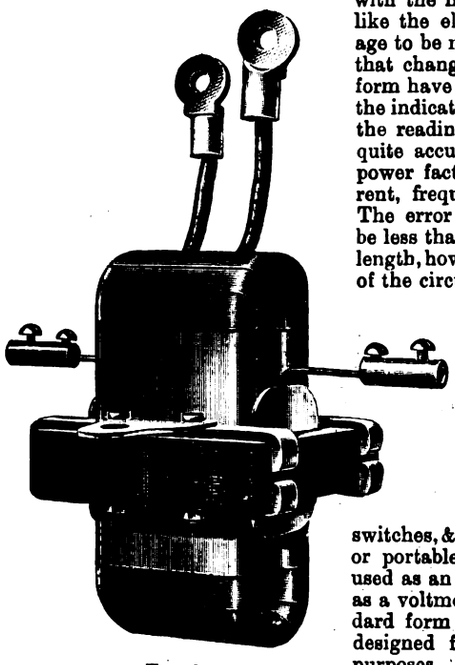
FIG. 3.

Wattmeters are made in two patterns, switchboard type and portable type (*see* Fig. 1), and by a suitable arrangement of switches, &c., either the switchboard or portable standard type can be used as an idle current ammeter or as a voltmeter. The portable standard form of instrument has been designed for general experimental purposes. It is provided with two scales, one for volts and the other for watts. Normally, it can be used as a voltmeter having two ranges, or as a wattmeter having two ranges for volts and three ranges for amperes. The switching arrangements provided are such that the moving coil can be connected up to any condenser, transformer or other device for some special experimental purpose. One of the scales supplied will apply to the measurements made if the correct constant be ascertained in each case. The behaviour of these instruments has formed the subject of an exhaustive series of tests by Dr. Sumpner, and the results have been embodied in two Papers published in the *Proceedings* of the Institution of Electrical Engineers.

The construction of the magneto-static voltmeter is identical with that of the wattmeter already described, and consists essentially of an iron-cored electromagnet and a moving coil which turns in the strong magnetic field produced by the electromagnet, a condenser being placed in series with the moving coil. The terminals of this moving coil with the condenser in series are joined in parallel with the electromagnet across the mains, as shown in Fig. 2. The strength of the magnet is directly proportional to the voltage applied to the coil, and inversely proportional to the frequency of the current. Although the indications of the instrument are independent of variations in frequency or wave form, provided the core does not become excessively magnetised, it is clear that to prevent this the voltage used for each instrument must be kept below a certain maximum for circuits of a given frequency. The General Electric Co. also supply quadrature transformers (*see* Fig. 3) for use with their alternating-current wattmeters.

CORRESPONDENCE.

MECHANICAL ACTION OF CURRENTS ON CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the article in your current issue under the above title a curious error has crept into the explanation of the motions produced in liquid conductors. The calculation of the pressure from equation 2 (p. 830) is right enough (the formula ought to contain an expression for the permeability of the material in the numerator), but this pressure can no more cause circulation in a circular cylinder than the hydrostatic pressure in a closed tank can cause motion of the liquid there. The circulation does not take place in the manner shown in Fig. 7, and it is not due to the total radial pressure, but to differences in that pressure caused by differences in cross-section.

So long as the conductor is parallel-sided, the pressure due to the current tends merely to draw it into a circular cross-section, and no motion of the kind described can occur. But if the section of one part is reduced, the formula shows that the central pressure there will be greater than at the neighbouring sections. If the conductor is a fluid the pressure is exerted in all directions, and consequently the liquid will be squeezed, axially, out of the small section. This makes it still smaller, exaggerates the pressure difference and finally produces rupture.

In the case of a liquid in a groove the same actions occur, but the weight of the liquid keeps it in the bottom of the groove. The squeezing action then causes a depression of the surface at the small place and an elevation at the larger places. Gravity then causes a flow towards the small place along the whole periphery, but mostly along the upper surface owing to the smaller frictional resistance of the air compared with the sides of the groove. If the current be not too large, a steady state will be attained with a certain depression which will cause the surface inflow due to gravity to just balance the axial outflow produced by the current. But if the current is large enough rupture will take place.

Considering the matter from the energy point of view, work is done when the liquid moves radially. Owing to the greater pressure difference between the periphery and centre at the small section more energy is received by the liquid moving in there than is given out by it on moving out at the larger section. The balance is spent in the friction of the circulation.

The E.M.F.s mentioned in the article, being based on the assumed motions, are also quite wrong. In fact, they are impossible, as they would not absorb from the current the power required for maintaining the circulation, but with the deviation of the current which it is assumed they would produce they would actually give energy to the current. The radial motion of the liquid causes an E.M.F. parallel to the axis, which opposes the current in the narrow part and helps it in the wider part, where the liquid flows outwards. If the conductor is symmetrical about its axis this will cause no change in the distribution of the current, but will, on the whole, absorb the small power required to maintain the circulation. The motion parallel to the axis will give rise to radial E.M.F.s which act towards the centre where the motion is in the way of the current, and from it where the motion is against the current. These E.M.F.s will cause currents to flow towards the still parts of the liquid, which will complete their circuit against

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the main current along the motion streams, and with the main current in the still liquid between. The net result is that the parts of any section where there is no motion across the section carry more, and the remainder less, than their proper share of the current, but this effect is very small owing to the smallness of the E.M.F.s.—I am, &c.,

DAVID ROBERTSON.

Merchant Venturers' College, Bristol, Sept. 9.

[In another column our readers will find an article dealing fully with this subject.—ED., *E.*]

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

A junior assistant engineer is required in the business development section of Birmingham Corporation electric supply department. Applicants must have technical knowledge of the applications of electricity for lighting, and preference will be given to one with previous experience in designing and carrying out lighting installations. Commencing salary £100, rising to £150 per annum. Applications to the city electrical engineer (Mr. R. A. Chattock, M.I.E.E.), 14, Dale End, Birmingham, by Tuesday, Sept. 17. See also an advertisement.

Hammersmith (London) Bor ough Council require an assistant engineer, whose chief duty will be to act as canvasser and agent for the electricity department. Salary £2. 10s. per week, rising by annual increments of 5s. per week to £3. Candidates must have practical knowledge of the latest applications of electricity for lighting, heating and power and be competent to organise and take charge of a publicity branch of the department. Applications, on forms to be obtained from the borough electrical engineer (Mr. G. G. Bell), 85, Fulham Palace-road, Hammersmith, W., must be delivered to him by noon Sept. 20. See also an advertisement.

The Electric Construction Co. (Ltd.) require at Wolverhampton a thoroughly qualified designer of d.c plant of all sizes. Applicants must have had good theoretical training and possess up-to-date practical experience. Applications to the managing director, Dashwood House, 9, New Broad-street, London, E.C. See an advertisement.

A chief lecturer in mechanical engineering is required for the Auckland (New Zealand) Technical College. Candidates must have had good workshop experience, and, if possible, possess a diploma or degree in engineering. Salary £300 per annum. Particulars from the director of technical education and manual training (Mr. Geo. George, F.I.C., F.C.S.), c/o the High Commissioner for New Zealand, 13, Victoria-street, London, S.W. Applications by Oct. 8. See also an advertisement.

A lecturer and demonstrator in physics is wanted for the municipal technical college, Derby. Commencing salary £120, rising to £180. Particulars and application forms from the registrar. See an advertisement.

An engineer is wanted in the London district with first-class experience in the preparation of estimates for heavy electric power-plant and machinery. See an advertisement.

Capable electricians are wanted for English railways abroad. Experience in dynamos, accumulators and railway work and knowledge of Spanish necessary. See an advertisement.

An outdoor representative is required to call upon power and lighting consumers. See an advertisement.

Beckenham Council require a storekeeper for their electricity department. Wages 30s. Applications by 4 p.m. Sept. 23.

Battersea (London) Council want a shift engineer. Commencing salary £117. Applications to Town Clerk by noon Sept. 26.

Applications are invited for the position of chief lecturer in electrical engineering at the Bradford Technical College. Commencing salary £200 per annum. Particulars of duties and forms of application may be obtained from Prof. G. F. Charnock. Applications to the secretary of the Education committee (Mr. Thos. Garbutt), Education Office, Manor-road, Bradford, by Sept. 16.

Bristol Merchant Venturers' Technical College require a temporary assistant teacher for physics. Salary £3 per week. Particulars from the Registrar.

A mechanical instructor is required in the engineering workshops of Battersea (London) Polytechnic. Wages 40s. per week. Particulars from the Secretary.

A switchboard attendant is required for Kilmarnock electricity department. Applications to the Engineer by Sept. 17.

Mr. J. W. Groves and Mr. J. Sheridan, first-class staff engineers in the Postal Telegraph Department, have been appointed superintending engineers to succeed Mr. H. Haskayne and Mr. Geo. Cheetham, who have retired.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

King's College, London.—The Michaelmas term of the faculty of engineering and applied science commences on Wednesday, Oct. 2. A list of the teaching staff appears in an advertisement. Evening classes are held for civil, mechanical and electrical engineering, workshop practice, drawing, metallurgy, mathematics, physics and all science subjects. Prospectuses and further information can be obtained from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

University College, Bristol.—There are courses at this college for civil, mechanical, electrical and mining engineers and surveyors, and special facilities are offered in the way of college scholarships and engineering works scholarships. A diploma is awarded to students who pass the qualifying examinations, and the associateship of the college is conferred on students who obtain a first-class senior diploma. Applications for vacancies in October should be made to the registrar and secretary (Mr. James Rafter), from whom prospectuses, &c., may be obtained.

There are also lectures on inorganic, organic and physical chemistry, and the laboratories are fitted with the most recent improvements for study and research in chemistry and metallurgy.

Battersea Polytechnic (Battersea, London, S.W.)—The next term commences on Sept. 23. There are technical day college courses in mechanical, electrical and chemical engineering at this Polytechnic. The day courses are in preparation for London University engineering degree under recognised teachers. There are also evening courses in preparation for the engineering degree and evening classes in all mechanical and electrical engineering subjects. The evening courses begin on Sept. 30. Prospectuses from the Secretary.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms.

Evening technical courses in all branches of electrical and mechanical engineering commence on Monday, 23rd inst. The laboratories are well equipped for both alternate (single and polyphase) and continuous-current work and for all kinds of electrical testing.

Particulars as to fees, &c., can be obtained at the Institute, St. John's-street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

Hackney (London) Technical Institute.—The next session commences on Sept. 23. Evening lectures and laboratory courses are held in electrical engineering subjects, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses, &c., from the Principal, Dalston-lane, London, N.E.

Borough Polytechnic Institute.—A four years' course in electrical engineering is given at this Institute. There are also special courses in electric wiremen's work, the construction and design of electrical appliances and workshop fittings, &c. Detailed syllabus of courses can be obtained from the Institute, 103, Borough-road, London, S.E.

Sir John Cass Technical Institute (Aldgate, London, E.)—At this Institutethere are evening classes in chemistry, metallurgy, physics and mathematics, designed to meet the requirements of those engaged in the chemical, metallurgical and electrical industries, &c. Facilities are given for special and advanced practical work in well-equipped laboratories, both in the afternoon and evening. The new session begins on 23rd inst. Details of the classes may be obtained at the offices of the institute, or from the principal, Mr. Chas. A. Keane, M.Sc., Ph.D.

South-Western Polytechnic (London).—At this Polytechnic a complete three years' course is given in electrical engineering during the day and a four years' course in the evening. There are courses of lectures and practical work in elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, electrical wiring and fitting and the calculus for engineers.

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Argentina.—The "Review of the River Plate" says the plans and conditions for the construction of the Buenos Ayres Municipal underground railway have been forwarded to the Argentine Legations and Consulates abroad.

Mr. B. Saez has obtained a 30 years' concession to establish and operate a telephone system in General Pico (Pampa Central).

Australasia.—The agreement for the extension of the Fremantle tramways to North Fremantle has been signed. Cost of construction and equipment is estimated at £10,000.

The Waterholes Dredging Co. (Emmaville, N.S.W.) have put down electric generating plant for pumping and lighting. Current is supplied by a 35 H.P. generator on a barge.

Electric hauling plant is to be installed at the Chiltern Valley Consols Gold Mines, Victoria.

Electric coal cutters are now used at the Blackheath (Queensland) Colliery.

The Charters Towers (Queensland) Botanic Gardens are to be lighted by 44 flame arcs and about 30 incandescents.

Under the new toll system of charges for telephone facilities 4,300 applications for instruments have been received in five months ended June 30 last, whereas the total for the whole of last year, under the old system, was only 3,881.

The charge for conversations on the new Melbourne-Sydney trunk line (600 miles in length) has been reduced from 6s. to 5s. for three minutes or 2s. 6d. for three minutes between 8 p.m. and 8 a.m. Trunk call charges over shorter distances have also been reduced, the minimum being 2d. for 15 miles.

Award.—The British Westinghouse Co. have been awarded one gold medal for the best 25 B.H.P. gas engine and a second gold medal for the best general electrical exhibit at the Christchurch (N.Z.) Exhibition.

Ayr.—The Council have decided to apply for a provisional order to extend the tramways to the new racecourse.

Battersea (London).—The Council have agreed to supply electrical energy to the premises of the Grondal Kjellin Electric Furnace Co. at Nine Elms.

Mr. C. J. Mann has been elected chairman of the Lighting committee.

Mr. J. G. Westlake has resigned his appointment as shift engineer at the electricity works.

Bournemouth.—In connection with the new undercliff drive which is being constructed by the Corporation, Messrs. R. Waygood & Co. are constructing an electric passenger lift which will give easy access from the sands to the top of the cliffs.

Bray (Ireland).—The Council discussed the position of the electricity works last week.

Mr. BRADSHAW, referring to the recommendation of the Electric Light committee not to proceed with the proposed sale of the works, said the conditions imposed by the Board of Trade were such as to preclude purchase by anyone. He proposed that the electric light accounts be made up to date, that a balance-sheet be struck showing the financial position, that from Sept. 30 the management of the works be under the direct supervision of a committee of the Council, who undertake to personally superintend its management, that one of the present officials in the Town Clerk's office be deputed to open a special set of books for the undertaking in an office situated in the works, that a separate banking account be kept, and that until such time as the works are put on a firm financial position and made at least self-supporting the charge for current be increased to the maximum price laid down in the Electric Lighting Order, 1896.

The chairman of the Electric Lighting committee (Mr. M'CORMICK) said that before Mr. Bradshaw joined the Council they tried the experiment of having the Electric Light committee meetings in the works, and it proved unsatisfactory, both as to the working of the concern and obtaining of records or references. They had an excellent engineer and manager who was very careful, but the next might assume an authority which might compromise the Council further than they intended or had power to go. He held that the resolution really reduced itself to the question of increasing the price of current, and he learned from the engineer that the very suggestion that they might to do so had an injurious effect.

Mr. LEE argued that the undertaking was in a satisfactory position. They paid £931 in interest and sinking fund, which might not be enough, but it was a substantial sum, and would be called profit in a trading concern.

Mr. M'CORMICK agreed to the matter being referred to the Electric Light committee if the suggestion to increase the price of current were deleted from the reference.

Mr. BRADSHAW agreed to do so and the amended resolution was then adopted unanimously.

Brighton.—Portslade, Southwick and Shoreham Councils have appointed a joint committee to consider an offer by Brighton Corporation to supply electricity in their districts.

Sanction has been received by the Council to a loan of £2,843 for electricity meters, repayable in five years.

Bristol.—An inquiry was held on Tuesday into the application of the Corporation for sanction to borrow £34,000 for the Avonmouth electricity works.

The Town Clerk (Mr. E. J. Taylor) gave the usual particulars as to assessable value, outstanding loans, &c., and explained that the Corporation were constructing a new dock at Avonmouth, where a large supply of current would be required. It was felt that the present was an opportune time for developing the Bristol electrical undertaking in the direction of Avonmouth, which was a considerable distance from the generating station. With a view to seeing if the Corporation could supply current at Avonmouth, negotiations took place between the Electrical and Docks committees. The reason why the Corporation should supply the current was that the Docks committee could only supply themselves but not any other consumer. The result of the negotiations was that the Docks committee undertook to take 500,000 units per annum at 2d. per unit, an all-round charge for power and lighting, the Electrical committee to make the supply as they thought fit. Those arrangements were subject to revision from time to time, so that as the business at Avonmouth increased and more customers took current the arrangements would be revised. In addition to the 2d. per unit, £150 a year was to be paid, so that the Docks committee should have the current for power at two distinct pressures, 500 volts for the new dock and 250 volts for the old dock. The change from 500 to 250 volts involved the extra expense. In the application they asked for a loan of £34,600 but that would be reduced by £2,700, leaving £31,900, because the Board of Trade had now given their consent to the laying of three cables in one trench, instead of two as formerly required.

The city electrical engineer (Mr. H. Faraday Proctor) gave particulars as to the estimate for laying the cables to Avonmouth. He said that he had shown the Electrical committee that the cost of generation by the utilisation of the Temple Back plant was greater than the transmission scheme.

The INSPECTOR (Mr. H. ROSS HOOPER): Now I want the proof.

Mr. PROCTOR then supplied figures as to the comparative cost of the two schemes. He was pressed for further details, and said he could not supply figures concerning matters which had not come before the committee.

The INSPECTOR stated that, in view of want of evidence on certain points, he would adjourn the inquiry until Oct. 1.

Burnley.—Owing to the increasing demand for electricity, the Electricity committee are considering the question of the extension of the electricity station.

Calverley.—Negotiations are proceeding between Leeds Corporation and Calverley Council in regard to the transfer of the Calverley tramway order and the construction of tramways in the district.

Leeds Tramways committee offer the following terms: (1) The Council to maintain the tramway powers by applying for extension of time of order; (2) the Council to pay net cost of order and transfer; (3) Line to be constructed, say, to Post Office, and order to be transferred to Leeds; (4) Leeds Council to maintain road; and (5) local contribution towards loss during earlier years.

Colchester.—The Council have decided to purchase mechanical stokers for the electricity station at an estimated cost of £1,018, to be paid for out of revenue by four yearly payments.

Crook.—The County of Durham Electrical Power Distribution Co. have informed the Council that a supply of electricity will probably be available in this district by January.

Dowlais.—Dowlais Chamber of Trade have appointed a deputation to wait on the manager of the Merthyr Electric Traction & Lighting Co. to urge the construction of an electric tramway from Dowlais to Pant.

Dudley.—Application has been made for sanction to a loan of £95,000 for the purchase of the tramways and light railways in the borough.

At the meeting of the Corporation on Tuesday it was decided to replace the existing arc lamps by smaller ones. It was estimated that the smaller lamps would cost about £3. 10s. each, would use about half the current of the existing lamps, and would consume fewer carbons. The smaller lamps are to be placed on the tram poles and to be fed by two cables. The cost of carrying out the scheme is put at about £1,200, representing an annual charge for interest and sinking fund of £90.

Dundee.—The Town Council have decided not to accept any of the tenders lately received for high and low-tension cables, but will issue fresh specifications immediately and call for new quotations. In coming to this decision the Council were influenced by the position of the copper market, the price of copper having fallen considerably since the issue of the specifications.

The solicitors of the Electrical Contractors' Associatian (Messrs. Turner & Co.) have been in communication with the Electricity committee in regard to the power to let electric motors on hire, &c., which is to be sought by the Corporation.

The association threaten to oppose the provisional order unless the Corporation agree to insert a clause prohibiting the Corporation from carrying out wiring work except through the agency of a contractor.

East Ham.—The Council have received sanction to a loan of £4,000 for mains extensions.

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Edinburgh.—The Electric Lighting committee recommend the Council to reduce the price of electric current for private lighting from 3d. to 2¾d. per unit. The proposed reduction represents about £7,000 revenue per annum.

Exhibition.—An exhibition of electric light fittings, lamps, motors, &c., which has been organised by Devonport Corporation electricity department, was opened by the Mayor (Mr. W. J. Moon) yesterday (Thursday).

There are a number of interesting exhibits, including cooking and heating apparatus, electric motors driving printing and other machinery, electric lamps and fittings, telephones, electric clocks, electro-medical and X-ray apparatus, &c. The borough electrical engineer and manager (Mr. J. W. Spark) and the chairman of the Electric Power committee (Mr. H. Banbury) devoted a good deal of time and energy to making arrangements for the exhibition, which has excited considerable interest in the town.

Gillingham (Kent).—The Council have decided to charge consumers who purchase lamps from the electricity department 15 per cent. above the net prices paid by the Council.

Great Yarmouth.—The motormen and conductors on the Corporation tramways have applied for six days' holiday per annum, and the Tramways committee have decided to grant three days.

Grimsby.—At the last meeting of the Public Lighting committee the borough electrical engineer (Mr. W. A. Vignoles) reported that the load upon the generating plant was increasing even faster than had been anticipated. The plant would be fully loaded during the coming winter, leaving very little margin for maintenance of a satisfactory supply in case of breakdown. That was not a desirable position to be in, as any failure (even of a temporary character) would prove highly detrimental to the progress of the undertaking. In view of the rapid development going on at the docks, the probability was that the plant would become heavily overloaded, and the committee, therefore, decided to proceed with the erection of the new extension plant, which will increase the power of the station by 316 kw.

The L.G. Board have sanctioned a loan of £1,964, repayable in 18 years, for additional plant.

Hackney (London).—The electric lighting mains are to be extended to Gunton-road and Wick-road.

Harrogate.—Application has been made by the Council for sanction to borrow £16,000 for extensions of the electricity undertaking.

Hinckley.—The Council will oppose an application of a company for a provisional order.

India.—"Indian Engineering" states that electric power plant has been installed for working the water-hoisting pumps at the Tara Devi station of the Kalka-Simla Railway. The question of the adoption of electric traction appears to have been dropped for the present.

Inquest.—An inquest was held at Seaham Harbour on Monday on two men (named Dunn and Attwood) who were killed on Friday last at Dawdon Colliery.

William Pigg, banksman at the colliery, said that at 4:45 p.m. on Friday shots were fired in the pit. Immediately afterwards six men (including Attwood and Dunn) went down the pit in a kibble, witness being in charge at the top of the shaft. The chargeman in the kibble rapped to witness "hold," and witness signalled to the brakesman, who stopped the kibble. The electric lamp in the shaft was still travelling when witness heard a noise in the shaft, and he gave the order to stop the engine lowering the lamp cable. The engine, however, had already stopped through losing the weight of the cable. When he looked down the shaft he saw the cable lying slack round the wheel at the top of the shaft. Raps were heard on the kibble, and those at the bank thought they must be cutting the wire rope. The chargeman was heard to shout as the kibble approached the surface, "Send for the doctor." The manager (Mr. Wood) was soon on the spot, and the men were got out of the kibble. Dunn was taken to the colliery office, where he died, and Attwood was dead on reaching the surface. Witness thought the lamp would be from 10 to 15 fathoms from the bottom of the shaft; he could not give any explanation as to the cause of the cable breaking.

James Swinburne, enginewright, said it was his duty every 24 hours to examine the electric lamp cable, and he did so that morning. The cable had been in use since March, 1906, and was obtained new from Messrs. Reid, Ferens & Co. Witness examined the cable as it travelled slowly past him; it did not pass through his hand. As far as he could judge, everything was in proper working order. In his opinion fusing caused the cable to break. He did not think there was any flaw in the cable.

J. W. Johnson, sinker, said he was one of the men who went down in the kibble. When they had descended to about 15 fathoms from the bottom the cable parted. Before the accident the chargeman rapped "hold" in order to examine the shaft, and as they were just looking round they heard a noise, but could not tell what it was. Immediately after the electric lamp cable fell upon them, winding itself round the kibble rope, and it fell in a heap on the bow of the kibble. Witness was standing up, and it caught him on the neck. Attwood was lying in the bottom of the kibble on top of another man named Warlow, having been knocked down. Dunn was lying in the bottom shouting. "Oh, my back."

Mr. A. Andrews, electrical engineer, managing partner of Reid, Ferens & Co., said they supplied the electric cable. Before being sent out cables were thoroughly tested. The cable was placed in position under witness's personal supervision, and he considered it to be of ample weight and structure for the purpose for which it was used. It was wrapped with jute, and then armoured with 29 galvanised iron wires. Finally it was dressed with jute and copper wire to make it waterproof. The cable was stronger than that usually supplied for that purpose. He had examined the cable since the accident and was of the opinion that it had broken through fusion. There were no means of providing against fusion. The examination made by Swinburne was all that seemed necessary. The heat generated at the point of fusion would lower the breaking strain of the armour.

Mr. R. Curry, engineer to the Londonderry Collieries, agreed with the last two witnesses.

The jury returned a verdict of accidental death in each case.

Kirkcaldy.—On Monday the Council postponed consideration of the recommendation of the Tramways committee to increase the salary of the borough electrical engineer and tramways manager (Mr. O. F. Francis) from £300 to £350, but the Finance committee have been instructed to report once a year (in March) upon the salaries of municipal officials.

Light Railways.—The Clacton and St Osyth Light Railway (extension of time) Order, 1907, has been submitted to the Board of Trade for confirmation. Objections by Sept. 28.

The promoters of the Blackburn, Padiham and Whalley light railway are seeking an extension of 18 months for constructing the line.

London Brighton & South Coast Railway Electrification.—The "Daily News" reports that the directors anticipate being able to introduce within six months a regular 10-minute electric service between London Bridge and Victoria, by way of East Brixton and Peckham Rye. The journey will occupy 25 minutes from end to end. If the experiment is as successful as the company hope, "electrification" will be applied gradually to the entire Brighton surburban system. The line will be equipped on the single-phase overhead system and each train will be capable of carrying 564 passengers and will consist of three coaches, with a motor at either end, and will be built throughout of fire-proof material.

Longton.—The Council have received sanction to a loan of £2,000 for additional plant at the electricity works.

Lowestoft.—The Electric Lighting committee reported on Tuesday that there were 784 consumers, representing the equivalent of 39,430 8 c.p. lamps connected to the mains.

Luton.—The Council have obtained an extension to Aug. 11, 1908, for completing the tramways, and sanction has been received to a loan of £65,000 for constructing the system and to a loan of £2,500 for electric generating plant.

Manitoba.—The Provincial Government have let contracts for the construction of a telephone system for the province. A start has been made with Winnipeg, where the central exchange will be established, and as rapidly as possible the system is to be extended to the outlying parts.

Marlborough.—The period of the Council's provisional electric lighting order (1904) has been extended.

Municipal Insurance.—Bury (Lancs.) Borough Treasurer has been instructed to draw up a list of charges for the insurance of employés under the Workmen's Compensation Act, 1906, with a view to the creation of a municipal insurance scheme.

Municipal Ownership.—The United States Commission appointed some time ago to investigate the question of municipal and private ownership of electricity supply, tramway, gas and water undertakings have presented a report on their investigations made in Great Britain.

It is pointed out that in Great Britain, while municipal undertakings have permanent rights, companies' rights are limited, and that, therefore, municipal success in Great Britain should not be accepted as indicative of the certainty of similar results in the United States. The Commission emphasise the fact that the public utilities they were appointed to study are so constituted that it is impossible for them to be regulated by competition. Therefore, they must either be controlled and regulated by Government, or be left to do as they please, or be operated by the public. None of us (the report states) is in favour of leaving them to their own will, and the question is whether it is better to regulate or to operate. There are no particular reasons why the financial results from public or private operations should be different if the conditions are the same. In each case it is a question of the proper man in charge of the business and of local conditions. "We are of opinion that a public utility which concerns the health of the citizens should not be left to individuals where the temptation of profit might produce disastrous results, and therefore it is our judgment that undertakings in which the sanitary motive largely enters should be operated by the public."

A minority report states: "We have come to the conclusion that municipal ownership of public utilities should not be extended to revenue-producing industries which do not involve the public health, the public

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safety, public transportation, or the permanent occupation of public streets or grounds, and that municipal operation should not be undertaken solely for profit; also that all future grants to private companies for the construction and operation of public utilities should be terminable after a certain fixed period, and that meanwhile cities should have the right to purchase the property for operation, lease or sale, paying its fair value." To carry out these recommendations effectively and to protect the rights of the people, it is recommended that the various states should give to their municipalities the authority, upon popular vote, under reasonable regulations, to build and operate public utilities, or to build and lease the same, or to take over works already constructed.

The report proceeds: "Furthermore, we recommend that provision be made for a competent public authority, with power to require, from all public utilities, a uniform system of records and accounts giving all financial data and all information concerning the quality of service and the cost thereof, which data shall be published and distributed to the public like any other official reports; and also that no stock or bonds for public utilities shall be issued without the approval of some competent public authority. We also recommend the consideration of the 'sliding scale,' which has proved successful in some cases in England, in reference to gas, and has been adopted in Boston. In case the management of public utilities is left with private companies, the public should retain in all cases an interest in the growth and profits of the future, either by a share of the profits or a reduction of the charges, the latter being preferable, as it ensures the benefit to those who use the utilities, while a share of the profits benefits the taxpayers.

The Commission states: "Our investigations teach us that no municipal operation is likely to be highly successful that does not provide for (1) An executive manager with full responsibility holding his position during good behaviour; (2) exclusion of political office and personal favouritism from the management of the undertaking; (3) separation of the finances of the undertaking from those of the rest of the city; and (4) exemption from the debt limit of the necessary bond issues for revenue-producing utilities, which shall be a first charge upon the property and revenues of such undertaking."

The Commissioners conclude their report on this section of their labours with the statement that they found in England and Scotland a high type of municipal government, the result of many years of struggle and improvement. Business men seemed to take a pride in serving as city councillors or aldermen, and the government of such cities as Glasgow, Manchester, Birmingham and others included many of the best citizens of the city. Such conditions were distinctly favourable to municipal operations.

Municipal Telephony.—At the meeting of the Brighton Telephone committee last week the chairman (Councillor Lintott) referred to the final balance-sheet of the municipal telephone undertaking, and explained that its presentation had been delayed owing to pressure of work and some difficulty with outstanding accounts.

Although the committee had been freely criticised, the concern had been taken over by the Government without any loss to the ratepayers, and the town had been much improved by the up-to-date and efficient telephone system that now existed. In addition they had paid something like £900 or £1,000 in royalties to the Post Office and £174 per annum to the town hall establishment charges. There was a surplus of £2,509, the disposal of which had not yet been decided upon.

The committee's report was adopted.

The final meeting of the Swansea Telephone committee was held on Friday last.

The borough accountant (Mr. HOPTON) said that on Aug. 10 the Corporation received from the National Telephone Co. a cheque for £26,936. The total amount paid for the undertaking (inclusive of stores) was £31,641. 5s. 3d., but from that certain deductions had to be made in respect of sinking fund, for which the Corporation agreed to allow £2,213. 1s. 8d., unexpired rentals due subsequent to March 31, Post Office royalties, &c. Of the outstanding rentals all had been collected except about £270, and he thought that not more than £100 would have to be wiped out. The profit would be at least £1,000. They had £1,400 surplus profit on March 31, but they would have to pay 4 per cent. to the debenture bondholders up to Nov., 1908.

The Chairman (Councillor D. JONES) commented on the able manner in which Mr. Mackie (the general manager) and his staff had done their work, and moved that the committee place on record its thanks at the able way in which Mr. Mackie and staff had performed their services. The resolution was amplified by including the borough accountant and others, and in this form was adopted.

Northfleet.—Litigation is likely to ensue from the recent action of Gravesend Council refusing to carry out their agreement to supply electricity in Northfleet, the latter Council having decided to take counsel's opinion on the position.

Personal.—Mr. W. Wright, assistant controller of Postal Telegraphs, will act as deputy controller during the absence of Mr. J. Newlands, who is assisting in the reorganisation of the telegraph service in India.

Presentation.—The staff of the Sheffield electric supply department have presented a case of cutlery to Mr. F. A. Dear on his marriage.

Rating Appeal.—At Linlithgow County Court on Tuesday the National Electric Construction Co. and Bo'ness Council appealed against the assessor's valuation of the Bo'ness electricity works. The assessor's valuation was £1,800, and appellants wished the figure reduced to £400, which was the valuation fixed last year. After hearing evidence by Mr. G. W. Spencer Hawes, consulting engineer, and Mr. M'Gowan, the resident engineer, the Court reduced the valuation to £720. Appellants intimated that they would appeal.

Sale.—The experiment in street lighting by arc lamps has proved so satisfactory that the Highways and Lighting committee are considering the question of extensions.

Sheffield.—The electric light department has been authorised to order electric cable to the extent of £24,000, at such times as the copper market is most favourable for the purchase, and the L.G. Board are being asked to give their consent without waiting for the holding of a local loan inquiry.

On Wednesday the traders of High-street and Fargate petitioned the Council to extend electric lighting to these thoroughfares. The report of the Electric Lighting committee recommending the extension of electric lighting from the Town Hall to Blonk-street was referred back for the preparation of estimates.

We refer to a proposed contract with Messrs. Willans & Robinson under "Tenders Accepted."

South Africa.—The "British and South African Export Gazette" says Pretoria Municipality have decided to purchase additional electricity generating plant.

Johannesburg Council have decided to make an arrangement to take 1,300 kw. three-phase current (at 3,000 volts) from Victoria Falls Power Co., and will invite tenders locally for supply of generating plant of 1,000 kw. capacity.

The Natal Government will shortly place orders for material for the electric light and power extension at the Point and Bluff, Durban.

£5,250 is to be expended by Natal Government upon new telephone and telegraph lines, switchboards, &c., for the Greytown telephone exchange.

The Transvaal Government have notified their intention of retiring from the South African Customs Union at the end of June next.

Orders for electric cranes, &c., will be given out shortly in connection with the harbour improvement at Lourenço Marques.

A number of small electric motors and starting switches have recently been ordered through the colonial agents by Cape Town Municipality.

Table Bay Harbour Board are considering the question of ordering a new electric travelling crane for the graving dock, Cape Town.

It is believed that the South African Option Synd. will shortly require an electrical installation.

Stutterheim Municipality will shortly put down electric lighting plant.

Southampton.—The Council are recommended to obtain powers to extend the tramways to the Royal Pier.

Stockport.—Last week the chairman of the Electricity committee (Mr. G. Ball) stated that they proposed to reduce the charge for electric energy for power to a point which would be as low as that of any station in the north of England. Since June, 1906, the output of electricity had more than doubled, and since March, 1906, the total demand had increased from 200 H.P. to 500 H.P.

The sale of current for power would enable the committee in the near future to recommend the Council to reduce the charge for energy for lighting.

Telephone Charges.—The new measured rate system which is being introduced by the National Telephone Co. has caused many of the local authorities to protest against the new tariff. The National Chamber of Trade, which has taken up the question, has called a conference of public bodies for the 26th inst. at Blackburn.

At the recent meeting of the Newcastle Chamber of Commerce, Mr. A. M. J. Ogilvie, assistant secretary of the Post Office, attended and explained the charges. He said it was the Postmaster-General's desire to give an efficient service at a reasonably cheap rate. The underlying main principle of the new system was that the charges should be measured according to the quantity and quality of the service. Telephones had developed, but not to the extent possible. He thought they did not realise the possibilities of the telephone in all departments of life. As the system grew the number of calls made by individual subscribers would grow, and the needs of those who would be served by one line between two or four persons had to be looked after, as well as the interests of those who wanted several lines and separate office exchanges. The new measured rate aimed at meeting all those needs. The measured rate service simple was for a single instrument, with £5 for 500 calls, and a reduction for larger numbers. The maximum number of calls allowed for on that service was 4,500, that number being fixed in view of the probability that such a number of originated calls would fill the line. The filling of the line was one of their great difficulties, and in London 26 per cent. of calls were ineffective owing to that cause. The maximum of 4,500 was fixed at a reduced scale, with the view to additional lines for £4 at 4s. per 100 calls being fixed. Another scale provided for private branch exchanges with extension telephones, two lines being given at £3 each. For private residences a flat rate of £8 a year was given, because no private residence made excessive demands on a telephone and the calls were spread over a greater period of the day. For small users there was a two-party rate for private houses at four guineas per 400 calls. On the

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whole he thought his hearers would consider that was a sound business principle. Their objection was probably to the amount of the charge which was entirely apart from the principle. There might be some misapprehension as to the reasons for the revision and the lack of notice. The reason was that, under the agreement for the purchase of the National Co.'s business, it was arranged to have an interchange of calls, and the Post Office, therefore, had to revise the charges to make them alike. But for that, probably, the existing rates would have been left alone until 1911. The change was due largely to the initiative of the late Mr. W. E. L. Gaine, the late general manager of the National Co., who was a deep student of telephone working and development. The rates adopted were those which the Post Office thought best adapted to the provincial areas as a whole. Newcastle was the largest exchange of the Post Office, and others were expensive. The rates were lower in Newcastle than in those towns where the National Co. had the exclusive right to make the charges, and he thought that showed the Post Office did not unnecessarily raise the prices. It might be said that £5 for 500 calls was too much, but the future could only tell that, and by 1911 they hoped to know better what they ought to charge.

He admitted the variety of rates made the calculation of charges difficult, but there was a reason for it, and he thought the difficulty would pass away. As to the provision of an indicator, he thought they would find in practice it was unnecessary to check calls, because a very careful method was adopted at the exchange, where an indicator like a cyclometer was in use on each call, and if any mistakes were made it would be in favour of the subscribers. The charge for calls would have to be left for further experience to show. The suggestion that the measured service could check development was not borne out by America, where a great development had followed its adoption and the prices were from two to three times as great as those now proposed in England. With regard to the exchange of the flat rate for the measured rate in case of an extension, he could say the rule would not be enforced unreasonably. With regard to the difficulty in contracting in advance, cash would be returned if the full number of calls were not used.

Several members expressed their views, and Mr. Ogilvie, in reply, said the difficulty of an unlimited service was that, as a system grew, the cost grew more rapidly than the number of subscribers. He undertook to have an explanation of the new scale sent to every subscriber, but he could not give an assurance that no change would be made in the charges system if additions were made to the installation. He promised, however, to consider the possibility of substituting public wires when private wires broke down.

Trade Union Congress.—This important Congress, which was held at Bath last week, and was attended by 521 delegates (against 491 in 1906), representing 1,700,000 members.

At the opening sitting on 2nd inst. the Parliamentary Committee, reporting on the year's work in Parliament, gave a summary of the provisions of the several acts which affected labour.

On the vexed question of old-age pensions, the principle of which had been affirmed by the Congress and by special conferences for many years, the Committee recall the fact that the Prime Minister and the Chancellor of the Exchequer have both declared themselves in favour of universal pensions, so that the matter is ripe for treatment. The Trades Disputes and the Workmen's Compensation Bills having been disposed of, the Committee think that a serious effort should now be made in the House of Commons to get old-age pensions.

The report concludes: "We urge our members to take up the following social and industrial reforms: Miners' legal eight-hour day and a reduction of hours in all trades, old-age pensions, the unemployed, compulsory State insurance, land nationalisation, amendment of the Poor Laws, and legal restriction of systematic overtime."

Overtime.—The following resolution was carried unanimously: "That this Congress, believing overtime to be physically and economically evil and detrimental to the best interests of the State and its people, urges the Parliamentary Committee to take all needful steps to secure its speedy abolition."

Factory Act Amendment.—It was decided to instruct the Parliamentary Committee to urge upon the Government the amendment of the Factory and Workshops Acts with regard to prohibiting the running of machines in textile and paper factories and bleaching and dye works, except for repairs, between Saturday noon and Monday 6 a.m.; to make it illegal for workshops to be carried on in dwelling houses; and to prevent the employment of female workers in metal polishing, turning and screwing.

Government Contractors.—On the motion of Mr. G. N. Barnes, M.P., the Parliamentary Committee were instructed to move the following resolution in the House of Commons in the next session: "That, in the opinion of this House, all Government contracts should contain a clause stating that the contractor shall observe the conditions of labour and pay the wages recognised and agreed upon between the employers and trade unions of the districts (the rate to be paid irrespective of piece-work) in which the work is carried on, and a schedule of wages shall be posted in some conspicuous place in the workshops where the work is done; failing such an agreement as to conditions, hours or wages, the agreement in operation in the nearest town or district to that in which the work is carried on shall be taken to apply. Any firm which does not recognise the above-mentioned conditions on all its work, whether Government or otherwise, shall be deemed an unfair house and not eligible to contract for Government work." [It will be noted that this resolution takes no heed of the many contracts placed abroad where trade union conditions do not prevail and cannot be enforced.—Ed.]

Minimum Wage.—A resolution was carried to the effect that the Congress reaffirmed its belief in the justice of the workers' demand for trade union rates of wages in all trades and a minimum wage of 30s. for a 48-hour week for adult workers in the London district.

Bonus and Speed Systems.—By a large majority the following motion was carried: "This Congress is strongly of opinion that the modern methods of increasing the output by the introduction of the premium bonus and feed and speed systems of working is utterly opposed to the principles of trade unionism, inasmuch as it creates a form of sweated labour and acts as a factor in increasing the number of unemployed, and hereby recommends that societies should use every effort to stop the further development of these systems, and to take steps to abolish them wherever they have been introduced. We further call on the Parliamentary committee to take action by deputising the Government Departments to protest against the introduction of the premium bonus system into Government works."

General Eight-Hour Day.—On the motion of Mr. J. R. Clynes, M.P., the following resolution was unanimously passed: "That, in view of the present rapidity of production, the continuous introduction of labour and wage-saving machinery, and the consequent displacement of manual labour in many industries, this Congress declares in favour of a shortening of the hours of labour to not more than eight per day, or 48 hours per week, as a means towards the absorption of many of those workers who are at some season of the year thrown out of employment, and calls on all the organised workers of the United Kingdom to make this one of the test questions at all Parliamentary and municipal elections. The Congress declares that systematic overtime should be abolished in all trades, and instructs the Parliamentary Committee to formulate a general Eight Hours Bill to lay before Parliament next session.

Old-age Pensions.—On the motion of Mr. G. N. Barnes, M.P., it was resolved as follows: "In view of the fact that the question of old-age pensions has been prominently before the country for many years, and that at the recent general election the great majority of the present members of Parliament definitely pledged themselves to support a pension scheme, this Congress expresses its dissatisfaction at the failure of the Government to establish such scheme during the past session of Parliament. It further condemns the Government for surrendering national income by relieving income-tax payers of a million and a quarter of revenue during the present year, which might and should have been devoted to pension purposes. It therefore demands that the Chancellor of the Exchequer shall make provision in his next Budget for the commencement on Jan. 1, 1909, of the payment of pensions of not less than 5s. per week to all persons of 60 years of age and upwards; and, finally, the Congress instructs the Parliamentary committee to initiate and invite the co-operation of the Labour members of Parliament to conduct a vigorous campaign throughout the country during the ensuing winter months with a view of securing the immediate solution of this urgent social problem.

Arbitration in Trade Disputes.—Resolutions in favour of the settlement of trade disputes, &c., by arbitration were rejected.

Tramway Order Transfer.—Whitefield Council give notice of intention to lease to Salford Corporation for 20 years the tramways constructed under the Whitefield Tramways Order, 1900, Salford paying an annual rent of £1,623. 6s.

Wishaw.—On Tuesday the Council decided to promote a provisional order to confer further powers in regard to electricity supply, including the right to wire consumers' premises, and to borrow £3,000 for the undertaking.

Yardley.—A special meeting of the Tramways and Electric Lighting committee has been called to consider the revised terms of Birmingham Corporation for the transfer of the Yardley provisional order.

Sports.—The second annual sports of the Robertson Social and Athletic Club took place on Saturday on the club's ground at Shepherd's Bush.

Mr. F. P. Driver (work's manager), Mr. C. J. Robertson (director) and Mr. A. Heden officiated as judges; and Mrs. C. Wilson presented the prizes. Mr. A. W. Pettitt acted as starter, Mr. H. Purle as timekeeper, Messrs. A. Kirkby, F. Pluck and P. Pring as handicappers, Mr. G. H. Freeman (secretary) was also present, and a goodly crowd of other officials of the company. The ground was brilliantly illuminated by Robertson fairy lamps, and presented a pretty sight. The total attendance was between 700 to 800. There were 305 entries for races, the chief events being the men's 100 yd. handicap which was won by Mr. G. H. Freeman from scratch, time 11¼ seconds; a ladies' 3 lap bicycle race, won by Miss D. Dallender, from scratch. Inches only separated the winner from Miss R. Morgan.

Outings.—The annual staff outing of the Armorduct Mfg. Co. took place on Aug. 31. The London staff, accompanied by several of the company's depot managers and friends, joined the launch "Formosa" at Molesey Lock, and proceeded to Old Windsor, luncheon and tea being served on board. Dinner was served at the managing director's residence at Teddington, at eight o'clock. After dinner Mr. Schmahl, in a brief speech, expressed his appreciation of the efforts of the employés on behalf of the company, and accompanied his thanks with an agreeable surprise in the shape of substantial cheques to the staff.

On Saturday last the staff and employés of the Dundee electricity department had their annual outing at Monikie. The weather was good and a very enjoyable time was spent. The sports proved an interesting part of the programme, keen competition being shown, while matches in football and cricket were also enthusiastically entered into.

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ELECTRICITY SUPPLY AND TRAMWAY ACCOUNTS.

Barnstaple.—The report of the independent auditor (Mr. Leicester) appointed to investigate the accounts of the electricity department, states that the deficit is about £1,800, but this figure is arrived at by transferring certain items in the official accounts from capital to revenue account. Mr. Leicester suggests that £2,000 a year should be set aside for depreciation.

Bradford.—Ald. D. Wade made his annual statement of the past year's work of the trading departments of the Corporation on Tuesday, and said the outstanding feature was the small aggregate net profit (£365), having regard to the large capital invested.

With an invested capital of £6,500,000 a net profit of £365 left no margin for contingencies. Unforeseen disasters in gasworks, electricity works, waterworks and tramways—in which last-named department there had recently been experienced an unfortunate illustration—all pointed to the importance of taking into serious consideration the question of improving the small margin which those undertakings provided to meet contingencies. There were, however, surpluses of £4,451 on the electricity supply department and £14,536 on the tramways.

Darlington.—In moving the report of the Electricity and Light Railways committee the chairman (Councillor Wooler) stated that the tramcars carried about 6,000 workmen per day, and return tickets were increasing in number; receipts showed a decrease of £64. 7s. 7d. over last year. By returns from 12 towns of similar size to Darlington, eight showed serious decreases this year—an average of £30 per week—whereas at Darlington the decrease was only £2. 9s. per week.

Holyhead.—There was a profit of £373 on the past year's working of the electricity department.

King's Lynn.—The accounts of the electricity department for the year ended March show capital expenditure £49,766, increase £1,929.

Revenue was £7,052, total expenditure was £3,309, gross profit was £3,742 (compared with £3,631 in previous year). Interest required £1,208 (£1,273), and instalments for repayment of loans £1,924 (£1,814), net profit being £593 (£535). Fuel cost 0·41d. (0 39d.) per unit, works costs were 0·86d. (as in previous year), total expenses 1·20d. (1·24d.) The average prices received were 4·89d. (4·86d.) for private lighting, 2·25d. (2·50d.) for lighting by contract, 1·62d. (1·58d.) for power and 1·83d. (2·05d.) for public lighting, average price for all purposes 2·78d. (3·06d.) 564,072 (508,424) units were generated, 167,563 (163,103) supplied by meter, 5,220 (3,840) by contract, 143,480 (110,423) to motors and 197,766 (183,308) to public lamps. There are 575 (548) private consumers, and the total connections are equivalent to 29,685 (27,081) 8 c.p. lamps. 71 (61) motors of 306 H.P. (242½ H.P.) are connected. The maximum supply demanded was 335 kw. (315 kw.), and the load factor 17·52 (16·71).

Harrogate.—The accounts of the electricity department for the year ended March show capital expenditure £120,101, increase for the year £5,487.

Revenue was £17,301. Total expenditure was £8,057. Gross profit was £9,244. Interest required £3,329, instalment of principal £1,399, and sinking fund £2,427. £621 has been placed to reserve and £1,670 appleid to relief of rates. 1,552,842 units were generated, of which 110,800 were supplied to public lamps, 104,015 by contract and 951,207 by meter. The total maximum demand was 950 kw.

Plymouth.—Dealing with the report of the tramways manager (Mr. Everson) for the past year, Mr. Monk stated at the meeting of the Council on Monday that for the first time in the history of the undertaking they had a clean sheet, and with the exception of the sinking fund charges it was now absolutely free from liability.

The undertaking had a bright future before it. Profit on the past year was £1,352. His predecessor reduced the overdraft on the tramways by £3,200. Since he had been chairman they had paid off a further £5,000. They had paid for renewals, and when they considered the gradients, the price at which they carried passengers, and the price of electric energy, they had every reason to be satisfied with the year's working.

The Tramways committee recommended that no delegate be sent to the annual meeting of the Municipal Tramways Association, but an amendment to send the manager was carried.

Shoreditch (London).—The Electric Light committee has reported that for the year ended March 31 there was a large increase in the sale of current for lighting and power.

4,218,574 units were sold, against 3,702,457 in 1905 6. The total cost had dropped from 2·49d. to 2·28d. per unit, and the revenue had also decreased from 2·55d. to 2·36d. per unit. Net profit was £1,756. 16s. 11d. after meeting all charges, except renewals, and this amount has been placed to reserve to meet cost of change of pressure, &c.

Swansea.—In a report on the progress of the electricity undertaking, presented to the Council last week by the Electric Lighting committee, it was stated that the total units generated (excluding traction) from April 1 to Aug. 29 were 600,653, against 499,658 in the corresponding period of 1906. The number of consumers was 1,017, against 850.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

Dublin Lighting committee invite tenders for supply of 500 alternating-current single-phase meters and 100 three-phase meters. Specifications from the city electrical engineer (Mr. Mark Ruddle), Fleet-street, Dublin. Tenders to the Chairman of the Committee, 8, Cork-hill, Dublin, by noon Sept. 30. See also an advertisement.

London County Council invite tenders for the manufacture, delivery and erection of three electrically-driver boiler feed pumps, each of 9,000 gallons per hour capacity, at the tramways electricity station, East Greenwich. Tenders, upon official forms to be obtained from the clerk of the Council (Mr. G. L Gomme), County Hall, Spring-gardens, S.W., by 11 a.m., Oct. 8.

Aldershot District Council invite tenders for supply of cable (4,400 yds), bitumen (12 tons), troughing (1,100 yds.) and insulators (2,200) in connection with intended extension of mains. Tenders to the clerk (Mr. W. E. Foster), Municipal-buildings, Aldershot, by 9.30 a.m., Sept. 18.

The Committee of Management of the *Londonderry* District Lunatic Asylum invite tenders for supply, delivery and erection of a 22 kw. steam set with brush dynamo, pipe work, switchboard, connections, &c., for extension of plant at the Gransha Asylum. Tenders by 9 a.m., Sept. 20.

Maidstone Corporation want tenders by Oct. 7 for supply and erection of seven electric motors and centrifugal pumps, motor-driven air ejectors, cranes, switchboard, starting switches, &c., and a complete electric-light installation, for the sewage disposal works. Plans from Mr. G. R. Strachan, 9, Victoria-street, London, S.W.

Extension of Time.—The time for sending in tenders to the Town Clerk of *Kirkcaldy* for the construction and erection of steel dock gates and a swing bridge is extended until Oct. 7.

Extension of Time.—The time for sending in tenders for carrying out the City of *Winnipeg* hydro-electric development works at Pont du Bois is extended to Oct. 1.

Hastings Corporation want tenders by noon Sept 17 for six months' supply of best Welsh smokeless coal for the electricity works. Forms from the Borough Electrical Engineer.

Manchester Tramways committee require tenders by 10 a.m. Sept. 17 for supply of hard-drawn copper trolley wire. Specifications from Mr. J. M. M'Elroy, 55, Piccadilly, Manchester.

Aston Manor Corporation want tenders by first post Sept. 16, for supply of 12,000 tons of coal. Forms of tender from the Borough Electrical Engineer.

Swinton and Pendlebury District Council want tenders by Sept. 28 for wiring on the hire-purchase system.

Antwerp Municipal Council invite tenders for an electric lighting installation in the Salle de Fêtes (recently erected in the Place de Meir). Tenders to M. le Bourgmestre, Hotel de Ville, Antwerp, by Oct. 17. A deposit of 8,000 fr. (about £312) is required. Specification from the Hotel de Ville, Antwerp, price 0·50 fr. A copy may be inspected by British firms at the Board of Trade, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Sheffield Finance Consultative and Electric Light committees recommend that a contract be entered into with Messrs. Willans & Robinson for the supply of a 4,000 kw. turbo-generator for Neepsend power station, and that, in view of the urgent necessity for the supply of the plant, the L.G. Board be requested to sanction the ordering of the plant without waiting for the holding of a local loan inquiry.

Grimsby Corporation have accepted the tender of the Phœnix Dynamo Mfg. Co. for a 500 kw. steam dynamo (Belliss engine) at £2,383. The tender of Johnson & Phillips for two years' supply of cables has also been accepted at £1,358. 4s. 3d.

The following contracts have been recently received by Messrs. Johnson & Phillips:—

From the Admiralty, for supply and laying feeder and distributor cables, boxes, &c., for giving supply to the Royal Naval Barracks.

From the Birmingham, Tame and Rea District Drainage Board, for supply and erection of motors, pumps, high-tension switch gear, cables, &c.

From the Garden City Co. (Letchworth), for cables and troughing, &c., for extension to the existing network.

From Southampton electricity department, for supply of 530 yds. of 1 sq. in., 1,200 yds. 0·5 sq. in. and 300 yds. 0·15 sq. in. Paterson's vulcanised bitumen cable.

The Postmaster-General's Department (Brisbane, Queensland) have accepted the following tenders:—

Peter Fleming & Sons, for g.i. wire; Webster & Co., for cup head bolts and nuts, g.i. wire, sulphate of magnesia and sal ammoniac; Jas. Wilson, for w.i. brackets; Geo. Wills & Co., for Acme insulators and copper sheet; Lawrence & Hanson, for leading-in insulators and screws and porcelain tubes; Smith & Atkinson, for Acme spindles, butterfly con-

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necting screws and Leclanché zincs; Sachs & Co., for galvanised insulator carriers; Brisbane Electrical Co., for insulated copper wire, carporous pots, two-way switches and Delville microphones and fittings; Brabant & Co., for lead-covered copper wire; British Insulated & Helsby Cables, for fancy-covered copper wire; G. R. Hodson, for Baker's soldering fluid and brass terminals and nuts; and A. J. Parkes, for fuses in fibre or glass tubes.

Hackney (London) Electric Lighting committee received 18 tenders from seven firms for the supply of coal for the generating station, and the tender of Kaye, Son & Co. has been accepted for Pinxton nutty slack for six months from 1st. inst., at 13s. 9d. per ton, and that of Phillips & Co. for 1,500 tons of West Hall nutty slack at 13s. 5d., with an option to the Council to take (after Dec. 31) such quantity of Mapperley nutty slack as may be required at 13s. 5d. per ton.

Stockport Council have accepted the tender of the British Insulated & Helsby Cables for cables at £565. 10s., and also for materials for overhead equipment; and that of Hadfield's Steel Foundry Co. for alterations to Gorton-road tramway track at £121. 10s.

The Postmaster-General's department (Sydney, N.S.W.) have accepted the tender of R. B. Hungerford for extension of common battery telephone switchboard at £750 and that of James Bennett for construction and draining of manholes and the supply and laying of conduits.

The Postmaster-General's Department (Melbourne) have accepted the tenders of Davies, Shephard & Co. for brass fittings for cables and for washers; that of Jas. Henty & Co. for cross-arms, and that of R. B. Hungerford for telephone keys.

Battersea (London) Council have accepted the tenders of the British Insulated & Helsby Cables for five feeder pillars at £25 each, and that of the Switch Gear Co. for resistances at £146. 16s.

Salford Council have accepted the following tenders: Babcock & Wilcox, coal grab, £85. 10s.; Lancashire Dynamo & Motor Co., motors; Royce (Ltd.) motors and motor starters.

Johannesburg Council have placed orders with Harris, Lee & Co. for insulating materials and with the A.E.G. Electrical Co. of South Africa for insulating materials and electric lamps.

Prescot Guardians have accepted the tender of the British Insulated & Helsby Cables for wiring work at the casual and receiving wards at the workhouse.

Essex Standing Joint committee have accepted the tender of Christy Bros. & Co. for wiring work and fittings for the Shire Hall, Chelmsford.

Out of the tenders received for "free" wiring work, Lowestoft Council have accepted the lowest, that of Mann, Egerton & Co

Colliery Electrical Plant—Messrs. E Scott & Mountain have in hand a complete electric power installation for the Aspull Colliery of the Wigan Coal & Iron Co. The installation comprises three three-phase generators each of 560 k.v.a. capacity, running at 300 revs. per min., main switchboard, cables, transformers, overhead line, and three sets of mining pumps, each set delivering 420 gallons per minute against a 700 ft. head These pumps are driven by 120 H.P. motors. Messrs. Scott & Mountain also have in hand the electrification of the Lingdale iron mines in Cumberland for Messrs. Pease & Partners.

BUSINESS NOTICES.

Messrs. Charles P. and Hubert C. Sparks have taken offices at 49 51, Moorgate-court, Moorgate-street, London, E.C., where they will carry on business as consulting engineers under the style of Charles P. Sparks. Telegraphic address, "Sparkesque London"; telephone, Central 10401.

The United Electrical Co. of Buda Pesth (who are members of the European Incandescent Lamp Manufacturers' Synd.) have placed the sole agency for the sale of their incandescent lamps, including the "Wolfram" metal filament lamps, in the hands of G. Straus & Co. (Ltd.), who will furnish information respecting both carbon and metal filament lamps to contractors, central station engineers and other interested parties. Messrs. Straus hold large stocks of both types of lamp at their London warehouse.

The registered offices of the Electricity Supply Co. for Spain (Ltd.) have been removed to 88, Leadenhall-street, London, E.C.

BANKRUPTCIES, LIQUIDATIONS, &c.

Andrew Matson, electrical engineer, 10, Hardwick-terrace, Stockton-on-Tees, has been adjudicated bankrupt.

Claims against K. C. Moran, electrical engineer and contractor 80A, Teddesley-street, Walsall (late of 30, High-street, Coventry), by Sept. 21 to Mr. S. W. Page, 30, Lichfield-street, Wolverhampton.

Claims against McPhail & Simpson's Dry Steam Patents Co. (Ltd.) by Sept. 20 to Mr. J. W. Close, North British and Mercantile-buildings, Leeds.

A meeting will be held on Oct. 28 at 46, Gresham-street, London, E.C., to receive an account of the winding-up of Power & Industrial Securities (Ltd.).

Electro-Chemical Works for Sale.—The extensive buildings, plant and machinery belonging to the Scottish Cyanide Co. (Ltd.), with offices, foremen's houses, and large water power at Leven, Fifeshire, are for sale. The grounds are about 13½ acres, of which 2 acres are covered by buildings, and the water power (about 280 H.P. from the river Leven) can be increased. The machinery has been very little used, and comprises 10 Lancashire boilers, four Willans triple expansion engines (each of 800 H.P.), eight Mather & Platt low-tension alternators, condensing plant, Green's economisers, four "Achilles" water turbines, 15 electric furnaces with mechanical discharge complete, three Dowson gas producers, gas plant, &c., eight filter presses, six vacuum filters and two vacuum evaporators, Linde refrigerating plant, distillation plant, dynamos, electric motors, hoists, blowers, &c. The works have ample railway sidings, and are conveniently situated and compactly arranged. Can be seen at any time by appointment on orders from Messrs. Davidson & Syme, W.S., 28, Charlotte-square, Edinburgh, or Mr. Robert B. Lawrie, manager and secretary of the company, Kirkland Works, Leven, Fife, with either of whom tenders are to be lodged before noon, Sept. 30. See also an advertisement.

Sales by Auction.—Messrs. John W. Morley & Co. have been instructed to sell by auction on the premises, 8, Pembroke-villas, Pembroke-road, Kensington, London, W., on Sept. 18 and 19, at noon, the surplus stock and miscellaneous plant and (finished and unfinished) high-class furniture, including electrical accessories and lamps, electric and gas light fittings, bells, &c. On view day prior to sale. Catalogues on the premises and from the auctioneers, 176, Earl's Court-road, S.W. Telephone Kensington 1720. See also an advertisement.

Messrs. Fuller, Horsey, Sons & Cassell have been instructed to sell by auction at the Dockyard, Devonport, on Oct. 2 and following days, at 11 a.m. each day, old and surplus stores, including brass tubes and scrap brass, scrap white metal, old phosphor and manganese bronze, old zinc ashes and bottoms, foundry ashes, mild steel and steel and iron scrap, a quantity of electric cable, engines and dynamos and electrical gear and stores, lathes, tools, &c. Catalogues (6d. each) can be obtained at the Dockyard, and of Messrs. Fuller, Horsey, Sons & Cassell, 11, Billiter-square, London, E.C. See also an advertisement.

Messrs. Horne & Co., 8, Delahay-street, Storey's-gate, Westminster, S.W., will sell by auction at the Royal Arsenal, Woolwich, on 25th inst., at 11 a.m., obsolete stores, including iron and steel, brass, copper, gunmetal, lead, antimony, phosphor-bronze, tin, zinc, &c., travelling cranes, forced draught apparatus, lathes, electric cable and wire, telegraph instruments, &c. Catalogues from the War Office, Whitehall; the Ordnance Office, Tower; and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Plant, &c., for Sale.—Messrs. Fielding & Platt, engineers, Gloucester, have for sale a second-hand 90 B.H.P. Fielding suction gas engine, electric lighting type. See advertisement.

Messrs. Matthews & Yates (Ltd.), Swinton, Manchester, have a few electric fans with open type motors for sale.

Premises to Let.—Mr. Adams, Gattens, Hockley, Essex, has conveniently situated offices to let, suitable for engineers, metal dealers, &c.

"E.C.C." Dry Cells—The Electrical Power Storage Co., 4, Great Winchester-street, London, E.C., give notice to the trade that the arrangement whereby the well-known E.C.C. dry cells were sold exclusively by the General Electric Co. is terminated, and that in future the cells can be obtained (wholesale only) direct from the E.P.S. Company. We illustrate the two forms of the cells, round and square, and would call attention to the issue of a new list of particulars and prices. Copies of the list can be obtained by the trade on application to the company. The "Extra-sec" type of E.C.C. battery does not deteriorate by being kept in stock, even in hot climates, and is immediately made ready for work by pouring a solution of sal-ammoniac through the vent (shown in illustration) in top of cell.

"E.C.C." Cell. Round Type.

"E.C.C." Cell. Square Type.

Lundberg Specialities.—In the columns of *The Electrician* frequent reference has been made to the excellent switching devices placed on the market by the old-established firm of A. P. Lundberg

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& Sons. It is not too much to say that this firm of electrical apparatus makers has gained, as it has deserved, a world-wide reputation for novelty of design, for accuracy and finish of workmanship, and for the closest attention to the minutest detail of construction. The development of what may be termed the "domestic" side of electricity supply owes much to the Lundbergs. The publication of a new list of the various patented articles of this firm is, therefore, of interest. In the accompanying items we have selected some of the more recent additions to the list.

Fig. 1 shows the "Pivot Combination" switch of 10 amperes capacity, suitable for heating apparatus. This switch can be arranged with patent pins to prevent any possibility of lighting-circuit plugs being inserted in error and tapping current at cheaper power rates. It has a patent variable leverage action allowed by the movable fulcrum locking the contact arm in the "on" position, thus preventing annoying rupture of the circuit as might sometimes be caused through vibration such as found on board ship, in railway carriages, &c, ; a wide and long break, substantially designed, and looping in terminals. In addition the covers may be locked to bases when desired to prevent removal by unauthorised persons, or to allow for any directions to the user to be printed or engraved on them.

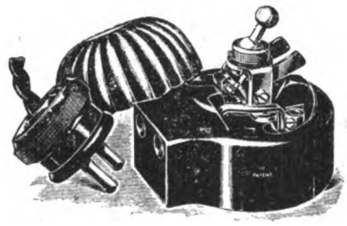

FIG. 1.—"PIVOT COMBINATION" 10 AMP. SWITCH.

Fig. 2. is a "Clincher" connection, a new fitting of small diameter, fixed without the use of unsightly screws, and intended for fixing in wood blocks, panelling, skirting boards, floors, furniture, desks, &c. The ring is provided with four strong spring arms formed out of one piece of metal as shown. The hole is bored just large enough to take the porcelain piece, and after wiring up, all that is necessary to fix the socket, is to force it in, when the spring arms securely hold it in position.

Fig. 3 shows a heating connector specially designed for heating work to prevent plugs attached to lighting circuits from tapping current on circuits intended for power and heating apparatus, current for which is supplied at a cheap rate. It allows the use of smaller size accessories as

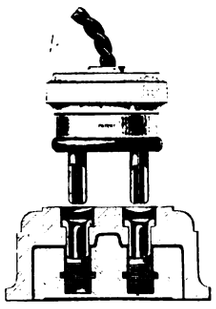

FIG. 2.—"CLINCHER" CONNECTION.

FIG. 3.—HEATING CONNECTOR.

fitted for lighting requirements, and the device is consequently acceptable to electric supply authorities owing to its non-interchangeability with lighting apparatus.

The same principle of construction is applied to Lundberg's "Triple" and "Multiple" plugs for special apparatus, and also to the two-pin type when current is required to pass in one direction only—for example, in Nernst lamps, plating, ignition cell charging, &c. One pin and one socket is specially arranged to ensure the plug being inserted in one way only, thus preventing any possible reversal of current in the apparatus attached. The principle is applicable to all types of connectors, whether flush, surface, extension, or combined with switches.

"Marvel" Switch.—We regret that in the description of this switch, made by Messrs. A. P. Lundberg & Sons, in our issue of 23rd ult., Figs. 2 and 3 were interchanged; this error may have caused some of our readers difficulty in tracing out the connections.

CATALOGUES, &c.

"Stearn" Lamps.—A tastefully-designed stand card of Stearn electric lamps reaches us from the Zurich Incandescence Lamp Co., 47, Victoria-street, Westminster. The trade can obtain copies on application.

Metallic Packing.—Tests made by the Sheffield Testing Works on the properties of the metallic packing of the Tandem Smelting Synd. are being published by the last-mentioned firm. Melting, expansion, compression and friction tests were made on the metal and the tables of results will bear careful study by engineers.

Handy Pocket-Knife, &c.—Mr. T. A. Mackneth, 81, Cockayne-place, Sheffield, sends us for examination an insulated pocket-knife and screw-driver contained within a single handle. The screw-driver and knife blade can be withdrawn with one hand by the turn of a lever which raises a spring cover over the compartments provided for the blades. Only one blade can be exposed at a time. The covering is of black celluloid, tested to 800 volts pressure. We think Mr. Mackneth could improve upon his lever arrangement.

Candle Fittings.—However much electricity may be "in its infancy" the electric light is "the light of the century," if we may take the word of Messrs. Miller & Sons, Conduit-street, London, W., who have just issued an artistic brochure on candle fittings. Most of the designs illustrated are in the Louis XVI. style and are for table and bracket use.

Nernst Lamps.—A leaflet and card folder on small pendant fittings and Nernst lamps are to hand from The Electrical Co., Ltd.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during August, 1907, and (*b*) during the current year from Jan. 1 to Aug. 31, with the increases or decreases compared with the corresponding periods of 1906:—

Electrical machinery, (*a*) £55,818 (decrease £5,310), (*b*) £393,344 (increase £2,975); telegraph and telephone cables, (*a*) £13,038 (increase £6,362), (*b*) £185,863 (increase £72,701); telegraph and telephone apparatus, (*a*) £24,489 (decrease £9,129), (*b*) £175,625 (decrease £75,821); other electrical wires and cables: rubber insulated, (*a*) £3,215 (decrease £2,393), (*b*) £51,245 (increase £7,040); with other insulations, (*a*) £8,227 (increase £3,277), (*b*) £55,203 (increase £8,747); other electrical goods and apparatus, (*a*) £55,276 (increase £16,926), (*b*) £376,450 (increase £61,879. Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £104,245 (increase £2,319), (*b*) £844,386 (increase £74,546).

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Sept. 4 to Sept. 10, with the ports of destination:—

Aden, £23. *Africa*—Alexandria, £207; Cape Town, £121; Chinde, £102; Delagoa Bay, £481; Durban, £1,040; Port Elizabeth, £23. *Argentina*—Buenos Ayres, £794. *Australasia*—Auckland, £100; Dunedin, £178; Fremantle, £82; Melbourne, £1,598; Napier, £36; Perth, £84; Sydney, £1,835 (including £883 telegraph material). *Belgium*—Brussels, £220. *Burma*—Rangoon, £30. *Canada*—Toronto, £53. *Ceylon*—Colombo, £243. *Chili*—Autofagasta, £298; Valparaiso, £713. *China*—Amoy, £11; Shanghai, £140. *Denmark*—Copenhagen, £32. *Germany*—Bremen, £2,414; Cologne, £25. *Gibraltar*, £306. *Holland*—Amsterdam, £109; Rotterdam, £74. *Hong Kong*, £217. *India*—Bombay, £1,624 (including £60 telegraph material).; Calcutta, £1,576; Madras, £365. *Italy*, Genoa, £783. *Japan*—Kobe, £2,589; Nagasaki, £161; Tokyo, £474; Yokohama, £2,078. *Malta*, £185. *Mexico*—Vera Cruz, £21. *Portugal*, Lisbon, £30 (telegraph material). *Roumania*, Galatz, £78. *Russia*—St. Petersburgh, £126. *Siam*—Bangkok, £168. *Spain*—Barcelona, £25 (telegraph material); Bilbao, £27 (telegraph material). *Straits Settlements*—Penang, £109, Singapore, £249; *Sweden*—Gothenburg, £285. *United States*—New York, £540 (telegraph cable). *West Indies*—Port Swettenham, £78 (including £24 telegraph material); St. Thomas, £5. Total, £23,174, against £15,124 in the corresponding week last year (Sept. 5 to Sept. 11).

The exports of electrical machinery, material, &c. (*a*) during August, 1907, and (*b*) during the current year from Jan. 1 to August 31, and the increases or decreases compared with the corresponding periods of 1906, are as follows:—

Electrical machinery (*a*) £97,008 (increase £37,597), (*b*) £645,715 (increase £85,981); telegraph and telephone cables, (*a*) £52,516 (decrease £431,389), (*b*) £648,848 (decrease £476,615); telegraph and telephone apparatus, (*a*) £13,624 (decrease £2,250), (*b*) £118,638 (decrease £3,634); other electrical wires and cables, rubber insulated, (*a*) £23,514 (increase £10,160), (*b*) £179,509 (increase £67,082); with other insulations, (*a*) £21,225 (decrease £85), (*b*) £149,838 (increase £52,264); other electrical goods and apparatus, (*a*) £45,790 (decrease £6,347), (*b*) £329,621 (decrease £27,323). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £156,669 (decrease £429,911), (*b*) £1,426,454 (decrease £388,226).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

July 1, 1907.

15,080 FARNSWORTH. Lubricating curves in tram and other lines.
15,099 FLETCHER. Electrical dumbells and the like.
15,147 THOMPSON. Primary galvanic batteries.
15,151 FYNN. Dynamo-electric machines of the neutralised conductio type.
15,169 DICKSON. Combined telegraph and telephone apparatus.*
15,171 B.T.-H. Co. (G.E. Co., U.S.) Insulating sheet metal and other electric conductors.

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July 2, 1907.

15,219 LIRONI. Driving gear of electric tramcars.*
15,224 HILDYARD. Indicators or annunciators.
15,225 HILDYARD. Shop or other alarm bells.
15,234 DAWSON & BUCKHAM. Electrical signalling apparatus for use with guns.
15,254 ANGER. Destination indicators for tramcars.
15,262 B.T.-H. Co. (G.E. Co., U.S.) Controlling mechanism for circuits.

July 3, 1907.

15,288 VON KRAMER. Electric hoists.
15,290 STEVENSON. Rapidly making and breaking an electrical circuit automatically and preventing it being made and broken slowly or left in an intermediate position.
15,291 HALLIWELL. Electrical signalling apparatus for railways.
15,292 DODWELL. Railway and tramway points, switches and signals.
15,302 ECKSTEIN, HEAP & MELLIS. Starting devices for alternating-current motors.
15,322 BLECH. Rail-shifting device for tramways.
15,335 PECK. Equalising devices for alternating-current circuits.
15,338 GEBRUDER SIEMENS & Co. Electrodes for searchlights. (Date applied for, 17/12/06.)*†
15,346 WILLANS & ROBINSON and IZOD. Improvements in turbines.
15,156 & 15,357 HAINES. Electrically transmitting images, pictures, &c., and reproducing same.
15,363 GEBE. Electrically-driven pulley blocks.*
15,367 & 15,451 B.T.-H. Co. (G.E. Co., U.S.) Producing refractory electric conductors.

July 4, 1907.

15,394 FINCH. Wall box for switches.
15,412 WALTER. Receivers for wireless telegraphy.
15,418 SIEMENS-SCHUCKERT WERKE G.M.B.H. Current distributing systems. (Date applied for, 5/7/06.)*†
1,5441 & 15,442 CONRAD. Voltage regulators. (Date applied for, 9/7/06.)*†
15,450 MUIRHEAD. Telegraphy.
15,452 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
15,453 LATOUR. Single-phase motors. (Date applied for, 5/7/06.)*†
21,243A/06 MEISSNER & DANISCHEVSKI. Vaporisers for incandescent vapour lamps. (Date applied for, 25/9/06.)*†

July 5, 1907.

15,504 HOLMQUIST. Folding electric-light bath cabinet.
15,509 KERSHAW & STRUTT. Means of transmitting energy.
15,510 DEUTSCHE GASGLUHLICHT A.-G. (AUERGES.) Manufacture of illuminating bodies for incandescence lamps. (Date applied for, 11/7/06.)*†
15,514 COWPER-COLES. Signalling and electric searchlight apparatus.
15,522 MASKELYNE. Operating electric light switches and the like.
15,525 SPEEDY & EYNON. Earthing contact for use in connection with flexible conductors and the like.
15,532 JUSTICE. (Sub-Target Company, U.S.) Signalling system and apparatus.*
15,549 B.T.-H. Co. and CLOUGH. Alternating-current dynamo-electric machines.
15,551 HADDAN. (Bergmnan Elektricitats Werke A.-G., Germany.) Electricity meters for alternating currents.*

July 6, 1907.

15,557 VAN ORTON & ROSE. Outside seats for tramcars.
15,579 COOKSON. Boxes and cells for accumulators.
15,594 DYMOND. (Eisemann & Co., Germany.) Armature for magneto-induction machines.*
15,604 WARWICK MACHINERY Co. (G.E. Co., U.S.) Buckets for turbines.

COMPLETE SPECIFICATIONS.

1906 SPECIFICATIONS.

21,008 GIBAUD. Supplying or controlling the current for electric igniters. (Date applied for, 22/9/05.)
21,164 FELTEN & GUILLEAUME-LAHMEYERWERKE A.-G. Electric signalling apparatus. (Date applied for, 22/9/05.)
21,390 LUNDBERG, LUNDBERG & LUNDBERG. Combination switch and wall connections.
21,874 B.T.-H. Co. (G.E. Co., U.S.) Arc lamps.
21,899 LAWRENCE. Point mechanism for tramways and the like.
22,617 JOHNSON-LUNDELL ELECTRIC TRACTION Co. & LÜBECK. Brush holders.
22,789 SCHMAHL & ARMORDUCT MFG. Co. Conduit fittings.
22,879 BERGLUND, HJORTH & LJUNGMAN. Telephonic telegraphy.
23,469 SHARPIN. Combination electric alarm and pressure gauge for forced lubrication.
24,500 HOWARD. Brakes for tramway cars.
24,532 BEVAN. Electric switches for railway signalling.
25,198 DAWSON. Current collectors for vehicles or trains.
25,209 SPROWSON, HALL & BURN. Control system for electric lifts or elevators.
25,508 MATZKA & TIMMERMANN. Electric fire-alarms.
25,761 LEITNER. Accumulator cells.
25,979 ATELIERS THOMSON-HOUSTON (ANCIENS ETABLISSEMENTS POSTEL-VINAY). Varying the speed of asynchronous motors. (Date applied for, 27/12/05.)
26,156 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerke Ges.) Braking electric hoists and the like.
26,534 RENSON. Signalling for tramway lines.
26,940 MARINO & BARTON-WRIGHT. Construction of accumulators.
27,269 LAMME. Electric motors. (Date applied for, 4/12/05.)
27,640 NEW CENTURY ARC LIGHT Co. & BAGGETT. Arc lamps.

COMPANIES' MEETINGS AND REPORTS.

MOTOR OMNIBUSES.—At the meeting of the London General Omnibus Co. last week Sir John Pound explained why the company had not made a profit on the past half-year's working. There had been an accumulation of adverse circumstances, and they had also been put to enormous expense in complying with the more stringent requirements of the Commissioner of Police in respect of their motor 'buses. The advent of bad weather had synchronised with the opening of fresh underground railways and the over-development of the London County Council electric tramway services. Besides those new forms of locomotion, other companies had placed on this company's routes a large number of motor omnibuses. The policy of reckless competition had at last been recognised as suicidal, and the directors were in friendly conference with the railway and omnibus companies with a view to a readjustment. Their receipts were £59,678 less and the omnibus-miles run were 700,000 less (15,900,000 against 16,600,000). It must be patent to those using the main arteries of London that the public-service vehicles were more numerous than could now be profitably employed. The most glaring instance was probably that of the London County Council electric trams. Anyone standing at certain traffic points on any day of the week would see a procession of those huge "traffic congesters" almost touching one another and carrying between them enough passengers to make a fair load for a quarter of the number of vehicles. Motor omnibus companies during the recent boom entered into contracts to purchase large numbers of motor omnibuses, and those as delivered and prepared for service were being put on the roads. Most of those companies had gone into liquidation. Some had actually disappeared, while others had been reconstructed or amalgamated. Some of the old horse-omnibus owners had already withdrawn their motors. Another favourable indication was that London traffic increased automatically year by year, and while it was, no doubt, true that at present the demand for accommodation had been exceeded by the supply, yet they might look for their traffic receipts to return ultimately to their former level. They had written down the motor omnibus bodies on the basis of a 10 years' life, and they had expended on motor chassis £50,000, the whole of which had been charged to revenue. The company's technical officers assured the board that after about another six months' heavy expenditure the chassis maintenance account should show a considerable reduction. The directors had written off, out of profits previously carried to the motor fund, the amounts expended in the cancellation of contracts for motor chassis which were considered unsuitable.

UNITED ELECTRIC CAR CO. (LTD.)—The directors' report for the year ended June 30 states that, after paying debenture interest (£2,500) and charging £6,106. 8s. 2d. for depreciation, the profit was £20,459. 11s. 7d., added to £2,135. 18s. 8d. from last year, making £22,595. 10s. 3d. After deducting preference dividend for the six months to Dec. 31 (£3,000) the available balance was £19,595. 10s. 3d. The balance preference dividend (£3,000) has been paid, and the directors recommend that the balance of preliminary expenses (£2,000) be written off and a dividend be declared on the ordinary shares of 5 per cent. (less tax) for the year, requiring £7,500. £2,000 is carried to general reserve and £5,095. 10s. 3d. carried forward.

CITY NOTES.

MEMORANDA (Sept. 12).—Bank rate 4½ per cent. (since Aug. 15, 1907) Price of silver 31⅜—31½d. per oz. Consols 82¼—82⅜ for money, 82 5/16—82 1/16 for account; 2½ per cent. annuities 80⅜—80⅝. Consols Pay Day, Oct. 3; Stocks and Shares Continuation Days, Sept. 25 and Oct. 10; Ticket Day, Sept. 26: Pay Days, Sept. 13 and 27; Mining Share Carry-over Day, Sept. 24.

BRUSH ELECTRICAL ENGINEERING CO. (LTD.)—Mr. W. L. Madgen has been appointed vice-chairman, Mr. B. Broadhurst and Mr. J. J. Steinitz joint general managers, and Mr. F. M. Hodson, secretary and chief accountant of this company.

BUENOS AYRES & BELGRANO ELECTRIC TRAMWAYS CO. (LTD.)—At an extraordinary meeting on Monday a resolution was passed approving the completion of the purchase agreement between the company and the Compagnie Generale de Tramways de Buenos Ayres.

CHLORIDE ELECTRICAL STORAGE CO. (LTD.)—The directors have declared a dividend of 10 per cent. for the past year, £5,000 has been placed to reserve, and £12,382 carried forward.

KALGOORLIE POWER & LIGHTING CORPN. (LTD.)—The dividend on the 6 per cent. preference shares has been declared for the half-year ended Sept. 30.

SCOTTISH CYANIDE CO. (LTD.)—The directors have issued a circular to the shareholders stating that, as it is practically impossible to produce cyanide with profit at its present low figure, the directors have been compelled to close down the furnaces, and recommend the shareholders to place the company in voluntary liquidation. Unsuccessful efforts have been made to dispose of the works as a going concern. The directors attribute their difficulties to the high price of coal.

An announcement relating to the sale of the works and plant appears in our advertisement columns.

WESTERN UNION TELEGRAPH CO.—The managing committee recommend the declaration of the usual quarterly dividend of 1¼ per cent.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 4	1,574	− 227	14	21,838	− 302
Airdrie	Aug. 30	225	− 12	34	7,593	− 44
Anglo-Argentine	Sept. 9	17,209	+ 1,892	36	592,338	+ 58,841
Ashton-under-Lyne Corp	,, 7	421	+ 45	24	9,609	+ 904
Ayr Corporation	,, 7	313	+ 9	17	6,738	− 163
Baker St. & Waterloo Ry.	,, 7	2,160	+ 770	10	22,775	+ 9,595
Barnsley	Aug. 30	167	+ 6	34	5,759	+ 49
Barrow	,, 30	308	− 28	34	8,903	− 159
Bath Electric Trams, Ltd.	Sept. 4	992	− 143	36	28,753	− 1,219
Birkenhead Corporation	,, 8	1,222	+ 3	...	...	...
Birmingham Corporation	,, 7	6,240	...	23	138,935	...
Birmingham & Mid.	Aug. 23	861	...	33	26,952	...
Blackburn Corporation	Sept. 4	1,217	− 14	¶33	26,411	+ 1,185
Blackpool Corporation	,, 5	2,269	− 330	22	34,125	− 2,652
Blackpool and Fleetwood	...	...	...	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 8	2,388	+ 214	53	53,781	+ 2,853
Bournemouth Corporation	,, 4	2,387	− 32	¶22	42,699	+ 558
Bradford Corporation	,, 7	4,839	− 59	23	109,364	+ 334
Brighton Corporation	,, 8	1,102	− 179	33	23,188	− 2,751
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 6	5,375	− 233	9	44,542	− 1,283
Burnley Corporation	,, 7	1,357	+ 32	23	27,629	+ 379
Burton Corporation	,, 8	301	− 7	23	6,946	− 364
Bury Corporation	,, 1	1,141	...	22	24,793	...
Calcutta Tramways Co.	,, 7	R48,454	+ R3,204	9	R424,620	+ R31,553
Camborne-Redruth	...	...	...	...	...	...
Cardiff Corporation	,, 7	2,136	− 132	23	51,692	+ 1,639
Cavehill	Aug. 30	103	− 40	34	2,977	− 53
Central London Railway	Sept. 7	4,581	− 897	10	48,277	− 5,728
Charing C., Euston & H'stead	,, 7	2,355	...	10	25,065	...
Chatham & Dist. Lt. Rys.	,, 5	798	− 193	‡36	25,959	+ 1,828
City & South London Rly.	,, 8	2,913	+ 530	10	30,381	+ 6,227
City of Birmingham	Aug. 30	2,809	...	34	95,608	...
Colchester Corporation	Sept. 4	247	− 41	...	...	...
Cork Electric Trams Co.	,, 5	498	− 83	36	16,749	− 740
Croydon Corporation	,, 6	1,480	− 119	23	33,743	− 2,019
Devonport & Dist. Trams	Aug. 30	528	...	34	15,816	− 159
Dover Corporation	Sept. 7	273	− 60	23	5,806	− 894
Dublin & Lucan Railway	,, 6	168	+ 21	10	1,575	+ 109
Dublin United	,, 6	7,575	+ 1,350	‡10	74,760	+ 16,505
Dudley Stourbridge	Aug 30	931	− 43	34	29,530	− 867
Dundee Corporation	Sept. 4	1,307	− 69	16	18,564	+ 358
East Ham Council	,, 7	938	− 52	23	21,532	− 476
Exeter Corporation	...	...	...	...	...	...
Falkirk and District	,, 4	313	...	...	...	...
Gateshead & Dist. Trams	Aug. 30	1,011	+ 44	34	34,487	+ 851
Glasgow Corporation	Sept. 7	18,315	+ 209	14	245,439	+ 3,982
Glossop	,, 7	136	− 10	36	4,903	+ 24
Gravesend—Northfleet	Aug. 30	293	− 4	34	8,439	− 65
Great Northern & City Rly.	Sept. 7	1,586	− 23	10	15,795	+ 80
Gt. Northern, Piccadilly, &c.	,, 7	3,675	...	10	38,650	...
Greenock & Port Glasgow	Aug. 30	716	− 123	34	22,577	− 544
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 30	365	− 34	34	10,018	− 628
Hastings Elec. Trams Co.	Sept. 5	1,603	+ 236	10	13,111	+ 3,595
Hong Kong	,, 7	$8,063	+ $1,022	22	$278,269	+ $37,201
Huddersfield	...	...	...	...	...	...
Hull Corporation	,, 7	2,455	+ 244	23	55,362	+ 2,815
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 4	156	− 6	23	3,370	+ 162
Ipswich Corporation	...	...	...	...	...	...
Isle of Thanet Co.	,, 7	1,505	− 103	49	28,559	− 795
Jarrow	Aug. 30	127	...	34	4,194	...
Keighley Corporation	Sept. 5	164	− 6	10	1,660	+ 80
Kidderminster & District	Aug. 30	167	+ 6	34	4,311	− 150
Kilmarnock Corporation	Sept. 7	155	− 8	16	2,741	− 61
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 5	1,414	+ 421	36	41,829	+ 10,338
Lancashire United	,, 4	1,362	+ 177	36	45,200	+ 11,349
Leamington	Aug. 30	199	− 5	34	5,624	− 747
Leeds Corporation	,, 31	6,453	− 108	‡23	152,817	+ 5,743
	Sept. 7	6,723	+ 43			
Leicester Corporation	...	...	...	...	...	...
Leith Corporation	...	...	...	...	...	...
Lincoln Corporation	,, 7	122	− 3	23	7,156	+ 61
Liverpool Overhead Rly.	,, 8	1,536	+ 34	10	16,902	− 1,076
Liverpool Corporation	Aug. 31	10,948	− 332	35	381,774	+ 6,924
*London County Council	,, 31	31,917	+ 5,349	22	689,548	+ 108,471
London United	Sept. 6	7,379	− 59	‡36	234,901	+ 7,397
Lowestoft	,, 7	374	− 13	49	9,942	+ 930
Maidstone Corporation	,, 7	116	− 20	23	2,619	− 230
Manchester Corporation	,, 7	15,971	+ 957	23	343,727	+ 24,817
Mersey Railway	,, 7	1,756	+ 101	10	18,157	+ 1,418
Merthyr	Aug. 30	217	+ 7	34	7,190	+ 366
Metropolitan Dist. Railway	Sept. 8	7,038	− 74	10	72,486	+ 462
Metropolitan Elec. Trams	Aug 30	5,584	+ 1,621	34	157,333	+ 35,387
Middleton	,, 30	422	− 27	34	12,248	− 317
Nelson Corporation	Sept 7	164	− 15	24	3,574	+ 31
Newcastle-on-Tyne Corp.	,, 7	3,954	+ 33	23	95,149	+ 367
Newport (Mon.)	,, 7	682	...	23	16,710	+ 1,579
Northampton Corporation	,, 6	460	− 42	‡23	10,345	− 510
Oldham, Ashton & Hyde	Aug. 30	601	− 42	34	20,774	+ 879
Oldham Corporation	Sept. 9	1,905	+ 43	23	49,125	+ 2,824
Perth (N.B.) Corporation	,, 4	166	− 14	16	2,808	+ 9
Perth (W.A.) Elec. Trams	,, 6	1,315	− 71	36	50,848	− 1,750
Peterborough	Aug. 30	155	− 8	34	4,374	− 274
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	Sept. 7	2,376	− 312	23	49,936	+ 2,684
Potteries	Aug. 30	1,845	+ 76	34	64,057	+ 1,789
Preston Corporation	Sept. 4	812	− 78	...	...	...
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 5	624	+ 103	‡23	13,775	+ 2,093
Rothesay	Aug. 30	524	− 61	34	8,345	− 676
Salford Corporation	Sept. 9	4,771	+ 297	23	109,509	+ 2,422
Sheerness	Aug. 28	92	+ 12	34	2,040	− 60
Sheffield Corporation	Sept. 8	5,639	+ 280	24	133,788	+ 5,57
Singapore Trams	,, 7	$8,063	+ $1,022	23	$217,582	+ $11,617
Southampton	,, 4	1,168	+ 6	...	...	... 6

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southend Corporation	Sept. 4	613	− 23	23	10,658	− 391
South Metropolitan	Aug. 30	1,038	+ 489	34	27,943	+ 5,216
Southport Tramways	,, 30	358	− 89	34	10,537	− 689
South Staffs	,, 30	1,069	+ 98	34	30,821	+ 2,033
Stalyb'dge, Hyde, &c., Jt. Bd	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 25	1,471	− 121	22	32,321	− 483
	Sept. 1	1,482	− 203			
Sunderland and District	,, 4	517	− 18	36	16,302	+ 1,885
Swansea Trams	Aug. 30	1,173	+ 198	34	31,320	+ 1,923
Swindon Corporation	Sept. 4	183	− 30	...	...	...
Taunton	Aug. 30	49	− 6	34	1,511	− 105
Tynemouth and District	,, 30	400	+ 16	34	8,751	− 743
Tyneside Trams Co.	Sept. 4	480	− 72	36	16,726	+ 637
Victoria, Elec. Supply Co. of	Aug. 4	753	+ 94	...	...	...
Wallasey District Council	Sept. 7	921	− 10	23	20,511	+ 339
Walsall Corporation	...	...	...	...	...	...
Warrington Corporation	...	...	...	...	...	...
West Ham Corporation	,, 5	2,321	− 98	23	54,750	+ 1,101
Weston-super-Mare	Aug 28	418	− 43	34	5,191	− 568
Wolverhampton Co.	,, 30	532	+ 58	34	15,676	+ 864
Wolverhampton Corpn.	Sept. 4	838	− 33	7	6,280	+ 25
*Worcester	Aug. 30	329	− 29	34	9,757	− 295
Wrexham	,, 30	116	− 13	34	3,514	− 88
Yorkshire W.R. Trams	Sept. 8	1,314	+ 442	36	41,615	...
Yorkshire Woollen District	Aug 30	912	− 63	34	32,825	+ 1,321

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., Sept. 11.	Rate % Yielded.	Dividend Due.	Business Week to Sept. 11. High-est.	Business Week to Sept. 11. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	Anglo-Argentine Ord. Shares	8¼–8⅝	4 15 9	Ap, Oct	8⅝	8⅛
5	..	Do. 5½ per Cent. Cum Pref.	5¹⁵⁄₁₆–6 1/16	4 8 3	Ja, Jul	6⅛	6 1/16
St.	6%	Do. Permanent 6% Deb. Stock	131 –134	4 9 9	Ju, Dec	133½	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 –105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3 1/16–3 1/16	3 2 0	May ..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅛–5⅛	4 18 6	My, Nv	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 –100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 –132	4 8 6	Mr, Spt	123⅛	..
St.	5%	Do. Pref. Ord. Stock	110 –114	4 7 6	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	104 –107	4 13 6	Ja, Jul	106	105½
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 –103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	101 –103	4 7 0	Ja, Jul	132½	100½
5	3/0	Buenos Ayres & Belgrano Ord.	4⅛–4⅜	8 9 6	Ap, Oct	4½	4 3/8
5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4⅜–5½	5 14 0	Ap, Oct	..	..
5	3/0	Do. "B"	4⅜–5½	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 –115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 –103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 –97	5 8 0	Ja, Jul	..	..
10	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 –103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 –105	5 14 6	Ap, Oct	101	..
5	4/6	Calcutta Tramways (1 to 137,610)	7⅜–7⅞	5 2 6	Mr, Spt	7⅜	7⅛
100	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅛	4 11 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 –105	4 5 0	Ja, Jul	..	..
St.	..	Cape Electric Tram Shares	15/16–1 1/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 –98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 –87	5 15 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	83 –93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	78 –82	7 6 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 –1¼	4 0 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 –1¼	4 16 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Debs	95 –98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 –99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 –103	4 7 6	Fb, Aug	..	..
..	8%	Perth E. Trams. 1st Mt. Db. Stock	100 –104	4 16 0	Ja, Jul	..	..
..	$%	Sao Paulo Tramway, Light & Power Co. $100 Stock	118 –123	6 1 0	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92⅞–94⅞	5 6 3	Ju, Dec	93⅛	92 1/16
		ELECTRICITY SUPPLY.					
5	3/0	†Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½–5	6 0 0	Mr, Spt	..	..
10	4/8⅔	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅞–8⅛	5 13 6	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 –95	4 13 9	Ja, Jul	94	..
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅞–7⅛	5 3 3	Ap, Oct	..	..
5	2/3	Do. (80,001 to 100,000)	6½–7¼	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 –53	4 14 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½–2¾	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	8½–29½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94½–96½	5 3 6	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	103 –106	5 13 0	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Consln. Deb. St.	94 –97	5 8 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	3/8–3/4	3 6 9	April ..	1/16	..
1	1 2/3	Do. 6 per Cent. non-Cum. Pref.	1 1/16–1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 –98	5 2 0	Ja, Jul	..	..
5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 –5⅛	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 –101⅞	4 19 0	Ja, Jul	99⅞	99⅜

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., Sept. 11.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 11. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord...	9⅜ – 10⅜	6 10 0	Mar, Sept,	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞ – 10⅜	4 8 0	Feb, Aug	10⅜	9⅞
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	9⅞ – 10⅜	5 12 6	Feb, Aug	10⅜	9⅞
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	99 – 102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5⅛	5 5 0	April, Oct	5⅛	..
St.	4½%	Do. Do. 1st Debs.	98 – 100	4 10 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7¼ – 7½	6 1 6	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7¼ – 7½	4 5 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4½ Guar.Db.Stock	99 – 102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross(W.End & City)El.Sup.Co.	3⅛ – 4	5 11 3	Feb, Aug	3⅛	..
5	2/3	Do. 4½ per Cent. Pref.	3⅛ – 4	5 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	95 – 98	4 1 6	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅛ – 3⅞	6 2 6	Jan, July	3⅛	..
5	2/3	Chelsea Electric Supply Ord.	3½ – 4½	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	101 – 104	4 6 6	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 – 9½	6 6 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11 – 12	5 0 0	Jan, July	11	10⅞
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	121 – 124	4 1 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	96 – 99	4 11 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.	3⅜ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛ – 4⅞	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	7 – 8	6 5 0	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.	10 – 11	5 8 6	Mar, Sept	10⅜	10½
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 – 109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	94 – 97	4 12 6	May, Nov	..	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅞ – 5⅛	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	96 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅜ – 7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼ – 9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6¼ – 7	4 5 0	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 – 102	3 18 0	April, Oct	..	..
3	2/4⅔	London Electric Supply Ord.	1⅝ – 2	6 0 0	Mar, Sept	..	..
5	3/0	† Do. 6 per Cent. Pref.	4⅜ – 5	6 0 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	88 – 92	4 7 0	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅜ – 5⅛	5 14 3	April, Oct	5⅛	5 1/16
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜ – 5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 – 107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	88 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp.for P.D.1st Mort.Db.	95 – 98⅞	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord.(£9 paid)	9 – 9½	4 17 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	98 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅜ – 6⅝	6 3 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 – 5½	4 17 7	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 – 98	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	— ..	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 – 99	4 11 10	Jan, July	..	..
10	6/0	Notting Hill Electric Ord.....	11 – 12	7 10 0	March ..	..	..
5	4/6	Oxford Electric Ord.	5⅛ – 6	5 17 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 – 97	4 2 6	Jan, July	..	..
5	5.0	St. James' & Pall Mall Elec. Ord.	7⅜ – 7½	6 1 4	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6⅞ – 7⅛	4 17 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86 – 91	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	½ – 1⅛	.. ..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	71 – 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	2 – 2½	6 0 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝ – ¾	3 6 9	.. ..	..	..
1	6/8⅔	† Do. 7 per Cent. Cum. Pref.	1 – 1⅛	5 12 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.	100 – 103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅞ – 2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	2⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
5	5.0	Westminster Elec. Sup. Ord.	8⅛ – 9	6 6 0	Mar, Sept	8⅜	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 2 0	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4Y Perp. Db. St.	88 – 93	4 6 0	Jan, July	83¾	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅜ – ⅞	5 14 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝ – ⅞	5 5 0	Jan, July	⅞	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	94 – 96	5 2 0	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 – 97	4 13 0	Jan, July	..	..
10	9½	Bristol Tramways & Carriage Ord.	14 – 14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid)	8⅞ – 9	4 8 11	.. ..	..	..
St.	4%	Do. 4 per Cent. Debs.	98 – 100	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	1⅜ – 1⅝	.. ..	June, Dec	2⅞	2⅝
10	6/0	Do. 6 per Cent. Cum. Pref.	6½ – 6⅞	8 18 0	Feb, Aug	6⅞	6⅝
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 103	4 17 0	April, Oct	101½	101
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 – 81	5 11 0	May, Nov	..	..
St.	8%	Central London Ordinary Stock.....	71 – 73	4 18 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Pref. Stock	89 – 91	4 8 0	Feb, Aug	89½	..
St.	..	Do. Deferred Stock	53 – 56	7 2 8	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	103 – 105	3 16 0	Jan, July	..	..
St.	4%	Charing X.Euston&Hmpstd Per.Db.Stk.	81 – 84	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm.Pref.	4⅛ – 4⅝	5 2 6	April, Oct	4⅛	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.	98 – 101	3 19 0	April, Oct	99	..
St.	2½%	City & South London Rly. Con. Ord. ..	46 – 48	4 18 0	Feb, Aug	48	47½
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1896)	113 – 116	4 6 0	Feb, Aug	..	..
St.	5%	Do. (1901)	113 – 116	4 8 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 – 105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13 – 14	4 5 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.	12⅞ – 13⅜	4 7 0	Feb, Aug	..	..
10	0/11½	Gt. Northern & City Rly. Pref. Ord. (4%)	1¼ – 1⅜	.. ..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Db.St	98 – 101	4 9 0	April, Oct	96½	..
10	9%	‡ Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10½ – 11	5 9 1	Mar, Sept	..	..
St.	4½	‡ Do. 4½ per Cent. Debs.	97 – 99	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1⅛	.. ..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	94 – 97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅛ – 1⅜	.. ..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	6⅔ – 7⅓	6 13 4	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	84 – 86	4 13 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	7⅜ – 7⅝	5 14 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	82 – 86	4 13 0	Jan, July	..	..
St.	..	Mercy Con. Ord. Stock	3 – 4	.. ..	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	— ..	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅛ – ¼	— ..	April...	⅛	—
1	0/6	Do. 5 per Cent. Cum. Pref.	5⅛ – 5½	5 8 0	Feb, Aug	5½	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 – 97	4 18 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	2 – 3	.. ..	May	..	..
1	0/3	Potteries Electric Traction Ord.	⅜ – ⅝	7 3 0	April, Oct	..	..
1	0.6	Do. 5 per Cent. Cum. Pref.	¾ – ⅞	6 18 0	Feb, Aug	⅞	..
St.	4½	Do. 4½ per Cent. Deb. Stock	95 – 98	4 11 9	May, Nov	..	..
1	0/3	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	7/8 – 1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	84 – 88	5 18 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	85 – 88	8 13 0	June, Dec	..	..
..	..	Yorkshire (W.R.) Elec. Trams. Ord.	1 – 1⅛	— ..	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	3⅝ – 3⅞	— ..	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – 90	5 0 0	Jan, July	..	..

SHRE.	LAST DIVIDEND	NAME.	Price Wed., Sept. 11.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 11. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	..	Aron Electricity Meter Ord.	⅛ – ¼	.. ..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅞ – 1	8 12 0	April, Oct	⅞	⅞
1	2/4⅓	Babcock & Wilcox Ord.....	3⅝ – 4	5 0 0	April, Oct	3⅝	..
1	0/7½	Do. Pref.....	1⅛ – 1⅜	3 14 0	.. ..	..	..
5	6/0	British Insulated & Helsby Cables Ord.	6⅞ – 7⅛	6 18 0	July, Feb	7	..
5	8/0	Do. 6 per Cent. Pref.	5⅝ – 6¼	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 104	4 6 6	Jan, July	..	..
St.	4½%	‡ British Thomson-Houst'n 4½% 1st Mt.Db.	85 – 89	5 1 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1⅛	.. ..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	60 – 65	6 3 0	Jan, July	..	..
2	..	Brush Electrical Engineering	⅛ – ¼	— ..	March ..	¼	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅞ – 1⅛	5 7 0	Mar, Sept	⅛	..
St.	4½%	‡ Do. 4½ per Cent. Perp. 1st Deb. Stock	84 – 87	5 3 0	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	69 – 72	6 2 6	Jan, July	—	—
5	10/0	Callender's Cable Con. Ord.	9⅜ – 10⅜	6 19 0	Jan, July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5½ – 5⅞	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105½ – 107½	4 3 6	Nov, May	—	..
1	0/9⅔	Castner-Kellner Alkali Co.	1⅝ – 1⅝	5 12 6	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 – 102	4 8 0	Feb, Aug	..	..
1	0/2⅔	Chadburn's (Ship) Telegraph Ord.	1⅛ – 1⅜	8 0 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	5 7 0	April, Oct	..	..
3	2/0	* Crompton & Co. (Nos. 1 to 56,000)	1⅛ – 2¼	7 3 6	Jan, July	—	—
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	95 – 98	5 2 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝ – 1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1⅜ – 1⅝	9 8 0	Feb, Aug	1⅜	..
5	4/2	Do. (£5 paid)	2¼ – 2⅝	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	89 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	¾ – 1	10 0 0	Jan, July	..	..
5	8/0	Do. 6 per Cent. Cum. Pref.	1½ – 2	.. ..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜ – ⅝	.. ..	Jan, July	..	..
2	..	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	.. ..	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	.. ..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 95	4 4 0	Mar, Sept	..	..
1	5/0	‡ Henley's Telegraph Works Ord.....	11⅛ – 12¼	6 2 6	Feb, Aug	11⅛	..
5	2/3	† Do. 4½ per Cent. Pref.	5 – 5½	4 2 0	Feb, Aug	5⅛	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½ – 107½	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14¼ – 15½	6 9 0	Feb, Aug	14¼	..
100	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April. Oct	..	..
1	1/2½	Richardsons, Westgarth & Co., Ltd. Ord.	2⅞ – 3⅛	7 14 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	2⅝ – 2¾	6 4 0	May, Nov	..	..
St.	4½%	I o. 4½ per Cent. Perp. Deb. Stock ...	93 – 96	4 14 0	Jan, July	—	—
1	..	Simplex Conduits Ord.	1⅛	.. ..	..	—	—
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	.. ..	..	—	—
12	12/0	Telegraph Construction & Maintenance	31 – 32	5 10 6	Mar, July	32⅛	31⅝
100	4%	Do. 4 per Cent. Deb. Bonds (1909) ...	99½ – 102½	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅝ – 2⅞	6 7 6	.. ..	2¾	2⅝
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛ – 1⅜	4 4 6	.. ..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 – 112	4 9 6	.. ..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102 – 104	3 17 0	June, Dec	103	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 – 108	4 3 3	June, Dec	107	10⅛
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9½ – 9⅝	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1½ – 1⅝	.. ..	Apr, Oct	1⅝	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3¾ – 4½	.. ..	Apr, Oct	4	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3⅛	— ..	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 – 88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	60 – 62	6 3 0	F,My,Ag,N	61⅜	..
St.	30/0	Do. Preferred	104½ – 105⅜	5 13 6	F,My,Ag,N	106	104⅜
St.	12½	Do. Deferred	17¼ – 18⅛	7 15 0	F,My,Ag,N	18	17⅜
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91½ – 93⅜	4 5 0	Jn,Ap,Jy,O	92	91⅜
10	5/0	Cuba Submarine Ord.....	6⅜ – 7½	6 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15½ – 16⅝	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅜ – 3⅝	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 – 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝ – 103⅝	4 7 3	Jan, July	..	..
20	6/6	Direct United States Cable	14⅜ – 14⅞	6 6 0	Ja,Ap,Jy,O	14⅞	14⅜
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	99¼ – 101⅛	4 8 6	June, Dec	..	..
St.	25/0	Eastern Ordinary	132 – 137	5 2 6	Ja,Ap,Jy,O	135⅛	132½
St.	17/6	Do. 5½ per Cent. Pref. Stock	86 – 88	3 19 6	Ja,Ap,Jy,O	88⅛	86⅜
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 – 105	3 16 6	May, Nov	104	103⅜
10	2/6	Eastern Extension	12⅞ – 13	5 4 6	Ja.Ap,Jy.O	13⅛	12⅝
St.	4%	Do. 4 per Cent. Deb. Stock	102 – 104	3 17 0	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 – 100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	98½ – 100½	4 1 0	May, Nov	..	..
10	5.0	G.N. (of Copenhagen), with Coupon 71...	34 – 36	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	99½ – 101½	4 8 6	June, Dec	..	..
5	12/6	Indo-European.....	56 – 58	5 12 0	May, Nov	..	..
100	$1	Mackay Companies Common	67 – 70	5 16 6	Jan, July	..	..
100	$1	Do. Preference	67 – 70	5 16 6	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜ – ½	.. ..	April	..	..
100	4%	Pacific & Europe'n Tel.4% Guar.Dbs.(red.)	98 – 100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10½	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛ – 1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 – 100	4 0 0	Jan, July	..	..
10	..	West India & Panama	1/16 – ⅛	.. ..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅝	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6⅝ – 7⅛	.. ..	May, Nov	7⅛	..
100	5%	*Do. 5 per Cent. Debs.	99 – 102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	12⅜ – 13⅛	5 7 6	Mr,Jn,O.D	13⅛	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 – 103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 – 92	4 7 0	Jan, July	..	..
St.	5%	‡Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 – 102	4 18 0	Mar, Sept	..	..
5	1.0	Chili Telephone	6⅞ – 7⅛	5 10 6	August ..	6⅞	..
1	0/4½	Monte Video Telephone Ord.	1⅜ – 1⅝	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾ – 1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	10 ¼ – 107½	5 11 6	Feb, Aug	10⅞	10⅝
St.	6%	Do. Def. Stock.....	106 – 107	5 12 0	Feb, Aug	106⅝	106⅜
10	6/0	Do. 6 per Cent. Cum. 1st Pref.	11 – 13	4 12 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	11	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5½ – 5⅞	4 13 0	Feb, Aug	5⅞	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	90 – 93	3 11 6	June, Dec	97	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 – 103	3 17 6	Jan, July	102½	101
1	0/9	Oriental	1⅛ – 1⅜	5 2 0	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜ – 1⅝	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 – 94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½ % Db.Stk.(red.)	98 – 101	4 9 0	Jan, July	..	..
5	1/0	United River Plate.....	6¾ – 7⅛	6 18 0	July	7⅛	6⅞
5	2,6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	June, Dec	5½	5⅜
		FINANCIAL, INVESTMENT, &c.					
5	3/0	Elec. & Gen. Investment 6% Cum. Pref.	3¾ – 4⅜	6 6 3	Jan, July	..	..
10	6/2	Globe Telegraph & Trust.....	10½ – 10¾	5 5 0	Ja,Ap,Jy,O	10¾	10½
10	4/0	Do. 6 per Cent. Pref.....	13⅜ – 13⅝	4 8 0	Ja,Ap,Jy,O	13⅝	13⅜
10	6%	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these.

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THE ELECTRICIAN:

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NOTES.

State Aid for Scientific Investigations.

IN last week's issue of *Nature* we notice an article dealing with the relation of Science to Government, in which the author draws a very unfavourable comparison between the United States and this country as regards the financial assistance given to scientific research by the respective Governments. From a detailed statement of the various grants, excluding those for educational purposes, it appears that, whereas the United States granted sums amounting to roughly two and three-quarter millions sterling, the Government of this country only granted about a quarter of a million. The contributions thus appear in the ratio of about 11 to 1, although the revenues of the two countries are not very different. It appears to us, however, that the author has failed to discriminate between the requirements of the two countries. Thus, in the case of the United States, £1,775,670 was granted to the Department of Agriculture. This, no doubt, is right enough in a country which depends very largely upon agriculture, but in this country the expenditure of such a sum would not, at present, be justified; the position of agriculture here, is unfortunately, secondary, though it may certainly be urged that the position might be improved if the subject were more scientifically treated. In the sum just mentioned is an item of £280,710 allocated to the Weather Bureau. This, again, may be very desirable in the United States, but the weather that we obtain over here seems to be almost too uncertain for such serious investigation. Then there is a further large sum of £260,000 expended on the surveying and investigation of public lands, for which we have no particular call. If, finally, the sum of £250,000 for completing the building of the National Museum, and the large sum of £198,000 granted for the coast and geodetic survey be taken into account, the expenditure comparable in the two countries will not be so dissimilar, though that in the United States will still be somewhat the larger of the two.

ON the other hand, turning to the expenditure in the United Kingdom, we notice a sum of over £13,000 granted to commissions on sewage disposal, tuberculosis and other subjects. For this there does not seem to be any equivalent in the United States. The grant for scientific services in the Navy is very much larger in this country than across the Atlantic, that for the Army is £6,480, to which there is no corresponding figure, and when we compare the sum of £51,679 allocated to scientific investigations with the sum of £78,000 granted to the Smithsonian Institution the difference does not appear to be so very great. We do not wish to suggest that a larger expenditure of public money on scientific investigation would not be advantageous—far from it; but nothing is gained by taking an exaggerated view of the question. Some writers, like the author in question, seem to think that scientific methods should be followed in statesmanship and government, probably forgetting that they have no knowledge of either and that diplomacy is not dependent upon scientific laws. It is this spirit which caused the manufacturer at one time to be so afraid of the man who carried out investigations upon ironless dynamos, and other matters equally practical. A commonsense point of view is essential in most matters, and the claims of science do not form an exception.

Electrification of Railways.

As will have been evident from the considerable space we have devoted to the subject in many of our recent issues, the electrification of main-line railways is at present one of the chief problems under consideration by electrical engineers, especially in the United States. As an example of work in that country the description of the New York, New Haven & Hartford Railway, given elsewhere in this issue, is of considerable interest, owing to this line being the first important example of single-phase main-line equipment

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A frequency of 25 cycles has been adopted, although the lower frequency of 15 cycles seems to be gaining in favour among American engineers. Other points of interest are that the rolling stock is also designed for working with continuous current obtained from a third rail over that part of the route which is operated conjointly with the New York Central Company, and also that three-phase generators are in use, the trolley wires forming one leg of the circuit, the running rails the second, and an auxiliary conductor carried throughout the length of the line for miscellaneous power purposes the third. The reason for adopting such an unbalanced system is not quite clear. As a further instance of the present activity in American railway electrification, we may draw attention to the appointment of Mr. F. J. SPRAGUE to advise the Southern Pacific Railway Co. on the electrification of a length of about 136 miles of their main line. As this line passes over the Sierra Nevada mountains at an elevation of 7,000 ft., it will be operated under rather severe conditions, and, considering the partiality of Mr. SPRAGUE to the high-tension continuous-current system, the whole scheme is likely to be of more than usual interest.

The Trades Union Congress.

THE lot of the manufacturer, like that of the operatic policeman, is not a happy one, and, judging by the resolutions carried at the recent Trades Union Congress, it is likely to be even less happy in the future. For there will be no overtime in those days, the unskilled labourer will receive, in London, 30s. per week of 48 hours, bonus and speed systems will be abolished, and since there is a continuous introduction of labour-saving machinery the hours of labour will be restricted to 48 per week. Although sympathy must be felt for all legitimate demands of labour, and more particularly for the unorganised workers, who are seldom heard and therefore in the hands of the "sweater" (unnoticed by such congresses), it becomes increasingly evident that the cost of production must rise except in countries unaffected by resolutions of this kind, or in which there is some compensating influence. It is time that Labour learnt that there are certain economic laws which cannot be forced, that the manufacturer at least is bound by them, and that if the manufacturer cannot comply with them in this country he must go elsewhere.

Loop Tramways.

THERE is a natural tendency for all main roads, and, therefore, for tramways, in any large town to radiate more or less from a centre, and, consequently, to become more and more separated as the suburbs are approached. For this reason it is often difficult, though nevertheless desirable, to get from one line to another without going a considerable distance round. This fact the London County Council appear to be taking into account in their present policy, for they have just decided to lay down a single line connecting up the main line tramways running down Kingsland-road and Essex-road. There is probably a good deal of room for loop lines of this description, though it may be doubted whether the conduit construction would be justifiable in such cases from the financial point of view.

Use of Electricity in Factories and Workshops.

IN our issue of August 23rd it was stated that the period for receiving objections to the proposed Home Office Rules for the use of electricity in factories and workshops would be 40 days from August 14th, the date of issuing the circular accompanying the draft of the proposed Rules. We are, however, now informed that, although it is desired that all objections should be sent in for consideration as early as possible, an extension of time to the end of October will be allowed for receiving any suggestions. We also understand that up to the present time only a comparatively small number of objections have been received, and these are largely due to incorrect reading of the regulations.

Electrical Engineering Graduates.—The *Electrical World* states that the General Electric Co. has taken on at its Schenectady works 248 of this year's graduates from electrical engineering courses.

Submarine Signalling.—At a meeting of the Association of Chambers of Commerce at Liverpool on Wednesday, a resolution was adopted to the effect "That in the opinion of the Association it is desirable that a system of submarine signalling should be established on the coast of the British Isles, and that the cost of the same should be paid out of the National Exchequer."

Electro-Harmonic Society.—The following dates have been arranged for the concerts of this society:—In the Holborn Restaurant, October 4th, November 8th (ladies' night), December 13th and January 10th; the last two concerts of the season, on February 21st (ladies' night), and March 27th, are to be held as an experiment in St. James's Hall, Great Portland-street, owing to the need of increased accommodation.

Nodon Valves.—A considerable number of these valves for rectifying alternating current are now in use by telegraph, telephone and railway companies for accumulator charging, operation of signals, and for operating the solenoids of electric lifts. In the small sizes air cooling is adopted, but in the larger sizes a small motor-driven pump is used for providing a circulation of water in a surrounding jacket, so that the electrolyte may be kept quite cool. Up to the present the largest size which has been made by Mr. H. Snowdon, the manufacturer of Nodon valves in this country, deals with a current of 75 amperes. The efficiencies claimed for these valves are as follows: current 90-98 per cent., voltage 70-82 per cent., watts 63-78 per cent.

Obituary.—We regret to record the death of Prof. L. F. Vernon-Harcourt, which occurred at Swanage on Saturday last. After graduating at Oxford in 1861 the deceased served for three years as a pupil of the late Sir John Hawkshaw, and was then engaged under him on many engineering works, including the South-West India Dock, the Alderney Harbour works and the railway to Wexford. In 1882 he became professor in civil engineering at University College, London, and later, emeritus professor at the same College. He was president of the Mechanical Science Section of the British Association in 1895, and served on the jury of civil engineering at both the Paris Exhibition of 1900 and the St. Louis Exhibition of 1904. He was the author of a number of works and Papers, including "Rivers and Canals," "Harbours and Docks" and "Civil Engineering as Applied to Construction." He also contributed articles on River Engineering and Water Supply to the 9th edition of the "Encyclopædia Britannica."

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma.....	July 12, 1906 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Brest—Dakar	July 22, 1907 ..	—
Dardanelles—Tenedos	Sept. 17, 1907 ..	Sept. 18, 1907

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New Resistor for Lightning Arresters.—The *Electrical World* states that in order to limit the amount of current which can follow a lightning discharge across the air-gap of an arrester use is generally made of a series resistor in the form of a rod containing a mixture of graphite and clay. It has been found that the conductivity of such a composition is not constant, but varies with each discharge of current. The graphite burns out, especially at the terminals of the rod, thereby increasing the resistance of the rod and finally open-circuiting the device. A patent recently issued to Dr. C. P. Steinmetz discloses a method of overcoming the difficulty by substituting oxide of iron or of chromium for the graphite. These oxides are to a certain extent conductive, yet their resistance is high. The resistor rod is made fairly homogeneous by the use of a binder of potassium silicate or sodium silicate.

Magnetic Handling of Glass.—The *Electrical World* gives an account of a new method of handling glass, due to Mr. C. T. Dodds, to whom a patent has been recently issued. Beneath the glass or other material is placed a sheet or pieces of magnetic material, and above the glass are electromagnets, manipulated and controlled by a crane, derrick or hoist. The pull on the metal beneath the glass, constituting the armature or armatures by the magnets, causes it to support the glass, thereby permitting the glass to be transported by the crane. Mr. Dodds naturally uses a number of adjustable magnets for this purpose, and, by having the magnetism sufficiently strong, boxes or crates of glass or similar non-magnetic material can be conveyed safely and expeditiously from one place to another so long as the magnets are energised.

Electric Traction on the Pacific Coast.—In our issue of September 6th we referred to a report that the Southern Pacific Railway Co. were considering the electrification of one of their main lines. The *Electrical World* now states that the company have requested Mr. F. J. Sprague to act as consulting engineer to investigate and report on the proposal to equip electrically part of the Sacramento Division of the Southern Pacific Railroad system—*i.e.*, the section from Rocklin to Sparks. He is also to advise the company on a general scheme of electric traction and has been asked to serve on a board which is to investigate the question. The Sacramento division is of great importance, as the road passes over the Sierra Nevada mountains at an elevation of 7,000 ft. The line is single track, very tortuous, and with grades running up to a maximum of nearly 2½ per cent.

Wireless Telegraph Notes.—The new Cunarder, the "Lusitania," is equipped with a very complete installation of Marconi wireless telegraph apparatus, which is operated by the Marconi Company.

It is announced that the United Fruit Co., a big American Trust engaged in exploiting fruit in all parts of the world, has applied to the United States authorities for permission to erect a wireless telegraph station at Point San Antonio, at the extreme west of Cuba. In their application the company state that they own and run over 100 steamships between the United States and the West Indies and Central America, all these vessels being engaged in the perishable fruit trade. The object of the application and the establishment of wireless telegraph communication is that their headquarters at Boston, U.S.A., may be in constant communication with their vessels at all communicable points. The company has already established wireless stations in the Gulf of Mexico and in the Caribbean Sea, including stations at Port Limon (Costa Rica), Bocas del Toro (Columbia), Bluefields (Nicaragua), Gracios a Dios and Puerto Cortez (Honduras) and Belize (Yucatan), and it is desired to add Point San Antonio to this network in order that the full benefit from the stations may be realised by the company. Application for permission to establish this station which had been originally made to the Government of Cuba had been unsuccessful, owing to the fact that the Cuban Government have under consideration a general system of wireless telegraphy on the Cuban coast, including a station at Pinar del Rio (60 miles distant from Point San Antonio). The United States Government have issued to the company a "revocable" licence, which is subject to the approval of the Governor of Cuba and revocable at any moment if the station is found to interfere with the Cuban Government's system.

It would appear that the above application has encouraged the formulation of a general plan of wireless communication by the War and Navy Departments of the United States. To this scheme the general strike of telegraphists in the U.S. has lent additional importance, and it is announced that it is the intention of these departments to include army wireless telegraph stations across the American Continent as well as in connection with the army transport section. The joint Army and Navy Board are said to be about to meet to consider the entire question. In the meantime the stations already established and equipped by the United Fruit Co. are under contract to afford facilities for U.S. Government use as required.

Colour Photography.—The Royal Photographic Society's annual exhibition was opened yesterday in the New Gallery, London. The exhibit which is arousing most interest is a fine series of autochrome transparencies made on a new kind of plate manufactured by Messrs. A. Lumière et Fils of Paris. A transparent support, covered with an adhesive matter, receives a coating of starch grains, each about $\frac{1}{300}$ in. in diameter, dyed blue-violet, green or red-orange. This coating is one grain in thickness so that the light must pass through a grain of one of these three colours at every point of the plate. The coating, after isolation with a waterproof varnish is coated with a special panchromatic emulsion. Exposure is made as usual, but with the plate reversed, so that the light reaching the sensitive emulsion first passes through the coating of coloured grains. The plate is first developed; then, without fixing, treated with an acid permanganate reducer, rinsed and re-developed, the result being a positive transparency in natural colours. The plates are shortly to be placed on the British market and should lead to something like a revolution in colour photography.

Engineering and Machinery Exhibition at Olympia.—This exhibition, the second of its kind, was formally opened yesterday by the President, Sir Alexander B. W. Kennedy, LL.D., F.R.S. After the opening ceremony there was an inaugural luncheon, with the President of the exhibition in the chair, supported by the Hon. Sir Horace Tozer (Agent-General for New Zealand), Mr. T. Hurry Riches (President of the Institution of Mechanical Engineers), Dr. Alex. Siemens, Sir William Preece, Sir Fortescue Flannery, Prof. Unwin, Dr. Hele Shaw, Prof. Dalby, Prof. Coker, Mr. J. Swinburne, Mr. W. Duddell and others. The toast of "The Engineering and Machinery Exhibition" was proposed by Sir Horace Tozer, who remarked on the representative character of the exhibition and its value to the colonies from a business point of view. Sir A. B. W. Kennedy, in reply, stated that there were 25 per cent. more exhibitors this year than last, a circumstance which answered the forebodings of failure he had heard. The managers, Messrs. Bridges and Smith, had, last year divided between the benevolent funds of the two leading engineering institutions, the Civil and Mechanical Engineers, the sum of £500, and he hoped that on the present occasion the results would be equally satisfactory. The exhibition of the present year was, he considered, more representative of British enterprise than on the previous occasion. Prof. J. A. Ewing, in proposing the toast of "The Engineering Industries," made a humorous speech which was well received, in which he drew attention to the work of engineering professors and the influence of scientific teaching on industrial progress. Prof. Ewing called attention to the fact that a present-day student could take up as much knowledge in a single lecture as had required years of research to acquire and render assimilable. In another part of the present issue we give a brief survey of the chief exhibits.

ARRANGEMENTS FOR THE WEEK.

THURSDAY, September 26th.

JUNIOR INSTITUTION OF ENGINEERS.

3.30 p.m. Visit to the Engineering and Machinery Exhibition at Olympia.

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ELECTRIC TRACTION ON RAILWAYS.*

IV.—RUNNING CURVES.

BY PHILIP DAWSON.

(*Continued from page 864.*)

Summary.—**In this article the author first considers the construction and use of (1) the kilowatt-second curve of a motor, (2) the tractive-force speed curve, and (3) the time tractive-force curve from which these two are derived. The value of such curves is shown by a practical application to part of the London, Brighton and South Coast Railway. The effect of varying the gear ratio is then considered, and the derivation of the curve giving the load on the generating station for a given service. Polar curves are the most convenient for this purpose, as is shown by an actual example. Effect of revolving masses is then considered.**

Having thus thoroughly examined and described a fairly simple and sufficiently accurate method for plotting these important curves, we will now briefly examine the influence of gear ratio, and how, for any given conditions, the most suitable gear ratio can be obtained.

It will at once be evident that, for a given size and type of motor, the nearer the ratio approaches to unity the greater will be the maximum speed possible and the lower will be the rate of acceleration obtainable. The fundamental formula which enables us to reconstruct curves based on tests made with one gear ratio to another is—Tractive effort × speed=constant for any given current. Thus, for instance, if we want to change from a gear ratio of 1:2 to one having a ratio of 1:3 the horizontal effort in the characteristic curve under consideration must be increased by $\frac{3}{2}$, while the speed-curve characteristic must be decreased by $\frac{2}{3}$.

It is therefore at once evident that if we possess the motor-test curve for any given gear ratio we can at once reconstruct the speed and horizontal or tractive-effort curve to any other ratio which we may think suitable. In general if we have

T_1 = tractive effort in pounds,
S_1 = speed in miles per hour,
$I : g_1$ = gear ratio,
d_1 = diameter of wheel,

and we wish to change the gear ratio to $I : g_2$ and the wheel diameter d_1 to d_2, then calling T_2 and S_2 the tractive effort and speed corresponding to the new gear ratio $I : g_2$, and the new wheel diameter d_2, the new tractive effort and speed can be expressed in terms of T_1 S_1, which are known to us through the motor characteristic curves as follows:—

$$T_2 = T_1 \frac{g_2 \times d_1}{g_1 \times d_2},$$

$$S_2 = S_1 \frac{g_1 \times d_2}{g_2 \times d_1}.$$

Another illustration of the effect of a change of gear ratio upon the running results is shown in Fig. 8 for the use of a single-phase equipment.

Having thus described one method by which new kilowatt and tractive-effort speed curves can be constructed, we may briefly mention another method which is at once apparent.

For the kilowatt speed curve all we have to do is to vary the ordinates in the proportion of the altered gear ratio. Thus for a gear ratio of 1 : 3 instead of 1 : 2 the ordinates in Fig. 2 would be only $\frac{2}{3}$ of those of the curve giving the results for a 1 : 2 ratio.

In considering the tractive-force speed curve in Fig. 4 the results are slightly more complicated if we wish to get at them directly without reconstructing the motor tractive effort curve.

In this case each ordinate for a ratio changed as suggested above, from 1 : 3 instead of 1 : 2, would be reduced by $\frac{2}{3}$ and the corresponding abscissa increased by $\frac{3}{2}$, which results from the fact which we have enunciated that for any given motor and load tractive effort multiplied speed must be a constant.

Having thus seen how the various curves corresponding respectively to the ratios 1 : 1·5 and 1 : 2·5 have been deduced from the known results of the ratio 1 : 1·95 given in the original motor test curve, we will now discuss the effects of the change of gear ratio under the condition of speed and running distance now under consideration, as shown in Figs. 9 and 10.

It will at once be seen that the highest rate of acceleration is obtained with the greatest gear ratio, 1 : 2·5, and that the highest maximum speed is reached with the smallest gear ratio of 1 : 1·5. The watt hours per ton-

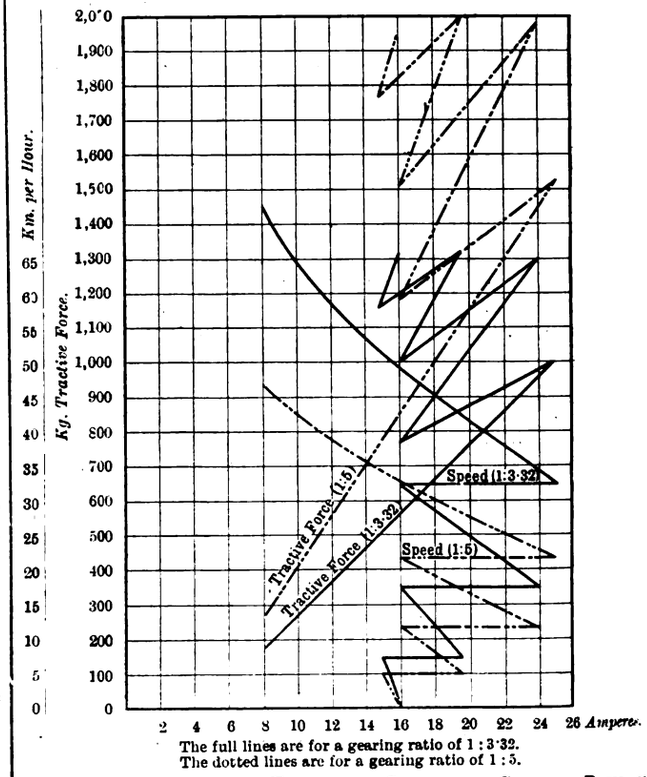
Km. per Hour.
Kg. Tractive Force.
Ampere.
Speed (1:3·32)
Speed (1:5)
Tractive Force (1:5)
Tractive Force (1:3·32)
The full lines are for a gearing ratio of 1 : 3·32.
The dotted lines are for a gearing ratio of 1 : 5.

FIG. 8.—CURVES SHOWING EFFECT OF CHANGE IN GEARING RATIO ON TRACTIVE FORCE AND SPEED FOR A SINGLE-PHASE MOTOR.

mile for the three-gear ratios considered as well as the maximum kilowatts and minimum speed work out, for the length of run under consideration, as follows:

Gear Ratio.	Efficiency.	Watt hrs. per ton-mile.	Max. speed reached in miles per hour.	Acceleration in ft. per sec. per sec.
1 : 2·5	74%	96	35	2·52 ft. per sec.
1 : 1·95	65%	104	35	1·9 ,,
1 : 1·5	63%	149	45	1·41 ,,

The above results are of course only applicable to the run on the level with a distance of 0·6 miles. Under ordinary working conditions the distances between stations will vary considerably, and gradients, as well as possibly sharp curves, may interfere. Under such circumstances the only way of ascertaining the best gear ratio is by means of trial and error, and complete calculations will have to be made for the entire run before it will be possible to ascertain what will be the best gear ratio to adopt for any individual case.

In making such calculations and in preparing the numerous running curves (under which heading all the curves discussed are classed), it behoves us to bear in mind that a certain amount must always be held in hand, so as

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to make up for lost time, and that in practice such a reserve may prove to be of the utmost importance.

From the kilowatt curve with a given service we are now in a position to plot a curve showing the load of the motors in amperes throughout the whole day. This curve will enable us to obtain the mean effective current to which a motor will be subjected and thus to see whether the motor under consideration is of such a design as to be fit for the service for which it is purposed.

The usual and very laborious method of obtaining the mean effective current would be to subdivide the area plotted into small rectangles and thus get the $\Sigma C^2 dt$, but a very much simpler way can be found by using polar co-ordinates as follows :—

The idea of transforming a rectangular plot into a polar plot is clearly shown diagrammatically in Fig. 11. As an example the following figures have been worked out and refer to the loading of the distributing cables in connection with the L.B. & S.C. Rly. Co.; these figures are only given as an example of the method which could, and would, be adopted in order to verify the size of the motors.

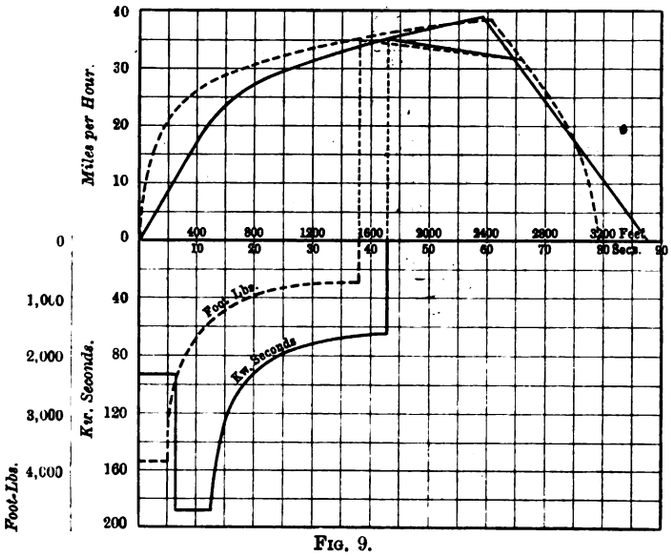

FIG. 9.

Running Curves for Gear Ratio 1 : 2·5.

Suppose a plot were made of a certain electrical distribution in which the scales were :—

abscissæ 1 cm. = 1 minute,
ordinates 1 cm. = 1 ampere.

This plot would then be transferred to polar co-ordinate paper by substituting angles for one of the linear dimensions of the rectangular plot. The scale for the polar plot may be chosen at will, but for this illustration we will take 10 degrees = 1 minute of time.

The next point is to find the radius at which one minute of time in the polar plot has a *length* of 1 cm., or the same scale as in the rectangular plot.

Since 10 deg. = 1 minute, 360 deg. = 36 minutes.

Now the radius of a circle whose circumference is 36 cm. is $\frac{36}{2\pi} = 5{\cdot}73$ cm. This constant 5·73 cm., which we will call R, is an important link between the two parts. Consider a small sector of the polar curve, Fig. 12, so small that the limiting values of current (I) included by it are sensibly equal.

Let Δt be the small increment of time which elapses as the vector passes from 0·1 to 0·2. Then at the Radius R (= 5·73 cm.) the linear distance Δt will represent the time, as does also the angle $\Delta\theta$. Since $\Delta\theta$ is very small 0, 1, 2, can be taken as a triangle and its area will therefore be $\frac{1}{2}$I × arc 1·2.

But $$\text{Arc . 1 . 2} = \frac{\Delta t \text{I}}{\text{R}}.$$

$\therefore$ Hence area $$= \frac{1}{2} \cdot \text{I} \frac{\Delta t \,.\, \text{I}}{\text{R}},$$

$$= \frac{\text{I}^2 \Delta t}{2\text{R}}.$$

And the whole area of the load curve in the polar plot will be $$\Sigma \frac{\text{I}^2 \Delta t}{2\text{R}},$$

$$\therefore \quad \Sigma \text{I}^2 \Delta t = \text{Area} \times 2\text{R}.$$

Hence the area of the polar curve, multiplied by a constant, gives us the sum of the squares of the different values, into the times during which they flow, which is the heating effect of the current.

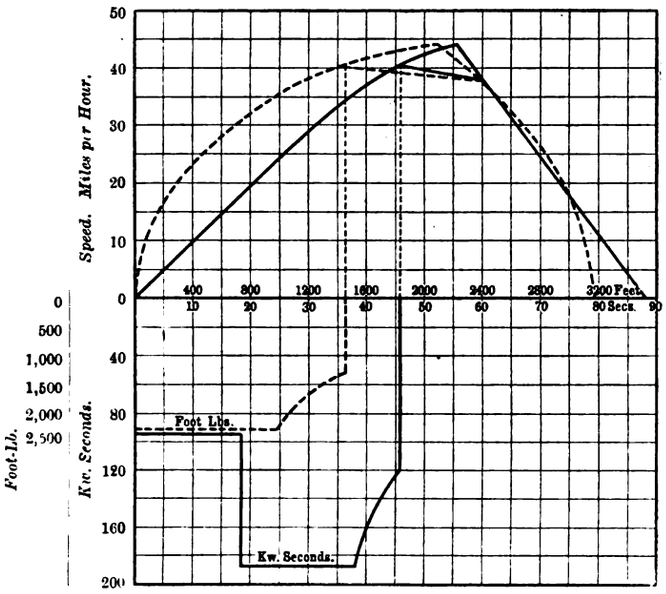

FIG. 10.

Running Curves for Gear Ratio 1 : 1·5.

The mean continuous current to give the same heating effect is obviously : $$\sqrt{\frac{\Sigma \Delta t \text{I}^2}{\text{T}}},$$

where T = total time for which we require the heating effect

$$\sqrt{\frac{\text{Area} \times 2\text{R}}{\text{T}}},$$

which, since T and R are known, can be found by measuring the plan curve with a planometer.

Concrete Example.—Take the L.B. & S.C. Ry. load curve from 5 p.m. to 5.36 p.m. (Fig. 13). Scale of rectangular curve, 1 cm. = 60 seconds, 1 cm. = 500 KW.

Polar curve (Fig. 14), 1 cm. = 500 KW., 10 deg. = 60 seconds.

$$\therefore \quad \text{R} = \frac{36{\cdot}0}{2\pi} = 5{\cdot}73 \text{ cm.}$$

The area of the curve is planimetered and found to be 88·2 sq. cm.

$$\therefore \quad \text{A} = 88{\cdot}2,$$
$$\text{A} \times 2\text{R} = 88{\cdot}2 \times 2 \times 5{\cdot}73,$$
$$= 1{,}010$$
$$= \Sigma \text{I}^2 \Delta t ;$$

or in this case $$= \Sigma \text{KW.}^2 \Delta t,$$

where KW. and t are expressed in centimetres.

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Multiplying by their scales, which are 500 and 60 respectively, we have $1{,}010 \times 500^2 \times 60 = \Sigma KW.^2 \Delta t$, in which the units are KW. and seconds.

$$\therefore \quad \Sigma KW.^2 \Delta t = 15{,}150{,}000{,}000,$$

and T=the whole time$=36 \times 60$,

and
$$\sqrt{\frac{\Sigma KW.^2 \Delta t}{T}} = \sqrt{\frac{15{,}150{,}000{,}000}{36 \times 60}}$$
$$= \sqrt{7{,}050{,}000}$$
$$= 2{,}650 \text{ KW.},$$

which is the mean effective KW., so that the mean effective current for an average power factor of 80 per cent. and at 6,000 volts will be

$$\frac{2{,}650{,}000}{6{,}000} \times 0{\cdot}8 = 550 \text{ amps.}$$

In Fig. 15 some curves are reproduced, for which the writer is indebted to the courtesy of the Allgemeine Elektricitäts Gesellschaft. These curves show the effect on gear ratio and energy consumption of varying each of the following conditions in turn and keeping the remainder constant, viz., voltage, train weight, length of run, schedule speed. The curves illustrate the following principles:—

(1) For the same service and equipments the gear ratio tends to advance with increasing train weights.

(2) Other things being equal, the best gear ratio advances with increased length of run.

This seems highly paradoxical at first sight, but it will be observed that in this consideration the best gear ratio has been taken to mean the gear ratio giving least energy consumption per ton mile (leaving aside the question of load factor). And it must be borne in mind that this advantage cannot be pushed too far at the expense of the size of the motor, and of unduly great fluctuations in load, &c., which have to be taken into consideration. For short-distance runs the energy losses in the resistances for high ratio of acceleration might assume very considerable proportions, and this question will be discussed hereafter in connection with the speed regulation of continuous and alternating current motors.

Reference has already been made to the fact that in calculating what size and number of motors are required for any given service it is necessary to make allowances (in ascertaining the tractive effort required) for the revolving parts, both when calculating acceleration and retardation, and for preliminary calculations an amount of 10 per cent. was taken as a basis.

It is evident that in finally determining the exact size and number of motors necessary to operate a given service more accuracy will be necessary and that the actual effect of revolving masses will have to be calculated for every individual case.

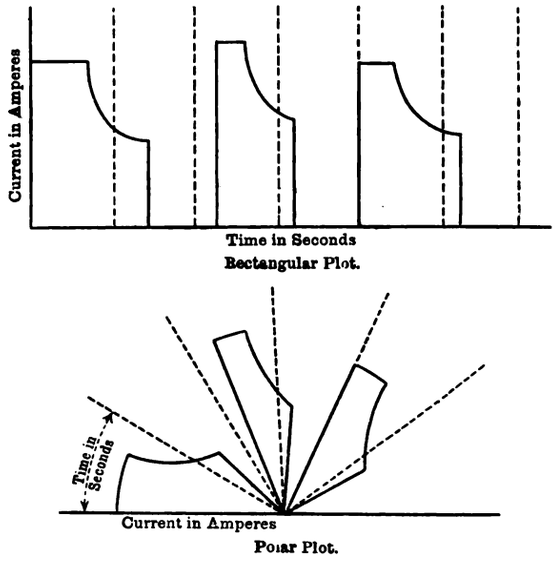

FIG. 11.

The motors are required to possess a capacity capable of (1) dealing with and overcoming train resistance, which, as will be seen in a future article where train resistances will be more carefully investigated, depend on such factors as condition and quality of track, friction of bearings, wind resistance, &c.; (2) the forces of gravity; (3) the inertia of the train.

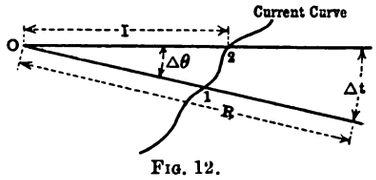

FIG. 12.

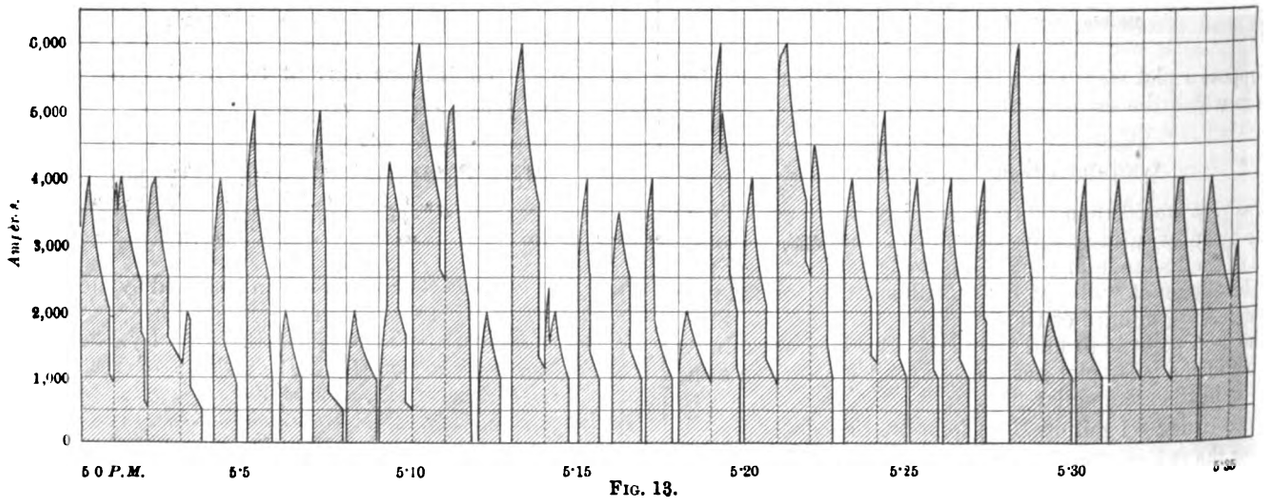

FIG. 13.

Load Curve from 5·0 p.m. to 5·36 p.m. for L.B. & S.C. Rly. Time Table worked out for Six Car Train Service.

As regards (2), the forces necessary to deal with these have already been fully described, and it is as regards (3) that more careful investigation is requisite, as it is into this that the effect of revolving masses enter.

Mr. Storrer pointed out in 1902 the importance of this factor, which had up to that time not been taken seriously into consideration. In tramway work with slower speeds

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its neglect did not seriously affect the actual results, but in heavy traction work this is no longer the case.

If a body undergoes both translation and rotation the total energy it possesses is made up of two portions—namely (1) that due to translation, (2) energy due to rotation, and this can be expressed by the following equation:—

$$E=E_t+E_R=\tfrac{1}{2}mv^2+\tfrac{1}{2}ma^2\rho^2,$$

in which the above letters represent E=total energy stored, E_t=energy of translation, E_R=energy of rotation, m=mass, a=angular velocity, ρ=radius of gyration.

Now, as $a^2\rho^2$ has the dimension of a velocity, we may therefore write

$$E_R=\tfrac{1}{2}mv_R^2,$$

in which v_R=linear velocity of a point at the radius of gyration.

If we consider the energy due to velocity as an increment Δm, to be added to the mass translated, then we see that as E_R can be expressed in dimensions of mass and velocity we can write

$$E=E_T+E_R=\tfrac{1}{2}mv^2+\tfrac{1}{2}ma^2\rho^2=\tfrac{1}{2}(m+\Delta m)v^2,$$

from which we find that

$$\Delta m=m\frac{a^2\rho^2}{v_2}.$$

Now for all masses which revolve with the same angular velocity as the wheels we can write

$$\frac{\text{angular velocity}}{\text{linear velocity}}=\frac{a}{v}=\frac{2}{d},$$

in which d=diameter of revolving body in feet; therefore we have $A^2/v^2=4/d^2$; hence we have

$$\Delta m=\frac{4}{d^2}\times\rho^2\times m.$$

Now as regards those parts which revolve at a different angular velocity to that of the wheels, if we call the gear ratio gr we have

$$\frac{a}{v}=\frac{2}{d}\times gr, \quad \text{or} \quad \frac{a^2}{v^2}=\frac{4}{d^2}\times gr^2,$$

and in their case $\Delta m=\frac{4}{d^2}gr^2\times\rho^2\times m$.

As in the course of this investigation we will have to ascertain the radius of gyration ρ of a certain number of different shaped bodies, in order to save, these values for the bodies with which this investigation is principally concerned will be noted down here in order to save time in calculation.

For a cylinder $\rho=0{\cdot}707\times r$ when r=extreme radius.

For a ring where r_1 represents the outside radius and r_2 the inside radius and $R=\frac{r_1+r_2}{2}$, and $h=r_1-r_2$, $\rho=\sqrt{R^2+\frac{1}{4}h^2}$.

As an example of the influence of revolving masses the following has been worked out:—Diameter of wheels at tread=3 ft. 7½ in.=3·625 ft., a/v for rotating masses at same speed of wheels=0·552,

$$a^2/v^2=0{\cdot}3045, \Delta m=0{\cdot}3045\times\rho^2\times m.$$

And if the weight is taken instead of the mass and designated by W, $\Delta W=0{\cdot}3045\times\rho^2\times W$. For all the masses driven by gearing, the gear ratio of which are designated by gr, for this calculation is taken at 1 : 4·24.

$$a/v=2{\cdot}34. \quad a^2/v^2=5{\cdot}48. \quad \Delta W=5{\cdot}48\times\rho^2\times W.$$

Weight of wheels in case under consideration is 1,013 lb. per wheel.

As regards the influence of revolving masses we have—

1. *For the axles*, whose radius is 0·28 ft. and $\rho=0{\cdot}197$ and weight=905 lb. $\Delta W=10{\cdot}7$ lb. per axle.

2. *For tyres of wheels* whose diameter=3·625 ft. $\Delta W=509$ lb. per tyre.

3. *For centre plates of wheels*, $\Delta W=82{\cdot}6$ lb. per wheel.

4. *For hubs of wheels*, $\Delta W=24{\cdot}9$ lb. per wheel.

So far as regards the masses revolving at the same number of revolutions as that of the wheels, for a three-car train comprising 12 axles, the allowances to be made work out as follow:—

12 axles	129 lb.
24 wheel tyres	12,210 lb.
24 centre plates	2,000 lb.
24 hubs	600 lb.
Total for above	14,939 lb.

Now we will ascertain the effect those portions which are revolving at speed different from that of the wheels, such as the motor armatures, and for these calculations a gear ratio of 1 : 4·24 has been presupposed.

1. *For armature*: $\Delta W=3{,}268$ lb., or for eight motors 26,144 lb.

Or for all revolving parts we have $\Delta W=18{\cdot}3$ tons.

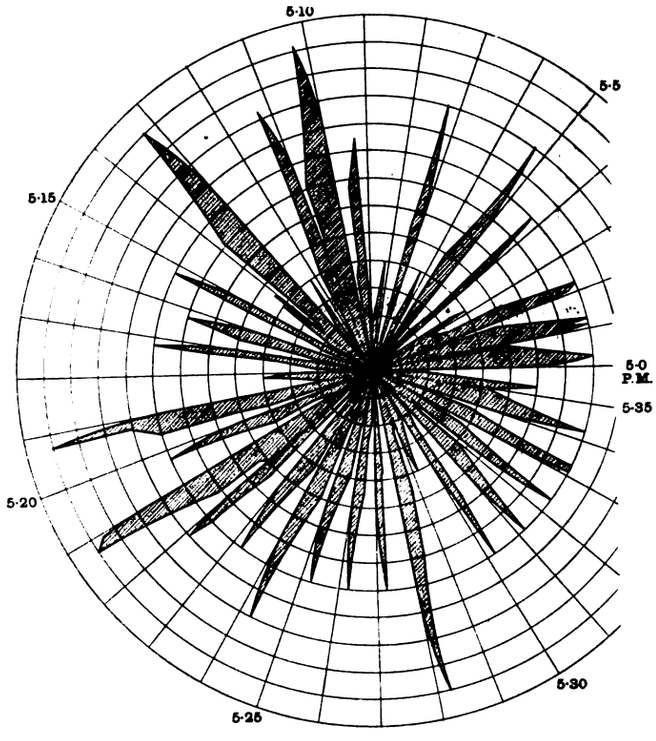

FIG. 14.

Load Curve from 5 p.m. to 5·36 p.m. for a Six Car Train Service as per Load Curve shown in Fig. 7. Mean Effective Current=550 Amperes.

From which it will be seen that assuming for argument's sake that the weight of the three-car train under consideration, including passengers, amounts to 150 tons, an amount of 6·7 tons will have to be added for the effect due to revolving wheels and axles and 11·6 tons more for motor armatures, or in round figures 12 per cent.

Or, in other words, in the above case 12·2 per cent. more energy is stored in the train than can be accounted for by its dead weight and 12·2 per cent. more motive power is required during acceleration and 12·2 per cent. more has to be taken care of by the brake equipments than the mere dead weight of the train would indicate, and, furthermore, the retardation of the train during coasting would appear to give 12·2 per cent. less train resistance than the true one.

It will at once be seen that what may be called the fly-wheel effect of the revolving parts must increase the energy consumption of the train, the actual increase depending on

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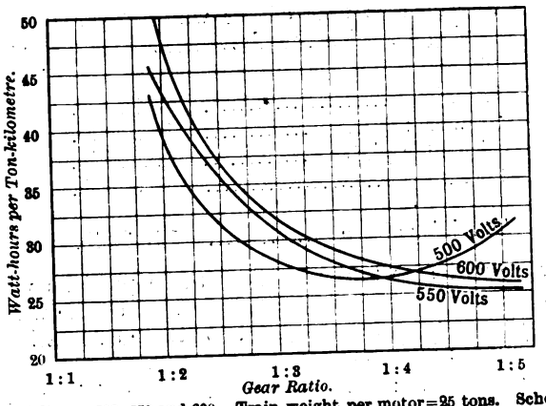
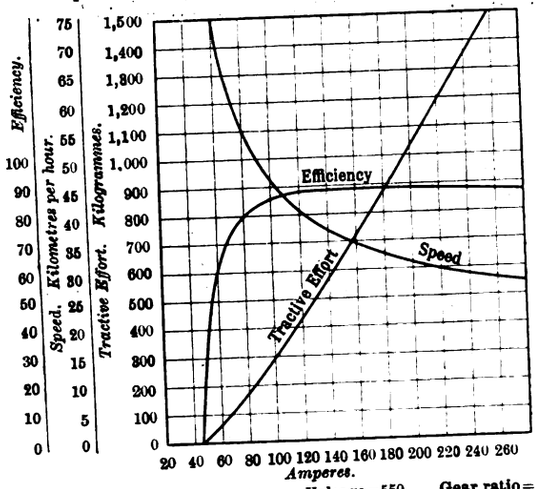
the rate of acceleration, the number of stops, the speed of the train at which brakes are applied, and on the train resistance. Where stops are frequent and high average speeds are attained, the energy lost in braking may amount to 75 per cent. of the total energy given out by the motors, and in such cases the extra energy consumption due to revolving parts may reach from 5 to 8, or even more, per cent. of the total.

From the above it will be seen that, although for preliminary calculations a value of, say, 10 per cent. of total train weight can be assumed as the effect of the revolving masses, final calculations with the actual motors, wheels, gear ratio, &c., must be made before it can be definitely decided that the motor proposed to be adopted will properly fulfil all the conditions for a given service or what the energy consumption will be.

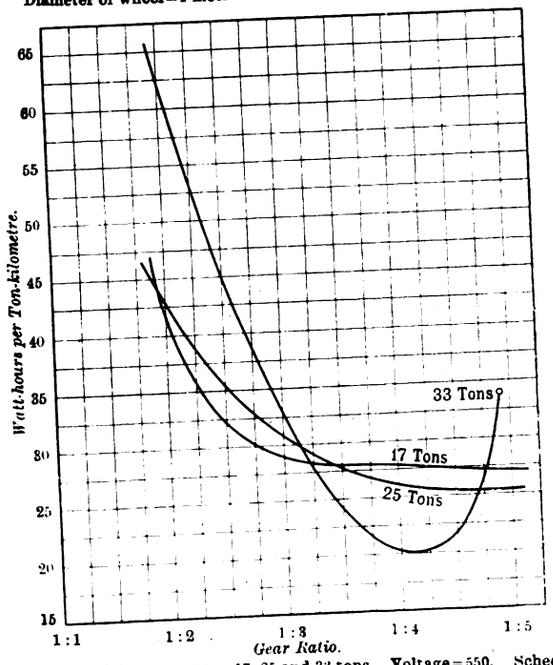
(*To be continued.*)



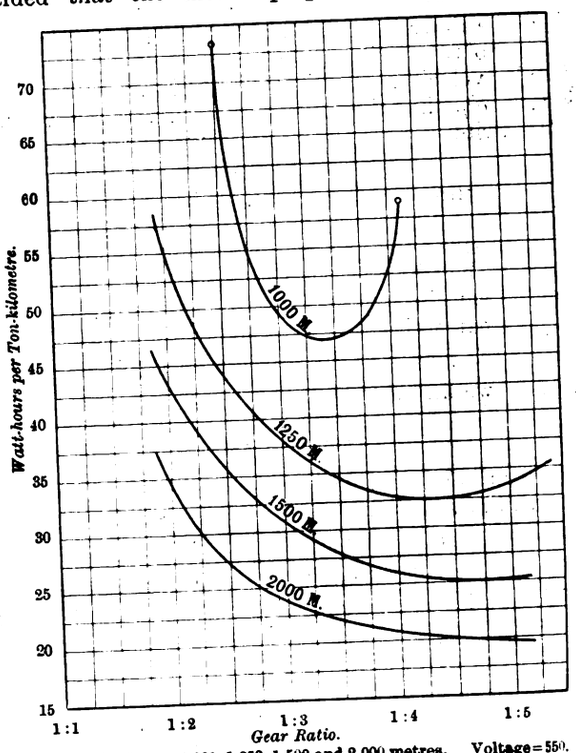
Voltage=500, 550 and 600. Train weight per motor=25 tons. Schedule speed=35 km. per hour. Length of run=1,500 metres.



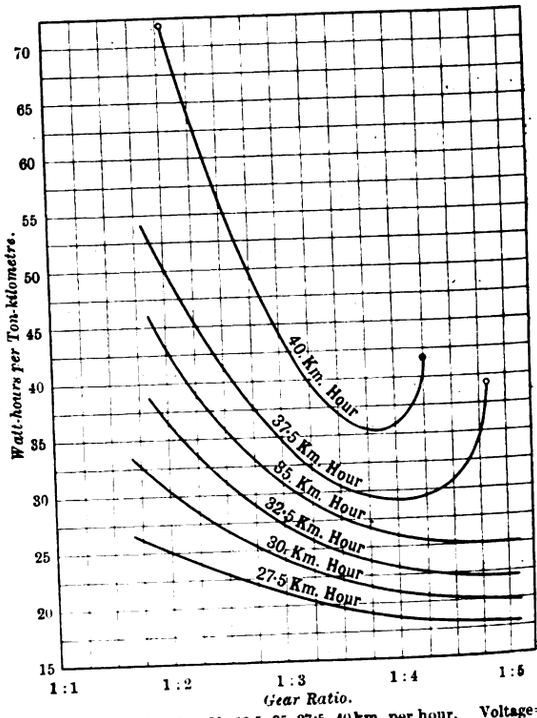
Characteristics for G.E. 66 motor. Voltage=550. Gear ratio=1:4. Diameter of wheel=1 metre. Internal resistance, hot=0·137 ohm.



Train weight per motor=17, 25 and 33 tons. Voltage=550. Schedule speed=35 km. per hour. Length of run=1,500 metres.



Length of run=1,000, 1,250, 1,500 and 2,000 metres. Voltage=550. Schedule speed=35 km. per hour. Train weight per motor=25 tons.



Schedule speed=27·5, 30, 32·5, 35, 37·5, 40 km. per hour. Voltage=550. Train weight per motor=25 tons. Length of run=1,500 metres.

FIG. 15.—CURVES SHOWING EFFECT OF VARIOUS GEAR RATIOS ON ENERGY CONSUMPTION FOR G.E. 66 D.C. MOTOR.

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BROWN BOVERI TURBO-ALTERNATORS AND TURBO-DYNAMOS.

In view of the very large number of turbo-generators which Messrs. Brown, Boveri & Co. have built during recent years, some account of the standard turbo-alternators and turbo-dynamos of this firm will be of interest to our readers. Since their acquirement of the Continental rights of the Parsons steam turbine in 1900, Messrs. Brown, Boveri & Co. have built or have on order up to the present time over 1,200,000 H.P. of steam turbines, the progress of this part of their business being shown by the following figures :—

Period.	Output of steam turbines ordered.
During the year 1900	6,000 H.P.
,, ,, 1901	9,000 ,,
,, ,, 1902	15,000 ,,
,, ,, 1903	126,000 ,,
,, ,, 1904	192,000 ,,
,, ,, 1905	218,000 ,,
,, ,, 1906	417,000 ,,
	983,000 ,,
Add, from Jan. 1, 1907, to June 10, 1907	217,500 ,,
Total to June 10, 1907	1,200,500 ,,

The great majority of these turbines (all built on the Parsons' principle, but with many modifications in important matters of detail) have been or are being built for coupling to electric generators, and the bulk of the remainder for ship propulsion, as shown by the following figures :—

Aggregate horse-power of turbo-alternators, to above date ..	867,402 H.P.
,, ,, turbo-dynamos, to above date	108,915 ,,
,, ,, turbines for ship propulsion, to above date	186,500 ,,
,, ,, turbines for coupling to pumps, compressors and blowers, to above date ..	37,683 ,,
Total.....	1,200,500 ,,

The generators, whether for alternating current or direct current, are entirely of Messrs. Brown, Boveri & Co.'s own design, and embody in their construction much pioneer work and many original features of design which have been nowadays in many cases (for instance, with regard to the method of ventilation and of field-magnet construction) embodied in the standard practice of many of the makers who have come later into the field.

Turbo-Alternators.—These are of the rotating cylindrical field totally enclosed type, with forced ventilation—a type created by Mr. C. E. L. Brown ;* the type lends itself to the greatest possible extent to the essential requirements of successful turbo-alternators, namely :—

(*a*) Solid and symmetrical arrangement of the field system, with the field coils positively secured and driven, the entire structure being capable of safe and silent running at the high speeds inherent to steam turbine work, combined with ease of balancing, and the elimination of possible troubles due to the rotating field system getting out of balance.

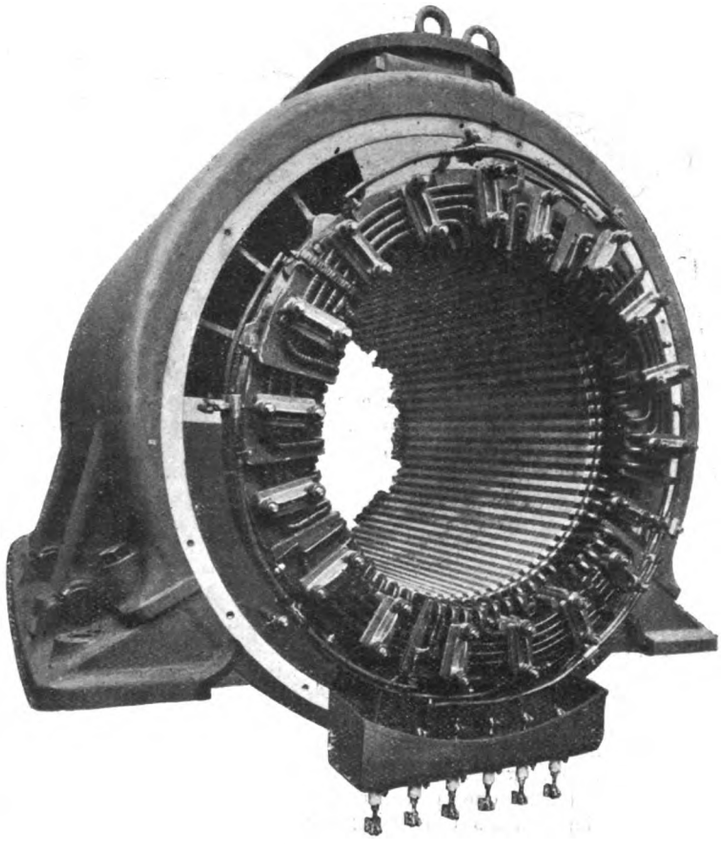

FIG. 1.—ARMATURE (WITHOUT END SHIELDS) FOR THREE-PHASE TURBO-ALTERNATOR OF 5,000 KW., 10,500 VOLTS, 50 CYCLES, AND 1,000 REVS. PER MIN. (OBERSPREE ELECTRICITY WORKS, BERLIN.)

(*b*) Efficient and positive ventilation of all parts of the alternator, whereby no internal portions of the machine are appreciably hotter than the accessible parts, thereby eliminating unequal expansions, possible shifting of windings, and ensuring permanent balance, together with great durability of the insulating material.

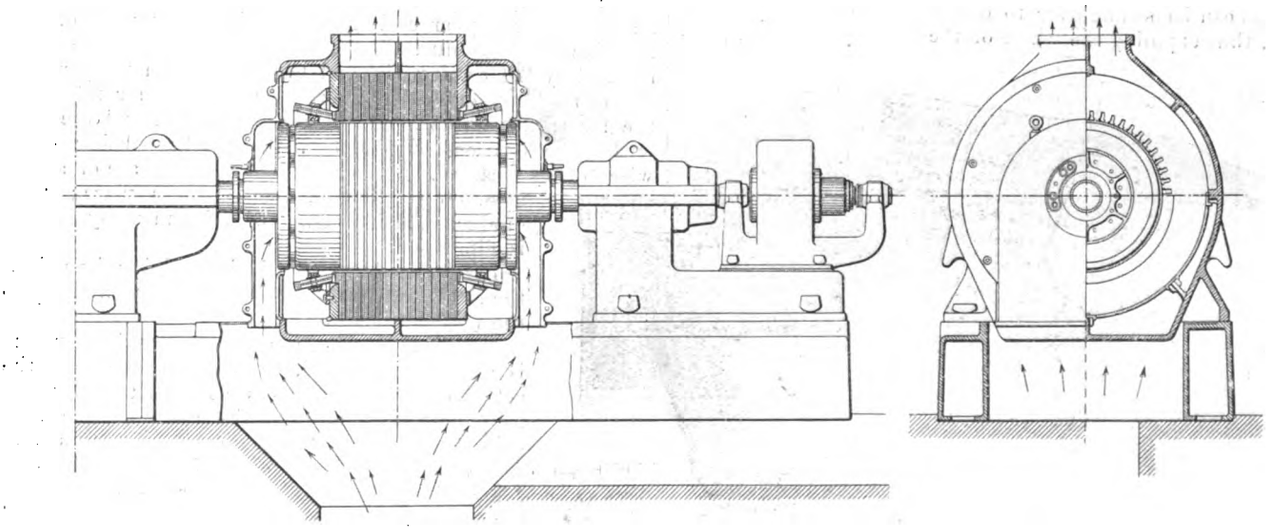

FIG. 2.—ILLUSTRATING STANDARD METHOD OF VENTILATION EMPLOYED FOR TURBO-ALTERNATORS.

(*c*) Silent and vibrationless running.

(*d*) Good pressure regulation.

It will be seen from the following description of the Brown

* See British patent specifications Nos. 24,632 of 1901 (field magnet construction), and 26,274 of 1903 (ventilation).

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Boveri turbo-alternators how well these machines conform to the above requirements.

Armature.—In all cases the armatures are stationary, the core discs being built up inside a cast iron casing which is totally enclosed, with the exception of a chimney-like opening at the top and an air inlet at the bottom on each side. Fig. 1 shows the appearance of the armatures for alternators of medium and large size respectively when the end covers are removed. Special features to be noted are: (1) The large number of air ducts in the core, the subdivision of the latter being carried to such an extent that the whole core and the windings must have the same temperature; (2) the considerable air space which exists all round the external periphery of the core for the circulation of air; and (3) the great care which is taken with the mechanical construction of the winding, especially in respect to the manner in which the ends of the coils and the connections from coil to coil are held.

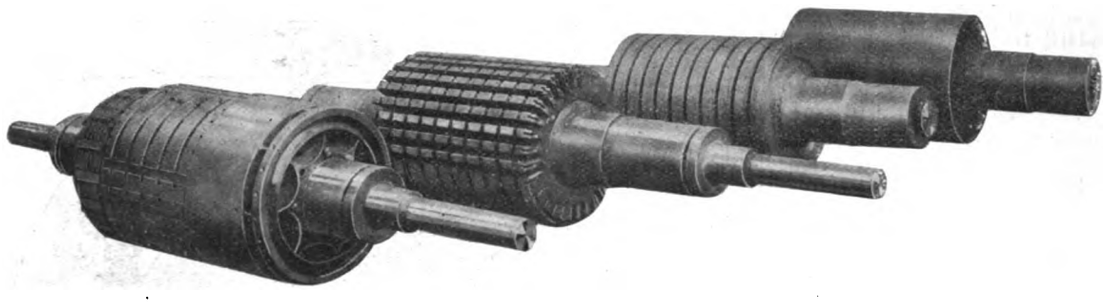

FIG. 3.—ILLUSTRATING STAGES IN THE CONSTRUCTION OF THE FIELD SYSTEM OF TURBO-ALTERNATORS FOR SMALL OUTPUT.

In the smallest machines the armature casing is made in one piece, but in the medium and larger sizes the casing is generally made in two pieces, the division of the core and casing being horizontal, as usual. When, however, six-pole machines are in question the casing of the largest alternators is sometimes made in three pieces. Such a construction is shown in Fig. 1, referred to above, representing the casing of one of the 5,000 kw. 10,500 volt turbo-alternators in the Oberspree station at Berlin; and it will be seen that the upper portions of the casing are hinged, and that, after removing a few bolts, these upper sections can be swung over to one side with the help of the crane, thus exposing the whole of the field system, and practically the whole of the armature, without the necessity of removing the former from the machine.

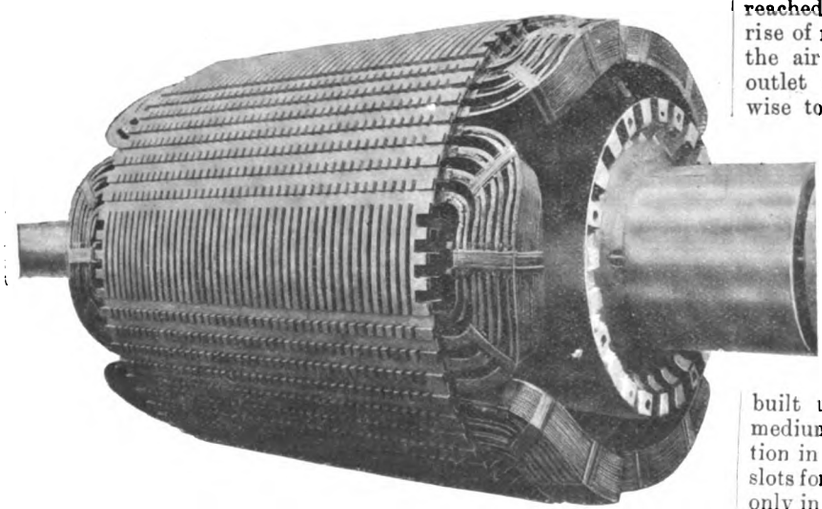

FIG. 5.—HUB, CORE, AND WINDINGS OF FIELD SYSTEM AS EMPLOYED WITH TURBO-ALTERNATORS OF LARGE OUTPUT.

Fig. 2 shows the manner in which the ventilation of these turbo-alternators is effected. The field system (the construction of which will be described later) is provided with vanes on the end caps, which have the effect (during rotation) of drawing from the outside that volume of cool air which is necessary for the effective ventilation of the alternator, and propelling the same through every part of field magnet and armature, afterwards ejecting it into the surrounding atmosphere. The air is drawn through the inlet openings at each end of the machine from the basement, or other source of cool, dry air, and it is then propelled through the cores and windings of both field magnet and armature into the annular space surrounding the armature core, and finally ejected into the atmosphere through the chimney-shaped opening at the top of the armature casing. Practically every part of the field magnet and armature copper and iron—that is, every part of the machine which becomes the seat of the generation of heat—is reached by the cooling air, and thus a uniform temperature rise of moderate amount is the result; the only air inlets are the air trunks at each end of the alternator, and the only outlet the opening at the top, the machine being otherwise totally enclosed, and as all these passages are of ample area, no trottling of the air takes place; thus one considerable source of noise in many designs is eliminated.

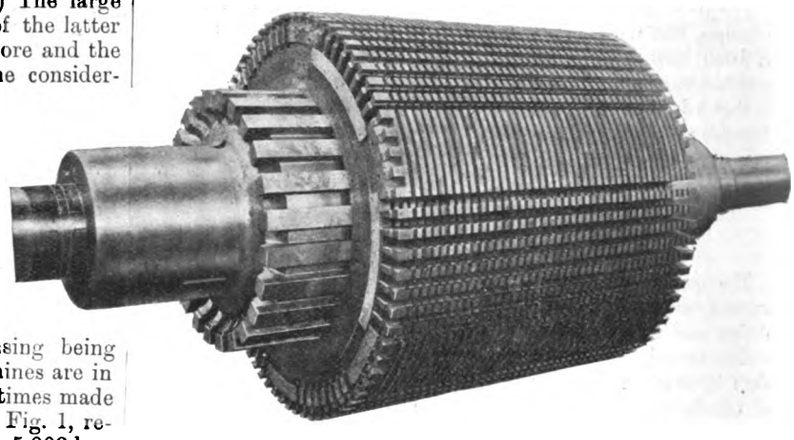

FIG. 4.—HUB AND CORE OF FIELD SYSTEM AS EMPLOYED WITH TURBO-ALTERNATORS OF LARGE OUTPUT.

Fig. 2 also shows a method of holding the ends of the armature coils, sometimes used alternatively to the method illustrated in Fig. 1.

The field system of the Brown Boveri alternators is always cylindrical, as stated above, but the actual construction differs somewhat in accordance with the size of the machine, the field core being solid for the small machines and built up of steel plates for the case of the machines of medium and large size. Fig. 3 shows the process of construction in the former case. It will be noted that the longitudinal slots for the reception of the coils are milled out from the core only in those places where they are wanted, there being no slots in those portions of the core which form the actual poles. The slip-rings are placed one at each end of the field magnet, and are of cast steel—in some cases with a bearing surface of copper; the greatest care is taken with the connections from the field coils to these rings, these being positively held down on the shaft, no part of the conductor being exposed. The purpose of the peripheral grooves which are turned in the core

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is to permit of effective ventilation of the winding. The iron and copper masses constituting the active material in the field system are so subdivided that the cool air drawn into the machine can reach practically every part.

Fig. 4 shows the core construction adopted for the case of large machines, and Fig. 5 shows the same core with the field coils in place, but with the end covers removed. These two illustrations again show very clearly the ample provision for ventilating the field system; the cool air entering at each end at the centre of the alternator divides itself into two main streams, one of which is propelled down the longitudinal grooves left for the purpose in the steel hub, and then out radially by way of the air spaces between the steel plates forming the field core.

The steel casting forming the hub is, of course, machined inside and outside, and the steel core plates are held thereon by keys and by the heavy end plates, which will be noticed in the illustrations.

The slots for the reception of the field windings are in all cases closed by metal wedges running the entire length of the slots and positively held therein by means of niches, or grooves, left for the purpose. The field windings themselves are of rectangular copper and are heavily insulated from the slots and from the metal wedges by means of a special heat-resisting material.

The rating of the Brown Boveri alternators with respect to temperature rise and pressure regulation is such that they will easily conform to the recommendations of the Engineering Standards Committee for normal machines, and as a matter of fact the temperature rises obtained are stated to be considerably lower than those permitted by these regulations, this being, of course, due to the very efficient manner in which ventilation is arranged for. At the same time, the expenditure of power for ventilation is no larger than is the case with machines of ordinary design—that is to say, the thorough ventilation is not obtained at the expense of efficiency.

With regard to the balancing of such field-magnet systems as those described above, it will be readily understood that, as compared with "polar" field systems, it is an easier matter to obtain perfect balance on account of the inherent advantages of the cylindrical construction in this respect; moreover, the balancing will be permanent and independent of changes in the load. The very perfect balancing obtainable with the cylindrical design, combined with the system of ventilation described above, renders the running of Brown Boveri alternators so noiseless that, for instance, in the St. Denis station at Paris (which will ultimately contain ten 6,000 kw. sets) the ticking of a watch, placed a few inches from the alternator, can be plainly heard.

(To be concluded.)

THE NEW YORK, NEW HAVEN AND HARTFORD RAILWAY.

Summary.—A description is here given of the overhead equipment, rolling stock and power station of the New York, New Haven and Hartford Railway. This railway is an interesting example of single-phase operation from an overhead line, in conjunction with a direct-current third rail over part of the route.

In our issue of June 7th we gave a brief description of the electrification of the New York, New Haven and Hartford Railway. The chief point of interest about this railway is that part of the track is equipped with a third rail for direct current working at 600 volts, whilst for 22 miles an overhead trolley construction supplying single-phase current at 11,000 volts is in use. We are pleased to be able to give now a more detailed description based on an article in the *Electrical World*.

Overhead Construction.

The catenary line work is one of the distinguishing features of the New York, New Haven and Hartford Railway. The supporting bridges are of varying lengths, so as to accommodate four, five, six, or as many as twelve tracks, as the local conditions require, and are of two types—anchor bridges, which are used only at intervals of about 2 miles, and intermediate bridges. The latter have side posts of square cross-section and are of comparatively light construction. On the other hand, the anchor bridges have A-shaped posts, and are made heavier to withstand the strain of the cable. The anchor bridges are provided with automatic circuit-breakers, by means of which the different sections may be isolated, and also the several parallel tracks may be electrically separated from one another in case of accident to any one track. The anchor bridges also carry lightning arresters, shunt transformers for operating the circuit-breakers, together with foot-walks, hand-railings, lamp circuits and the wires and conduit for the auxiliary control circuits.

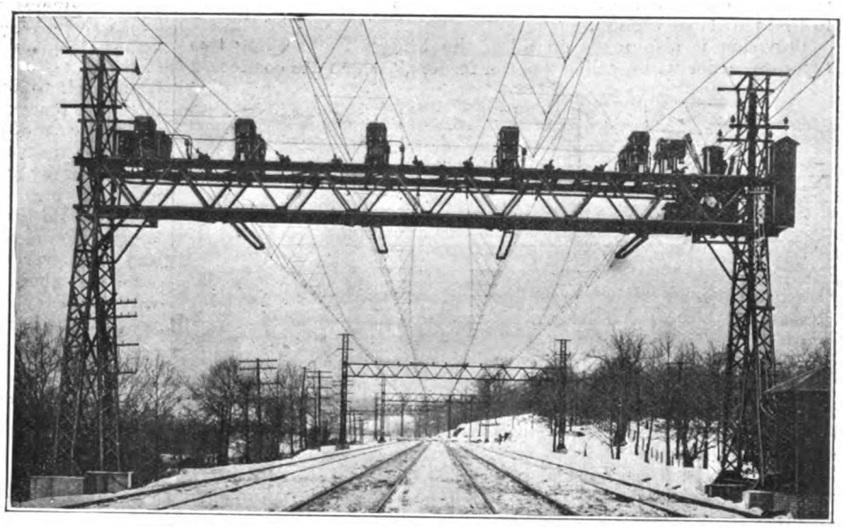

Fig. 1.—View of Overhead Construction Showing Anchor Bridge.

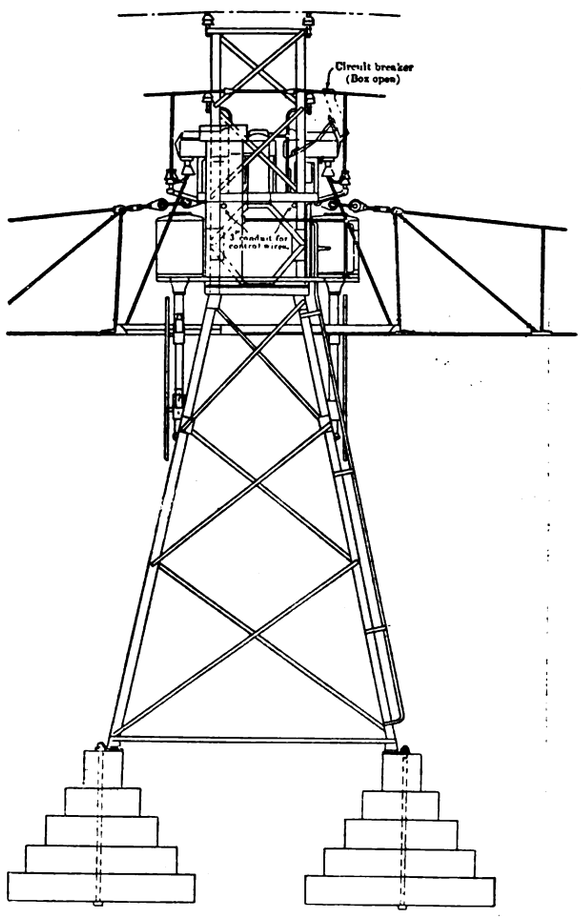

Fig. 2.—End View of Anchor Bridge.

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The working conductors have sufficient area for the working current, but two auxiliary feeders extend along the entire length of the line from Stamford to Woodlawn. These feeders are connected with the main conductors at each anchor bridge through circuit breakers and provide means for feeding around any one section in case it is cut out of service on account of some accident in that particular section.

Provision is also made on all of the bridges for carrying two separate feeder wires, called "power feeders," which are connected

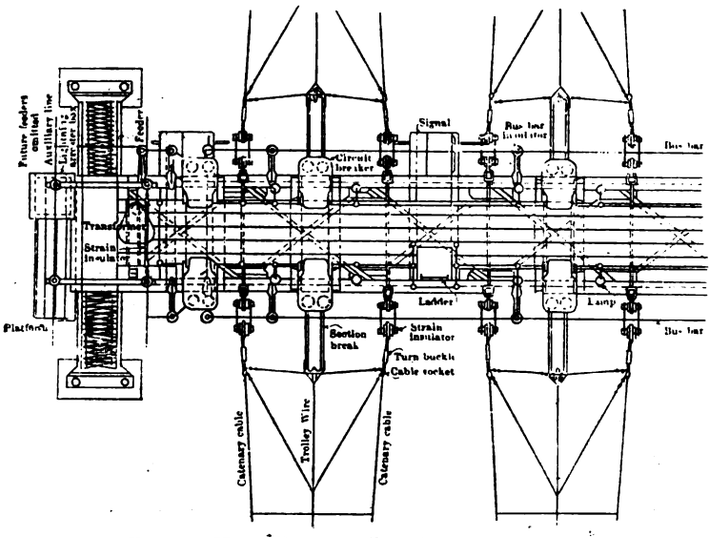

FIG. 3.—HALF PLAN OF FOUR-TRACK ANCHOR BRIDGE.

to the third phase of the generating system and are used for operating three-phase apparatus at certain intervals along the road. Provision is also made on the bridges for carrying two three-phase circuits, one circuit being supported on the top of each post at the ends of the bridges.

In laying out the bridges for the section from Woodlawn to Stamford, it was found that the sharpest curvature was 3 deg. As this curvature will permit of stringing the trolley wire in straight lines between points of support 150 ft. apart without deviating from the centre of the track more than 8½ in. on each side, it was decided to place all bridges a fixed distance of 800 ft. apart, and on curves to provide guy poles to which pull-over wires are attached and secured to the catenary spans. By this means a minimum amount of overhead wiring was obtained, and the deviation from the centre of the track was maintained within safe limits for use in connection with the sliding pantograph trolleys on the locomotives, the bow of which is 4 ft. long.

Intermediate Bridges.—The standard four-track intermediate bridge consists of two supporting side posts and a horizontal truss. Each supporting post is approximately 38 ft. long by 1 ft. 10 in. square. Each is composed of four 4 in. by 4 in. by $\frac{7}{16}$ in. angles secured together by 2½ in. by ⅜ in. lacing bars. Each post rests upon a concrete foundation containing about 9 cubic yards of concrete. Anchor bolts extend entirely through the concrete foundation and hold the base of the post to the foundation by means of heavy nuts. The cross-truss is attached by means of bolts to the vertical posts, allowing a distance of 23 ft. 4 in. from the lower side of the truss to the top of the rails. The truss is 4 ft. 6 in. deep from back to back of the upper and lower chord angles, which latter are placed 1 ft. 10 in. from back to back. The lacing bars of the upper chord are depressed below the upper surface of the chord angles so that the latter are left free from rivets or other obstructions, thereby affording a ready means for attaching the insulators at any point. The lacing bars of the upper chord consist of flat strap, while the diagonals in the sides and bottom of the truss consist of angles. The upper cord angles are 3½ in. by 6 in. by ⅜ in., and the lower are 4 in. by 3½ in. by $\frac{5}{16}$ in. The extensions of the side posts above the trusses are utilised for supporting the feeder wires, which are carried upon angle iron cross-arms bolted to the posts. The lower cross-arm carries two insulators, upon the inner one of which is carried the auxiliary feeder. The upper cross-arm is located 5 ft. above the lower one and carries two wires of the three-phase circuit. The third wire of the three-phase circuit is carried upon a light vertical channel-iron support.

FIG. 5.—MAIN LINE INSULATOR WITH SUPPORTING YOKE.

In the calculation of these bridges very heavy weather conditions were assumed, and provision was made for clamping the catenary cables on the intermediate bridges so that they are obliged to partially withstand the longitudinal pull of the cables. It was assumed that the entire system of the bridges and cables might become coated with sleet, and this coating might be ½ in. in thickness around all surfaces. It was assumed also that the wind pressure on the bridges and the catenary spans might at the same time be as high as 25 lb. per square foot. It was further assumed that the effective area of all round cables would be two-thirds of their projected areas. Each catenary cable is clamped to its supporting insulator on every intermediate bridge, and it was assumed that if one pair of cables should be broken, the remaining cables would exert a balancing influence on the bridge. The truss, however, was made strong enough to prevent its buckling under the strain produced by the breakage of any pair of cables.

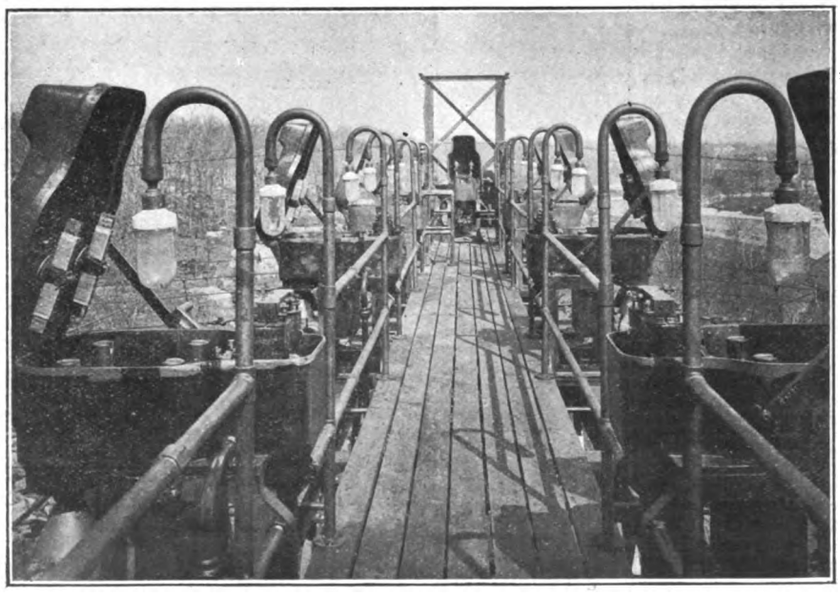

FIG. 4.—VIEW OF PLATFORM ON ANCHOR BRIDGE, SHOWING CIRCUIT BREAKERS ON EITHER SIDE.

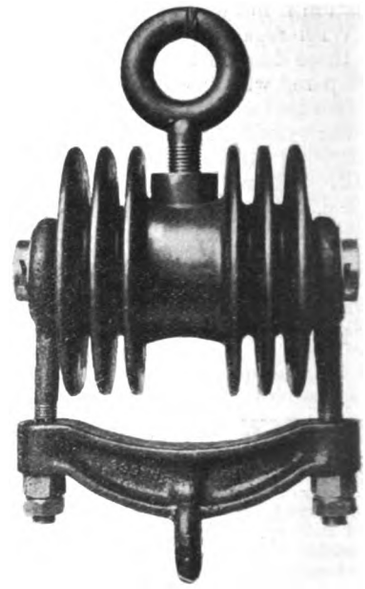

FIG. 6.—STRAIN INSULATOR.

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Anchor Bridges.—Anchor bridges of especially heavy construction are placed every 2 miles and against these bridges the catenary cables are anchored. Fig. 1 gives a view of a standard four-track anchor bridge with the auxiliary apparatus mounted upon it. The four-track anchor bridge consists of two A-shaped posts, each having a spread at the base of 15 ft., and a width at right angles to the track of about 2 ft. The main members of these posts consist of 6 in. by 4 in. by $\frac{5}{8}$ in. angles, These posts are also extended above the truss in the manner shown in the illustration for the purpose of carrying the feeder wires. The truss is bolted to the side posts, allowing a clearance above the rails to the lower side of the truss of 24 ft. 3 in. The truss is 4 ft. 6 in. deep by 5 ft. wide between the backs of the chord angles. The upper chords consist of 8 in. by 8 in. by $\frac{9}{16}$ in. angles, and the lower chords consist of 4 in. by 3$\frac{1}{2}$ in. by $\frac{9}{16}$ in. angles.

Fig. 2 represents the side view of the anchor bridge, and Fig. 3 a half plan of the same bridge from which additional details of the construction may be noted. A ladder is provided on one of the posts leading to a small platform at the end of the truss. This platform is provided with a hand-rail and carries upon it a box containing an 11,000 volt low equivalent lightning arrester. A portal is provided in the end of the truss, by means of which the attendant may step on to the platform supported upon the lower chord of the truss. From this platform access is provided to the short ladders leading to the signal lanterns, and a second short ladder extending up to another 2-A platform supported upon the upper chord of the truss. This platform, a view along which is given in Fig. 4, is surrounded by a hand-rail, which is also attached to the iron supporting frames of the circuit-breakers in such a manner that the attendant can in no way come in contact with live parts of the circuits. At each end of the truss a 5 kw. 11,000 volt shunt transformer is provided, one of them being connected directly into a 'bus bar which runs around the outside of the circuit-breakers and which is supported upon porcelain insulators and 'bus-bar brackets, secured to the upper chords of the truss. The other transformer is connected directly into one of the "power" feeders. As the "power" feeder is connected to the third-phase of the generating system, means are available for operating the switches in case of accident to the trolley section. The four-track anchor bridge is secured to a concrete foundations by means of long anchor bolts and nuts. Each post rests upon blocks of concrete, each block containing about 12 cubic yds. of concrete.

Catenary Cables.—Each of the two catenary cables which support the copper trolley conductor consists of an extra high-strength steel cable, $\frac{5}{16}$ in. in diameter, consisting of seven strands. This steel has an ultimate strength of about 200,000 lbs. per square inch, and each strand is heavily galvanised. The completed cable has a total strength of 33,800 lb. These cables are strung between the bridges with a sag at mean temperature of 6 ft. in a standard span of 300 ft. Owing to obstructions at certain places along the right of way, the spacing of the bridges is occasionally varied from the standard distance of 300 ft. In order to allow for this the cable is run out in long lengths and is pulled up to a uniform tension until the sag in the span of 300 ft. is 6 ft. The sag in the other spans is allowed to adjust itself, since the tension is the same. After being pulled up to the proper tension the catenary cables are anchored to the anchor bridges and are clamped to the insulators of the intermediate bridges.

Main Line Insulators.—The insulators which support the catenary cables of the intermediate bridges consist of heavy porcelain insulators of the skirt type, which are 15 in. in diameter and about 7 in. high. These insulators are cemented upon short lengths of double extra-strong pipe, which in turn is held by means of U-bolts to a cast-iron yoke, bolted to the upper chords of the truss. The catenary cable rests in a groove in the top of the porcelain, and is held by means of a malleable-iron clamp fitted with U-bolts and placed one on each side of the insulator. The head of the insulator is conical in shape and is surrounded by means of a split malleable-iron clamp and a lead packing. Fig. 5 represents the main line insulator complete with its supporting yoke.

One feature of the construction to be noted is the arrangement of the clamp and the collar, which is such that in case of the breakage of the messenger cable on one side of the insulator the pull of the cable on the other side will cause the clamp to swing downwards, thereby lowering the point of application of the pull of the cable. Thus the porcelain is put in compression, and there is no tendency to shear off the top of the porcelain, as is usually the case with porcelain line insulators. Each porcelain is subjected in the shop to a test of 55,000 volts when assembled.

Anchor Bridge Strain Insulators.—Fig. 6 represents the general appearance of the strain insulators which are used for dead-ending the catenary cables at the anchor bridges. These insulators, which are of special construction, are designed to withstand a shop test of 50,000 volts and a working load of 20,000 lb. Each consists of a length of 2 in. extra heavy iron pipe, surrounded at its middle point by an iron collar. Outside of this collar a long insulating tube, composed of especially hard and reliable insulating material, is pressed. This tube is surrounded by a second collar, into which a bolt is screwed and to which the turnbuckle of the catenary cable is attached. The entire surface of the insulating tube and the inner and outside collars are then effectively sealed against moisture by means of a high-grade insulating compound applied by means of hydraulic pressure. The insulator thus made up is supported by means of an iron yoke from cast-iron hooks bolted to the upper chords of the anchor-bridge truss. One of these insulators is provided in each catenary cable at each anchor bridge, thereby electrically dividing the road up into separate sections between the anchor bridges.

Guy Poles.—Midway between the supporting bridges and curves a guy pole is located on the outside of the curves. These guy poles are of two types—namely, rigid and anchored, the former being used wherever there is room on the right of way for the anchorage, while the latter is used in places where the width of the right of way is restricted. Heavy strain insulators are attached to the guy poles at the proper height, and pull-over wires are attached to these strain insulators and to the catenary cables and trolley wires of the several tracks. The strain insulator is somewhat similar in appearance to the well-known "giant strain," except that it is designed to withstand a test of 50,000 volts and a mechanical pull of 15,000 lb. It is made up of steel castings and solid mica insulating cones and is sealed with a high grade insulating compound. These strain insulators are attached by means of one loop to the guy poles, and the pull-over wires are attached to the other loop.

Insulating Separators.—In order to enable any one track to be electrically disconnected from any other parallel track when the circuit breakers on the anchor bridges are open, insulating separators are provided in the pull-over wires between the tracks. Each separator consists of a 5 ft. rod of selected hickory, thoroughly impregnated and fitted at the ends with malleable-iron heads secured

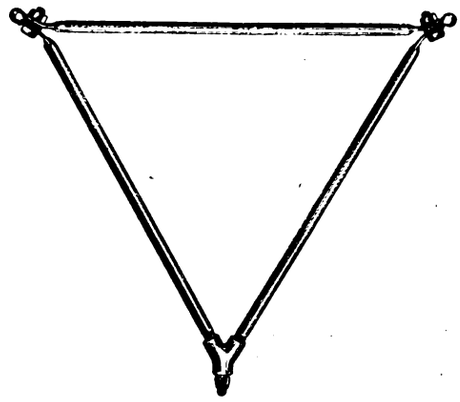

FIG. 7.—TROLLEY HANGER.

to the conical-shaped heads of the rods by means of bolts. Each insulator has an ultimate strength of about 16,000 lb. At no point in the entire construction is wood relied upon for insulation to earth, and it will be noted that these wooden separators normally have no difference of potential upon them. They are merely provided in case of accident, when it is necessary to isolate one section of track from another. They are, however, subjected to a test of 30,000 volts.

Trolley Hangers.—The trolley wire is supported from the catenary cables at 10 ft. intervals by means of triangular trolley hangers of varying lengths. These hangers are so adjusted in length that the trolley wire is maintained in a horizontal position (Fig. 1), it being 6 in. below the catenary cables at the middle point of the span. The appearance of a hanger is shown in Fig. 7. It consists of a pair of small drop forged steel jaws, which engage with the grooves of the trolley wire, and are clamped by means of a malleable-iron Y, which is screwed down upon the threaded portions of the jaws. The side of the triangle are then screwed into the Y and are bolted to the messenger cable above. As all of the threads are right-handed it is impossible for the hanger to come loose.

Section Insulators.—At each anchor bridge it is necessary to provide an insulator in each trolley wire, and this is accomplished by means of the piece of apparatus shown in Fig. 8. Each consists of two bronze end castings, to which the ends of the trolley wire are bolted. Two parallel sections of impregnated hard wood are fastened to these castings, and to these wooden strips are fastened renewable pieces of trolley wire in such a manner that the ends of these renewable pieces overlap one another in distance along the track, although the two wires are electrically distinct. By this means it is possible for the sliding contact on the locomotive to pass from one section to the next without opening the circuit, thus avoiding all flashing. It will be noted, however, that an effective

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insulation is provided, so that when the circuit-breaker on the anchor bridge is open the two sections will be disconnected. The manner in which this section insulator is installed is clearly shown in the end view of the anchor bridge (Fig. 2). Insulators in place under an anchor bridge are shown in Fig. 1.

Low Bridge Construction.—At a number of points along the road overhead bridges reduce the clearance above the tracks. The construction consists of a corrugated porcelain spool, mounted upon an iron pipe, which in turn is supported at each end from a skirt-type

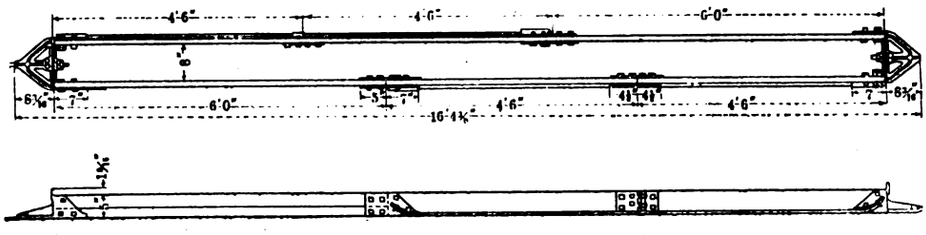

FIG. 8.—SECTION INSULATOR.

porcelain insulator, of the same design as that used on the intermediate bridges. The messenger cables where they pass under the bridge are heavily insulated, and the hangers which support the trolley wire from the messenger cable are placed midway between the porcelain insulators, so that the maximum amount of flexibility is obtained. The trolley-wire hangers are constructed of impregnated wood, so that the trolley wire is completely insulated from the catenary cables. A waterproof shield is attached to the bridge above the insulating structure, so as to prevent accumulations of dirt and water on the insulators.

Automatic Circuit-breakers.—The type of circuit-breaker which has been developed for this installation is shown in Fig. 9, which gives the details of the device, while Figs. 1 and 4 show the breakers in place on the anchor bridges. The breaker consists of a cast-iron framework adapted to be bolted to channel irons resting upon the upper chords of the anchor bridges. This framework carries an iron box provided with a hinged cover. This cover is arranged to fit tightly in place, so as to exclude all rain and snow and be entirely weatherproof. The moving parts of the circuit-breaker are contained within this box and are made especially strong and reliable in their operation. The terminals of the switch are brought out through specially-constructed insulators mounted in an overhung portion of the box at the rear (Fig. 9). Upon the tops of insulators are carried knife-switch jaws, and there are corresponding jaws mounted on the upper ends of the circuit-breaker contacts. Two switch blades are carried on insulating pillars fastened to the hinged cover of the box in such a manner that when the cover of the box is closed one terminal of the switch is connected to the 'bus-bar on the anchor bridge and the other is connected to the trolley wire. Arrangements are provided so that if the cover is opened the circuit-breaker will be automatically tripped and thus prevent any possibility of the attendant taking hold of live parts.

The circuit-breaker is capable of handling 11,000 volts on heavy, short circuit. A tripping coil is provided, together with closing magnets, both of which are operated from a circuit supplied from the small shunt transformers on the anchor bridge. The switch is also arranged to open automatically on overload. The control wires for the closing magnets and the tripping coils are carried in iron conduit and lead-covered cable to the adjoining signal tower, where a switchboard panel is provided. This panel is fitted with switches so that any circuit-breaker may be tripped by hand, or closed by the attendant in the signal tower. There is also a switch by means of which the attendant may connect either of the shunt transformers on the anchor bridge to the control circuit.

The auxiliary feeders, which are supported on the inner insulators of the lower bracket arm on the bridges, are looped in to the 'bus-bars on each alternate anchor bridge. These connections are made through automatic circuit breakers, so that in case of the earthing of the 'bus-bar structure to any anchor bridge, one of the auxiliary feeders will pass around the earthed bridge to the next section beyond. On each other anchor bridge one auxiliary feeder is broken by a strain insulator, and connections are made through circuit-breakers to the 'bus bar. The other auxiliary feeder is carried directly through, and a single tap connection is made from the feeder through the circuit-breaker to the 'bus bar. Upon the next bridge these conditions are reversed, so that each auxiliary feeder is divided into 4 mile sections. This arrangement provides a maximum flexibility of control.

Track Bonding.—Both rails of all tracks are bonded by means of No. 4-0 compressed terminal flexible bonds placed around the fish-plates. The trolley wire itself consists of standard No. 4-0 grooved copper.

Turn-outs and Cross-overs.—Whenever one track diverges from another a section insulator is inserted in the trolley wire. Insulators are also inserted in the catenary cables supporting the diverging wire between parallel tracks. The diverging trolley wire is connected to the main wire by means of a frog of standard design, and, in order to prevent the contact shoes on the locomotive from catching, deflector wires are placed in the angle between the trolley wires. These deflectors are carried by yokes secured to the trolley wire and are attached to yokes at the rods which are fastened to the catenary hangers. There being a certain amount of flexibility in the overhead trolley system, when the bow is pressed upward against the contact wire, this wire is raised above the level of the other contact wires in the immediate neighbourhood. Thus, certain portions of the short length of trolley wire used to interconnect the two main trolley wires at cross-overs would tend to remain in a plane below that of the active trolley wire as the locomotive passes

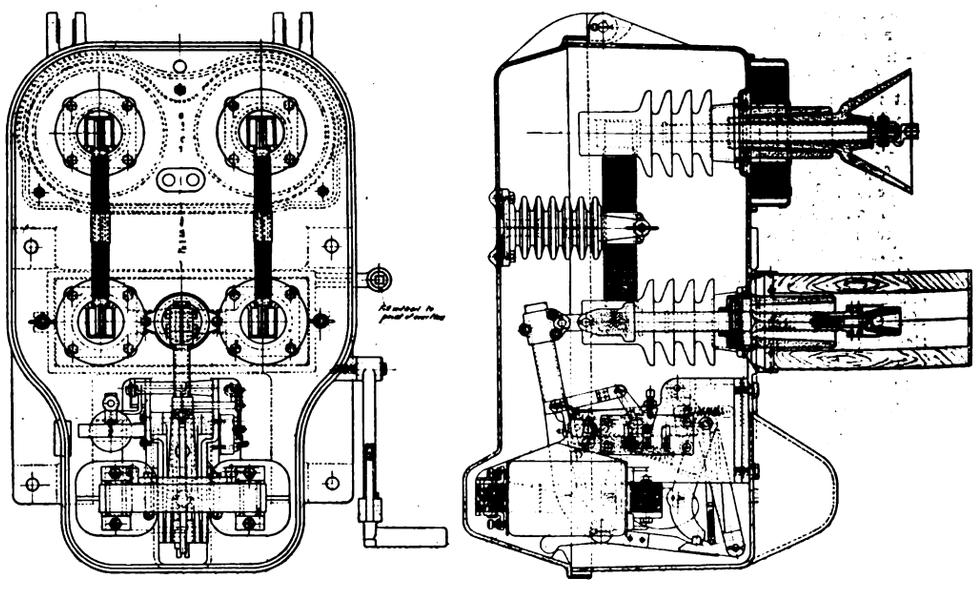

FIG. 9.—DETAILS OF OIL CIRCUIT-BREAKER.

this point. The deflector wires are designed to tend to cause the cross-over trolleys and the main trolley to be raised partly in unison by decreasing the upward movement of the main trolley and increasing the upward movement of the cross over trolley. The contact bow of the trolley mechanism on the locomotive is given a certain amount of upward curvature towards the centre, so that the bow has no tendency to catch in either the cross-over trolley wires or the intermediate deflector wires.

(To be continued.)

The Tramways and Light Railways Association.—The official circular for September contains a list of the results obtained by the promoters of tramway bills during the session 1907, references to tramway orders, light railway orders, &c., a copy of the Home Office's proposed regulations for the generation, transformation, distribution and use of electrical energy in premises under the Factory and Workshop Act, 1901, a copy of the Light on Vehicles Act, just passed, and a reprint of Mr. W. Worby Beaumont's British Association Paper on the "Origin and Production of Corrugation on Tramway Rails."

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WESTINGHOUSE METALLIC FLAME ARC LAMP.

The endeavour to increase the efficiency and reduce the cost of maintenance of arc lamps has resulted in the production of the Westinghouse metallic flame arc lamp, which is claimed to have practically double the efficiency of the carbon arc and to give very good illuminating results, owing to the whiteness of the light and the uniformity of its distribution. In this lamp the use of carbon electrodes has been abandoned; a metallic oxide is used for the negative or upper electrode and the lower or positive electrode is formed by a metallic button. The use of these electrodes results in the formation of a highly luminous arc, which greatly increases the efficiency of the lamp for lighting purposes; the consumption of current has been reduced and the burning life of the electrodes has been lengthened. Another difficulty which has been overcome is the deposit of soot from the burning electrodes, not only upon the reflectors and globe, but upon the electrodes themselves. The lamp has been designed to operate upon a direct constant current. This current may be supplied from a constant-current generator, but a rectified alternating current affords an equally satisfactory method of operation, with the additional advantage of much better economy.

Advantages claimed for the Westinghouse Type of Construction.—The length of the negative electrode, which in this lamp is the one that burns away, is not limited, except by the height of the lamp itself, thus permitting the use of a much longer electrode than is possible with the inverted type of construction. In addition, this location of the electrodes brings the brilliant surface of the negative electrode to its proper position, where it acts as a reflector to throw the light downward: at the same time the luminous incandescent envelope of volatilised oxides surrounds the upper half of the arc and greatly increases the efficiency with which the light is distributed. Dark shadows below the lamp are avoided, as are highly concentrated zones of light in its immediate neighbourhood. A third advantage accruing from this arrangement is that it enables the use of a simple down-feed instead of the more or less complicated and troublesome up-feed necessitated with the inverted type of lamp. In the past the use of metallic electrodes has been handicapped by the fluffy reddish oxide produced sticking to everything it touched and accumulating very rapidly upon the globe and reflector, as well as upon the electrode, requiring removal mechanically, provided proper means were not employed, to prevent such deposits. In this lamp the foregoing trouble has been carefully guarded against by means of air currents. In order to prevent the deposit on the negative electrode, where it would hang down like a curtain, obscuring the arc, a current of air has been directed downwards, surrounding this electrode with a wall of air. A similar wall of air is provided which prevents the oxide from collecting on the reflector or globe. These two currents of air meet and pass up the chimney carrying the fumes from the arc, and preventing the soot-like oxide from coming into contact with the central guide tube, protecting the upper electrode holder, or the exterior walls of the chimney. In short, the draught arrangements are designed to remove all the by-products of the arc entirely from the lamp without affording them an opportunity to come in contact with anything except air. The top of the chimney and the air inlets are so designed that reverse currents of air are impossible, and while the intensity of the wind naturally affects the intensity of the draught, high winds cause no trouble, but are, to a degree, advantageous as contributing to increase the efficiency with which the by-products of combustion are removed from the lamp. While these air currents are designed to prevent deposits, they are also intended to centre the arc and steady it, and to prevent it from running up the side of the electrode.

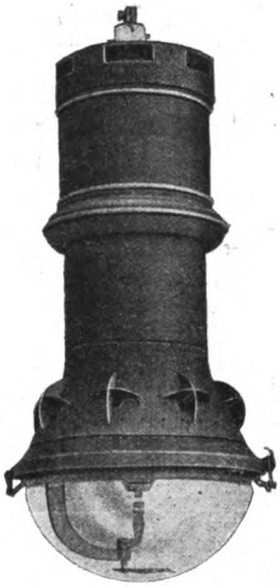

FIG. 1.

The energy required is much less than in the carbon arc. The metallic oxide arc operates on a current of 4 amperes with a drop across the arc of from 65 to 70 volts and is said to have an illuminating effect superior to that of the enclosed carbon arc operating on a current of 6·6 amperes with 75 to 80 volts drop. Further, the carbon arc does not give a satisfactory light when the voltage across the arc drops below 65, while the metallic flame arc will give good results with less than 55 volts.

The light emanates from an incandescent mantle of volatilised oxide surrounding the upper portion of the arc and a small portion is reflected from a molten pool of oxide on the upper electrode. We understand that the all-round distribution of the light is, therefore, superior to that of the inverted type of this lamp, and far exceeds that of the enclosed carbon arc. The light from the Westinghouse metallic flame arc radiates from the arc itself and spreading out in a horizontal direction, affords a brilliant general illumination. With the enclosed carbon arc the light issues from the incandescent crater on the bottom of the top electrode, and the major portion of the light is concentrated within a cone-shaped pyramid, the radius of whose base is equal to its height.

Another advantage claimed for the Westinghouse metallic flame arc lamp lies in the length of the burning life of the electrodes, which exceeds that of the enclosed carbon arc; this increases the number of lamps which can be attended to by one trimmer; and in addition, the inner globe required by the enclosed carbon arc is dispensed with, which naturally tends to reduce the cost of maintenance in a very effective manner.

General Description—Being designed for out-door service the lamp presents a simple and inconspicuous, but symmetrical exterior (*see* Fig. 1). The chimney tube forms the main portion of the frame, carrying at its lower end the metal frame which supports the globe, and being hung from a cap, on which the two terminal binding posts are placed and to which the hanger is attached. The lamp is 33½ in. in height and has a maximum diameter of 14½ in. The case is formed of heavy sheet copper with a black finish. The upper portion, surrounding the mechanism and magnet chamber is secured to the cap by a bayonet joint. The lower portion surrounds an air chamber which contains the porcelain resistance spools. This case is so designed that all portions of the mechanism are readily accessible, owing to the telescopic form of construction adopted. A portion of the lower case is double, enclosing an annular air passage, the outer shell being pierced with a number of openings supplemented with wind guides. The inner shell has openings which are staggered with those in the outer shell. The inner openings are so located that the water cannot reach the interior of the lamp and are provided with insect screens.

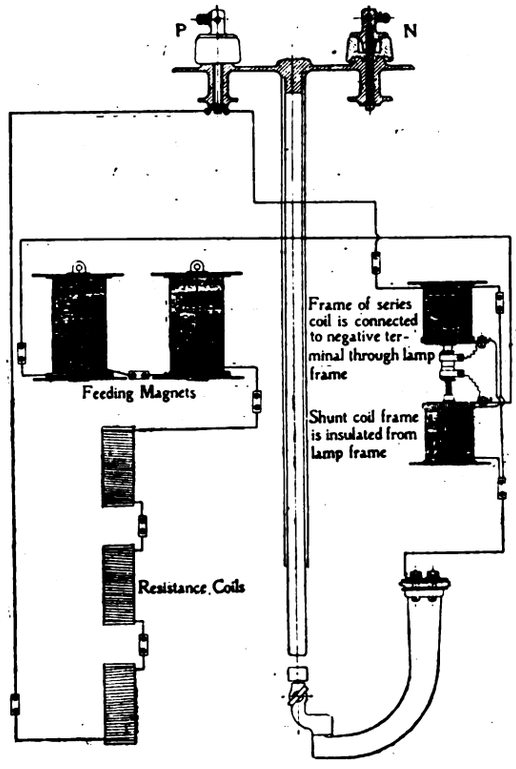
P
N
Frame of series coil is connected to negative terminal through lamp frame
Feeding Magnets
Shunt coil frame is insulated from lamp frame
Resistance Coils

FIG. 2.—DIAGRAM OF INTERNAL CONNECTIONS.

The lower electrode holder consists of a goose-necked composition casting which can be swung to one side to permit the insertion of the upper electrode. The upper electrode holder consists of a split bronze sleeve with a stem and flexible conductor attached to its upper end. The holder slides freely in an aluminium guide tube, one side of which is grooved its entire length. The flexible negative conductor is connected to a thimble in the upper portion of the guide tube and attached to the electrode holder. The guide tube is completely closed and arranged to protect the upper electrode holder from any fouling by deposits of oxide or dirt. The positive or lower electrode consists of a composite metallic button designed to produce a slag or cinder which will be a conductor when either hot or cold. The cinder protects the surface of the anode and prevents its rapid wasting away. A 12 in. electrode has an average burning life exceeding 150 hours.

At the present time these lamps are only being made in America.

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INTERCOMMUNICATION ON TRAMWAYS.

Although standardisation has been very pronounced in the case of manufactured apparatus in recent years, it has been comparatively neglected in dealing with engineering problems as a whole. Perhaps the most marked example of this is electric traction. It is, no doubt, rather early to talk of uniformity in systems of electrification on railways, as there is still a great deal to be learned, though it is quite obvious that if one railway adopts the ordinary low-tension continuous-current system, another a considerably higher pressure system of the same kind, a third polyphase working, a fourth single-phase working at 25 cycles, and yet a fifth single-phase working at 15 cycles, a good deal of inconvenience may result. Railway electrification is, however, still in the experimental stage as a whole, and therefore we must be content to await developments, and trust that the question of uniformity will not be overlooked, in so far as it affects the general convenience and the important question of intercommunication.

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In the case of electric tramways, on the other hand, the state of affairs is very different, for that branch of electric traction has been more fully developed and cannot be considered as experimental. For this reason it appears all the more desirable that serious attention should have been paid some years ago to standardisation in the schemes adopted. As it is, the tramway systems of neighbouring towns are being extended to meet one another, and yet through-running from town to town, which is so characteristic a feature in America, often becomes impossible. The gauge is frequently the cause of the difficulty. Thus at Halifax the gauge is 3 ft. 6 in., at Bradford and Keighley 4 ft., at Huddersfield 4 ft. 7¾ in., while at Leeds, Sheffield and many other towns it is 4 ft. 8½ in. It is thus impossible to adopt through-running between these towns, although they are comparatively near together. Other cases of isolated towns are Wolverhampton and Lincoln, through the adoption of surface-contact systems. Occasionally the inconvenience becomes acutely felt, and may be remedied in some such way as at Bradford, where the engineer, Mr. C. J. Spencer, is introducing a special type of truck in which the wheels are adjustable, so as to enable cars to be run on either of two gauges and to pass from one to the other. Generally, however, where such systems meet it is necessary for the passengers to change cars if they wish to travel from one system to the other.

Although this disregard of standardisation may lead to some inconvenience in provincial towns, the inconvenience in the neighbourhood of London by its disregard is likely to prove much more serious. The London County Council, so far, has adopted almost exclusively the conduit system for its tramways. As is well known, this system is the most expensive, and its selection is justified only in those parts of the city where the overhead trolley system can be seriously considered as a disfigurement or as an obstruction to other traffic. As the tramway system of the Council becomes extended it becomes necessary therefore to consider what other systems are most suitable for the extensions, taking into account the varying conditions of the routes of the new lines. Not only have these varying conditions to be taken into account, but there is the important question of coupling up the outlying systems belonging to other authorities so as to secure through-running. So far as the passing from the conduit system to a trolley system is concerned, the means of doing so are sufficiently simple. This is effected in Paris as a regular thing, not only on the conduit lines, but on surface-contact and accumulator lines also, by suitably equipping the cars. In the suburbs of London, however, a difficulty arises owing to the fact that many suburban tramway systems are already in existence. It will be a comparatively simple matter for the London County Council to adapt its cars so that they can run over the suburban lines belonging to other authorities, but it is a more serious matter for the smaller local authorities to alter their rolling stock so as to be capable of running on a conduit system. The suburban councils will probably feel that they cannot afford the necessary outlay. The position of affairs has been accentuated recently by the proposal of the London County Council to adopt the "G.B." surface-contact system for the tramways along Mile End-road and Bow-road as a way out of the difficulty in which it has been placed by the objection of the Stepney Borough Council to the overhead system which was proposed. The adoption of the surface-contact system would, however, introduce further complications in the way of through-running, and, since the West Ham Corporation considers through-running to be essential, a deadlock for the moment has been reached.

The West Ham tramways are but a single example of the many tramway systems surrounding the metropolis with which it would be a public convenience to have through-running. There is the system of the London United Tramways on the west, the tramways of Croydon, Beckenham, Bexley, Gravesend and other places on the south, and Leyton and Walthamstow on the north, and therefore it is to be hoped that the London County Council, in extending their tramways, will do all that is possible to avoid the introduction of any system of working likely to interfere with through-running between the outlying metropolitan services.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Machine Design. By CHARLES H. BENJAMIN. (London: Archibald Constable & Co.) Pp. 202. 8s. net.

This book embodies to a considerable extent the author's experience in teaching and in commercial work. It contains numerous tables, many of them giving the results of experiments made by the author. The experiments on cast-iron cylinders, pipe fittings, springs, ball and roller bearings, gear teeth, pulley arms and bursting strength of flywheels supply very useful data for the designer and manufacturer. The book is not overloaded with mathematical formulæ, but, as the author says in the preface, "contains the necessary facts and principles and not too much else."

The chapters into which the book is subdivided are: Units and tables relating to strength of materials; Frame design; Cylinders and pipes; Fastenings; Springs; Sliding bearings; Journals, pivots and bearings; Ball and roller bearings; Shafting, couplings and hangers; Gears, pulleys and cranks; Flywheels; Transmission by belts and ropes. Nearly every chapter bears evidence of the author's own contribution to the sum of knowledge of that part of the subject; the book forms, therefore, a welcome variation from the usual style of text-book, in which paste and scissors, with possibly a variation in the arrangement of old material, have played the most prominent part. For example, the author's experiments on flywheels and pulleys with solid and jointed rims, although now well known all over the world, are here given in a form convenient for easy reference by the designer.

The book is to be recommended not only to students, but also to every mechanical engineer who wants to be kept up to date.

Transformatoren für Wechselstrom und Drehstrom. By GISBERT KAPP. 3rd edition. (Berlin: Julius Springer.) 8m.

Although the general plan of this well-known work has remained unaltered since its first appearance some 10 years ago, the author has introduced various improvements and additions with a view to bringing it up to date. We accordingly find a number of new features in this, the 3rd, edition of the book. Little need be said about the first chapter, which deals with general principles and the calculation of the E.M.F. induced in a transformer coil, and which remains the same as in the two previous editions. In Chapter II., which deals with the core losses in transformers, we find data relating to the newer brands of transformer stampings. Chapter III., in which are considered the various types of core construction and the heating of transformers, contains an interesting new formula connecting the weight of a transformer with its output and frequency, and a table of the numerical values of the coefficient which occurs in the formula, for various types of

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transformer. In Chapter IV. we have a sketch of alternate-current theory, an account of the method of pre-determining the no-load current and of the design of a choking coil. Chapter V. contains a detailed design worked out in illustration of the principles explained in the preceding chapters. Chapter VI. deals with the voltage regulation of transformers, a subject which has been largely enriched by the author's own contributions to it. Chapter VII. is devoted to a more general theory of the transformer and its leakage coefficients, and the establishment of the circle diagram. Chapter VIII., which deals with the theory of the wattmeter and the testing of transformer iron, has undergone very considerable expansion. We are glad to notice that the author strongly upholds the value of ballistic methods of measurement. It is somewhat puzzling to find, on p. 225, in connection with the calibration of a ballistic galvanometer by means of a standard cell and condenser, the value of the E.M.F. of the Clark cell given to six significant figures! The methods described by Messrs. Morris and Lister in their recent Paper are included in the account of iron testing, and the author's own recently devised ingenious method of determining the hysteresis loss during a half-cycle is also given at the end of the chapter. Chapter IX. deals with safety devices, boosters, series transformers, compensators and phase transformers. In Chapter X. we have an excellent account of capacity effects in cables, of resonance phenomena and their danger. The concluding Chapter XI. contains, as in previous editions, an illustrated description of some typical transformers.

In its present form the work may be regarded not only as a standard treatise—a claim which it has long established for itself—but as an up-to-date and extremely readable account of the design, construction and use of the alternate-current transformer.

THE POULSEN ARC AS A MEANS OF OBTAINING CONTINUOUS ELECTRICAL OSCILLATIONS.*

BY J. A. FLEMING, D.SC., F.R.S.

The author describes experiments on the Poulsen arc, the apparatus being constructed on the same lines as that of Mr. Poulsen. The carbon made one rotation every two or three minutes. The field used did not exceed 1,000 C.G.S. units in strength, and generally was about 600 units. This field was so directed as to cause the arc to spring between the upper edge of the carbon and a copper beak, terminating a water-cooled brass tube and forming the other electrode; the arc was forced upwards in an arch. Using a direct-current supply at a pressure of 400 to 500 volts, with a suitable rheostat interposed, it is easy to form an arc having a P.D. between the the carbon and metal electrode of 300 to 350 volts and taking 5 to 10 amperes.

These electrodes were connected by an oscillatory circuit consisting of a condenser made with metal plates separated by sheet ebonite, the whole being immersed in an insulating oil. The capacity of the condenser generally used by me was 0·00289 mfd. In series with the condenser was an inductance consisting of a coil of insulated copper wire No. 7/22 wound in square form over a wooden cross, so as to make a circuit 60 cm. in the side, having eight turns. The inductance of this coil for high-frequency currents was 116,200 cm. An additional sliding inductance was used consisting of bare copper wire wound in a spiral on a wooden rod 1¼ in. or 3·2 cm. in diameter having eight turns to the inch. Two such spirals were placed on a support parallel to each other and cross-connected by a sliding copper saddle, so that by moving the saddle, more or less inductance could be thrown into the circuit without interrupting it. The full inductance of the double spiral was 200,000 cm. If, then, an arc is created between the electrodes and adjusted to be of such a length as to take about 8 amperes with 300 to 350 volts between the carbons, then powerful oscillations are set up in the square circuit in series with the condenser. A hot-wire ammeter inserted in this circuit indicated a current of about 5 amperes. If an electrostatic voltmeter is joined across the terminals of the condenser, we find a P.D. of 1,200 to 1,500 volts (R.M.S. value), vastly exceeding the steady P.D. of the arc electrodes.

The existence of a powerful oscillatory current in this square circuit may be shown by holding near to it a circular coil of about 30 turns, 30 cm. in diameter, formed of well-insulated wire, to the ends of which a 50 volt carbon filament glow lamp is attached. When this round coil is held near and parallel to the square coil, the lamp lights up brilliantly in consequence of the secondary current induced in the lamp coil.

It is, however, seen that the lamp often flickers a good deal, showing that the primary oscillation current is not absolutely constant, and this flickering varies with the adjustment. It is, however, possible to adjust the arc so that the glow lamp remains fairly steady, and if its incandescent filament is examined in a revolving mirror its image will be seen spread out into a uniform band of light.

This, however, is not an absolute proof of the uniformity of the oscillatory current. To the above-mentioned condenser circuit I then attached a long helix of fine silk-covered wire (No. 30 S.W.G.) wound in one layer of closely adjacent turns on an ebonite tube (*see* Fig. 1). This length of this helix was 210 cm., its diameter 4·78 cm. and the number of turns 5,470. This helix was supported horizontally on insulating stands about 45 cm. above the table, a sheet of zinc as long as the helix being placed on the table to act as an earth plate. This earth plate was connected to the metallic electrode of the arc and the helix to the junction point between the condenser and inductance coils in series with it.

The far end of the helix was provided with a number of needle points formed by a bunch of sewing needles attached to a wire.

On adjusting the inductance in series with the condenser so that the whole inductance in series across the arc terminals had a value of about 215,000 cm., powerful stationary oscillations were excited in the helix. Under these conditions, vivid blue electric brushes 1 cm. or 2 cm. long appear on the needle points at the far end of the helix, thus showing that the potential at that end has been increased by resonance to many thousand volts. These brushes are not of the same harmless character as the ordinary electric brush of an electrostatic machine, but are veritable flames or arcs taking

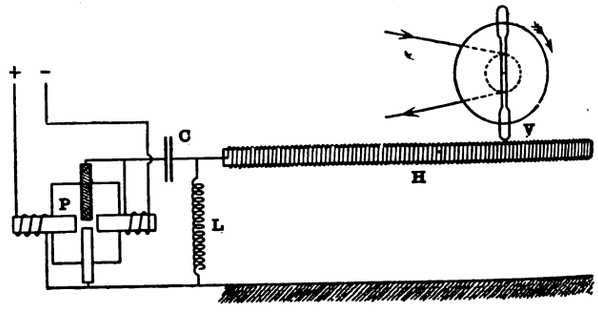

FIG. 1.

place into the air. They are very hot and will melt sealing wax and set fire to paper, and inflict the most painful burns if incautiously touched. They make a rushing or whistling sound and are of a strong blue colour.

If the inductance in the condenser circuit is varied even a little the brushes disappear. The above-described helix considered simply as an open circuit oscillator, has a natural time period of electrical oscillation of very nearly 5 one-millionths of a second, or a frequency of $0{\cdot}197 \times 10^6$. This value had been exactly determined in previous experiments with it.* As the value of the capacity in the condenser circuit is 0·0029 mfd., and the total inductance in series with it 215,000 cm., the time period T of the condenser circuit is given by:

$$T = \sqrt{0{\cdot}0029 \times 215000} = \frac{5}{5{\cdot}033 \times 10^6} = \frac{5}{10^6} \text{ nearly};$$

and this shows that to obtain the brush discharge effect the condenser circuit has to be exactly tuned to the period of the fundamental electrical oscillation of the helix.

The effect of these oscillations in the wire is to create an intense electric field round the helix extending in all directions for a distance of nearly a metre. Vacuum tubes of all kinds glow brilliantly when brought near the helix. Especially brilliant is the glow in the form of Neon tube I employ with my cymometer, which, as I showed some three years ago, is extremely sensitive to a high-frequency electric field. The form of tube I use is of the spectrum type, the straight part being a glass tube with a bore of 1 mm., and the enlarged ends cylinders of about 1 cm. diameter and 5 cm. long.

The beautiful discovery made some time ago by Sir James Dewar that Neon and other rare atmospheric gases can be separated from the commoner constituents of air by means of charcoal cooled to a very low temperature, renders it possible to fill spectrum vacuum-tubes with nearly pure Neon, and such tubes are of very great utility in high-frequency research. When filled with Neon at the proper pressure they glow with an intensely brilliant orange-

* Abstract of a Paper read before the Physical Society. This Paper has been already referred to in giving the proceedings of the Society in the current volume of *The Electrician*, p. 483.

* See J. A. Fleming, "On the Propagation of Electric Waves along Spiral Wires," *Phil. Mag.*, Ser. 6, Vol. VIII., p. 434 (October 1904).

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red light in a high-frequency field. If one of these tubes is held near the helix when in action, it shows by its glow that there is an electric field increasing in intensity all the way up the spiral to the free end.

But more, the Neon tube shows us that the oscillations are not perfectly continuous. If the tube is waved rapidly to and fro in front of the spiral, by the persistence of vision its image is expanded into a fan-shaped area of light. Examining this, we see it crossed vertically by narrow or broad lines irregularly placed. This indicates that the tube is extinguished at intervals, and this is because the electric field disappears and the oscillations are interrupted. Not only Neon tubes, but all other vacuum tubes show this effect provided they are narrow tubes. If a wide tube is used, the effect is not seen because the intermittent images of the tube overlap each other. The phenomenon is well shown by rapidly rotating a Neon tube near the spiral. The tube must be fastened by silk threads to a strip of ebonite held on an ebonite axle, and this rapidly rotated by a turntable (*see* Fig. 2).

The intermittency is always most marked when the arc is first started and then diminishes, but it is always present more or less, and it shows that the oscillations, even if undamped, are not absolutely continuous, but are cut up into irregular groups. It seems to be caused by the arc changing its point of departure on the carbon electrode. It is increased if the rotation of the carbon is irregular, but I have never been able to abolish it altogether. Another proof of the same fact is derived as follows :—

The helix is removed and another square coil of 12 turns or so of insulated wire wound on a frame 60 cm. inside is placed parallel and at a distance of 2 or 3 metres from the similar coil in the condenser circuit (*see* Fig. 2). This secondary coil is tuned by a condenser to the same frequency as the arc condenser circuit. Across the terminals of the secondary circuit another circuit is joined which consists of the oscillation valve or glow-lamp wireless telegraph detector devised by me four years ago, and already described.* This valve stops all movement of electricity in one direction, and in series with the valve is placed a telephone. On listening to the

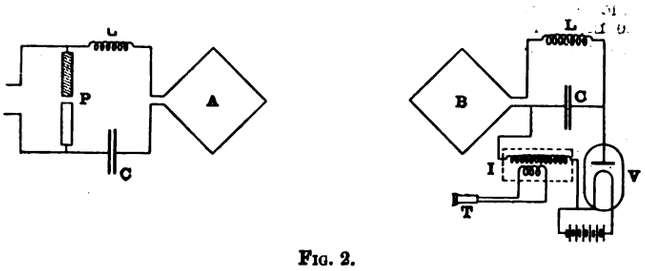

FIG. 2.

telephone when the arc is in operation and is quite steady, a crackling sound it heard, which is not sufficiently regular to be called a musical note. If the oscillations in the arc circuit were continuous and absolutely persistent, they would induce similar secondary currents, and my oscillation valve would separate out all the unidirectional constituents, and send through the telephone a perfectly steady continuous current. But this is not case. The telephone yields a sound which shows that the continuous current through it is interrupted irregularly, and this can only be because the oscillations in the arc circuit are interrupted. If the telephone is not inserted directly in circuit with the valve, but is inserted in the primary circuit of an induction coil, or air core transformer, the secondary of which is inserted in series with the valve, the sound in the telephone is still more increased.

We have, therefore, strong indications that the arc method of exciting undamped oscillations gives rise to irregular groups of oscillations which are separated by short intervals of time.

In order to be successful at all in producing high-frequency oscillations by the arc method, I find it essential to pay attention to a number of details. One important condition of success is, as Mr. Poulsen has already pointed out, that the carbon electrode should be kept in slow rotation. If the carbon is not rotated a bulbous deposit of carbon soon grows on the electrode and builds up a beak or pimple of carbon which makes the arc irregular and soon puts it out. The end of the round carbon should be cut off square to begin with, but it soon gets rounded off and a little corrugated or milled, and seems to work better when it has been used for a short time. Hard arc carbons are better than soft for producing oscillations. Secondly, as regards the gas. Pure hydrogen works with difficulty. Coal-gas is better, but the coal-gas cannot be used over and over again, as it is altered in composition by the arc, and this seems to create a difficulty in the use of the Poulsen arc as a transmitter in wireless telegraphy on board ship. The deposit of soot in the chamber is sometimes excessive. The coal-gas must be passed through quickly, but not too quickly, and my experience is that if the sides of the containing chamber are not kept cool, the deposit of soot is greatly increased. The more enriched the coal-gas is, the worse becomes this trouble. I find it necessary in any case to clean out the chamber after a few hours of continuous use. In the next place, the magnetic field required careful adjustment. If it is too strong the arc cannot be maintained without constant interruption; if too weak the oscillations are feeble.

The various factors—gas, field, arc length, rotation of carbon and water cooling—all require exact adjustment to obtain the best result. In laboratory or in lecture experiments, when effects are only required for a few minutes, this is not difficult; but if the apparatus is used as a transmitter in wireless telegraphy, it must be possible to maintain constant for hours together the production of the oscillations, and so far I have not found that this is a very easy thing to do. I have tried many methods for making the arc self-regulating as to length, but without success. The best plan is hand regulation by a skilled assistant. There is a particular length of arc which for given current and voltage produces the oscillations most effectively, and this length has to be maintained constant.

When employed as a wireless telegraph transmitter, the question which presents itself for consideration is the efficiency of the arrangement as an energy transformer. We supply the arc with continuous-current power, and we create by it high-frequency persistent oscillations in the antenna. There are several sources of energy dissipation. In the first place, the arc must be arranged in series with certain regulating or ballast resistance to permit of adjustment. I have found that very good effects are obtained when working off a 400 volt public supply of direct current or from a 500 volt continuous-current 5 kw. dynamo. Then from 50 to 100 volts may be dropped in the regulating resistance when working with an arc 8-10 amperes.

In the next place there is a large production of heat in the chamber containing the arc, the greater part of which is removed by the cooling water. We have then a portion of the power converted into high-frequency current in the condenser circuit, and this dissipates itself partly as heat in the inductance and condenser, and only a fraction of this power is radiated by the antenna. We are not really concerned to know the manner in which these heat losses are distributed. We cannot subject the matter to mathematical discussion unless we make certain assumptions as to the form of the curve representing the oscillations, which form has not yet been determined. I have found by experiment that the power factor of the arc when working is not far from unity, and hence the power given to the arc in the form of continuous current can be very approximately determined by the product of the arc current and the supply voltage. For instance, in one case the P.D. of the arc electrodes was found to be 320 volts and the arc current 8·4 amperes, whilst in two separate measurements with the wattmeter the power taken up was found to be 2,632 and 2,674 watts. The product of amperes and volts is 2,688, and hence the power factor by these measurements is 0·98 or 0·99, or practically unity.

If the current through the arc can be kept sufficiently constant, which is rather difficult, the power radiated may be also measured by the wattmeter. For suppose that we have a direct-coupled antenna joined at some point to the condenser circuit, we may then take wattmeter readings with and without the attached antenna, and the difference will be the power radiated.

In the case of the long helix above mentioned, the power given to the arc when the helix was attached to the condenser circuit was 2,674 watts, as measured by the wattmeter, and with the helix removed it was 2,632 watts, the arc current remaining constant at 8·4 amperes. Hence in this case it appears that the radiation and power consumption due to the attachment of the helix is 42 watts. The measurements, however, cannot be made very accurately in the case of small power radiation.

In the case of a direct-coupled antenna which is emitting a wave-length corresponding to its fundamental oscillation, the radiation can be approximately calculated from a formula given by Hertz. Hertz shows that in the case of a dumb-bell oscillator having an electric moment Q, the energy E radiated per period is given by the expression

$$E = \frac{16\pi^4 Q^2}{3\lambda^3} \text{ ergs per period,}$$

where λ is the wave-length of the radiation.

If C is the capacity of one-half of the oscillator with respect to the other, and V is the maximum P.D. of the parts during an oscillation, and l the effective length, then $Q = CVl$.

If I is the maximum value of the current in the oscillator during a period, then $I = 2\pi nCV$ and $Q^2 = I^2 l^2 / 4\pi^2 n^2$, where n is the frequency.

Accordingly,

$$E = \frac{4\pi^2 I^2 l^2}{3\lambda^3 n^2} \text{ ergs per period.}$$

Now $u = 3 \times 10^{10}$ cms./sec. $= n\lambda$ is the velocity of radiation.

* See J. A. Fleming, "On the Conversion of Electric Oscillations into Continuous Currents by means of a Vacuum Valve," *Proc.* Roy. Soc., London, Vol. LXXIV., p. 476 (1905). Also *Phil. Mag.*, May, 1906.

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In the above equation, I is the maximum current in electrostatic measure. If A is the ampere value of the same current, then $\frac{A}{10}=\frac{I}{u}$. If, then, the oscillations are persistent and with frequency n, the energy in ergs radiated per second from the antenna is

$$W=\frac{4\pi^2 I^2 l^2}{3\lambda^3 n} \text{ ergs per second;}$$

$$=\frac{4\pi^2 u\, l^2}{300\ \lambda^2} A^2 \text{ ergs per second;}$$

$$=40\pi^2\frac{l^2}{\lambda^2}A^2 \text{ watts.}$$

For any antenna the ratio of wave length λ emitted to effective length l is a fixed quantity and approximates in practice for single-wire antennæ to 2·5. We have, therefore, this curious result which does not seem to have been previously noticed, that the power radiated in watts from a linear antenna of any length is given by the expression $W=64A^2$, where A is the maximum value of the current flowing into the base of the antenna. If (A) is the current as read on a hot-wire ammeter inserted at that point, then

$$(A)=\frac{A}{\sqrt{2}}, \quad \text{and} \quad W=128(A)^2 \text{ watts.}$$

Thus, if such a hot-wire ammeter showed an antenna current of 1 ampere (R.M.S. value), the radiation would be 128 watts, and for the same current is quite independent of the height of antenna or the frequency.

Seeing, then, that open antennæ have such enormous radiative power, we can in practical radio-telegraphic work employ very small antenna currents when using persistent oscillations.

A complete explanation of all the phenomena involved in the Poulsen arc can hardly yet be said to have been reached. It has been shown by experiments made under the author's direction in the Pender Electrical Laboratory of University College, London, by Mr. W. L. Upson, that the characteristic curve or volt-ampere curve for a carbon-metal arc in hydrogen is a curve falling down with a much steeper slope than the characteristic for a carbon-carbon arc in air.

Also that the time during which the E.M.F. can be removed without permanently extinguishing the arc, is very much shorter in the first case than in the second. Both these facts undoubtedly contribute to enable the production of oscillations of a higher frequency to be obtained with a carbon-metal arc in coal-gas, as compared with those which can be reached with a carbon arc in air.

In order that oscillations may be produced when a condenser circuit is shunted across the arc electrodes, the condenser, during its charge and discharge, must cause a variation of current through the arc, and this in turn must cause a variation in the P.D. of the electrodes in such direction as to assist the charge or discharge. Thus when the condenser is robbing the arc of current and so decreasing the arc current, this must automatically raise the P.D. of the electrodes, and when the condenser is discharging it must decrease the P.D. The greater this P.D. variation for a given current decrement or increment, the greater will be the energy conveyed to the condenser circuit.

In the case of a carbon carbon arc worked at 10 amperes and, say, 60 volts arc P.D., the characteristic curve is rather flat. Hence, if we employ a small capacity in the shunt circuit we have very little variation of arc current and arc P.D., and little or no energy in the condenser-circuit oscillations. We can, however, obtain more energy by using, as Mr. Duddell originally did, a condenser of rather large capacity, say 1 to 5 microfarads. Moreover, the carbon arc has a persistence which renders it irresponsive to very rapid variations of current. Hence with a large current carbon-carbon arc in air, we can only obtain rather slow oscillations.

If, however, we employ a carbon-metal arc, carbon negative and cooled copper positive electrodes in hydrogen or coal-gas, we then have an arc with a very steep characteristic curve, and one which responds to exceedingly rapid variations of current through it. We can, therefore, employ in the shunt-circuit a condenser of small capacity, and yet convey to it a considerable amount of energy owing to the large P.D. variation in the arc caused by a small arc-current variation. Hence we can produce oscillations of high frequency. This theory is confirmed by the observation that in the case of the carbon-carbon arc in air for small currents, and in the case of the carbon-aluminium arc, the characteristic curve is nearly as steep as for large current carbon-metal arcs in hydrogen; and with these particular arcs, viz., the small current carbon arc in air and carbon-aluminium arc in air, we can obtain oscillations of high frequency.

Much further investigation is, however, necessary to enable us to state precisely the action of the surrounding medium, hydrogen, or better coal-gas, in producing this steep characteristic volt-ampere curve for the carbon-metal arc in these gases.

SOME FACTS AND PROBLEMS BEARING ON ELECTRIC TRUNK-LINE OPERATION.*

BY F. J. SPRAGUE.

(*Continued from page 868.*)

Summary.—In this Paper the author makes a vigorous and detailed attack upon single-phase traction for trunk railways. The various parts of the electrical equipment are considered in turn. Conductors, when used for alternate currents, suffer loss of current capacity through impedance. Single-phase motors, although effective, are much heavier than continuous-current motors of the same capacity when considered on a thermal basis, and the weight of the complete single-phase equipment for a locomotive comes out to be about double. The differences between single-phase and continuous-current motors are given in some detail. Polyphase motors also are considered by the author to be unsuitable. After considering the pros and cons of electric braking, the author discusses the various systems of working conductors at present available, and describes an improved form of under-contact third-rail, designed by Mr. Wilgus and himself. Recent suggestions to use 15 cycles instead of 25 cycles show some advantages, but the total weight of single-phase apparatus on a car will remain much the same. After describing recent examples of locomotives, and considering some minor points, the author concludes that the field of the single-phase system is on roads with sparse traffic, and that where the traffic is dense a comparatively high-pressure continuous-current system is to be preferred.

Electric Braking.—Recuperation of energy to reduce the amount of power used, and to make the motors act as brakes to retard the acceleration of a train, has been a favourite project, and attended by many prophecies since the beginning of the electric railway industry. Experiments carried out on the Manhattan Elevated Railway for several months in the winter of 1885-6 proved the advantages claimed; but the system is not used to-day, despite its enormous possible saving of power and station capacity, because it required the use of shunt motors with their fine-wire field windings, and hence necessarily reduced capacity compared with the modern series motor; it required, also, a very exact equalisation of the characteristic of motors and maintenance of like wheel diameters, and an increase of motor capacity and weight, because of the double duty and consequent heating. Here, again, capacity has been an important and finally-determined factor in motor requirements and practice. On ordinary railroads the gradients are not sufficient to make it worth while to attempt any recuperation of energy. On mountain roads, however, electric braking may become an important adjunct, not because of power economy, but for safer operation. In any case, simplicity of application and absolute reliability of action are first essentials.

There are two general methods available: one, in which the energy of the descending train drives the motors, acting with shunt or independent-field characteristics, at an aggregate potential above that of the line at the rail, and sending current back into the line; another, in which the motors are disconnected from the line and driven as self-exciting generators on a closed circuit, as much of the energy of the descending train as desired being used up in heating rheostats. The first method is dependent on the line, requires external excitation of the field magnets, and where direct-current motors are directly connected to the line two armatures should be thrown in series if the power to slow the train down to or below its ascending speed on heavy grades is desired. This is because the excitation of the fields is carried to saturation on ascending work, when the motor E.M.F. is much less than that of the line plus the drop on the supply conductors, and permits of no further increase of flux to raise it. Such independent excitation of the fields should be through a motor generator set to get the current of low potential in large volume necessary for the series fields. This method is, of course, possible of application, and will give a range of control of speed from about the mean speed on ascending grades to double that speed, but it will be with inequality in heating of the armatures and the fields, the latter running cool, and the former practically at their average maximum.

The second method of braking is to use the motors without disconnecting the field and armature circuits from each other, simply closing them upon themselves, and varying the resistance in circuit, the reversers on down grade being set for backward movement. This method requires no change in the organisation of the machine, puts equal duty on armatures and fields, as in ascending grades, and the duty on the armatures being considerably less than in the other method of braking they will heat much less. This method, if provision be made for moving the controller, is independent of the line, and permits of the most complete variation of speed; moreover, there is no possibility of the application of the air-brake entirely destroying the braking power of the motors. This latter method of braking does not depend upon line supply, nor require interposition of any motor-generators, and is, therefore, more direct

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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and reliable. Another fact of importance is that the aggregate motor potential strains are less. Provision for both methods of braking, although possible, is not advisable because of the introduction of too great a variety of apparatus and methods, which may give rise to confusion and accident, which in all cases of railroad operation should be avoided as far as possible.

With polyphase motors kept in connection with the line, the braking effect is very similar to that of pure shunt motors, and the excess of down speed is very small. It is doubtful, however, whether with the varying grades and curves of our mountain roads it is desirable to run down-grade at an approximately fixed speed, but rather it seems likely that the existing practice of speeding where the grades and curves are light, and reducing the speed where the grades are heavy and the curves are sharp, will remain the preferred practice. Self-exciting braking is impracticable with polyphase motors.

Comparison of Direct-current and Alternating-current Braking.—With continuous-current motors there is always a residual magnetism in the fields, and such machines, therefore, can always promptly build up automatically when properly closed upon themselves and the reverser is set in the proper direction. A similarly effective method of braking has been claimed for motors operated by single-phase alternating currents, but it would seem that in this case there is not the same degree of reliability. In such motors the field is laminated to the last degree to cut down heat losses and to increase the capacity; it will hold but little residual magnetism under any circumstances, and furthermore the field is excited by a rapidly varying alternating current. It is, therefore, possible that at times the field will be nearly inert, and comparatively slow, with its low-turn winding, in building up, or possibly the field may be entirely inert and may refuse to build up at all. All things considered, reliability and simplicity of operation dictate the use of the self-exciting method of braking with the direct-current motor, which lends itself to that purpose in the highest degree.

Extent of Electric Braking.—However theoretically desirable it would be from an economic standpoint to utilise the energy of a descending train to generate current available for partial propulsion of trains moving on up grades, it is to be borne in mind that the localised braking of an electric locomotive is not intended to, nor can it entirely, replace air braking; it is proposed primarily for the purpose of eliminating certain existing troubles unavoidable in connection with air brakes when used continuously on long down grades. In trains made up of the average run of freight cars there is a non-simultaneous action of the air brakes, and often, if after long-continued application the brakes are released for a brief time so as to re-charge the train pipe, the front end of the train, being unbraked, will surge ahead, and the rear part will for a brief time be held back by the non-released or partially-released air brakes, resulting in a parting of the trains. Another serious trouble, overheating of brake shoes and wheel rims, leading to breakage of parts on account of expansion or sudden chilling, cannot well be avoided where there is such a continuous application of air brakes as is required on free movement of freight trains on long grades; this is a difficulty which it is best to avoid by supplementing the air brake by other braking means not dependent upon brake-shoe application.

The objections cited will be largely removed if the duty on air brakes can be materially reduced and sometimes entirely relieved. Electric braking on the method I have indicated will accomplish this, and it seems wise normally to divide the duty between electric and air braking. For that reason I will give an illustration of the duty on the motors, as this will have a direct bearing upon the capability of the radiation of energy in the form of heat from the rheostats in circuit.

Suppose a 700 ton train operates on a grade requiring tractive efforts per ton of

For lifting	25 lb.
For traction and curves	8 ,,
Total	33 ,,

On down movement, 17 lb. only will be available for acceleration of speed, which must be taken up by braking in some form. If divided between electricity and air there would be required from the locomotive—

Average retardation per ton	8·5 lb.
Total for 700 ton train	5,950 lb.
Foot-tons per minute, at 20 miles	5,192 lb.
Equivalent electrical rate	235 kw.
Dissipated in rheostats at 90 per cent. machine efficiency	212 kw.

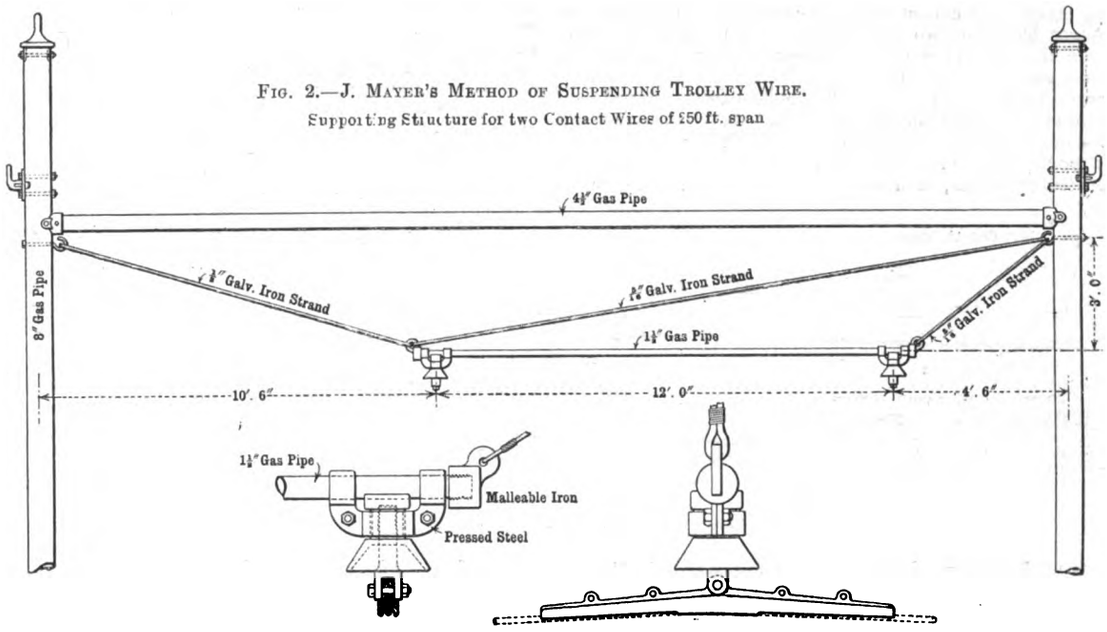
which would be a light duty for four motors and rheostats, and would leave ample margin for them to take the full braking effort up to the skidding of the wheels whenever it might become necessary.

Working Conductors.—Generally speaking, conductors may be divided into two classes: flexible or rigid overhead and third-rail. The overhead system has been a distinctive feature of all electric roads operated by direct current since the days of the historic Richmond road, with the exception of those using the third rail; and until recently the only practical modification has been the somewhat limited use abroad of the sliding bow or roller in place of the grooved trolley wheel. This latter, although used with high speeds on inter-urban roads, is unfitted for trunk-line operation, and where overhead trolley wires are used the long collector will probably take its place. Physically, the overhead trolley is not individual to any particular system; practically, its use depends upon the amount of current which has to be collected. If at low potentials, then it must be either strongly reinforced and there must be a plurality of contacts, or, if these are diminished, the amount of current to be collected must likewise be reduced and the potential raised. In the abstract, therefore, the possible use of the overhead trolley, no matter by what system, is a question of allowable operative potential and the amount of current which can be practically collected.

Until recently the invariable practice with overhead construction has been to use a flexible wire supported at comparatively long distances on tangents, with pull-offs at curves, and easily yielding to the pressure of a trailing trolley. The introduction of high tensions has, however, now made it necessary to provide by additional supports against the possible breakage of the trolley wire. This has led to the introduction of catenary construction, the catenary being either single and supporting the trolley at frequent intervals, or double to prevent lateral swaying. In the former case, the trolley is only partly flexible, and in some cases the support has been supplemented by an intermediate catenary, as on the Blankenese-Ohlsdorf railway, where greater flexibility of the trolley wire itself is ensured by loosely suspending it from the lower member of the catenary, instead of making the latter the trolley wire, and providing for varying the tension. In other cases it is to some extent maintained by having less frequent supports, and also by introducing a movable part at the suspender.

FIG. 2.—J. MAYER'S METHOD OF SUSPENDING TROLLEY WIRE.

Supporting Structure for two Contact Wires of 250 ft. span



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The most recent and extended application of double-catenary construction is that on the New Haven road for use with its single-phase locomotives. Here a trolley wire is put under high tension and is supported at frequent intervals by solid clips attached to rigid triangles, in turn secured to galvanised iron wire cables carried on insulators on the top of bridges which span the tracks at intervals on tangents of about 300 ft. The catenaries are drawn together between the spans, so as to give the utmost rigidity to the whole system, the intent being to maintain the trolley wire as nearly as possible in one plane. At cross-overs and sidings the supporting triangles overlap, and the angle between the junction and the trolley wires is filled with additional conductors, more readily to ensure safe passage of the vertically moving sliding contact which has been adopted. At intervals of about two miles the trolleys are sectionalised at anchor-bridges, where are provided the necessary switches for cutting out sections and for looping to extra supply conductors.

Among the innumerable trolleys which were tried in early days was a roller of considerable length, mounted at the end of a rod having a vertical telescopic motion in a tube carried on top of the car, and pressed against the wire by a spring in the tube. This was abandoned in favour of the trailing trolley which would more readily follow variations in the trolley-wire. The modern pantograph is an elaboration of this early idea, and has a very much greater latitude of vertical movement. It consists of a sliding or rolling contact, which forms the upper number of a light yet strong collapsible structure maintaining an upward spring pressure. The theory of this system of collection is, of course, that a locomotive normally moves between two parallel planes, on one of which it runs and from the other of which it collects current, and that the ordinary motion of the contact will be inappreciable. This assumption is, however, modified in practice. The collectors are carried normally 22 ft. above the track, on a superstructure which must respond in some measure to track irregularities and which has considerable inertia and some friction. There is a drag because of friction against the trolley wires, and wind-pressure due to motion of the locomotive. This upward pressure must necessarily be changeable because of variation of angle, friction and the resultant motion. To maintain contact it must rise and fall. When travelling 70 miles an hour it passes supports which are more or less rigid nine times a second, and between these supports the trolley wire, no matter what the tension, will be convexed upwards. As the collector approaches any suspender the pressure will normally considerably increase, and, as it leaves it, diminish. The practical question arises whether, considering all the forces acting on it and its inertia, it can satisfactorily respond, in addition to other requirements, to a double change in vertical direction nine times a second. If contact depended upon the whole structure of the pantograph moving thus rapidly some trouble might be anticipated, but possibly the elasticity of the upper part will prove sufficient.

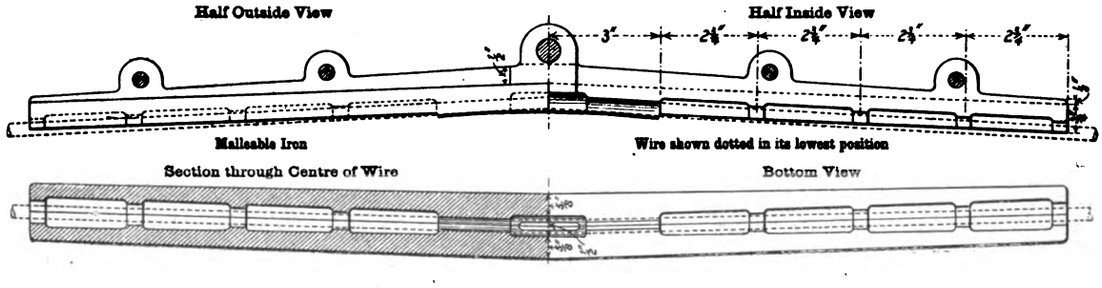

FIG. 3.—SUSPENDER FOR CONTACT WIRE.

It is interesting to note that Mr. Joseph Mayer, the former chief engineer of the Union Bridge Company, in a Paper read before the American Society of Civil Engineers, and also in several other communications, has given a great deal of thought to the question of overhead construction, and has made elaborate calculations of strains involved. His conclusion was to the effect that no trolley wire put up under high tension, and supported in the rigid manner provided by the present catenary, offered either a sufficiently safe or economical method of construction, and he was therefore led to the development of two departures in practice. The first was the use of an overhead rigid iron rod 1·25 in. in diameter, suspended by catenaries and provided with extension joints; the second (the first method apparently having been found too expensive) is a method of flexibility supporting a trolley-wire at long intervals from inverted pivoted suspenders, which provide a support for the various section-lengths according to the end slopes (Figs. 2, 3). The suspender grips the trolley wire only along the centre, and then it opens out in large radii to give a graduated resistance to both vertical and lateral deflection. Mr. Mayer's analysis of conditions, the mathematical deductions, and his proposed remedies as illustrated by his detail plans, well merit serious consideration.

(To be continued.)

POSTMASTER-GENERAL'S ANNUAL REPORT.

The fifty-third annual report of the Postmaster-General has just been issued and gives particulars of the business carried on by the Post Office during the year ended March 31, 1907. The following points in the report are of more particular interest to electrical engineers:—

Telegraphs.—During the year ended March 31, 1907, 89,493,000 telegrams passed over the Post Office wires, as compared with 89,478,000 in 1905-6, an increase of 0·02 per cent. The total value is £2,787,110, an increase of £43,924 over 1905-6. The estimated value of the railway free telegrams is £59,600, against £59,000 in 1905-6; that of the Government free telegrams £22,700, against £18,500 in 1905-6. The decrease in Press telegrams exceeds 11 per cent., which is no doubt mainly due to the restoration of peace abroad and to the absence of any special event at home. During the year the telegraph has been extended to 227 offices in country districts and in the areas of the larger towns. There are now in the United Kingdom 10,587 telegraph offices at post offices, and 2,406 at railway stations and other public places. The extension to Edinburgh of the underground line between London and Glasgow has been taken in hand on the Edinburgh side. Permanent cable has been provided for the spur line from Manchester to Leeds. Good progress has been made with the construction of the underground line from London to the landing places of the submarine cables in the West of England; at the end of the financial year pipes had been laid as far as Bristol, and the cable had been drawn into them to within 4 miles of Bath. Interruptions of the telegraph service by severe storms at the beginning of 1907 led to renewed and pressing requests for an immediate extension of the underground telegraph system in various directions. The following programme of works is proposed to be undertaken if possible before the end of the present financial year: (1) The completion of the western underground line as far as Exeter; (2) the provision of a new cable between Warrington and Liverpool to strengthen the connection of that city with the main underground system; (3) the construction of a line between Newcastle and Durham to connect eventually with the main underground system by way of Leeds and Manchester; (4) the extension, from the Glasgow side, of the line which will eventually complete the underground system between London and Edinburgh.

The number of foreign telegrams sent to and from the United Kingdom during the year (exclusive of certain telegrams dealt with entirely by cable companies) was 9,147,000, an increase of 351,000 (or 4 per cent.) on the number sent during 1905-6. Experiments, which give promise of satisfactory results, have been conducted during the past year with a view to the improvement of the telegraphic services between London and certain important Continental towns. Direct communication has been established between Liverpool and Antwerp. No new Government cables from the United Kingdom have been laid during the year; but the cable of the Great Northern Telegraph Co. between the Shetland Islands and Iceland, via the Faröe Islands, has been opened for business, and a new cable has been laid by the Eastern and Western Telegraph Companies from Porthcurno (Cornwall) to the Azores, and thence to St. Vincent (Cape Verde), with a view to strengthening their line of communication with South America.

Wireless Telegraphy.—The Wireless Telegraphy Act of 1904, by which it was made illegal to instal or work wireless telegraph apparatus within the United Kingdom or its territorial waters without a licence from the Postmaster-General, was passed for a term of two years only. It was, however, extended to December, 1909, by an act of last year, and steps have been taken for the renewal of the licences granted under the Act of 1904 (particulars of which appeared in a Parliamentary return published last year)* for the period covered by the new act, except where experiments licensed under the former act have since been abandoned. During the year 45 new applications for licences have been received, of which 36 were required for experimental purposes only. The latter have all been granted; but some of the other applications have been held over pending the consideration of the whole question of the use of wireless telegraphy in the United Kingdom for commercial communication with ships. This question, again, turns largely on that of the ratification by His Majesty's Government of the International Radio-telegraphic Convention formulated by the International Conference which met at Berlin in October and November last. This Convention, which is based substantially on the deliberations of a preliminary Conference held in 1903,† will for the first

* See *The Electrician* for July 13, 1906.

† Complete records of the proceedings at the Berlin Wireless Telegraph Conferences of 1903 and 1906 are published by "The Electrician" Company. Price (1903 Conference) 8s. 6d. net; and (1906 Conference) 21s. net. The latter work contains the complete Convention and Service Regulations in the original French and a full translation into English (approved by H.M. Postmaster-General), besides a full report of the proceedings at the 1906 Conference in English.

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time place commercial communication between shore stations and ships at sea on an international basis, affording a guarantee for the exchange of messages, at reasonable rates, between ships and the shore, so far as material circumstances admit, without regard either to nationality or to the system employed, and for the acceptance, transmission and delivery of such messages by means of the ordinary telegraph systems of the various contracting countries.

The formulation of detailed regulations for the prevention of confusion and interference under the scheme of general intercommunication contemplated by the Convention, together with adequate provision for enforcing those regulations, was a matter of great importance to this country, in view of the extent to which wireless telegraphy has already been developed in the narrow waters of the English Channel. With this object, amendments to the draft originally laid before the Conference were proposed by the British delegates, and were readily accepted by the Conference. To these was added a further important provision proposed by the British delegates whereby the right was given to such Governments as desired to possess it of exempting from the obligation of general intercommunication any station which they might at any time think fit, on condition that some other station shall be open for general intercommunication in the same region. The Convention does not apply to naval or military stations, or to commercial stations which are not open for communication with ships, save that all stations, without exception, are required to carry on their operations as far as possible without interfering with other stations and to accept messages from ships in distress. Some doubt having been expressed in the course of a debate in the House of Commons as to the extent to which the objects aimed at by the Government had been secured by the Convention and especially as to its probable effect on the existing organisation of the Marconi Company, a Select Committee of the House was appointed early in the present session to consider the question. This Committee has reported in favour of the ratification of the Convention and the Government has announced its intention of ratifying the Convention.

The Post Office has continued during the year to collect and deliver the Marconi Company's telegrams to and from ships at sea under the arrangements settled in 1904. The total number of outward telegrams dealt with during the year was 1,140, as compared with 558 in 1905-6, and of inward telegrams 15,853 as compared with 11,094. The Post Office stations for communication between Tobermory and Loch Boisdale (Hebrides), and between Hunstanton and Skegness, have been completed and handed over by the contractors. So far as can be stated at present, they seem likely to work satisfactorily; but it is too soon yet to say whether they will fulfil all the requirements of ordinary inland traffic, for which they are intended.

Telephones.—The number of telephone trunk wire centres open on March 31, 1907, was 533, as compared with 487 on the corresponding date in 1906. During the year 288 new trunk circuits were provided, bringing the total number in use up to 2,043, containing about 73,000 miles of double wire. The capital expenditure on the purchase and development of the trunk wire system up to March 31 last amounted to £3,376,252, including an expenditure during the past year of £478,749. The total number of conversations which took place over the trunk wires during the year 1906-7 was 19,803,300, showing an increase of 10·18 per cent. upon the number for the previous year. The gross revenue derived from the trunk service was £480,658, against £449,004 in 1905-6, an increase of 7·05 per cent. The average value of each conversation was slightly less than in 1905-6, 5·82d. instead of 5·97d. During the year 56 Post Office telephone exchanges were opened in the provinces, and 23 public call offices connected with the Post Office trunk line system were opened at places where the number of prospective subscribers was not sufficient to warrant the opening of exchanges. In the districts of Melton Mowbray, Chipping Norton, Malton and Bourne, it has been possible to give a telephone service restricted to the local area by utilising the wires erected for the transmission of telegrams—which are not numerous—between the central town and the post offices of surrounding villages. The growing use made of such rural call-office systems shows that the additional facilities thus afforded are appreciated.

As stated in the last report, the postal reforms announced by the Chancellor of the Exchequer last year in the Budget speech included the introduction of more liberal terms for the extension of the telephone system to outlying places under guarantee. Whereas formerly the guarantors of telephone extensions were required to bear the whole of any loss incurred, two-thirds of it is now borne by the State. The telephone has thus been brought within the reach of many fruit-growing and agricultural districts, and it is hoped that some of the guaranteed call offices will in time develop into small exchanges. The total number of subscribers to the Post Office provincial telephone exchanges on March 31, 1907 (excluding those at Glasgow and Brighton), was 10,010, as compared with 8,425 on March 31, 1906, and the number of telephones rented increased during the year from 10,380 to 12,006. The foregoing figures represent the normal growth of the Post Office provincial system due to the opening of exchanges in places hitherto without a telephone service and to the accession of new subscribers to existing exchanges. But that system has during the past year received important additions through the purchase of the telephone undertakings of two municipal authorities. The Glasgow Corporation system, which was worked by the Corporation on behalf of the Post Office from June 1st (the nominal date of purchase) up to September 10, 1906, included on March 31st last 11,103 subscribers' lines with 12,964 telephones. The system of the Brighton Corporation, which passed under Post Office control on October 22nd, included at the end of the financial year 1,542 subscribers' lines with 1,881 telephones. Arrangements are being made for local intercommunication between the subscribers to the exchanges of the Post Office and the National Telephone Co. both at Glasgow and Brighton.

The agreement made in 1905 for the purchase of the National Telephone Co.'s system at the end of their licence in 1911 provides for local intercommunication in the meantime between all the exchanges of the two systems, subject to the condition that the rates of charge are to be the same for both systems. After considerable discussion with the company a new scale of rates was adopted for this purpose on May 1st. These rates are based on the principle of a measured service, under which each subscriber pays according to the quantity and quality of the service he requires. He may contract for any number of calls, from 400 upwards, and he may share a line with another subscriber, or he may rent a line for his own exclusive use. The large user can have a private branch exchange connected by two or more lines with a public exchange, and with extension instruments to the different parts of the subscriber's establishment. By intercommunication between these extension stations a very convenient internal service is provided, in addition to the exchange service, and this is a great convenience in hotels and large places of business. The new rates do not include the unlimited service or "flat" rate, except for lines to private residences. No satisfactory flat rate can be devised for lines on which the calls may vary from a few hundreds to many thousands a year. An equal rate for such varying conditions must necessarily be very unequal and unfair between different subscribers, the charge being unduly low in one case and excessive in another. Even if a fair average rate could be fixed at any one time, it would soon become unsatisfactory, because the cost of the telephone service increases in greater proportion than the number of subscribers or the number of calls, owing to the increasing complexity of lines and apparatus as an exchange system grows. Another very important objection to the flat rate is that it induces subscribers to overload their lines. It has been one of the chief difficulties and drawbacks of the telephone service in this country that the lines of large users are so frequently engaged when calls are made by other subscribers. This condition not only increases the cost of the service by causing useless operating work, but it is also a source of unnecessary trouble and inconvenience to the public. The principle of a measured service now adopted for the telephone system is the same as that which has long been in use for the supply of water, gas and electric light. It has been adopted almost universally in the United States, where it has led to an enormous increase in the number of telephones in use, and the same principle is becoming generally recognised in the principal countries of Europe.

The Corporation of Swansea has applied for permission to sell its telephone system to the National Telephone Co., and this has been granted subject to the acceptance by the company of certain conditions intended to safeguard the interests of the taxpayer when the combined system is purchased by the State at the end of 1911. The number of telephones connected with the exchanges of each of the municipal systems in existence on March 31st last, according to returns furnished by the Corporations concerned, were: Hull 2,128, Portsmouth 2,553, Swansea 1,432. The sum received as rental in respect of private wires was £183,008, as compared with £177,111 for the preceding year.

The number of telephones connected with the Post Office telephone system in the metropolitan area increased during the past year from 32,879 to 41,236, and additional subscribers are being connected at the rate of about 150 a week. New exchanges were opened during the year at Harrow, Esher, Hounslow, Malden and Wembley. There were 425 Post Office call offices open in the London area on March 31st last, and the number of calls made from call offices increased by 42 per cent

The length of the underground pipes which had been laid in the metropolitan area for telephone purposes up to March 31st last was 2,030 miles, 349 miles of which were laid during the year. Cables containing 317,789 miles of wire have been laid, including 69,066 miles rented by the National Telephone Co., and 52,255 miles provided for telegraphs, private wires, &c. The lines of the present subscribers and the junction lines connecting exchanges amount to 111,516 miles, and 84,952 miles of wire remain available for the future development of the telephone system. About 65,000 miles of telephone wire were laid by the Post Office in the metropolitan area during last year.

The average cost of constructing an exchange circuit in that area (including the installation of telephone instruments and of exchange apparatus, but excluding the provision of spare plant) has been £33.5s. 2d., as compared with £35. 13s. 10d. in the previous year. Taking into account the whole system, including spare plant of all kinds, the capital expenditure per station (*i.e.*, per telephone connected with an exchange) stands now at less than £50, as against £54 and £64 in the two preceding years. Thus the anticipation expressed in earlier reports, that the expenditure per station would continue to diminish as spare plant was brought into use, has been fully realised. The proportion of spare plant is still, however, very considerable.

Accounts, for the year ended March 31, 1907, of the income and expenditure relating to the London service, the provincial exchange system, and the trunk system are printed in an appendix (O). The year's working of the whole telephone system shows a balance of £451,787, after payment of the working expenses, while the estimated amount required to provide for depreciation of plant and interest at 3 per cent. on the capital expenditure of £7,255,000 is £432,726. The amount of royalty received during the year from the National Telephone Co. was £240,331 and from other licensees £3,101.

The amalgamation of the systems of the Post Office and National Telephone Co., which is to take place at the end of 1911, is being kept steadily in view, the former providing for the company on rental terms, in both the metropolitan and provincial areas, an increasingly large number of wires, which will be available for immediate use as part of the Post Office system when the transfer is effected. In other cases the company is providing wires for the Post Office. Endeavours are also being made in some instances to find accommodation in Post Office buildings for call boxes and small exchanges of the company. By these means not

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only is it possible to avoid present expenditure on cables and other plant which will not be needed after the transfer, but the actual arrangements for the transfer will be rendered less complex and less liable to result in inconvenience to the users of the telephone service.

The following estimated figures show the extent to which the telephone is being used for sending messages for onward transmission as telegrams and express or ordinary letters: Telegrams, 3,123,700 (increase 21·6 per cent.); express letters, 89,800 (decrease 0·6 per cent.); ordinary letters, 7,700 (increase 89·6 per cent.). It is estimated that during the past year about one and a-half million telegrams were delivered to the addressees over their private telephone circuits.

The capital sums (£7,300,000 in all) voted by Parliament under the Telegraph Acts of 1892-1904 for the extension of the telephone system are nearly exhausted, and an act has been passed in the present session to authorise the expenditure of a further sum of £6,000,000. This sum will, it is hoped, suffice for the development of the system until 1911. In that year, or possibly at an earlier date, it will be necessary to introduce legislation for providing funds and for other matters connected with the purchase of the system of the National Telephone Co. Wayleave difficulties continue to cause embarrassment and delay in the execution of telephone works. The experience of several years shows that it is at present electrically impossible to maintain an efficient trunk telephone service over long distances unless the wires are kept overhead, and the failure to recognise this necessity causes regrettable differences with local authorities and private landowners, and important towns which may be many miles distant from the scene of the difficulty are meanwhile left with inadequate telephone facilities. Local lines, serving often no more than two or three subscribers, can only be placed underground by increasing the present scale of charges of the telephone service. The same wayleave difficulties occur also in regard to telegraph lines.

SURFACE CONDENSERS.

Mention was made some time ago in *The Electrician* of the fact that Messrs. Willans & Robinson (Ltd.), of Rugby, who have during the past few years added a department to their works for the manufacture of surface-condensing plants, had acquired the rights for the use of the "Contraflo" type of condenser, and also for the "Vacuum Augmenter" system. The accompanying illustration (Fig. 1) shows a contrast in sizes between two surface condensers: the smaller size machine being capable of dealing with 8,250 lb. and the larger with 52,500 lb. of steam per hour. Two surface condensers which Messrs. Willans & Robinson are building for the London County Council power station at Greenwich are, however,

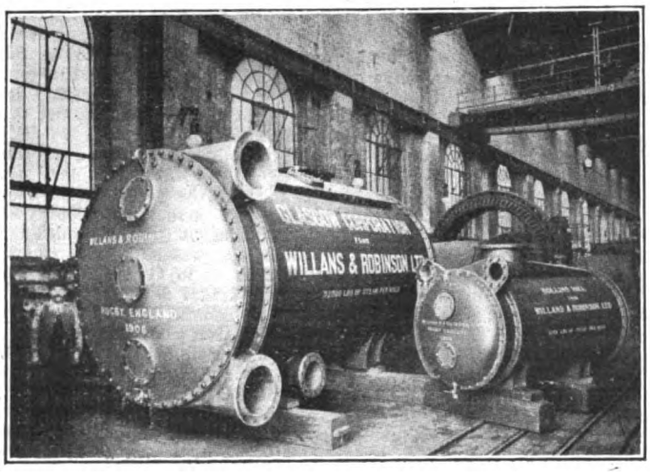

Fig. 1.

capable of dealing with 75,000 lb. of steam per hour each—*i.e.*, they will be approximately of 50 per cent. greater capacity than the larger of the two condensers shown in Fig. 1.

Fig. 2 shows an Edwards type of air pump built by Messrs. Willans & Robinson, and which is being chiefly used in connection with the condensing plants manufactured by this firm. The illustration is intended to show the ease with which this particular make of air pump can be dismantled for overhaul purposes. The pumps are made in standard sizes ranging from a two-line pump of 9 in. diameter by 6 in. stroke, to a three-throw pump of 31 in. diameter by 17 in. stroke. During the past 12 to 18 months some 55 sets of this type of plant have been ordered and set to work, the more recent contracts being:—

Two sets for dealing with 75,000 lb. of steam per hour for London County Council tramways.

One set for dealing with 16,000 lb. of steam per hour for the Shanghai Municipality.

One set for dealing with 20, 00 lb. of steam per hour for Portsmouth Corporation.

One set for dealing with 24,000 lb. of steam per hour for the Waste Heat and Gas Electrical Generating Station.

Two sets for dealing with 19,000 lb. of steam per hour for Wolverhampton Corporation.

Two sets for dealing with 20,000 lb. of steam per hour for the Osaka Electric Lighting Co.

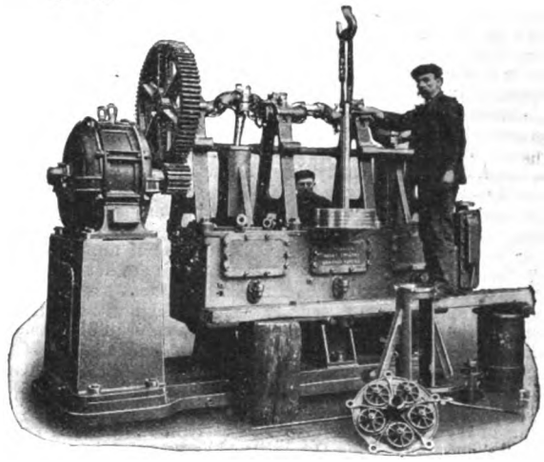

Fig. 2.

The earlier plants were of the ordinary surface type, but the latter orders are being principally filled with condensers of the "Contraflo" type, and in some cases with air pumps fitted with the "vacuum augmenter."

ENGINEERING EXHIBITION AT OLYMPIA.—I.

The second engineering exhibition at Olympia, which remains open until Oct. 19, is even more than last year a collection of machine tools. In the present issue we cannot give more than a brief survey of the chief exhibits, as the majority of the stands were incomplete on the day preceding the opening. We refer to the inaugural ceremony in another column. The body of the large hall is well filled with exhibits and the annexe also has been devoted in part to the stands of numerous engineering and allied firms. Like its predecessor, the exhibition may be considered "international," as the products of Continental and American firms are being displayed. There appears, however, to be a more fully representative "British section" this year, particularly in the matter of machine tools.

From an electrical point of view the exhibition should do much good in directing the attention of visitors to the merits and importance of electric driving. One might expect this to happen unconsciously, because the machine tool will doubtless claim the greatest amount of notice, and its electrical equipment will be "thrown in," so to speak, as a matter of course. The machine tool exhibits are all electrically-driven, but individual operation is more in evidence than was the case at the last exhibition. Electrical energy is on this occasion taken entirely from the Hammersmith Borough Council, and no steam units driving direct-current generators are employed. Their place is taken by two sub-stations, one on each side of the building, fitted with motor-generator units of 150 kw. output. These machines are of the General Electric Co.'s make, and consist of a single-phase motor, supplied direct at 2,200 volts, and a direct-current generator supplying at 220 volts. Separate brick buildings for the machines and high and low tension switchgear have been erected against the main wall of the hall. We shall describe these machines more fully in a later issue.

The number of electrical manufacturers exhibiting is small, but many makers of motors have their machines in use driving tools and other exhibits of machinery. The Phœnix Dynamo Mfg. Co., of Bradford, are showing five of their electric sensitive variable-speed drills and portable bench grinders (These were fully described in our "Industrial Supplement" for August.) The drills are mounted on a new form of base, which is fitted with compartments for storing drills and other small tools. The drills and grinders are being shown in operation from a direct-current circuit, but an alternating-current type motor is built for both the drills and the grinders. The exhibit of grinders includes a pattern for internal work, the shaft being extended through a long bearing, at the end of which the emery wheel revolves. Holes up to 5 in. diameter and 17 in. deep can be ground with this machine. The Johnson-Lundell Electric Traction Co. are showing a number of their laminated field-yoke type direct-current motors. Types ranging in size from 1 H.P. to 50 H.P. are on view, and also a combined set, motor and

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generator, which is supplying a number of Foster arc lamps. We were informed that the lamination of the field yoke tends to keep down armature reaction to such an extent that interpoles are not required on machines intended to have a wide range of speed. The commutation is said to be excellent. The construction of the yoke is slightly modified from the earlier form. The laminæ are cast in with the side plates instead of being bolted to them. There are now no bolts passing through the laminæ at all. The pole-pieces are clamped against the yoke by screws which pass through the side plates and into tapped holes in the blocks holding the pole laminæ. A neat tandem carbon plate brush-holder is fitted to these machines. We reserve further particulars till our next issue.

The exhibits of portable electric tools appear to be more numerous than last year and include those of British makers. The Consolidated Pneumatic Tool Co. have a number of drills, grinders and blowers driven by alternating and direct-current motors in operation on their stand in the centre of the main hall. The drills are being used on both metal and wood, and are also shown tapping holes. Among the direct-current drills is a three motor geared type for work up to 2½ in. diameter. Magnetic drill pillars are also shown. Other portable tools are shown by Light Motors (Ltd.), these including drills and grinders and also a speciality of the firm—a motor driven hair-brush. S. Wolf & Co. have a good collection of portable electric drills and grinders, which are made in a variety of sizes for both alternating-current and direct-current circuits. A number of these tools are shown in operation. Messrs. Schuchardt & Schutte also show several portable electric drills. Their exhibit of other machine tools is, however, from the point of view of individual motor driving, the finest in the exhibition, and affords a striking contrast to group driving with shafting, which is noticeable on some other stands. The collection of machine tools, which comprises lathes, boring mills, drills, millers, &c., stands out distinctly, and is unobscured by belting and overhead columns. Each tool has a motor fixed near to it, and the visitor is not confused by a mass of belts and pulley wheels when inspecting the machines. Iron-clad switch-gear of the Berry-Igranic type is placed near each tool for control purposes, and a distribution board fitted with Berry switch fuses is in use at the point where the cables enter the stand. Some 20 motors are employed, aggregating about 80 H.P. The exhibit is surmounted by an artistic sign supported on columns, and in the centre is a corona fitted with upwards of 200 incandescent lamps. We think this exhibit is typical in every way of modern electric tool equipment, and is all the more distinctive by reason of the comparison with other stands using belt drive from single motors. Messrs. H. Pels show a number of heavy tools for girder notching and joist cutting, which are individually driven through Morse chains by Westinghouse motors. The largest of these is an 8 H.P. machine, driving a plate shears, for taking plates up to ⅞in. thickness. On the stand of Craig & Donald is an interesting plate-bending and straightening roll, driven by a 12 H.P. Hall motor. The motor has a magnetic hold-off brake, which is in operation when the machine is running, but the brake comes on when current is cut off the motor. Plates up to 5 ft. wide by ¾ in. thick can be dealt with on the machine exhibited.

Among the other interesting exhibits are CO_2 recorders, draught gauges, steam load meters and gas-measuring and analysing apparatus by Sanders, Rehders & Co., high-speed engines by W. H. Allen, Son & Co., air compressors by Reavell & Co., and suction gas plant and high-speed gas engines by E. S. Hindley & Sons. Ludwig Loewe are showing a special casting process known as the "veeder," by which small castings in light metals are turned out of the mould to $\frac{1}{1000}$ in. accuracy. Bates Peard Annealing Furnace Co. have an exhibit in the Annexe, in which they show Prescot paper pinions and the Prescot welder. The annealing furnace is being shown in operation. Several machine tools are also to be seen about the Exhibition driven by motors through Prescot pinions. Clarke, Chapman & Co. have a large stand in the body of the hall, and exhibit, in addition to their steam boiler and condenser specialities, a number of electrically-driven machines, such as pumps, winches, drills, &c. Searchlights and generating sets are also among their exhibits. Willans & Robinson show specimens cast by their Eatonia process and samples cast in the ordinary way, these including brass piston rods, white metal bearings, slide valves, &c. Alexander Wright & Co. have a stand on which the CO_2 apparatus of Simmance & Abady is exhibited, and J. Dugdill & Co. are showing adjustable electric light fittings for workshops and other purposes.

We hope to give a more detailed account of the exhibits next week.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"The Corpuscular Theory of Matter." By J. J. Thomson, F.R.S. (London: Archibald Constable & Co.) 7s. 6d. net.

"The Engineering Index for 1906." (London: The "Engineering Magazine.") 10s.

CORRESPONDENCE.

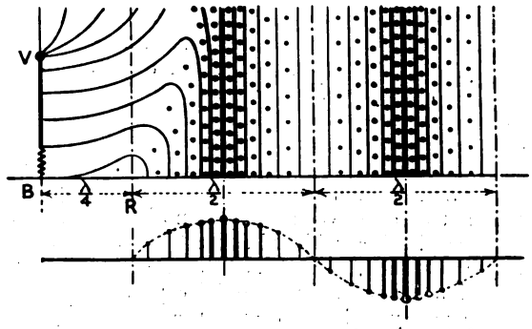
AN UNGROUNDED CLOSED CIRCUIT FOR RECEIVING WIRELESS SIGNALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to correct a somewhat misleading statement which appears in an article entitled "An Ungrounded Closed Circuit for Receiving Wireless Signals," by Mr. Pickard, in your issue of July 19th. The statement in question is found in the latter part of the second paragraph of the article and is to the effect that "in this section (speaking of the vertical section of the incident plane polarised Hertzian field), which includes only the lower portion of the waves," the electric component, "which in the immediate neighbourhood of the earth's surface is normal thereto, is shown in full line, *while the magnetic component, 90 deg., or a quarter wave-length behind the electric component*, is shown as a series of dots," &c. (The italics are mine.)

Any work on electrodynamics shows that, in a pure plane wave in an insulator such as the ether, the electric and magnetic forces are *in phase* and not 90 deg. out of phase. At the source the Hertzian waves have the character of a stationary wave whose electric and magnetic components in general are 90 deg. apart anywhere.

As Stokes has shown for light and Maxwell for Hertzian waves, the components approach in phase outward from the source, until at about ¼ wave-length they impress the character of a true wave on the radiation by coinciding in phase thenceforth.



A closer consideration of the facts also shows the necessity of this without going into the mathematics of the subject; for, since the electric field in a pure plane wave front is due to the forward motion of the magnetic field, and reciprocally, we find that, to mutually support each other, they must progress together with the velocity of etheric disturbances, and hence must be in the same space-phase or time-phase at any given point.

Furthermore, the fact that the electric and magnetic energies are always equal in a true plane wave shows that no phase displacement is possible in the components of such a wave in an insulator; on parallel wires with zero leakage and resistance there is no phase displacement in the components.

In a conductor, on the other hand, a pure plane wave has everywhere its electric component shifted ahead by 45 deg., or ⅛ wave-length, to keep the balance of energies of the fields.

We may now re-draw Fig. 1 of Mr. Pickard's article as shown above. The sinusoid with dotted outline shown is a conventional representation of the main figure. Strictly represented, the dots should be shown "threaded" on their "supporting" electric lines; considerations of clearness in the figure prevent this, however. As shown in the figure, the electric lines leave the vertical with a component almost horizontal (see an elegant treatment of this subject by J. S. Stone, *Electrical Review*, New York, October 15, 1904), creating a relatively enormous current in the "earth," and having a theoretically infinite velocity at B which becomes that of a true wave at R, if we consider the waves to approximate plane waves.

It is also of interest to consider more carefully an assertion made by the author of the article in the last two sentences of

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the third paragraph, which would lead one to infer that the magnetic lines of force in the incident plane polarised field contribute but very little toward the oscillations in the antennæ. In other words, because the electric lines are "earthed" or "grounded" they only are effective, the magnetically-induced electric lines of force supposedly extending solely from one-half of the vertical to the other, and therefore furnishing very little energy to the receiver, when the latter is placed between the base of the vertical and "earth."

Closer examination of the facts shows that this is a mistake so far as the inference that the magnetic lines of force may be neglected goes; for, although there are antennæ in which the large surfaces used permit an accumulation of electrostatically stored energy at first glance, to the relative exclusion of magnetically induced or "Faraday" lines, yet, since the incident components of the magnetic and electric fields are always automatically tending to equalise each other by continuous absorption, re-radiation, reflection, &c., whenever the balance is destroyed we find that this so-called accumulation of electrostatically stored energy per half-cycle is at the expense indirectly of the magnetic lines of force; both fields change their vectors (*i.e.*, shape) at any point where an unbalancing occurs. (O. Heaviside has dealt with great power on this aspect of the question in connection with wave propagation in cables, and Prof. W. S. Franklin has given a simple but thorough illustration of it in a Paper in the *Journal* of the Franklin Institute, July, 1905.)

It is, therefore, only a half truth to say that one set of lines of force contributes but little; it yields its contained energy whenever the value of its "supporting" electric field is decreased. The fact that the induction loop of Mr. Pickard, which is not electrically distinct from the induction loop of Preece and others, will absorb directly the energy of the magnetic lines does not show, on the other hand, that the electric lines of force are not being used also. The E.M.F.s induced by the two are in phase, and combine to add their energies per half-cycle to operate the receiver, unless differential effects are present.

It should be remembered that, even were there no reciprocal flow between the two kinds of energy, when a vertical is placed near the earth its field is so distorted by the latter's presence that its effective capacity is no longer determined by both halves of itself considered as electrical filament electrodes perfectly conducting, and with an infinite capacity per cm.^{2} at their junction (*i.e.*, by its "dynamic" capacity), but by a much increased capacity added to that of the filament by the earth's capacity to the rod, which may be infinite per cm.^{2} at its lower end. In this case most of the stored energy may dissipate itself between the filament (or vertical) and earth through a connected detector instead of between both halves of the filament considered as a linear oscillator in free space.—I am, &c.,

O. C. Roos.

31, State-street, Boston, Mass., U.S.A., Aug. 27.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant electrical engineer is wanted for the harness and saddlery factory, Cawnpore, India. Age not over 30. Candidates should possess sound engineering and electrical training, with subsequent workshop and central station experience, a working knowledge of steam, ability to erect steam sets, mains and motors, and take charge of such power as may be required. Five years' agreement, with option to Government to extend. Pay to commence at Rs.280 per month, rising annually by Rs.10 per month to Rs.320. On re-engagement Rs.350 per month. Free quarters and medical attendance provided. Second-class passage out and home. Forms of application, &c., from the director-general of stores (Mr. E. Grant Burls), India Office, London, S.W., to be returned not later than Sept. 30. See also an advertisement.

A chief lecturer in mechanical engineering is required for the Auckland (New Zealand) Technical College. Candidates must have had good workshop experience, and, if possible, possess a diploma or degree in engineering. Salary £300 per annum. Particulars from the director of technical education and manual training (Mr. Geo. George, F.I.C., F.C.S.), c/o the High Commissioner for New Zealand, 13, Victoria-street, London, S.W. Applications by Oct. 8. See also an advertisement.

A lecturer and demonstrator in physics is wanted for the Municipal Technical College, Derby. Commencing salary £120, rising to £180. Particulars and application forms from the registrar. See an advertisement.

The chief electrical engineer of a London electricity supply station has a vacancy for a premium pupil. See an advertisement.

A draughtsman is required, with sound electrical and mechanical knowledge, for electrical works in Manchester. See an advertisement.

A junior master for the elementary school is required to teach physics and English subjects. Salary £150. Particulars and forms of application from the Registrar of Merchant Venturers' Technical College, Bristol. See an advertisement.

Dublin Lighting committee require a meter reader. Commencing salary £65, rising to £91. Applications to Chairman, 3, Corkhill, Dublin, by 4 p.m., Sept. 23.

Shoreditch (London) Council have appointed Mr. W. Weeks assistant electrical engineer, at £175 per annum, to be raised in four months to £200 per annum, and increasing annually to £250. Mr. Weeks has been for eight years with the Council as electrician-in-charge, and has for the past two months satisfactorily carried out the duties of assistant engineer.

Mr. E. F. Kent, of Croydon, has been appointed technical assistant in the electricity department of Sunderland Corporation.

Mr. E. W. Dean, formerly chief engineer to the Primitiva Gas and Electric Lighting Co., has been appointed electrical engineer to the Rosario Railway Co., and will superintend the erection and running of the power plant at their Rosario workshops.

EDUCATIONAL NOTICES.

University of Durham.—The matriculation and exhibition examinations at Armstrong College, Newcastle-on-Tyne, for the 1907-1908 session will take place from Sept. 30 to Oct. 5. The term opens on Oct. 8. Particulars of curricula for university degrees and college diplomas in engineering, electrical engineering, mining, metallurgy, &c., and of fellowships, scholarships and exhibitions from the secretary, Mr. F. H. Pruen, Armstrong College, Newcastle-on-Tyne.

King's College, London.—The Michaelmas term commences on Oct. 2. In addition to the day courses, evening classes are held for civil, mechanical and electrical engineering, workshop practice, drawing, metallurgy, mathematics, physics and all science subjects. Prospectuses and further information can be obtained from the secretary, Mr. Walter Smith, King's College, Strand, London, W.C.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. Entrance examination on Sept. 25 and 26, when three entrance scholarships of the value of £52 each will be offered for competition. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms.

Evening technical courses in all branches of electrical and mechanical engineering commence on Monday, 23rd inst. The laboratories are well equipped for both alternate (single and polyphase) and continuous-current work and for all kinds of electrical testing. Particulars as to fees, &c., can be obtained at the Institute, St. John's-street, Clerkenwell, E.C., or on application to the principal, Dr. R. Mullineux Walmsley.

We have received a copy of the "Announcements" (educational and social) of this institute for the session 1907-8.

The provision last session of increased accommodation in the rooms of the British Horological Institute, Northampton-square, has made it possible to introduce further developments in the work of the departments which continue to find their quarters in the original building as well as in that of the department of technical optics.

The most noteworthy of these developments is a course on the production and measurement of light, which is being given to both day and evening students by the electrical engineering and applied physics department and by the department of technical chemistry jointly. The lectures and laboratory work in the electrical engineering department deal with all the various kinds of electric lamps (arc and luminescent), with the problems of the production of light and photometry and general questions of radiation. In the technical chemistry department the subject is taken up from the chemical side and the whole subject of incandescent lighting dealt with. The properties of rare metals and rare earths, their production, extraction and use for all kinds of incandescent lighting, both gas and electric, are fully dealt with, and the production of metallic filaments for electric glow lamps is thoroughly studied. In the engineering day courses further options have been introduced for the more advanced work of the third and fourth year, and advanced work for an additional year has been provided in the technical optics day courses. The subject of electric wiremen's work has been re-modelled and is dealt with in accordance with the revised syllabuses recently issued by the City and Guilds of London Institute. The classes in telegraphy and telephony have also been re-modelled. In the technical optics department four new

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classes, especially suitable for artisan students, are being started, and minor changes have been made in the syllabuses. There are also special classes for the instruction of kinematograph operators which it is hoped will meet a much-felt want and place this kind of work upon a sound scientific basis. Many minor developments in various directions have been made or are in contemplation.

Hackney (London) Technical Institute.—The next session commences on Sept. 23. Evening lectures and laboratory courses are held in electrical engineering subjects, including electrical measurements, dynamos and motors, alternating currents, electrical design, &c. Prospectuses, &c., from the Principal, Dalston-lane, London, N.E.

Sir John Cass Technical Institute (Aldgate, London, E.)—At this Institute there are evening classes in chemistry, metallurgy, physics and mathematics, designed to meet the requirements of those engaged in the chemical, metallurgical and electrical industries, &c. Facilities are given for special and advanced practical work in well-equipped laboratories, both in the afternoon and evening. The new session begins on 23rd inst. Details of the classes may be obtained at the offices of the institute, or from the principal, Mr. Chas. A. Keane, M.Sc., Ph D.

Rutherford College, Newcastle-on-Tyne.—On the 12th inst this college, which was founded by the late Dr. J. H. Rutherford, was formally handed over on behalf of the trustees to the Newcastle-on-Tyne Corporation, whose Education committee have acquired it from the trustees and council.

Wigan Mining College.—We have received a copy of the calendar of the evening classes of the Wigan and District Mining and Technical College for the session 1907-8, which commenced on Monday last. There are classes in electrical and mechanical engineering, physics, mathematics, chemistry, &c.

Tuition by Correspondence.—Prof. Andrew Jamieson, M.Inst.C.E., M.I.E.E., (16, Rosalyn-terrace, Kelvinside, Glasgow), prepares pupils, by correspondence, for all examinations in mechanical, electrical and engineering science. Prof. Jamieson's announcement appears on another page.

Alleged Noisy Tramcars.—The President of the Board of Trade is to be invited to receive a deputation from the Councils of Hammersmith, Ealing, Hampton Wick, Hanwell, Teddington and Twickenham with regard to the noise alleged to be caused by the tramcars of the London United Tramways Co.

Teddington Council has asked the Board to cause an inspection to be made by one of the inspectors of the tramway track in Teddington, under a section of one of the company's acts, but the Board have replied that they were not disposed to order an inspection unless action had first been taken against the company and such action had failed on the evidence available.

Argentina.—The "Review of the River Plate" states that the plans for the electric railway in Cordoba, under the Steward concession, have been approved by the Intendente of the city.

Mr. S. C. Marengo, manager of the Buenos Ayres and Belgrano tramways, is retiring, in consequence of the purchase of the undertaking by the Anglo-Argentine Tramways Co.

Messrs. Gandulfo and Diaz Valdez have petitioned Congress for a concession for a double-track tramway from Buenos Ayres port to Calle Maipu, Avenida Rosales and Avenida Sarmiento.

The Belgian Electric Tramway Co., which took over the Roux concessions, are petitioning Buenos Ayres Council for a two years' extension for carrying out the works which, under the concessions, should be completed by December next.

Mr. J. H. Bouwer, manager of the Concordia station of the Anglo-Argentine Electric Light Co., has returned to Buenos Ayres to take up the position of general superintendent of the company's stations.

Ashton-under-Lyne.—The Markets and Lighting committee recently proposed to light a street by incandescent gas, but the proposal was referred back with an instruction to consider the question of electric lighting.

Australasia.—The "Australian Mining Standard" states that imports of electrical machinery into Australia in 1906 were valued at £212,070, the principal contributions being from the United Kingdom £138,887, U.S.A. £41,240, Germany £23,258, Canada £792, Belgium £6,894, and Sweden £655.

Electrical plant is in course of erection at Mount Kembla (N.S.W.) mine.

At the Long Tunnel Extended mine, on the Walhalla Goldfield, Victoria, underground telephones have been fitted, generating plant has been put down and the underground levels are being wired for electric lighting. At the Long Tunnel Inclined Shaft, in the same group, a 150 kw. plant has been put in for pumping and ore crushing.

Mr. Jolly, manager for Messrs. Noyes Bros., has prepared specifications for the Leonora (W.A.) Council for electricity supply works and for the electrification of the Leonora-Gwalia tramway.

The total capital expenditure is put at £7,370. The annual consumption of current for lighting and power is estimated at 25,000 units (at 1s. per unit). The total expenses (including 10 per cent. for depreciation), would be £661, or 6·90d. per unit. After providing for distribution costs a profit of £384 per annum is anticipated. The conversion of the tramway is expected to cost £2,620, the running cost is estimated at £900 per annum and the profit at £268 per annum.

Australian Customs Tariff.—The new Australian tariff of import duties contains the following duties on articles and materials used in or in connection with the electrical industry. The figures in parentheses show the duties upon products or manufactures of the United Kingdom, and other figures relate to the general tariff:—

Arc lamps and accessories, incandescent lamps, metal reflectors and shades, and fittings for lighting (exclusive of glass globes and shades), 25 per cent. (15 per cent.); electric stoves, 30 per cent. (20), miners' safety lamps, 10 per cent. (free); *turbines, boilers, pumps, elevating and conveying machinery, economisers and cranes*, 30 per cent. (25); steam engine indicators and recorders, 10 per cent. (free); tools of trade, free; *metal manufactures n.e.i.*, 30 per cent. (25); *mining engines and machinery*, 35 per cent. (25); electrical machinery—viz., generators, motors up to 500 H.P., fans, starting and regulating rheostats, 30 per cent. (25); n.e.i., 17½ per cent. (12½); electrical appliances—viz., electroliers, pendants, brackets, switches, controlling devices n.e.i., radiators, and zinc tubing, 20 per cent.; n.e.i., 12½ per cent. (12½); electrical materials—viz., accumulators or storage batteries, including glass cells, cable and wire (covered), carbons, testing meters and instruments, translators, insulating tapes, meters, resistance coils, static transformers and terminals, photometers, 5 per cent. (free); rails, fishplates, &c., for railways and tramways, 12½ per cent. (12½); copper strip, wire sheets, &c., and platinum, free; wire (n.e.i.), 10 per cent. (free); zinc (bar, scrap, sheet, &c.), free; electric fuses, 5 per cent. (free); X-ray apparatus (without motors), galvano cautery batteries, &c., 10 per cent. (free); scientific instruments and apparatus, free.

On the items printed in italic an increase of 2½ per cent. in the duty (for British and other goods) will be made as soon as these classes of manufactures are sufficiently established in the Commonwealth. In the cases of rails, fishplates, &c., for railways and tramways the increases will be 5 per cent. on British and 10 per cent. on other goods.

Any dutiable machinery, or machine tool, or any part thereof specified in any proclamation issued by the Governor-General in pursuance of a joint address passed on the motion of Ministers by both Houses of the Parliament, stating that such machinery, machine tool, or part cannot be reasonably manufactured within the Commonwealth and that it should be admitted free will be so admitted.

Capt. R. M. Collins, the officer representing the Commonwealth in London, points out that the tariff has yet to be considered by the Commonwealth Parliament, and arrangements have been made whereby alterations in the schedule will, as they are made by the Commonwealth Parliament, be telegraphed to Capt. Collins and published here.

Ayr.—The salary of the burgh electrical engineer (Mr. R. Marshall) has been increased by £50 per annum. The equivalent of 50,000 8 c.p. lamps is now connected to the mains.

Ayrshire.—The Northern District committee of the County Council are considering a proposal by a syndicate to construct electric tramways between Largs and Skelmorlie.

Bermondsey (London).—The Council have declined the offer of the County of London Electric Supply Co. to supply current (at 1½d. per unit) to 48 arc lamps for lighting the main streets of St. Olave's.

Boiler-House Economy.—Further indications of the growing interest in mechanical stoking and the abatement of black smoke was recently shown when about 40 members of the Rochdale and District Motive Power Mutual Improvement Society (of which Mr. C. Claremont Atchison, the borough electrical engineer, is president) visited the works of Messrs. Ed. Bennis & Co. at Little Hulton, Bolton.

Accompanied by several members of Little Hulton District Council, the clerk and surveyor, the party was piloted through the various shops by Mr. Ed. Bennis, managing director, Mr. A. W. Bennis and members of the staff, who explained the processes employed in the manufacture of boiler-house plant. Considerable interest was evinced in the erection of Bennis patent machine stokers and self-cleaning compressed-air furnaces, including one of 24 which are being supplied to Bordeaux (France) Municipal electricity works. The Bennis improved chain-grate stoker was also the object of much attention. The department for the construction of conveyors, elevators, truck tipplers, &c., was inspected, and a visit was made to the foundry, smithy, dressing shops, pattern shops, &c.

Brierfield.—The Electricity committee recommended the Council to discontinue the electric lighting of the main road and substitute double incandescent gas-lamp brackets, to be fixed on the tramway pillars. The Council have, however, referred this recommendation back, especially as they are considering the advisability of erecting municipal electricity works.

Burslem.—A sub-committee has been appointed to consider the question of the salary of the borough electrical engineer (Mr. A. Bremner).

Camberwell (London).—On July 30 the Hon. T. H. W. Pelham presided over a Board of Trade inquiry into appeals of the County of London Electric Supply Co. against the condition imposed by the Council—viz., that the mains proposed to be laid by the company be used only in respect of the supply of electricity within the borough. The Board of Trade have now allowed the appeal of the company, and have approved the laying of the mains proposed by the company.

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Canadian Telephones.—The Hon. W. H. Cushing, Minister of Public Works at Alberta, states that this province of the Dominion will have 500 miles of trunk telephone lines in operation by the end of the autumn.

Carmarthen.—The Council have sealed the agreement with J. B. Saunders & Co. for the erection of electricity works and for supplying electric current for street lighting for 14 years. Messrs. Saunders propose to form a subsidiary company to carry out the contract.

Dundee.—In connection with the erection of the new Carolina Port generating station, plans of the proposed cable routes have been passed by the Harbour trustees, and the conditions under which the cables will be laid have also been approved of by the board.

Edinburgh.—On Tuesday the Council had before them a recommendation by the Electric Lighting committee to reduce the charge for electric current to private consumers from 3d. to 2¾d. per unit, but it was decided by 20 votes to 16 to make no reduction at present.

Electric Mains in the Metropolitan Area.—London County Council has issued a circular letter to the Metropolitan Borough Councils suggesting that electric mains under carriage-ways should be laid at a minimum depth of 3 ft. 6 in where there is any likelihood of a tramway being constructed or where street improvements may become necessary.

Electrical Equipment for Rolling Mills.—It is announced that Messrs. Sir Theodore Fry & Co. have decided to adopt electric power for the operation of the whole of the plant and machinery at their Rise Carr Rolling Mills, Darlington. The details are not yet settled, but the installation will include 31 Westinghouse motors (one 400 H.P., four 250 H.P., and one 75 H.P. motors for driving rolls, and one 50 H.P., two 25 H.P., three 15 H P., 12 10 H.P. and seven 5 H.P. squirrel-cage motors for driving shears, punches, drills, &c.) All the drives are to be by means of ropes, and in the case of three of the drives the motors will be placed in a specially constructed house below the floor level, so as to cut up the floor space as little as possible. The various motors are for use with three-phase current at 440 volts 40 periods, but the company have not yet decided whether to generate their own energy, to take current from Darlington Corporation, or to enter into an arrangement with the Cleveland & Durham Electric Power Co.

Exhibitions.—An interesting exhibition of electric motors, lamps, fittings, electro-medical apparatus, &c., was opened at the Town Hall, Loughborough, on Monday. There are a number of exhibitors, including the Edison & Swan Co., who, although they have not taken a stand, are showing, in operation, four of their new 10 ampere size white flame Ediswan-Carbone lamps, and two examples of their new enclosed arc, "the Radiant," which is also of the white-light type, although not a flame arc.

The electrical exhibition which was opened at the Public Hall, Devonport, on the 12th inst. will remain open until the 25th. The exhibitors include the General Electric Co. (London), who show the method of glass-blowing in the manufacture of Robertson electric lamps; W. G. Heath & Co. (Plymouth) exhibit direct-coupled petrol engine sets, dynamos, motors, arc lamps, &c.; W. J. Corse & Co., electrical impulse clocks, electric light fittings, electro-medical apparatus, &c.; and Devonport Corporation electricity department have a large display of motors, radiators, lamps, street-lighting fittings, &c.

Fatality.—On Friday last a youth named Edwards was killed while working at Littleton Collieries, Huntington. Deceased was employed to look after an electric motor in the mine, and in some way came in contact with a wire conveying current at 500 volts.

Fire.—On Tuesday morning a fire broke out in some railway arches used as stores by the General Electric Co., at the rear of their works in Union-street, Southwark, London. We are informed that the damage is slight and will not cause any serious interruption of the company's business.

Handsworth (Staffs.)—The Council have given the City of Birmingham Tramway Co. notice of intention to purchase the lines authorised by the Birmingham Central Tramways (Extension) Order, 1886.

Harrogate.—The borough electrical engineer (Mr. G. Wilkinson) has been instructed to report as to the cost of fitting the transformer chambers in the centre of the town with modern transformers.

Heating Plant for Japanese Steel Works.—An order has been recently placed with Messrs. Davidson & Co., of Belfast, for the complete heating plant to be installed in the new steel works now in course of erection in the north of Japan.

This plant, one of the largest of its kind supplied to Japan, includes 10 separate sets, which are to provide heat for two large machine shops, measuring 600 ft. by 130 ft. and 650 ft. by 168 ft. respectively. Each set comprises a large "Sirocco" multitubular air heater, and an electrically-driven centrifugal fan. The air heater consists of a central furnace from which the products of combustion are led through a series of tubes arranged horizontally on either side. The current of fresh air passes round the outside of the tubes, and there is no possibility of it becoming vitiated by coming in contact with the flue gases. Owing to the long distance the products of combustion have to travel before they reach the chimney, almost all the heat which can be obtained from the fuel is usefully applied in warming the air current, which makes it possible for these heaters to warm a large volume of air with an exceedingly low fuel consumption. Attached to the heater is an electrically-driven "Sirocco" centrifugal fan, which draws the air through the heater and discharges it, warmed to a suitable degree, into the building.

With the system of heating which will be installed in the works, no duct work is required, which means a considerable reduction in the first cost of a plant of this character, as well as a decided economy of valuable space. Further, the running cost of this system is low, owing to the fact that the fans are not propelling the warm air through ducts, which, by setting up a resistance to the air current, increase the amount of power required to operate the fans.

In addition to the heating plant the Japanese steel works have also ordered from Messrs. Davidson & Co. four "Sirocco" induced draft fans, 55 in. in diameter, directly coupled to electric motors. These fans are to deal with the flue gases from two batteries of boilers in the same works.

Leeds.—The Tramways committee recommend the City Council to obtain sanction to the borrowing of £40,000 for the construction of additional tramways.

The committee have decided to visit Farnley and Wortley in connection with the proposed extension of the tramways in those districts.

The committee have also decided to arrange, in conjunction with Bradford Tramways committee, for the running of dual-gauge cars similar to that which has been recently tried in order that a through service may be maintained between the two cities.

The manager of the electric lighting department (Mr. H. Dickinson) has reported to the Electricity committee on developments in the manufacture of incandescent electric lamps. The report states that a number of different types of metallic filament lamps are on the market, and Mr. Dickinson considers that at least one of them is at any rate worth a trial by consumers, as it appears to be quite suitable for use under certain conditions in connection with the system of supply of electricity in Leeds (the alternating system), and is asserted to effect a saving of about 50 per cent. in the quantity of energy required for a given amount of illumination, compared with the carbon filament lamps. To facilitate trial by consumers the committee have sanctioned the purchase of a few lamps for re-sale at 4s. per 32 c.p. lamp, believing that any loss to the Corporation due to the reduced consumption of electricity per lamp would ultimately be more than compensated for by a resulting large increase in the number of consumers.

Llansamlet.—A provisional electric lighting order is to be applied for by Swansea Rural Council.

L.C.C. Tramways.—London County Council have notified Hackney Council of their intention to construct a single line of tramway from Essex-road, Islington, to Kingsland-road (via Englefield-road and Stamford-road), and from Kingsland High-street to Mare-street (via Ridley-road and Dalston-lane), together with a double line in Lea bridge-road, between Cornthwaite-road and Lower Clapton-road.

St. Pancras Council have been asked by the L.C.C. to contribute towards the cost of making a road across the Metropolitan Railway station, King's Cross, in connection with the Pentonville and Gray's Inn-road tramways.

L.C.C. Tramway Employes.—It is reported that the men employed by the tramways department of London County Council are formulating a list of their demands, and these include the appointment of a board of conciliation to consider any dispute or difference that may arise between the men and the tramways department, a working day of eight hours, pay for motormen 7s. per day, and a week's holiday every year. It is claimed that 90 per cent. of the tramway employés of the L.C.C. are members of the Amalgamated Association of Tramway and Vehicle Workers.

Malta.—The total length of aerial telephone lines belonging to the military authorities at March 31 last was 626½ miles, the total length of these lines open to the public being 18½ miles only. The Malta Telephone Co. has 696 miles of wire in operation. There is no local telegraph service in Malta.

The revenue from electricity supply at Malta for the year to March 31 last was £18,293, against £17,468 in the previous year. Working expenses, including interest, &c., were £11,057 against £12,548. The total capital expenditure was £69,544, and the net profit on the year's working £7,236. Total units generated, exclusive of current used at works, was 972,659, compared with 1,042,167 in the previous year. 3,279 tons of coal were consumed against 3,753 tons. It is stated that the reduced number of units generated was due mainly to the introduction of a new patent lamp which reduced the consumption of energy by about 28 per cent. The coal consumption per unit generated was reduced from 8 lb. to 7·5 lb.

Manchester and Salford Electrical Exhibition (1908).—The secretary of the National Electrical Manufacturers' Association (Mr. Walter Davenport) has issued a circular letter to local authorities asking for financial and other support for this enterprise.

It is pointed out that "this exhibition will have a far-reaching effect in a largely populated and important manufacturing area, and will undoubtedly tend greatly to increase the present use of electricity for lighting,

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power and other purposes. It is intended to ask for support in the form of donations, in exchange for which tickets of admission to the exhibition (printed specially for each local authority) will be supplied to the various contributors for free circulation in their respective areas at 8s. per dozen, proportionate to the amount voted. So soon as the list of contributors is complete, a meeting will be arranged to elect representatives to serve on the advisory committee. The profits arising from the exhibition will be allocated, in a percentage, to a return to exhibitors, to a return to contributors, to the charities connected with the electrical industry and to a charitable institution nominated by the Manchester and Salford Corporations, and situated in their respective districts. The general scheme of carrying on the exhibition will be based on the lines adopted so successfully by the supply companies and municipal councils at Olympia (London) in 1905. The Lord Mayor of Manchester, supported by the Mayor of Salford, has kindly consented to convene a meeting of chairmen and engineers of corporations, urban councils and supply companies in the district, to be held on Tuesday next, Sept. 24."

Merthyr.—Last week the Council were recommended by the Public Works Committee to accept the tender of the Merthyr Electric Traction & Lighting Co. for public lighting.

The company offered to supply current to and maintain 2-light Osram lamps at £3 each per annum and 4-light Osram lamps at £6 per annum, the Council providing brackets, &c. The local gas company offered to light the road by 68 single burner lamps and 10 3-light lamps at £267 per annum, the burners to be of an improved type, the single burner lamps to be of 100 c.p. and the 3-light lamps 300 c.p.

After discussion it was decided to refer the matter back to the committee, along with a recommendation that the electric company be allowed to fix overhead wires for lighting at Dowlais.

Municipal Trading and Wiring Contractors.—During the past six or eight years many Corporations have obtained special powers to undertake wiring and installation work. Naturally wiring contractors resent this incursion into their province and have combined to resist the extension of such municipal activity. In many cases they have been successful in imposing a special clause upon local authorities which forbids them to do wiring and fitting work except through the medium of a wiring contractor. If the following statement of the A.E.G. English Mfg. Co. is true (and we have no reason to doubt its authenticity), it would appear that in many cases the contractor has only himself to blame for the competition of municipal electricity departments. The A.E.G. English Mfg. Co. state—

We have from time to time during the last year approached contractors in various towns offering to fit certain improvements which we have brought out, free of charge, and to send a qualified electrician to attend to any Nernst lamps which were unsatisfactory. We duly advised the contractors in question, but regret that they would not take the trouble to advise clients of theirs to have these improvements fitted, although they would have been put to no expense whatever. We therefore approached the electricity departments in different towns, and they readily acceded to our request the result being that the Corporations in question issued forms to all their consumers notifying them of these improvements and that same would be fitted free of charge. Further, a large number of people availed themselves of our offer and we have sent out our electrician to inspect the various installations and put the lamps in order. We regret to say that the state of things during our inspection showed us that, although there was a defect in the lamp (*i.e.*, faulty cutout), it was burning under such conditions that it was impossible to obtain good results: (1) ½ ampere burners were being used on 1 ampere lamps; (2) ½ ampere burners were being used with 1 ampere resistances; (3) holders of B and D lamps were not slotted; and (4) Luna and A types were connected to wrong polarity. We have engaged travellers, and they are calling on the trade and private users. We have notified various contractors that we shall hand any orders our travellers take over to the contractor who usually does the wiring and repairs; under no circumstances shall we quote trade terms to private users. We regret to say that the result of our travellers taking orders has been that the consumers have advised them in many cases that they would prefer orders executed by us, and have hinted that if we do not agree to do this work the contractor would probably refuse to supply. We are anxious to co-operate with the electrical contractor, but under the above conditions it seems it is impossible.

Municipal Telephony.—Glasgow Telephone committee are considering the best course to pursue to meet the deficiency (estimated at from £15,000 to £17,000) in connection with the late municipal telephone department. The sum represents the difference between the expenditure incurred by the Corporation and the price received from the Postmaster-General. It is urged that the deficiency can only be met by taxation, but that the amount can be spread over a number of years.

Oystermouth.—At a recent meeting of the Works and General Purposes committee the clerk (Mr. J. H. Robinson) reported that the committee had had about a dozen applications for information in regard to the proposed electric lighting scheme, but only one company had sent in a tender and submitted particulars of its proposed scheme. He suggested that a small committee should be appointed to ask the other parties who had applied for information to supply particulars of their schemes. A sub-committee was, therefore, appointed to consider tenders, which are to be sent in within a month.

Patent Amendment.—The British Westinghouse Electric & Mfg. Co. (Ltd.), 2, Norfolk-street, Strand, London, W.C., seek to amend the specification of Letters Patent, No. 18,786, of 1902, granted to Hugo Bremer for "improvements in electric arc lamps." Particulars of the proposed amendment are set out in the "Illustrated Official Journal (Patents)" of 18th inst, and notices of opposition must be given within one calendar month of that date.

Plymouth.—Important reports on the municipal tramway system especially in regard to the tramcars and the overhead equipment, have been prepared by the borough electrical engineer (Mr. E. G. Okell) and the tramways manager (Mr. C. R. Everson), and these will be considered at the next meeting of the Tramways committee.

In his report Mr. Okell states that the total number of cars is 42, the number in use for ordinary daily service being 27. All the cars, with the exception of those recently purchased, show considerable signs of wear, due to the hilly and crooked nature of the routes traversed, and also to the rough state of the track, which tends to considerably increase the wear through shock and vibration. Many of the truck attachments show signs of movements where bolted to the frames, the frames and parts being worn at the points. A number of bolts were found slack. A number of main axle springs have been broken, and in several instances broken springs were found in cars in service. Mr. Okell suggests the desirability of trying other forms of springs and of adopting a type better adapted to withstand the rough usage to which they are subjected. In some instances the guide bolts of the truck springs were bent, impeding the action of the springs, and in some cases check washers were missing, allowing the bolts freer play to rattle about, causing noise and wear. Many of the bearings were considerably worn down, and in some cases the wear had been allowed to go too far, so that the bearing cases had been cut into. One or two bottom plugs were missing from oil wells, under bearings, allowing the oil to escape. The chains and rods of the brake gear were generally in a sound condition, but rusty. A number of cotter pins connecting bolts were very loose and much worn, and several were missing. In one instance he found the main bolt between the hand-brake lever and connecting rod without nut or cotter pin, so that the bolt could be easily lifted out. Several of the rods examined were worn at the points and connections and were not lubricated. Many of the gear cases were found with slack bolts. All the link gear of the life guards and swinging gates were rusty, and the bearings were without lubrication. Several of the motor access doors were found with broken hinges, patched by pieces of wire. Some of the cable connections of the motors were slack and liable to shake out when the cars were running. Very many of the motors examined were burnt in the neighbourhood of the commutators through flashing over. When that took place there was a very heavy discharge of power through the car, and was probably the cause of many of the interruptions of the supply. The trolley standard was connected through an indicating device and fuse, but the fuse was placed in an inconvenient position, and a number of the fuse wires were missing. The electrical equipment and car wiring generally did not appear to be subjected to any regular systematic test, as there were no testing instruments provided. Defects might, therefore, be in existence for some time, and might only be finally discovered through the breakdown of a car when in service. The tools and general provision for repair work appeared to be inadequate for the efficient and economical management of the cars. If the cars were to be maintained in good working order for the full periods of the various loans under which they had been purchased a larger sum must be spent on repairs in future. The amount expended for cleaning and repairs during the past three years had averaged 0·934d. per car mile, and he estimates that a yearly sum of at least £3,230 would be required during the next five years. In regard to the overhead equipment, the smaller iron fittings and the bracket arms at the outer ends were in a very rusty state, small bolts and screws were considerably eaten into, and a number of small finials at the end of the bracket arms were found with screws rusted away and were removed to prevent the risk of their falling into the road. On three sections the trolley wires showed considerable signs of wear, especially at the ears and fittings, and on the curves in the centre of the town. The town section now required frequent careful inspection. Some of the small iron bolts in the trolley wire supports were badly worn or corroded, and should be replaced. Corrosion was also taking place on the insulation bolts. On the Peverell section portions of the wire had become slack, and should be tightened up. All the section insulators were in need of attention. Some should be replaced by new ones, and in every case vertical anchors should be fitted to relieve these fittings of some of the strain they now carry. In several places the guard wires were no longer required and should be taken down. Many of the guard wire supports were in a rusty condition, and a few were twisted out of place. The section pillars were in a dirty condition, and the inside fittings needed repair. Mr. Okell estimates that during the next five years the average amount necessary for maintaining the overhead work will be about £250 per annum.

Mr. Everson's report is, we understand, a reply to Mr. Okell's statements, many of which are challenged.

Presentations.—Salford Tramways staff have presented an oak clock, a pair of bronzes, a flower stand and a pair of vases to Mr. J. W. Blakemore on his marriage.

The Rugby staff of the British Thomson-Houston Co. have presented a cabin trunk, a pair of binoculars, a gold fountain pen, Kempe's "Handbook," a silver matchbox and an illuminated address to Mr. W. L. Hogg, chief assistant to Mr. F. G. Smith, head of the generator department, on his departure for Canada.

Railway Station Lighting.—At the meeting of the Great North of Scotland Railway Co. on Tuesday the chairman (Sir D. Stewart) stated that up to last year they generated electric current with their own plant for lighting the Palace Hotel and the Aberdeen joint station. The machinery was reported to require renewal, but, as

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they received an offer from Aberdeen Corporation to supply current at a reasonable rate, they accepted it and decided to sell their plant. £4,174 represented the amount which the directors had set aside as depreciation on the plant and the proceeds of the sale, and there was no loss on it. They had also lighted their Waterloo goods yard and Kittybrewster shunting yard, Aberdeen, by electricity, which was a great improvement, the current in these cases being also supplied by the Corporation.

St. Pancras (London).—During the quarter ended June 30 the electricity department sold 1,404,533 units and the receipts were £14,474, against 1,533,142 units and £14,748 in the corresponding period of 1906. The decrease is due to the lessened demand for current for power (280,369 units against 475,056) owing to the completion of the construction of the tube railways in the district.

The district auditor (Mr. Carson Roberts) in his annual report, states that in the electricity accounts the share of the central establishment charges allocated to the trading revenue appears to him to be too low by at least £100, the whole of the uncollected income (excluding bad debts written off) is shown as an asset and no provision has been made for bad debts which it may include (a sum of rather under £100 should, Mr. Roberts thinks, be taken into account to cover the probable losses), and to some extent the incidence of the loan repayments has been deferred by failure to raise loans in advance of capital expenditure and by running an overdraft on the account. Although £18,220 had up to the present been transferred from the undertaking for the aid of the rate funds, the transfers had stripped the undertaking of any working balance except the reserves. Of the £35,630 appropriated as reserve, but not invested as such, only about £10,000 was, on March 31 last, available for the purposes for which it was so appropriated (after deducting the £5,000 subsequently transferred to the rate funds), the remainder being in use for the purpose of meeting the revenue outgoings which ante-date the corresponding income. In regard to the question whether sufficient provision had been made for depreciation, that was (continues Mr. Roberts) in the first place an engineering, and, in the second, an accounts question, and could only be dealt with by audit in a strictly limited sense. As far as the Council's loan period was concerned all apparent charges for maintenance or renewal of plant, including costs of change of voltage had been charged to revenue or reserve account, and condemned items had been written off capital if not replaced out of revenue. The works had been running since 1892, and there was, therefore, some ground for supposing that they had reached the critical period in regard to special burdens arising on the renewal of machinery. But the chief engineer (Mr. S. W. Baynes) stated that, beyond the special item for the replacement of an engine condemned by injunction on account of vibration, which had already been to a considerable extent provided in the accounts on which he (the auditor) was reporting, he (Mr. Baynes) did not anticipate any unusual burden from that source. There could be no doubt that the delays in raising loans to meet the capital expenditure and the consequent postponement of loan-repayments had considerably relieved the revenues of some of the past years, but of late this had been reduced to small proportions. The charge for street lighting was at the rate of 1¼d. per unit for current including distribution, but excluding cost of maintaining and providing lamps, standards, &c. That was in his (the auditor's) opinion a fair rate of charge.

School Lighting.—The Gellygaer (Glam.) School Managers have asked Messrs. Guest, Keen & Co. for terms for supplying electricity for lighting the local schools.

Shoreditch (London).—Hoxton baths are to be re-wired at a cost of £102. 10s. Application is to be made to the L.C.C. for sanction to borrow £6,444 to cover cost of extensions of mains and laying service pipes already carried out. Two arc lamps, in place of three gas lamps, are to be used for lighting Whitmore canal bridge.

Southampton.—At the meeting of the Corporation last week an unsuccessful attempt was made to place the electricity supply and tramways departments under separate committees.

Ald. EMANUEL said he had been on the Electricity committee since it was first formed, and had had experience of the work, and there had always been friction between that committee and the Tramways committee, while there there was no unanimity. Since the two committees had been amalgamated everything had gone on as smoothly as possible, and had worked well, without any desire to benefit one or the other. If they were to make a change was the borough electrical engineer and tramways manager (Mr. H. F. Street) to have a reduction made in his salary of £200 per annum, and another manager to be appointed at £400? If so, they would increase the expenses by having two managements.

The proposal to form two committees was rejected by 21 votes to 17.

Southwark (London).—The equivalent of 34,578 8 c p. lamps is now connected to the mains for lighting and 13,679 8 c.p. for power, a total increase during the vacation of 477 8 c.p. lamps.

Steam Turbines for the "Lusitania."—Messrs. John Brown & Co., builders of the turbines for the "Lusitania," acquired a licence from Messrs. Willans & Robinson to enable them to use the special method of building up the blades in sections, which patent forms so important a feature of the Willans-Parsons turbine. Her sister ship, the "Mauretania," the turbines for which have been built by the Wallsend Slipway Co., also employs this method of blading, and in the case of this ship the blading was manufactured by Messrs. Willans & Robinson. It should be noted that with both these ships the turbine rotors and casings had already been made when it was decided to adopt Messrs. Willans & Robinson's method of blading; consequently the channel-section shrouding, into which the ends of the blades are riveted—another feature of the Willans-Parsons turbine—which necessitates a slightly increased diameter of the casing, could not be adopted in the blading of either of these ships. It is of interest to note that since the introduction on a commercial scale of this method of building up the blades in sections other turbine builders (including Continental manufacturers) have copied the principle by wiring together the necessary blades and dividing caulking pieces by stringing blades and caulking pieces alternately on a wire, sufficient in number to make up a given segment. The result (Messrs. Willans & Robinson point out) can, however, scarcely be claimed to be as mechanically perfect as the principle on which the "Lusitania" and the "Mauretania" blading has been built.

Swindon.—The Council have authorised the Electricity and Tramways committee to undertake the sale of electric lamps to their consumers at retail market prices, and the borough electrical engineer (Mr. R. G. Grubb) has been instructed to advise customers on electric lighting matters generally. A specification for the wiring of consumers' premises is being prepared by Mr. Grubb.

Tramway Strikers and Private Bill Legislation.—For some time past there has been a strike of the tramway employés of the Musselburgh & District Electric Light & Traction Co.

The company refused to grant the demands of the men, and proceeded to fill up the vacancies caused by the strike. At a meeting on Tuesday, Mr. J. A. Seddon, M.P., addressed the tramway men, and in regard to the strike said that, while it was true the numbers of the strikers had decreased, and perhaps the company were beginning to crow over a victory, it was merely the close of a skirmish. He said that the battle with the parent company would be fought on the floor of the House of Commons when next the parent company asked for Parliamentary powers for their enterprises.

Wednesbury.—An inquiry was held here last week into the Council's application for sanction to a loan of £10,000 for electricity supply.

The town clerk (Mr. THOS. JONES) explained that the Corporation considered the time had come when they should have their own electricity undertaking. They were at present taking energy in bulk from the Midland Electrical Corpn. for Power Distribution, but the mains belonged to the Corporation and they had now only to instal their own plant.

Mr. HAYWARD, on behalf of the Midland Co., opposed the application, urging that it would not pay the Corporation to generate their own electricity, and he pointed out that in the event of the Corporation generating their own current the present agreement between the company and the Corporation would be liable to be determined. The result of that would be that there would be three concerns which would have the power to supply electricity in Wednesbury—the Corporation, the Midland Co. and the Mond Gas Co.

Wigan.—The electrical engineer (Mr. J. Slevin) is preparing a report on the advisability of closing the Pemberton station and using it as a sub-station.

Willington.—The Council recently asked the County of Durham Electrical Power Distribution Co. for terms for the supply of electricity, partly by overhead and partly by underground mains. The company offer to give supply by overhead mains at 3¾d. per unit less 5 per cent.

Workhouse Lighting.—At the last meeting of Hammersmith (London) Guardians the consulting engineers (Messrs. J. & J. S. Enright) forwarded a copy of certificate granted by them to W. J. Fryer & Co. as to the completion of their electric lighting contract.

Messrs. Enright also sent a long letter giving particulars of further deductions from Messrs. Fryers's account. As to the "flex" fittings, about which so much was heard at the recent inquiry, Messrs. Enright state that the substitution of tubular fittings would cost £700 extra, or double the amount which the flex fittings cost. Had the tubular system been installed in the first place they urge that they would have been accused of extravagance.

Yardley.—The Council, who have decided to put into force the terms of their provisional order, 1904, have agreed to purchase the local generating station of the British Electric Traction Co. for £12,500 and to give a supply of electricity for lighting and power.

By the terms of the agreement the Council undertake to remove, at their own cost, the entire plant from the company's premises within 12 months from the date upon which the L.G. Board and the Board of Trade give their consent. The company agree to take from the Council the whole of the electricity required for the tramways now owned or which shall be owned by them within the district of Yardley during the unexpired term of the agreement of Dec. 17, 1902, at 1d. per unit (direct current) net at the Council's station at Hay Mills on the company's side of the switchboard at 500 volts, this price to be subject to revision on the company giving the Council three months's notice before the expiration of seven years, and thereafter at the end of every five years. The Council undertake to feed into the company's existing cables, and to bear any additional cost in altering or increasing the length of the cables. The company agree not to bring in or establish (directly or indirectly) any other electric supply in Yardley for any purpose whatever during the period of the agreement, unless from any cause whatever the Council is unable to supply electricity to the company. It is assumed that the company will require 600,000 units per annum.

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Electro-Harmonic Society.—Particulars are issued of the 1907-8 season of this Society, which opens with a smoking concert in the King's Hall, Holborn Restaurant, London, on the evening of Friday, Oct. 4. In consequence of the inadequacy of the accommodation in the King's Hall, it has been decided to hold the last two concerts (a ladies' night and a smoking concert, the former on Feb. 21 and the latter on March 27) in the new St James's Hall, Great Portland-street, London, W. Should the experiment prove successful, and an increased membership justify the heavy extra expenditure involved, it is probable that the future concerts of the Society may be held in this new hall. The membership of the Society now numbers nearly 600.

Marriages.—At St. Martin's Church, Roath, Cardiff, on the 12th inst., the wedding was solemnised of Mr. S. B. Haslam (of Messrs. Haslam & Shontheil, engineers, Cardiff) and Miss Eleinor Madeleine Riches, youngest daughter of Mr. T. H. Riches, J.P., locomotive superintendent of the Taff Vale Railway, and president of the Institution of Mechanical Engineers.

Mr. A. E. Uttley, government electrical engineer of Rhodesia, who has for the last few months been on a visit to this country, was married on the 11th inst. to Miss Gertrude M. Lunn, of Lea, Lincs. Mr. and Mrs. Uttley sailed for South Africa on Saturday last.

ELECTRICITY SUPPLY ACCOUNTS.

Bath.—The report and accounts of the electricity department for the year ended March 31 last were presented to the Council on Tuesday.

Receipts for current for light and power sold to private consumers were £12,801, against £12,411 in 1905-6, and from public lighting £4,390, the total income being £18,564, against £18,148. 1,136,553 units were sold, against 1,050,588. Expenditure was £10,473, against £9,915; coal cost £257 more, distribution £236 more (nearly all in respect of maintenance and renewals of mains) and renewals and maintenance at the works £86 more. Gross profit was £8,090, against £8,233. Interest and sinking fund amounted to £9,530 (nearly £1,000 more than last year) and the deficit is £1,440. On capital account £162,195 has been sanctioned, and £158,697 has been raised.

In moving the adoption of the report and accounts the chairman of the Electric Lighting committee said the committee had always realised that about this period in the history of the undertaking they would be in a position of severe financial stress, because the increased profits would not meet the increased capital charges. They had, however, to face unforeseen difficulties. He did not think the profits of the undertaking would ever relieve the rates in Bath, but he saw no reason why it should ever be a charge on the rates. They proposed to utilise a certain sum in reserve to reduce the deficit on the year, and to carry the remainder of the loss forward to the current year, the accounts for which he thought would about square themselves. He denied that the accounts had been kept back for fear of disclosing the deficit to the syndicate who had sought to acquire the undertaking. When they realised what the loss on the year would be Mr. Schenk was at once apprised of it. He had no doubt as to the final completion of the sale of the undertaking, which would have to be completed by March 31. If the sale did not go through, there was a deposit of £2,500 which would be forfeited and become the property of the Corporation.

The report was adopted.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The directors of the *Metropolitan Railway Co.* invite tenders for supply of general stores during 12 months ending Oct. 31, 1908. Manufacturers and others desirous of tendering should apply to the secretary (Mr. R. H. Selbie), 32, Westbourne-terrace, London, W., for forms. The company's requirements include electric wires, cables, lamps, carbons, fuses, ebonite battery jars, zincs, &c. Patterns and samples will be on view from Sept. 30 to Oct. 5 inclusive. Tenders to the Secretary by 10 a.m. Oct. 7. See also an advertisement.

West Ham Corporation invite tenders for supply and delivery of indiarubber-covered wires and cables for the six months ending March 31. Forms of tender, &c., from the engineer and manager (Mr. A. Hugh Seabrook), 84, Romford-road, Stratford, E. Tenders to the town clerk (Mr. Fred. E. Hilleary), Town Hall, West Ham, E., by 4 p.m. Oct. 3. See also an advertisement.

Tenders are invited for the supply of 466 d.c. and 200 a.c. meters for the city of *Melbourne* (Victoria) electricity department. Specifications from the agents for the City Council, McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon Oct. 4. See also an advertisement.

London County Council invite tenders for the manufacture, delivery and erection of three electrically-driven boiler feed pumps, each of 9,000 gallons per hour capacity, at the tramways electricity station, East Greenwich. Tenders to the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 11 a.m. Oct. 8.

Maidstone Corporation want tenders by Oct. 7 for supply and erection of seven electric motors and centrifugal pumps, motor-driven air ejectors, cranes, switchboard, starting switches, &c., and a complete electric-light installation, for the sewage disposal works. Plans from Mr. G. R. Strachan, 9, Victoria-street, London, S.W.

Dublin Lighting committee invite tenders for supply of 500 alternating-current single-phase meters and 100 three-phase meters. Tenders to the Chairman of the Committee, 3, Cork-hill, Dublin, by noon Sept. 30.

Dundee Electricity committee want tenders by first post Sept. 30 for supply of two turbo-alternators, condensing plant, water-tube boilers, mechanical stokers, economisers and coal-handling plant. Specifications from City Electrical Engineer.

The *East Indian Railway Co.* require tenders by noon Oct. 2 for supply of 600 kw. d.c. generator. Particulars from the Secretary, Nicholas-lane, London, E.C.

Portrush District Council want tenders by 8 p.m., Nov. 2, for an electric (or gas) lighting installation. Specification from Mr. John Woodside, Ocean-buildings, Belfast.

Glasgow Corporation want tenders by 10 a.m., Sept. 24, for supply of 2,000 tons of tramrails and 25 tons of fishplates. Specification, &c., from Mr. Jas. Dalrymple, 46, Bath-street, Glasgow.

Southampton Corporation require the loan of a steam dynamo (about 200 kw.) for about four months. Particulars to be sent to the Borough Electrical Engineer.

Croydon Council want tenders by 11 a.m. Sept. 30 for supply and erection of an overhead runway at the electricity works. Forms of tender from the Electrical Engineer, Factory-lane, Croydon.

Tenders are invited for additions to the existing common battery equipment at G.P.O., *Sydney* (N.S.W.), comprising five additional subscribers' sections, one junction line section, extensions to main frame, intermediate frame, relay racks and power plant (tenders by 2:30 p.m. Oct. 9), and supply of 1,000 wall and 100 table common battery telephones (tenders by 2:30 p.m. Dec. 11). Tender forms and specifications from the Electrical Engineer, G.P.O., Sydney, the G.P.O., Melbourne, Brisbane, Adelaide, Perth and Hobart, or the Australian Commonwealth Offices in London, 72, Victoria-street, S.W.

The Deputy Postmaster-General, *Sydney*, N.S.W., also wants tenders (by 2:30 p.m. Oct. 30) for supply of copper wire, &c. Specifications, &c., from the Commonwealth Offices, 72, Victoria-street, London, S.W.

The Deputy Postmaster-General, *Melbourne*, Victoria, wants tenders by 3 p.m. Nov. 12 for supply of 6,000 dry cells. Specifications may be obtained at the Commonwealth Offices in London, 72, Victoria-street, S.W.

Tenders are wanted by Oct. 1 by the *Swedish State Telegraph Department* for supply of insulators, wires, &c. Further particulars from the Board of Trade, 73, Basinghall-street, London, E.C.

Antwerp Municipal Council want tenders by Nov. 11 for supply and erection of 30 ton electric crane for the new docks. Deposit of 7,000 fr. (£280) required. Specifications from the Hôtel de Ville, Antwerp.

TENDERS RECEIVED AND ACCEPTED.

The Metropolitan Asylums Board received 10 tenders (varying in amount from £175 to £400) for alterations to the fire alarms and telephones at the Gore Farm upper and lower hospitals, and the lowest, that of the Electrical Engineering & Maintenance Co., was accepted. The engineer-in-chief's estimate was £180.

Worksop Council have accepted the tender of W. T. Glover & Co. for cables and joint boxes at £1,391. 0s. 5d.

Portslade Council have accepted the tender of the G.P.O. for the installation of fire bells at £20. 12s. 6d. per annum for 10 years.

Windsor Council have accepted the tender of F. A. Greene for supply of battery plates at £20.

The Postmaster-General's Department, Sydney, N.S.W., have accepted the tenders of Rabone, Feez & Co., for g.i. wire; Zwicker, Todd & Co., for white porcelain insulators; Clyde Engineering Co. and J. T. Jay, for c.i. brackets; Siemens Bros. Dynamo Works, for soldering solution; British Insulated & Helsby Cables, for copper wire and copper binding tape; R. J. Connelly, for main battery outer cells, cups and balloons; R. B. Hungerford, for subscribers' indicators, Western electric switchboards, iron-clad ring-off indicators, spring jacks, metallic plugs and order wire and ringing and listening keys; Paton & Russell, for head, double-pole receivers and stop watches.

Cable Contracts.—The following tenders have recently been obtained by Messrs. Johnson & Phillips:—

Grimsby Electricity committee, for supply of cables for next two years.

Derby Electricity department, for supply of Paterson's vulcanised bitumen cable.

Directors of Loch Leven Water & Electric Power Co., for supply and erection of overhead transmission lines, including telephones, lighting and traction (with aluminium cables).

Keighley Corporation for supply of Paterson's vulcanised bitumen cable.

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BUSINESS NOTICES.

On and after 30th inst. the London office of the Western Electric Co. will be at Norfolk House, Victoria Embankment, W.C. The company's P.O. telephone number will remain Central 2889, but the National number will be Gerrard 5349.

Mawdsley's (Ltd.), Dursley, Glos., have appointed Mr. D. C. Bate, 40, Brazennose-street, Manchester (telegrams, Zonal Manchester; telephone, 5602), their agent for Lancashire and district; and Messrs. D. M. Malloch & Co., 50, Wellington-street, Glasgow (telegrams, Cryselco Glasgow; telephone 2175), their agents for the West of Scotland.

Messrs. Imeson Bros., Finch & Co., Stockton-on-Tees, have taken over the sole agency for Great Britain of the American Sun Electric lamp.

Harry Lewarne and Ernest John Swift, trading as the Victoria Garage & Electrical Co., St. John-street and Parkside, Coventry, have dissolved partnership. Debts by Mr. Swift.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of Andrew Matson, electrical engineer, 10, Hardwick-terrace, Stockton-on-Tees, the first meeting of creditors will take place on Sept. 24 at 8, Albert road, Middlesbrough, and the public examination on Oct. 23 at the Court House, Stockton-on-Tees.

A supplementary dividend of 2s will be payable on Sept. 25 at the O.R.'s, Wolverhampton, in the bankruptcy of G. Aaron Benton, electrical engineer, Shareshill, Staffs., formerly of 8, The Exchange, Muswell Hill, Middlesex.

Electro-Chemical Works for Sale.—The extensive buildings, plant and machinery belonging to the Scottish Cyanide Co. (Ltd.), with offices, foremen's houses, and large water power at Leven, Fifeshire, are for sale. The grounds are about 13½ acres, of which 2 acres are covered by buildings, and the water power (about 280 H P. from the river Leven) can be increased. The machinery has been very little used, and comprises 10 Lancashire boilers, four Willans triple expansion engines (each of 800 H.P.), eight Mather & Platt low-tension alternators, condensing plant, Green's economisers, four "Achilles" water turbines, 15 electric furnaces with mechanical discharge complete, three Dowson gas producers, gas plant, &c., eight filter presses, six vacuum filters and two vacuum evaporators, Linde refrigerating plant, distillation plant, dynamos, electric motors, hoists, blowers, &c. The works have ample railway sidings, and are conveniently situated and compactly arranged. Can be seen at any time by appointment on orders from Messrs. Davidson & Syme, W.S., 28, Charlotte-square, Edinburgh, or Mr. Robert B. Lawrie, manager and secretary of the company, Kirkland Works, Leven, Fife, with either of whom tenders are to be lodged before noon, Sept. 30. See also an advertisement.

Sales by Auction.—Messrs. Walter Phelps & Son are instructed to sell by auction on the premises, St. John's House, Little Sutton-street, Clerkenwell, London, E.C., on Tuesday, Wednesday and Thursday, Oct. 1, 2 and 3, at 10:30 a.m., the whole of the very extensive letterpress and litho printing plant and machinery, together with 29 electric motors (530 volts), each with starting switch and resistances, all in good running order and driving the whole of the machinery in the extensive works of Messrs. Gilbert & Rivington; also the works telephonic installation of 13 instruments. Catalogues from the auctioneers, Warwick Chambers, Birmingham, and at place of sale. See also an advertisement.

Messrs. Jno. W. Morley & Co. are instructed by the executors of the late T. W. Heath to sell by auction, at the Motor Garage, 20, Avonmore-road, West Kensington, London, W., on Sept. 24 and two following days, at 11 a.m., the surplus stock and miscellaneous plant and (finished and unfinished) high-class furniture, electrical accessories and lamps, electric light fittings, bells, &c. On view on Monday. Catalogues on the premises and at the auctioneers' offices, 176, Earl's Court-road, S.W. See also an advertisement.

Sale of Old P.O. Stores.—Tenders are invited for the purchase of about 25 tons of gutta-percha, about 100 tons of copper, about 110 tons of lead and a quantity of other metals, i.r. covered copper wire, tools, glow lamp tops, &c. Forms of tender from the Controller of Stores, G.P.O., 17-19, Bedford-street, Strand, London, W.C. Tenders until 10 a.m., Oct. 9. See also an advertisement.

Plant, &c., for Sale.—Messrs. Fielding & Platt, engineers, Gloucester, have for sale a second-hand 90 B.H.P. Fielding suction gas engine, electric lighting type. See advertisement.

Messrs. Matthews & Yates (Ltd.), Swinton, Manchester, have a few electric fans with open type motors for sale.

Premises to Let.—Mr. Adams, Gattens, Hockley, Essex, has conveniently situated offices to let, suitable for engineers, metal dealers, &c.

A compact, well-fitted factory, close to the city and equipped with two gas engines, lathes and tools, is advertised to be let on lease.

Agencies Wanted.—A Canadian firm, experienced in the engineering and allied trades and about to open an office in Montreal, would be willing to act as agents for British manufacturers of electrical and mechanical apparatus. Further information from the Canadian Government City Trade Branch, 73, Basinghall-street, London, E.C.

Army Contracts.—Manufacturers who desire to be invited to tender for Army requirements should address the Secretary, War Office, London, S.W., by letter, stating the particular articles which they manufacture and the names of at least two well-known firms or public bodies who have purchased from them and are in a position to certify as to the quality of their productions. Tenders for specified quantities of goods are invited from time to time as required, and the articles purchased include chemicals, clocks, electrical stores, fuses, lamps and lanterns, indiarubber goods, oils, paint, scientific instruments, tools, traction plant, wires, &c. Firms whose names are on the War Office list need not apply. An advertisement gives some further particulars.

More "Lundberg" Specialities.—We have already referred to a number of the more recent introductions of Messrs. A. P. Lundberg & Sons in the way of switches, blocks and connections, and we may take the opportunity of the forthcoming issue of a new Lundberg list to complete our notice of these patented articles.

In the accompanying illustrations, Fig. 1 shows a two-way type "Tripin Combination." By the aid of this device ordinary single-way

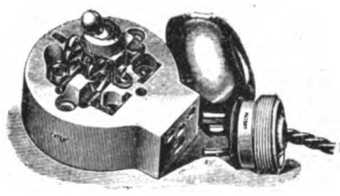

FIG. 1.

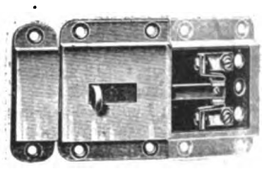

FIG. 3.

FIG. 2.

FIG. 4.

switches, as at present fitted near the door of a room, may be replaced without alteration of the wiring, and a flexible with a two-way pear switch attached taken to any desired position, thus allowing control of lamps from either fixed or extension switch as desired. A single-way type of this switch is also made. Fig 2 shows a type of switch for fitting under the bases of portable lamp standards. It is made in both single and two-way types, and can be so fitted that only the handle need be in view at the edge of the lamp standard base. Fig. 3 illustrates Wynn's door bolt, a flat type of switch which conveys its own

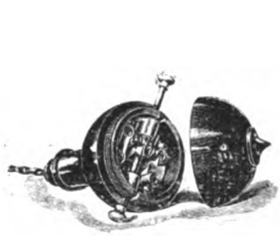

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

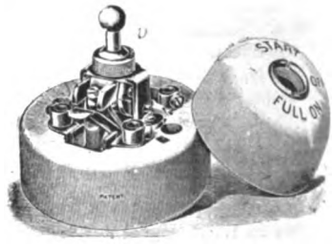

FIG. 9.

explanation. The next two, Figs. 4 and 5, show respectively the single and the two-way types of "See-Saw" pear switches, and Fig. 6 one of the various types of "Tripin" wall connection which has numerous adaptations. A novel type of removable key switch is shown in Fig. 7. As this switch cannot be easily "picked," by its use interference by unauthorised people is prevented. It is applicable to the 5 ampere size of "Pivot" single and two-way switches and also the "Pivot" combination. Fig. 8 is a new type of arc lamp isolating switch of the tumbler type, and Fig. 9

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represents a new type of tumbler motor-starting switch made in 5 and 10 ampere sizes. It is intended for induction-type motors, in which a starting coil is employed, this being cut out of circuit by throwing the knob over into the "full-on" position after the motor is fully started. To prevent damage to the motor the knob is so arranged that it cannot remain in the starting position, but flies out automatically when the pressure of the hand is removed. Fig. 10 is a neat form of flush connection with spring flap made in 2½ and 5 ampere capacities. Fig. 11 shows a "Reverse" door contact for strong-rooms, &c., in which contact is made when the button is protruding. All current-carrying parts are enclosed in vitreous porcelain to prevent absorption of moisture from damp walls. Fig. 12

FIG. 10.

FIG. 11.

FIG. 12.

shows a "Tripin" combination switch and charging plug for the convenient and safe charging of small ignition cells for motor vehicles. This switch simply replaces an ordinary single-way switch on direct-current circuits without extra wiring, and allows control of the lamp circuit independently of, or in series with, the battery that is being charged. The battery may be left in connection without the possibility of damage resulting

Gas Engineers and Flame Arc Lamps.—Gas engineers appear to have very original views in regard to flame arcs, for at a recent meeting Mr. J. H. Canning (of Newport) stated that flame arcs threw off poisonous fumes, became corroded by the volatilised salts condensing on the mechanism, burned costly carbons, and emitted a light of unpleasant hue. The Ediswan Co states that their Ediswan-Carbone white flame type throws off no poisonous fumes, does not corrode, burns pure carbons of an inexpensive type, and gives a light the spectrum of which is exactly similar to daylight. Mr. Canning may fairly be invited to visit the Ediswan showrooms and become acquainted with this lamp.

CATALOGUES, &c.

Motor Starters.—Particulars of improvements in design and reduction in price of Ward-Leonard motor starters are furnished in an illustrated pamphlet issued by Geipel & Lange. Some illustrations are given in our Industrial Supplement this issue.

"*Liverpool*" *Cables.*—A substantial publication reaches us from the Liverpool Cable Co., dealing with the complete range of its products in "First Quality" and non-association cables. The book is prefaced by some 10 pages of useful tables of stranded and solid conductors and extracts from the I.E E. wiring rules. Cables and wires for motor car work are catalogued in a special section. The pages are thumb indexed, and we understand that the list will be forwarded to engineers interested on request.

Dynamos and Motors.—The Wilson-Wolf Engineering Co. (Ltd.), Bradford, are issuing a useful list of dynamos and motors for direct currents. It contains complete specifications of the machines dealt with and numerous illustrations of standard types. Motors are built from quite small sizes—$\frac{1}{12}$ H.P. up to 20 H.P., and dynamos from 0·25 kw. to 12 kw.

Instruments.—"Castle" ammeters and voltmeters and portable testing sets are described, illustrated and priced in a pamphlet just issued by J. H Holmes & Co. These instruments are of the moving-coil type.

Fittings, &c.—The latest pamphlets issued by the Electrical Co. (Ltd.) are No. 248, on inexpensive cord pendants, 249, dealing with hand lamps, 250 with motor car inspection lamps, and No. 251 with Louis XV. fittings.

Telephones.—Messrs. J. McMillan & Co., Clun House, Surrey-street, London, W.C., send us a handsome publication dealing with the telephone products of the Elektrisk Bureau (Ltd.), Christiania. The catalogue is divided into 12 sections, each of which is devoted to special telephone apparatus and materials.

Fire Tests.—The Safety Non-Explosive Reservoir Co. (Ltd.), Alderman's Walk, London, E.C., is distributing copies of Red Book No. 122 of the British Fire Prevention committee, dealing with fire tests with petrol tanks. Tramway managers running motor omnibuses should secure a copy, and if possible arrange to attend the demonstration at St. John's Wood on the 25th inst. Invitations will be issued on request.

Nicholson's Bulletin.—This is the title of a publication issued only to the trade by R. J. Nicholson & Co., Macdonald's lane, Manchester, for the express purpose (to quote from the first issue) "of explaining the "Ideal" products more fully than we can in catalogues, and to offer suggestions in matters connected with self-contained electrical plants for country lighting."

Air Compressors.—A well-compiled catalogue of Reavell air compressors is now being sent out by Reavell & Co. (Ltd.), Ipswich. Those of our readers who are visiting the Olympia Exhibition will find several interesting exhibits of these compressors at the company's stand in the main hall.

"*Installation News.*"—We may well describe the September issue of this publication as the special "Northcote" number. It mainly applauds the Wholesale Electric Traders' scheme of that versatile gentleman.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Sept. 11 to Sept. 17, with the ports of destination:—

Africa—Alexandria, £31; Cape Town, £69; Delagoa Bay, £27; Durban, £1,044 (including £108 telegraph material); [Kilindini, £11; Mombasa, £27; Port Elizabeth, £96. *Argentina*—Buenos Ayres, £6,645 (including £3,895 telegraph material). *Australasia*—Adelaide, £73; Auckland, £443; Fremantle, £1,488; Launceston, £50; Lyttelton, £151; Melbourne, £327; Perth, £544; Sydney, £954 (including £28 telegraph material); Wellington, £166 (including £132 telegraph material). *Burma*—Rangoon, £23. *Canada*—St. John's, £77; Toronto, £694. *Canary Islands*, £10. *Ceylon*—Colombo, £142. *Cuba*, £518 (telegraph material). *France*—Boulogne, £183. *Germany*—Bremen, £713; Hamburg, £157. *Gibraltar*, £26. *Holland*—Amsterdam, £184; Rotterdam, £161. *Hong Kong*, £978. *India*—Bombay, £1,904; Calcutta, £1,000; Madras, £48. *Italy*—Genoa, £213 (including £20 telegraph material). *Japan*—Kobe, £960; Nagasaki, £10; Tokyo, £175; Yokohama, £3,159. *Madeira*, £13. *Malta*, £52 (including £27 telegraph material). *Mexico*—Salina Cruz, £2,601. *Russia*—St. Petersburg, £236. *Spain*—Vigo, £33 (telegraph material). *Straits Settlements*—Penang, £27; Singapore, £43. *U.S.A.*—Boston, £180; New York, £540 (telegraph cable). Total, £27,206, against £43,180 in the corresponding week last year (Sept. 12 to 18).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

July 8, 1907.

15,619 CORK. Double action sanding apparatus.
15,620 PILLING & KLYNE. Apparatus for the automatic regulation of dynamo-electric machinery.
15,634 EBERT. Systems for controlling electrical devices.*
15,636 DALEY & DALEY. Automatic station indicators for electric railways.
15,642 ROSS. Collecting current for electric trams or railways.
15,646 JOHNSTON. Insulation of submarine cables.
15,648 BRUNCKEN. Regulating starter for single and polyphase induction motors.*
15,692 BAKER. Manufacture of metallic sodium by electrolysis.
15,693 BAKER & HAWORTH. Manufacture of metallic sodium by electrolysis.
15,715 SCHUER. Arc lamps.

July 9, 1907.

11,853/A06 JOHNSON. (Felten & Guilleaume-Lahmeyerwerke A.-G.) Compensating load variations in electrical installations. (Date applied for, 21/5/06.)*†
15,751 TANNER & CLAREMONT. Improved high-tension cable.*
15,755 ANKER. Earguard with holding attachment for telephone receivers.*
15,769 BEECHER. Electrical railway systems.*
15,789 EDGAR. Receiving instruments for telegraphy.
15,798 KUZEL. Incandescent lamp with U or V-shaped supported metal filaments. (Date applied for, 31/5/07.)*†
15,799 POPE. Manufacture of incandescent lamps.
15,810 PFANSTIEHL. Sectional induction coils.*
15,813 WARWICK MACHINERY CO. (G.E.Co., U.S.) Bucket wheels for turbines.

July 10, 1907.

15,820 SOMERVILLE. Permanent magnet generator.
15,824 SCHWARTZ & METCALFE. Incandescent lamps.
15,830 FENNELL & PERRY. Mould for casting accumulator grids.
15,834 LA COUR. Induction motors and starting, connecting up and controlling the speed of combinations of same operated from a single-phase supply.*
15,841 TANDY. Locating and telephonic device for submerged submarines.
15,846 FENNELL & PERRY. Electrical distribution.
15,847 MOUNTAIN & GIBSON & G. LAURIE-WALKER. Axle-box suspension devices.
15,857 GIRDLESTONE & THORKELIN. Arc lamps.*
15,878 SIEMENS BROS. & Co. & GRIMSTON. Electrically controlled selective switch.
15,904 EBERDING. Rail joints. (Date applied for, 11/7/06.)*†
15,907 WARWICK MACHINERY CO. (G.E. Co., U.S.) Bucket wheels for turbines.

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July 11, 1907.

15,922 POLLIT. Winch.
15,929 FENN. Rail joints.*
15,931 HANSEN. Stands for table telephones.
15,946 SHAW. Rail joints.*
15,966 VANDERVELL. Electric lamps for carriages, and the like.

July 12, 1907.

16,027 CHALMERS & ROBERTSON. Arc lamps.*
16,034 THOMSON. Pocket electric lamp with secondary battery.
16,044 HARRISON. Cap and holder for lamps having more than one filament.
16,051 & 16,052 SIEMENS BROS. DYNAMO WORKS & PARKER. Dynamo-electric machines.
16,053 HATFIELD & LEWIS. Arc lamps.
16,073 WILLIS. (Waring, U.S.) Electrically operated cloth cutting machines.
16,087 MACKENZIE. (C. Lorenz, Germany.) Telephone alarm with attuned call.*
16,090 B.T.-H. Co. (G.E. Co., U.S.) Liquid gauges.
16,091 B.T.-H. Co. and WEDMORE. Switches.
16,092 ALLGEMEINE ELECTRICITÄTS GES. Alternating-current machines of the commutator type. (Date applied for, 13/7/06.)*†
16,098 COWPER-COLES. Apparatus for electroplating.*

July 13, 1907.

16,114 SEDDON. Steam turbines.
16,137 ALLGEMEINE ELEKTRICITÄTS GES. Signal operating mechanism and signalling systems. (Date applied for, 14/7/06.)*†
16,145 BOWIE & PHELPS. Safety electric apparatus for lighting miners' lamps.
16,166 HIGHFIELD. Supplying of current to electric motors.
16,175 MORGAN CRUCIBLE CO. & MCCOURT. Attaching flexible conductors to commutator brushes.

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

7,920 JOHNSON. (Felton & Guilleaume Lahmeyerwerke Akt.-Ges.) Dynamo-electric machines.
8,039 RAMBALDINI. Continuous electrolysis. (Date applied for, 3/4/05.)
10,218 ROBERTS. Party line telephone systems. (Date applied for, 1/5/05.)
14,809 DAVY. Arc lamps.
14,922 ROBERTS. Electrolytic diaphragms.
15,178 PIEPER. Electrical connections of motor road vehicles having electro-mechanical propulsion.
15,180 PIEPER. Electro-mechanic vehicles having electric storage.
15,200 SEGNITZ & PARKES. Covers of cells.
15,200A SEGNITZ & PARKES. Supporting plates of secondary batteries. (Date applied for, 5/6/06.)
15,310A OLIVER. Arc lamps. (Date applied for, 5/7/06.)
15,499 BINKO & PHŒNIX ELECTRIC HEATING CO. Electric vulcanising apparatus.
15,615 SHARMAN & DE FOREST WIRELESS TELEGRAPH SYND. Amplification of signals produced by variation of the local currents in wireless telegraph receivers.
15,711 HUNT & SANDYCROFT FOUNDRY CO. Windings for alternating current dynamo-electric machines.
15,839 WICHLER & RENNERT. Electric driving gear for machine tools.
15,988 TILNEY. Regulation of electric currents subject to large fluctuations of load.
16,066 COAN. Rests for telephone receivers.
16,263 WEIGHT. Automatic switching apparatus for use in installations for electrically lighting railway trains.
16,308 CROCKER. Turbines.
16,319 CHAUMONT. Adjusting devices for brakes, tramway, and like cars.
16,342 STOTHERT & PITT and HEATH. Magnetic control appliances.
16,590 MARTIN. Railway train electric lighting apparatus.
16,747 HELLYAR & JOHNSON SECRET WIRELESS TELEGRAPH & TELEPHONE TESTING SYND. Receiving apparatus for wireless telegraph systems.
17,355 FARRELL. Dynamo-electric machines.
17,459 FELTEN & GUILLEAUME-LAHMEYERWERKE, A.-G. Electrical machines having flywheels. (Date applied for, 21/11/05.)
17,617 COWPER COLES. Rapid production of electrotypes.
17,742 CURTIS & ADAMS. Solenoid-controlled switches.
17,946 GEORGE ANDERSON & Co (1905) & ROSS. Rotary bar electric-ignition.
18,070 JUDKINS. (Hutchinson.) Automobile and like electric horns.
18,156 JOHNSON. (Felten & Guilleaume Lahmeyerwerke A.-G.) Regulation of electrical machines.
18,186 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control.
18,220 BROUGHALL. Utilisation of wind power for generating electricity.
18,279 B.T.-H. Co. (Kintner.) Electric railway systems.
18,343 MAVOR and MAVOR & COULSON. Cores of dynamo-electric machines, transformers, &c., having ventilating spaces therein.
18,516 SMITH. Starting switches for electric motors.
18,621 TORDA. Dynamo-electric machines with compensating windings.
18,733 LEDERER. Filaments of metallic tungsten or molybdenum for incandescent lamps.
18,877 B.T.-H. Co. (G.E. Co., U.S.) Electric-motor control.
18,889 WEMAN. Switches for telephones.
18,905 RICHMOND & Co., BURNETT & LYON. Switch for automatic electric lifts.
19,005 ECKSTEIN, HEAP & MELLIS. Oil-break electric switches.
19,248 CHILTON, NEWTON & BRUSH ELECTRICAL ENGINEERING Co. Liquid seal glands for turbines.
19,395 HALLETT. Operating railway or tramway points or switches.
19,411 COWPER-COLES. Electrodeposition of alloys.
19,627 MATHER & PLATT. (Rosenberg.) Self-regulating dynamo-electric machines.
19,690 HIBST & GUNNER. Effecting junctions between main and main and branch cables in conduit junction boxes without soldered joints.

CITY NOTES.

MEMORANDA (Sept. 19).—Bank rate 4½ per cent. (since Aug. 15,'1907) Price of silver 31 5/16—31 7/16d. per oz. Consols 82—82⅛ for money, 82 1/16—82 1/8 for account; 2½ per cent. annuities 80⅞—80⅝. Consols Pay Day, Oct. 3; Stocks and Shares Continuation Days, Sept. 25 and Oct. 9; Ticket Days, Sept. 26 and Oct. 10; Pay Days, Sept. 27 and Oct. 11; Mining Share Carry-over Day, Sept. 24.

AMERICAN TELEPHONE & TELEGRAPH CO.—The directors have declared a quarterly dividend of 2 per cent.

BRITISH ALUMINIUM CO. (LTD.)—Dividends at the rate of 7 per cent. are announced on the preference and ordinary shares.

BRITISH INSULATED & HELSBY CABLES (LTD.)—Warrants for the interim dividend to June 30 on the ordinary shares have been posted.

DICK, KERR & CO. (LTD.)—The directors' report for the year ended June 30 states that the profits earned during that period amounted to £80,475 17s. 7d. Out of this sum has been paid debenture interest and trustees' fees, and the sum required to provide for premium payable on redemption of present debenture stock has been reserved. These items absorb £13,112. 9s. 6d., leaving £67,363. 8s. 1d., added to £56.076. 15s. 11d. brought forward, making £123,440. 4s. The dividend on the 6 per cent. preference shares requires £18,300, and a dividend of 10 per cent. is declared on the ordinary shares (tax free), absorbing £26,000, leaving £79,140. 4s. to be carried forward. The directors consider the result of the twelve months' trading very satisfactory, in view of the severe competition which has prevailed, the greatly increased cost of all raw materials and the advance in the cost of labour. The directors do not consider it necessary to make any further additions to reserve at the present time, and have therefore increased the amount carried forward by the balance of this year's profits (£23,063. 8s. 1d.), making the total profits carried forward to next year £79,140. 4s.

DIRECT SPANISH TELEGRAPH CO. (LTD.)—The directors have decided to pay, in addition to the dividend at the rate of 10 per cent. per annum on the preference shares, an interim dividend at the rate of 4 per cent. per annum (tax free) on the ordinary shares, both for the half-year ended June 30, and payable on Oct. 1.

DIRECT WEST INDIA CABLE CO. (LTD.)—The directors' report for the year ended June 30 states that the net profit was was £2,098. An interim dividend of 3 per cent. has already been paid, and the directors now recommend a further similar payment, leaving £298 to be carried forward. The disastrous earthquake at Kingston, Jamaica, on Jan. 14 last caused the interruption of the Turks Island-Jamaica section of the company's cable until Feb. 23 and the Bermuda-Turks Island section was also interrupted from March 14 to April 7, probably due to similar earth disturbances. The balance at credit of revenue account, which was last year increased to £36,124, has been debited with the £7,276 expended in repairs during the year and credited with £298 surplus revenue of the past year. The report and accounts were adopted at the meeting yesterday.

EASTERN TELEGRAPH CO. (LTD.)—This company announces the payment on Oct. 15 of a dividend at the rate of 3½ per cent. per annum (less tax) on the preference stock for the quarter ending Sept. 30. and the second quarterly interim dividend of 1½ per cent. on the ordinary stock (tax free) in respect of profits for the year ending Dec. 31, 1907. The transfer books of the ordinary stock will be closed from Oct. 7 to 14, inclusive.

GLOBE TELEGRAPH & TRUST CO. (LTD.)—The directors announce a quarterly interim dividend of 3s. per share on the preference shares and 2s. per share on the ordinary shares.

HALIFAX & BERMUDAS CABLE CO. (LTD.)—At the meeting yesterday the directors reported that the net profit on the past year's working was £3,182. The directors recommend a further dividend of 2½ per cent., making 5 per cent. for the year, leaving £682 to be carried forward. For the first time after 16 years' uninterrupted working, the company's cable developed a fault which last October had to be cut out at the cost of £2,094. The business of the year was further adversely affected by the earthquake at Jamaica, which severed the Direct West India Co.'s cable, and which was unable to supply through messages from Jan. 14 to Feb. 23, and later by the interruption of the Bermuda-Turks Island section from March 14 to April 7. The balance to credit of revenue, which was last year increased to £18,010, has been debited with the £2,094 expended in repairs during the year and credited with £682 surplus revenue of the past year. The report and accounts were adopted.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Sept. 27 a special settling day in scrip (fully and partly paid) for £200,000 4½ per cent. perpetual consolidated mortgage debenture stock of the *Shawinigan Water & Power Co.*, and have ordered £200,000 partly-paid scrip of the same company, and a further issue of £67,000 first mortgage 4 per cent. £100 prior lien gold bonds of the *Montreal Water & Power Co.* to be quoted. The committee have been asked to allow $158,661,800 $100 capital stock of the *American Telephone & Telegraph Co.* to be quoted.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a
		£	£		£	£
Aberdeen Corporation	Sept. 11	1,585	- 144	15	23,423	- 446
Airdrie	,, 6	238	- 18	35	7,831	- 52
Anglo-Argentine	,, 6	16,997	+ 1,587	37	609,335	+ 60,428
Ashton-under-Lyne Corp ...	...	...	...	...	...	...
Ayr Corporation	,, 14	324	- 4	18	7,063	- 167
Baker St. & Waterloo Ry....	,, 14	2,155	+ 645	11	21,930	+ 10,240
Barnsley.....	,, 6	171	+ 5	35	5,930	+ 56
Barrow	,, 6	309	- 30	35	9,211	- 189
Bath Electric Trams, Ltd...	,, 11	1,024	- 46	37	29,777	- 1,265
Birkenhead Corporation ...	,, 15	1,117	+ 71	...	...	...
Birmingham Corporation...	,, 14	6,272	...	24	145,308	...
Birmingham & Mid.	Aug. 30	871	...	34	27,823	...
Blackburn Corporation	Sept. 11	1,430	+ 241	¶24	27,842	+ 1,412
Blackpool Corporation	,, 12	2,780	+ 681	23	36,905	- 2,014
Blackpool and Fleetwood ...	,, 14	1,576	+ 319	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation.....	,, 15	2,381	+ 284	34	56,162	+ 3,138
Bournemouth Corporation..	,, 11	2,352	+ 118	¶23	45,051	+ 676
Bradford Corporation.....	,, 14	4,865	+ 346	24	114,229	+ 680
Brighton Corporation	,, 15	1,167	+ 27	24	24,356	- 2,724
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage...	,, 13	5,542	- 38	10	50,084	- 1,321
Burnley Corporation	,, 14	1,554	+ 359	24	29,183	+ 738
Burton Corporation	,, 15	281	- 7	24	7,227	- 371
Bury Corporation	,, 8	1,240	+ 195	23	26,033	+ 2,435
Calcutta Tramways Co.....	,, 14	₹48,142	+ ₹1,864	10	₹472,763	+ ₹33,417
Camborne-Redruth	...	...	...	...	...	...
Cardiff Corporation	...	...	...	...	...	...
Cavehill.....	,, 6	90	- 55	35	3,056	- 108
Central London Railway ...	,, 14	4,563	- 1,308	11	52,840	- 7,036
Charing C., Euston & H'stead	,, 14	2,455	...	11	27,520	...
Chatham & Dist. Lt. Rys....	,, 12	826	- 104	‡37	26,785	+ 1,724
City & South London Rly...	,, 15	3,144	+ 147	11	33,525	+ 6,434
City of Birmingham	,, 6	2,811	...	35	98,414	...
Colchester Corporation	,, 11	256	- 8	...	...	...
Cork Electric Trams Co. ...	,, 12	536	- 31	37	17,285	- 771
Croydon Corporation	,, 13	1,562	- 27	24	35,304	- 2,046
Devonport & Dist. Trams...	,, 6	516	- 37	35	16,333	- 192
Dover Corporation	,, 14	282	- 16	24	6,089	- 910
Dublin & Lucan Railway...	,, 13	160	+ 17	11	1,735	+ 126
Dublin United.....	,, 13	7,381	+ 2,014	‡11	82,142	+ 18,465
Dudley Stourbridge	,, 6	936	- 100	35	30,466	- 978
Dundee Corporation	,, 11	1,217	+ 53	17	19,781	+ 411
East Ham Council	,, 14	962	+ 34	24	22,494	- 442
Exeter Corporation.....	,, 6	363	+ 2	24	7,503	+ 642
	,, 13	375	+ 44			
Falkirk and District	,, 11	537	...	...	...	...
Gateshead & Dist. Trams...	,, 6	1,041	- 8	35	35,528	+ 841
Glasgow Corporation.....	,, 14	18,745	+ 1,017	16	264,184	+ 4,099
Glossop	,, 14	148	- 5	37	5,051	+ 19
Gravesend—Northfleet.....	,, 6	285	- 21	25	8,723	- 92
Great Northern & City Rly..	,, 14	1,582	- 103	11	17,377	- 23
Gt. Northern, Piccadilly, &c.	,, 14	3,805	...	11	42,456	...
Greenock & Port Glasgow...	,, 6	703	- 159	35	23,560	- 601
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 6	345	- 54	35	10,364	- 669
Hastings Elec. Trams Co....	,, 13	1,680	+ 401	11	14,791	- 227
Hong Kong	,, 14	$7,108	+ $27	23	$285,377	+ $37,174
Huddersfield	,, 14	1,665	+ 160	24	38,963	+ 1,934
Hull Corporation.....	,, 14	2,418	+ 139	24	57,751	+ 2,954
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council ...	,, 11	150	+ 3	24	3,521	+ 165
Ipswich Corporation	,, 7	474	- 90	24	10,630	- 899
	,, 14	498	- 5			
Isle of Thanet Co.	,, 14	1,360	+ 68	50	29,919	- 727
Jarrow	,, 6	134	...	35	4,328	...
Keighley Corporation	...	...	...	...	...	...
Kidderminster & District...	,, 6	143	- 13	35	4,355	- 194
Kilmarnock Corporation ...	,, 14	158	- 5	17	2,899	- 66
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co. ...	,, 12	1,499	+ 564	37	43,329	+ 10,903
Lancashire United.....	,, 11	1,535	+ 498	37	46,735	+ 11,844
Leamington	,, 6	185	- 9	35	5,709	- 772
Leeds Corporation	,, 14	7,011	+ 516	24	159,828	+ 6,212
Leicester Corporation	,, 14	2,264	+ 51	11	24,207	- 606
Leith Corporation	,, 7	543	- 39	‡18	9,735	- 23
	,, 14	541	- 1			
Lincoln Corporation	,, 14	120	+ 10	24	2,976	+ 71
Liverpool Overhead Rly. ...	,, 15	1,510	+ 107	11	18,442	- 1,183
Liverpool Corporation	,, 7	11,267	- 81	36	393,041	+ 6,843
*London County Council ...	,, 7	31,512	+ 4,938	23	721,000	+ 113,409
London United	,, 13	8,090	+ 818	‡37	212,994	+ 8,245
Lowestoft	,, 14	353	+ 30	50	10,295	+ 960
Maidstone Corporation.....	,, 14	128	- 14	24	2,747	- 244
Manchester Corporation ...	,, 14	15,887	+ 1,637	24	359,614	+ 26,534
Mersey Railway	,, 14	1,748	+ 89	11	19,965	+ 1,507
Merthyr.....	,, 6	221	+ 8	35	7,411	+ 373
Metropolitan Dist. Railway	,, 15	6,981	- 396	11	79,467	+ 66
Metropolitan Elec. Trams...	,, 6	5,587	+ 1,270	35	162,920	+ 39,339
Middleton.....	,, 6	403	+ 9	35	12,651	- 207
Nelson Corporation	,, 14	183	+ 36	25	3,758	+ 67
Newcastle-on-Tyne Corp. ...	,, 14	4,053	+ 33	24	99,202	+ 399
Newport (Mon.)	,, 14	708	+ 18	24	17,419	+ 1,597
Northampton Corporation.	,, 13	478	+ 6	‡24	10,824	- 534
Oldham, Ashton & Hyde ...	,, 6	678	+ 64	35	21,453	+ 942
Oldham Corporation	,, 15	2,073	+ 247	25	49,198	+ 3,071
Perth (N.B.) Corporation ...	,, 11	180	- 2	17	2,989	+ 6
Perth (W.A.) Elec. Trams...	,, 13	1,271	- 73	37	52,119	- 1,817
Peterborough	,, 6	141	- 26	35	4,515	- 266
Pontypridd District Coun..	...	...	...	...	...	...
Portsmouth Corporation ...	...	...	...	...	...	...
Potteries	,, 6	1,941	+ 108	35	65,997	+ 1,913
Rotherham Corporation ...	,, 12	671	+ 150	‡24	14,446	+ 2,242
Rothesay	,, 6	351	+ 43	35	8,696	- 647
Salford Corporation	,, 16	4,814	+ 408	24	114,323	+ 2,829
Sheerness	,, 4	78	- 6	35	2,117	- 71
Sheffield Corporation.....	,, 15	5,630	+ 387	25	139,418	+ 5,964
Singapore Trams	,, 14	$9,306	+ $126	24	$226,888	+ $11,491
Southampton	,, 11	1,176	+ 72	...	...	...

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southend Corporation	Sept. 11	613	+ 17	24	11,271	- 378
South Metropolitan	,, 6	956	+ 368	35	28,898	+ 5,584
Southport Tramways.....	,, 6	389	- 16	35	10,956	- 705
South Staffs.....	,, 6	879	+ 6	35	31,699	+ 2,043
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Sunderland Corporation	,, 8	1,508	- 63	24	35,300	- 462
	,, 15	1,470	+ 85			
Sunderland and District ...	,, 11	491	+ 21	37	16,794	+ 1,907
Swansea Trams	,, 6	1,104	+ 139	35	32,424	+ 2,052
Swindon Corporation	,, 11	189	- 2	...	...	...
Taunton	,, 6	53	- 2	35	1,564	- 107
Tynemouth and District ...	,, 6	331	- 94	35	9,085	- 837
Tyneside Trams Co.....	,, 11	500	+ 35	37	17,226	+ 672
Victoria, Elec. Supply Co. of	Aug. 11	727	+ 56	...	...	...
Wallasey District Council...	Sept. 14	952	+ 99	24	21,463	+ 438
Walsall Corporation	,, 7	569	+ 45	37	18,938	- 190
	,, 14	578	+ 64			
Warrington Corporation....	,, 12	389	+ 22	24	9,138	+ 348
West Ham Corporation.....	,, 12	2,412	+ 73	24	57,162	+ 1,173
Weston-super-Mare	,, 4	368	- 30	35	5,558	- 598
Wolverhampton Co.	,, 6	492	+ 20	35	16,167	+ 948
Wolverhampton Corpn.....	,, 10	833	+ 2	8	7,121	+ 27
*Worcester	,, 6	363	- 29	35	10,091	- 298
Wrexham	,, 6	130	+ 6	35	3,645	- 54
Yorkshire W.R. Trams	,, 15	1,358	+ 416	37	42,903	...
Yorkshire Woollen District.	,, 6	840	- 201	35	33,665	+ 1,119

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., Sept. 18.	Rate % Yielded.	Dividend Due.	Business Week to Sept. 18. High-est.	Business Week to Sept. 18. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
£5	4/0	Anglo-Argentine Ord. Shares	8¼–8⅜	4 14 0	Ap, Oct	8 1/16	8 3/32
£5	..	Do. 5½ per Cent. Cum Pref.	5 11/16–6 3/16	4 8 3	Ja, Jul	6⅛	6 1/16
St.	6%	Do. Permanent 6% Deb. Stock...	131 –134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 –105	4 15 0	Ja, Jul	..	..
£5	2/0	Brisbane Electric Trams. Invest. Ord.	3½–3¾	2 17 0	May ..	3 1/32	3 1/16
£5	2/6	Do. 5 per Cent. Cum. Pref.	4⅜–5⅛	4 18 6	My, Nv	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 –100	4 10 0	Ja, Jul	96	..
St.	7%	British Columbia El. Ry. Df. Ord.	127 –132	4 3 6	Mr, Spt	129¾	129
St.	6%	Do. Pref. Ord. Stock	111 –115	4 7 0	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock..	104 –107	4 13 6	Ja, Jul	..	..
£10	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 –103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102 –104	4 6 6	Ja, Jul	102¾	..
£5	3/0	Buenos Ayres & Belgrano Ord.....	4 1/16–4 1/16	3 9 3	Ap, Oct	4⅛	4 1/16
£5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4⅜–5⅛	5 14 0	Ap, Oct	..	..
£5	3/0	Do. "B"	4⅜–5⅛	5 14 0	April ..	5	4 7/8
St.	5%	Do. 5 per Cent. Debs.	105 –115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 –103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 –97	5 3 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 –103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds..	100 –105	5 14 6	Ap, Oct	..	..
£5	4/6	Calcutta Tramways (1 to 137,610)...	7¼–7⅜	5 3 0	Mr, Spt	7⅜	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅛	4 11 0	Ja, Jul	..	..
£1	4½%	Do. 4½% 1st Deb. Stock (red.) ...	102 –103	4 5 0	Ja, Jul	..	..
St.	..	Cape Electric Tram Shares	5/16–7/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 –98	5 2 0	My, Nv	..	..
£1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 –87	5 15 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 –93	5 6 8	Ja, Jul	..	..
£5	6%	Do. 6 per Cent. "B" Ditto	78 –82	7 6 0	Ja, Jul	..	..
£5	1/0	Lisbon Elec. Trams. Ord.	1 –1¼	4 0 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 –1¼	4 16 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb.	95 –98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 –99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922).....	101 –103	4 7 6	Fb, Aug	..	..
St.	5%	Perth E. Trams. 1st Mt. Db. Stock	100 –104	4 18 0	Ja, Jul	..	..
..	$	Sao Paulo Tramway, Light & Power Co. $100 Stock	115 – 12	6 13 3	..	117⅜	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	92¾–94¼	5 6 3	Ju, Dec	93½	..
		ELECTRICITY SUPPLY.					
£5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4⅛–5	6 0 0	Mr, Spt	..	..
10/	4/8⅓	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅛–8	6 0 0	..	7⅞	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 –93	4 13 9	Ja, Jul	95⅛	91⅝
£1	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6⅞–7⅛	5 3 3	Ap, Oct	..	..
£5	2/3	Do. (80,001 to 100,000)	6¼–7¼	..	..	..	..
£5	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 –53	4 11 3	Ja, Jul	..	..
£5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2¼–2⅞	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock.....	85½–89½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94 – 96	5 4 0	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.....	102 –105	5 14 6	Ja, Jul	..	..
£1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	—	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.....	94 –97	5 3 0	Ap, Oct	..	..
£1	0/6	River Plate Electricity Co. Ord. ...	⅝–¾	3 6 9	April..	..	..
£1	1/2⅝	Do. 6 per Cent. non-Cum. Pref...	¾–1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 –98	5 2 0	Ja, Jul	..	..
£5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 –5⅛	5 9 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 –101¼	4 19 0	Ja, Jul	99⅛	..

*. In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE	LAST DIVIDEND	NAME.	Price Wed., Sept. 18.	RATE % YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 18. High-est.	Low-est.
		ELECTRICITY SUPPLY.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord...	9⅜ – 10⅜	6 10 0	Mar, Sept,	10⅛	–
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅜ – 10⅜	4 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	9⅞ – 10⅜	5 12 6	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	£9 – 10 2	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜ – 5½	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	£8 – 100	4 10 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7½ – 8⅛	6 1 6	March....	7⅝	..
5	3/6	Do. 7 per Cent. Pref.....	7¼ – 7⅝	4 5 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co. 4% Guar. Db. Stock	£9 – 10 2	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅛ – 4	5 11 3	Feb, Aug	3⅜	..
5	2/3	Do. 4½ per Cent. Pref.	3⅝ – 4	5 11 6	Feb, Aug	3⅝	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 – 99	4 1 0	Jan, July	97⅞	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	8⅜ – 8⅞	6 2 6	Jan, July	..	..
5	2/0	†Chelsea Electric Supply Ord.	3 – 4	5 9 8	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	102 – 105	4 5 9	June, Dec	104	102⅛
10	5/0	City of London Electric Lighting Ord...	9 – 9½	6 6 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11 – 12	5 0 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	122 – 125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 – 100	4 10 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	3⅞ – 4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜ – 4⅞	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	6⅜ – 7⅛	6 9 0	Feb, Aug	7⅛	7
10	6 0	Do. 6 per Cent. Cum. Pref.	10 – 11	5 8 6	Mar, Sept	10⅜	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 – 109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	96 – 99	4 11 0	May, Nov	94⅜	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜ – 4⅝	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5⅜	4 11 0	Mar, Sept	1⅜	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	£6 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅞ – 7⅛	6 4 0	April, Oct	7	..
5	5/0	Kensington & Knightsbridge Ord.....	8½ – 9½	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½ – 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	£9 – 102	3 18 0	April, Oct	..	..
3	2/4⅔	London Electric Supply Ord.	1⅝ – 1⅞	6 5 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4⅛ – 4⅜	6 6 0	Mar, Sept	4⅛	4⅛
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	88 – 92	4 7 0	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	4⅜ – 5⅜	6 1 6	April, Oct	5⅛	5
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜ – 5	4 10 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1⁰4 – 107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	£8 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 – £8⅞	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9 – 9½	4 17 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	98 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	£8 – 6⅞	6 3 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 – 5⅛	4 19 0	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 – 18	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 – 99	4 11 10	Jan, July	..	..
10	£/0	Notting Hill Electric Ord.....	11 – 12	7 10 0	March ..	..	..
5	2/6	†Oxford Electric Ord.	5½ – 6	5 17 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£5 – 97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.	7⅜ – 8	6 5 0	Feb, Aug	7⅞	..
5	3/6	Do. 7 per Cent. Pref.	6½ – 7½	4 17 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	£6 – 91	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	⅜ – 1⅜	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	£/0	South London Electric Supply Ord,.....	1⅞ – 2⅛	6 6 0	April	2⅛	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝ – ¾	3 6 9	..	..	..
1	0/6⅔	Do. 7 per Cent. Cum. Pref.....	1 – 1⅛	5 12 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 – 103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅜ – 2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 – 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	94 – 97	4 12 9	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8½ – 9	6 6 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 – 5⅛	4 2 0	Jan, July	5⅛	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	£8 – £3	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	3⅛ – 3⅜	5 7 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	3⅛ – 3⅛	5 5 0	Jan, July	..	..
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ...	£3 – £7	4 12 6	April, Oct	24½	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 – £7	4 18 0	Jan, July	94	..
10	9½%	Bristol Tramways & Carriage Ord.	14 – 14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	£4 – 9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	£8 – 100	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	£2 – £3	..	June, Dec	2⅛	..
10	£/0	Do. 6 per Cent. Cum. Pref.....	6¼ – 6⅝	8 8 0	Feb, Aug	£⅛	6⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 – 103	4 17 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	£8 – 81	5 11 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock.....	£6 – 68	4 8 0	Feb, Aug	70	66⅛
St.	4%	Do. 4 per Cent. Pref. Stock	89 – 91	4 8 0	Feb, Aug	..	..
St.	..	Do. Deferred Stock	£1 – 53	7 10 0	Feb	..	..
100	4%	Do. 4 per Cent. Debs.	103 – 105	3 16 0	Jan, July	104	..
St.	4%	Charing X. Euston & Hmpstd Per. Db. Stk.	£1 – £4	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4⅛ – 4⅜	5 2 6	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	£8 – 101	3 19 0	April, Oct	..	..
St.	2½%	City & South London Rly. Con. Ord. ..	45 – 47	4 17 0	Feb, Aug	46⅛	46⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	115 – 118	4 4 9	Feb, Aug	..	..
St.	5%	Do. (1896)	113 – 116	4 6 0	Feb, Aug	..	..
St.	5%	Do. (1901)	113 – 116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 – 105	3 16 0	May, Nov	104½	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13 – 14	4 5 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	12⅜ – 13⅜	4 7 0	Feb, Aug	..	..
10	0/11⅓	Gt. Northern & City Rly. Pref. Ord. (4%)	1¼ – 1⅜	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 – 85	4 14 0	Jan, July	..	..
£1.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ b. St	98 – 101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10½ – 11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 – £9	4 10 11	Jan, July	..	..
£	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	1 – 1½	..	Mar, Sept	..	..
£1.	4%	Do. 4 per Cent. Deb. Stock.....	£6 – 71	5 12 6	Jan, July	..	..
£1.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	94 – 97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1⅞ – 2	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	7⅛ – 8	6 5 0	Feb, Aug	..	..
£1.	4%	Do. 4 per Cent. Deb.	£5 – £7	4 12 0	Jan, July	..	..
10	5/0	London United Trams. 5% Cum. Pref. ...	7⅜ – 7⅝	5 14 8	Jan, July	7⅝	8⅛
£1.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	£2 – 86	4 18 0	Jan, July	..	..
£1.	..	Mersey Con. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
£1.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways. Def.	⅜ – ⅝	—	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝ – ¾	5 8 0	Feb, Aug	¾	..
£1.	4½%	Do. 4½ per Cent. Deb. Stock	£4 – 97	4 13 0	Jan, July	94	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾ – 1¼	..	May	..	..
1	0/3⅓	Potteries Electric Traction Ord.	⅛ – ⅜	7 8 0	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½ – ¾	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 – £8	4 11 9	May, Nov	..	..
1	0/4⅔	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅞ – 1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£0 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db.	£4 – £8	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London ...	£5 – £8	8 12 0	June, Dec	..	..
£5	..	Yorkshire (W.R.) Elec. Trams. Ord. ...	1 – 1½	—	March ..	..	..
£5	..	Do. 6 per Cent. Cum. Pref.	8½ – 9⅜	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – £0	5 0 0	Jan, July	..	..

SHARE	LAST DIVIDEND	NAME.	Price Wed., Sept. 18.	RATE % YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 18. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅝ – ¾	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅝ – ¾	8 12 0	April, Oct	..	..
1	2/4⅔	Babcock & Wilcox Ord.....	3⅝ – 4	5 0 0	April, Oct	..	..
1	0/7½	Do. Pref.....	1⅛ – 1⅜	3 14 0	..	..	..
5	4/0	†British Insulated & Helsby Cables Ord.	6⅝ – 7	7 3 0	July, Feb	6⅞	..
5	3/0	Do. 6 per Cent. Pref.	5⅝ – 6⅛	4 18 0	Jan, July	6⅛	5⅞
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 – 104	4 6 6	Jan, July	..	..
St.	4½%	British Thomson-Houst'n 4½% 1st Mt. Db.	85 – 89	5 1 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 – 1½	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	60 – 65	6 3 0	Jan, July	..	..
2	..	Brush Electrical Engineering	⅜ – ⅝	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅝ – 1⅛	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	83 – 86	5 4 6	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	69 – 72	6 2 6	Jan, July	68⅛	68
5	10/0	Callender's Cable Con. Ord.	9⅜ – 10⅜	6 19 0	Jan, July	10⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛ – 5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105½ – 107½	4 3 6	Nov, May	..	..
5	2/6	Castner-Kellner Alkali Co.	1⅛ – 1⅜	5 12 6	May, Nov	1⅜	1⅛
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 – 102	4 8 0	Feb, Aug	..	..
1	1/2½	Chadburn's (Ship) Telegraph Ord.	1⅜ – 1⅝	7 12 0	March ..	1⅝	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛ – 1⅛	5 1 0	April, Oct	..	..
3	£/0	* Crompton & Co. (Nos. 1 to 66,000) ...	1⅞ – 2⅛	7 3 6	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	£6 – £9	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝ – 1⅞	6 3 0	Sept	1⅝	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 – 1¼	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	102⅛	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1⅛ – 1⅜	9 12 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛ – 2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock	£9 – 92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½ – 1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1¼ – 2	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜ – ⅝	..	Jan, July	..	..
2	..	Do. 7 per Cent. Cum. Pref.	1⅜ – 1⅝	..	July	..	..
St.	⅔%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 8½	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 – 96	4 4 0	Mar, Sept	..	..
£	£/0	Henley's Telegraph Works Ord.....	11½ – 12½	6 2 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 – 5½	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½ – 107½	4 3 6	Mar, Sept	105⅛	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14 – 15	6 13 0	Feb, Aug	14⅞	..
10	4%	Do. 4 per Cent. Debs. (red.).....	97 – 99	4 1 0	April, Oct	..	..
1	1/2⅔	Richardsons, Westgarth & Co., Ltd. Ord.	⅜ – ⅝	7 14 0	Nov	⅝	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅜ – ⅝	6 4 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 – 96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	1⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	31 – 32	5 10 6	Mar, July	31⅛	..
100	4%	Do. 4 per Cent Deb. Bonds (1909) ...	£9½ – 102½	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord. ...	2⅛ – 2⅞	6 7 6	..	2⅞	2⅝
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜ – 1⅝	4 5 6	..	1⅝	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	£9 – 112	4 9 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	103½ – 104½	3 16 6	June, Dec	104⅛	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 – 103	4 3 3	June, Dec	..	..
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9½ – 9⅝	6 3 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1⅜ – 1⅝	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	⅜ – ½	..	Apr, Oct	½	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 – 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 – 3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	£5 – £8	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	60 – 62	6 3 0	F, My, Ag, N	..	..
St.	£0/0	Do. Preferred	104½ – 105⅜	5 13 6	F, My, Ag, N	105⅛	104⅝
St.	13⅔	Do. Deferred	17⅛ – 18⅛	7 15 0	F, My, Ag, N	18⅛	17⅝
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91½ – 93½	4 5 0	Jn, Ap, Jy, O	92⅝	92
10	5/0	Cuba Submarine Ord.....	£4 – 7½	6 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞ – 16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅛ – 3⅜	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 – 9⅜	5 6 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝ – 103⅜	4 7 3	Jan, July	..	..
20	0/6	Direct United States Cable	14½ – 14⅝	6 7 6	Ja, Ap, Jy, O	14⅝	14⅜
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 – 102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	122 – 125	5 4 0	Ja, Ap, Jy, O	124	123
St.	17/6	Do. 3½ per Cent. Pref. Stock	86 – 88	3 19 6	Ja, Ap, Jy, O	88	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103½ – 105½	3 15 9	May, Nov	104⅜	104⅛
10	2/6	Eastern Extension	15⅞ – 16⅛	5 5 9	Ja, Ap, Jy, O	16⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	102½ – 104½	3 16 6	Feb, Aug	104	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	97½ – 100¾	3 19 6	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	100 – 102½	3 18 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71...	84 – 86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 – 102	4 8 0	June, Dec	..	..
£1	£2/6	Indo-European.....	55 – 57	5 14 0	May, Nov	56⅛	55⅞
100	£1	†Mackay Companies Common	64 – 67	5 19 6	Jan, July	..	..
100	£1	† Do. Preference	£4 – £7	5 19 0	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	⅜ – 1	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	93 – 100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 – 10½	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅝ – 1⅞	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	93 – 100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅛ – ⅜	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛ – 7⅝	7 15 0	May, Nov	7⅝	..
10	..	Do. 5 per Cent. 2nd Pref.....	6⅞ – 7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 – 102	4 18 0	Jan, July	99⅛	..
10	3/0	Western Telegraph	12⅞ – 13⅜	5 5 6	Mr, Jn, O, D	13⅜	13⅛
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 – 103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 – 92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	19 – 102	4 18 0	Mar, Sept	..	..
5	£/0	Chili Telephone	6¾ – 7½	5 10 6	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	⅞ – 1⅛	4 14 0	Nov	1	..
1	0/6	Do. 5 per Cent. Pref.	¾ – 1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	10⅛ – 10⅞	5 11 6	Feb, Aug	10⅞	10⅝
St.	6%	Do. Def. Stock.....	10⅛ – 10⅞	5 11 6	Feb, Aug	10⅞	..
10	£/0	Do. 6 per Cent. Cum. 1st Pref.	11 – 13	4 12 0	Feb, Aug	13	..
10	£/0	Do. 6 per Cent. Cum. 2nd Pref.	10 – 12	5 0 0	Feb, Aug	11⅞	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5½ – 5⅞	4 13 0	Feb, Aug	5⅞	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	96 – 18	3 11 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 – 103	3 17 6	Jan, July	102	..
1	£/0	Oriental	1⅛ – 1⅜	5 6 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛ – 1⅜	4 10 0	April, Oct	1⅜	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 – 94	4 5 0	Jan, July	94	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	£8 – 101	4 9 0	Jan, July	..	..
5	£/0	United River Plate.....	6¾ – 7½	6 18 0	July	6⅞	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 – 5½	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	8/0	Elec. & Gen. Investment 6% Cum. Pref.	8¼ – 4½	6 13 3	Jan, July	3⅝	..
10	6/2	Globe Telegraph & Trust.....	10½ – 10⅝	5 2 0	Ja, Ap, Jy, O	10⅝	..
10	4/0	Do. 6 per Cent. Pref.....	12½ – 13⅜	4 7 0	Ja, Ap, Jy, O	13⅜	..
10	6%	Submarine Cables Trust (Cert.).....	127 – 130	4 12 0	April, Oct	129	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote them.

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THE ELECTRICIAN INDUSTRIAL SUPPLEMENT.

Electrician No. 1531. Indust. Suppt. No. 14.] SEPTEMBER 20, 1907. [Gratis to Subscribers.

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Influence of Electric Power on Labour Saving Machinery.

CONCRETE opportunities are afforded from time to time of witnessing the results of changes in methods and processes which arise from developments in the application of power to industry. Progress in the introduction of labour-saving machinery was also necessarily inseparable from the advances made with the means of driving it. In itself the labour-saving machine, primarily intended to economise in the production of some article or part of an article, is incapable of development apart from the power agent required to actuate it. In fact, power in one form or another was a primary necessity to labour-saving machines. This association of the driving and the driven elements in industry has had an inevitable and natural result. The machine has been designed and constructed with immediate reference to the power agent by which it would be operated. The speed limits of the power agent were those of the driven machine. Motions in the machine unsuited for those in the power agent were adjusted and adapted thereto. The actual result "biassed" the machine in favour of the engine, the latter proceeding by practically independent paths of development.

In this manner the development of reciprocating prime movers can be regarded as lying parallel to that of productive machinery until the coming of the electric motor. Electric power distribution is now changing all this. It is giving a new lease of life to productive machinery. In the domain of engineering tool construction the new methods of the electric motor have had the greatest play. Originally driving a few tools from lines of countershafting, or individual machines through belt and chain, the electric motor has come to form an integral part of the machine itself and now practically influences the main points of the design of the tool. Higher speeds, greater control over output improved quality of work—all these are the proved accompaniments of the electric drive with modern machine tools. The applicability of the power required at the machine itself, as is possible with the electric motor, affords the designer of machinery new opportunities. The matter does not end with the use of one motor to each machine. The power needed can be subdivided among several small motors. Motions not easily combined mechanically for operation by one motor are kept distinct, except at the point of electrical control of the separate motors driving them. No machinery built for operation by steam or gas engines could be designed in this way.

The collection of machinery at the ENGINEERING EXHIBITION now open at OLYMPIA, London, will be found in great measure to bear out the statements made above. They will also be better appreciated if a comparison is made between apparatus operated by electric motors and that driven by gas or steam engines. Machine tools particularly will afford unmistakable evidence of the influence of the electric motor on their design and operation. What has transpired in machine-tool circles will happen elsewhere. The ultimate issue of the present tendency to bring the motor to the driven machine, in contradistinction to the opposite practice formerly in vogue, cannot be definitely foreseen. Something approaching a correct surmise may, however, be formed at this stage of developments. The labour-saving machine will be more closely than ever identified with the electric motor, whose peculiar driving properties and control facilities will find their proper reflex in the manner of constructing and operating these machines.

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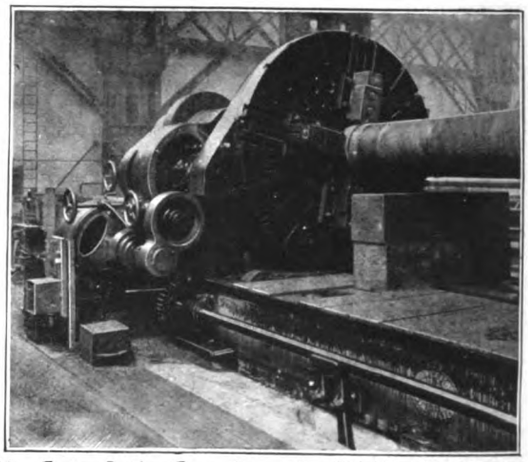
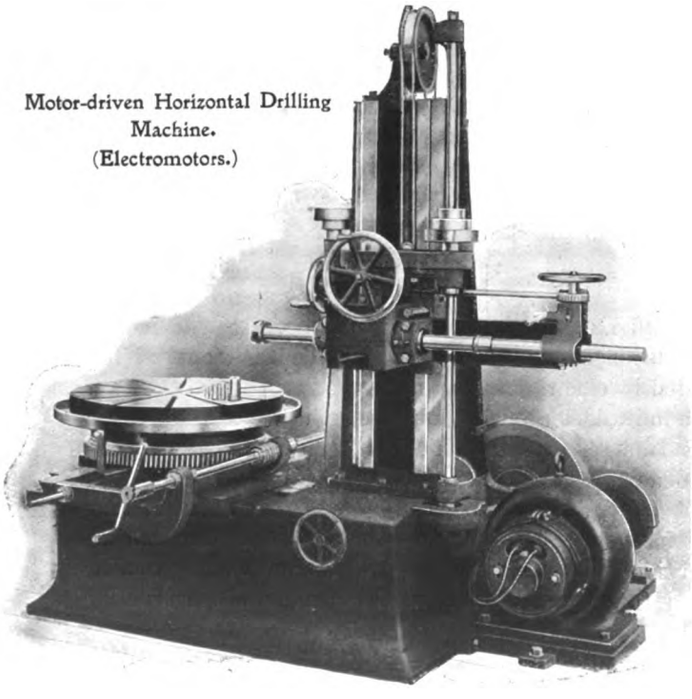
Machine Tools and Electric Driving.

ELECTRIC power has been responsible for many industrial changes, and many more will yet be attributed to it, but some of its best records have been achieved in the province of machine tool construction. The initial stages of the progress made in machine tool operation by electric motors are directly traceable to the workshops of the makers of dynamo-electric machinery. The organisation of factories for the construction of generators and motors naturally obtruded itself upon the attention of electrical manufacturers. Not only were they faced with the problems of designing efficient electrical plant and apparatus, but, also these same problems introduced others bearing upon constructional details and shop operations in their turn, which naturally involved the question of machine tools. Many of these tools had to be specially designed and built, and when made required power for their operation. Nothing was more natural than the employment of electrical energy for this purpose. As a power agent the electric motor presented the problem of power application in an entirely different aspect to that originally put forward by the steam engine. Transmission,



40 in. Centre Lathe Gear driven by 30 H.P. Variable Speed D.C. Motor.
(Vickers, Sons & Maxim.)



Motor-driven Horizontal Drilling Machine.
(Electromotors.)

subdivision and distribution of the available energy was on such novel lines that the full advantages of the newer method were not at first realised. The *Ultima Thule* of industrial electric power applications was a motor for each tool, but, however much pioneers appreciated this, time was required to bring it forcibly home to engineers. Under steam conditions driving of tools from shafting was imperative. The manufacturer had no alternative but to submit to a labyrinth of belts and long lines of shafting about his shops.

The advent of the electric motor could not, of course, be expected to bring about the immediate removal of these wasteful forms of mechanical transmission, and in its initial applications to machine tools group driving from large motors was resorted to, mainly as a compromise between what had been done with the old systems and could be done with the new. The employment of the individually-operated tool has taken time, and the experience leading up to it furnishes evidence in support of the desirability of evolutionary rather than of revolutionary change from former things.

At this time, when there is open in London an exhibition, at which many fine examples of machine tools are displayed to view, it will be interesting to

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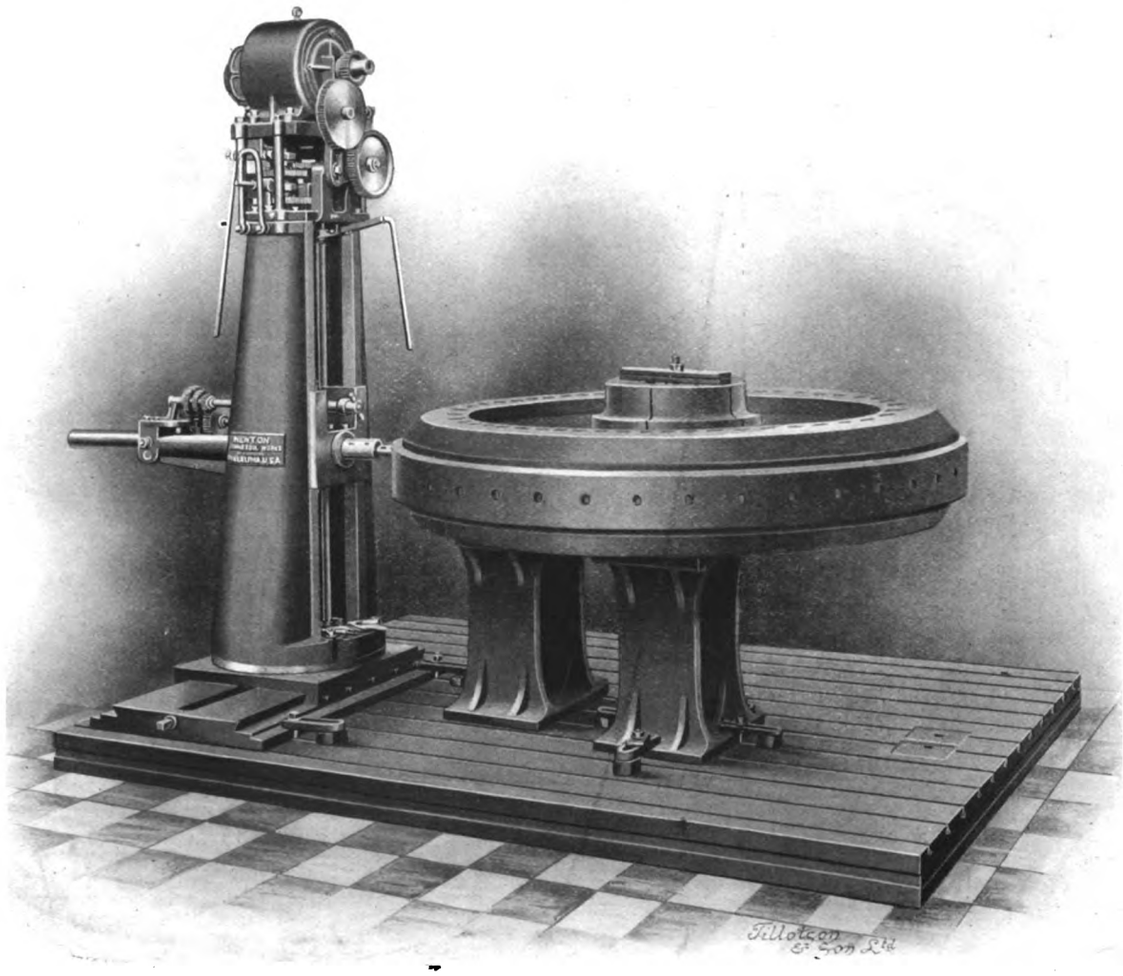

Special Electrically-driven Boring Machine operated by Small Motor.
This tool is quite portable and may be lifted by the hook clips shown at the top of the pedestal.
(Lancashire Dynamo & Motor Co.)

briefly survey the electric power situation in its relation to machine tool design, construction and operation. If this is "punctuated," as it were, with illustrations of typical examples of tools driven by individual electric motors the review will be all the more convincing. "Every picture tells a story," to borrow a well-worn advertisement catch-line.

The most casual observer of the tendencies towards the independent driving of machine tools will probably be immediately impressed with their influence upon the accessories and adjuncts of mechanical power transmission. The demand for shafting, pulley wheels, bearings and belts is giving place to a call for gear wheels, pinions and chains. These latter are a significant indication of the manner in which the power agent is getting nearer to its work.

Shafting and belts at once convey the idea of distance. Pinions and chains are synonymous terms for proximity, and suggest a compact, speedy power agent. There can be no disputing the truth of this tendency, and it should impress itself deeply upon those who are giving consideration to the question of electric driving.

Another thing will suggest itself to the student of this

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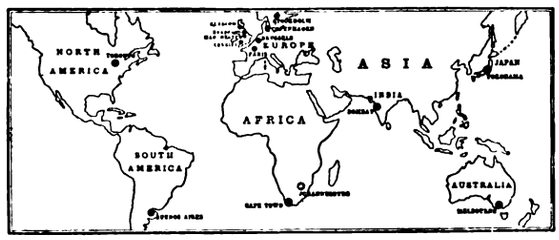

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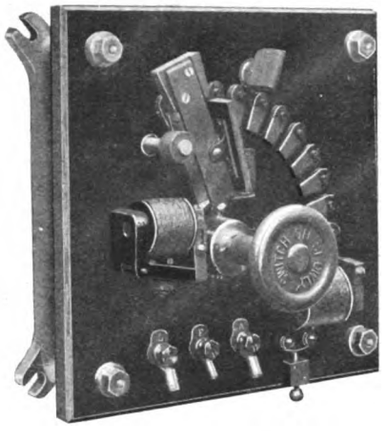

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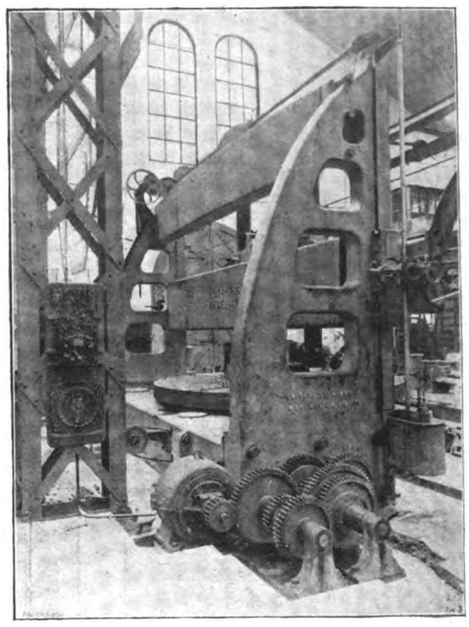
problem of electric power application to machine tools. The motor, in becoming part and parcel of the tool which it drives, will receive more attention in its relation to the work done by the machine. In a word, it will be designed and built for the type of tool with which it will subsequently be associated. Evidence can already be furnished in support of this. Under the older system of group-driving the motor was run at a constant speed, and the tools were adjusted, in so far as speed was concerned, by suitable gearing or speed cones. With the adoption of the individual drive it soon became desirable to effect speed regulation at the motor rather than with the gearing contained in the tool, to meet the original requirements of

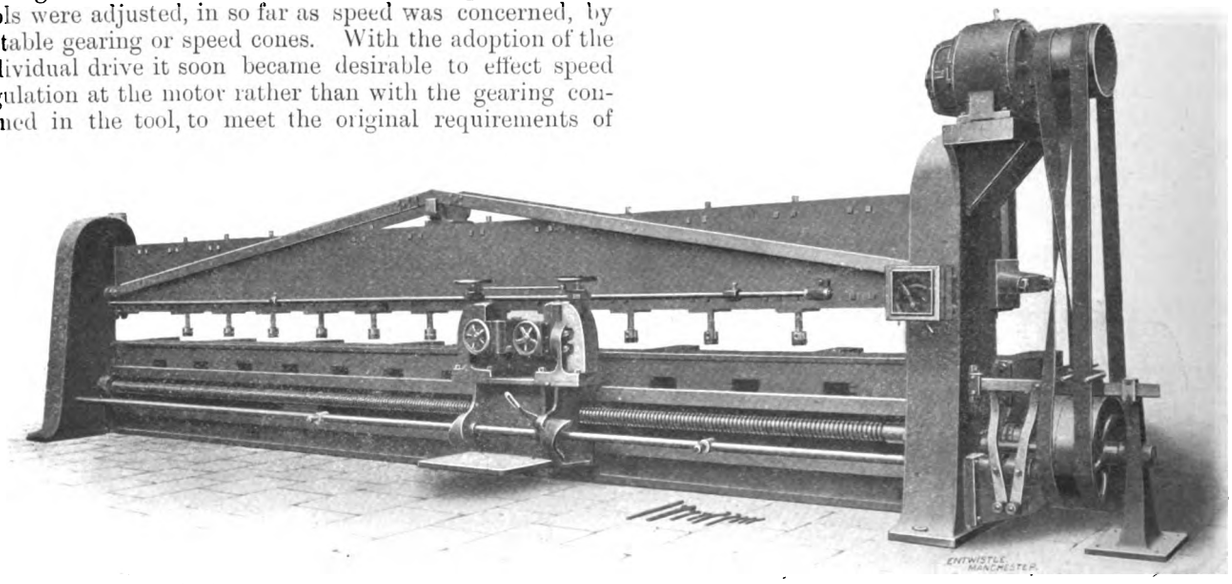


20 ft. Boring Mill driven by Independent Motor.
(Lancashire Dynamo & Motor Co.)

belt driving. From the slow-speed motor of the group-drive a change was therefore needed to the variable-speed machine of the independent drive. Now direct-current motors are chiefly applied to machine tools, and with them the speed variation problem was soon solved. By the use of interpoles between the ordinary poles of a shunt-wound motor a range of speed from 3 to 1 to 6 to 1 was possible by field resistance adjustment only.

In the interpole or auxiliary-pole direct-current motor we may see the influence of individual operation of machine tools on the motor. The construction does not differ greatly from the ordinary machine, except in the matter of the interpoles, but the motor is much lighter for its output, and it can dispense with a large quantity of gearing in the body of the tool to which it is coupled.

The tool maker is obviously interested in these developments. The electrical engineer, in his determination to drive machine tools with independent electric motors, has



Electrically-driven Rail-bending Rolls with Motor Mounted on extension of Main Frame of Machine.
(Lancashire Dynamo & Motor Co.)

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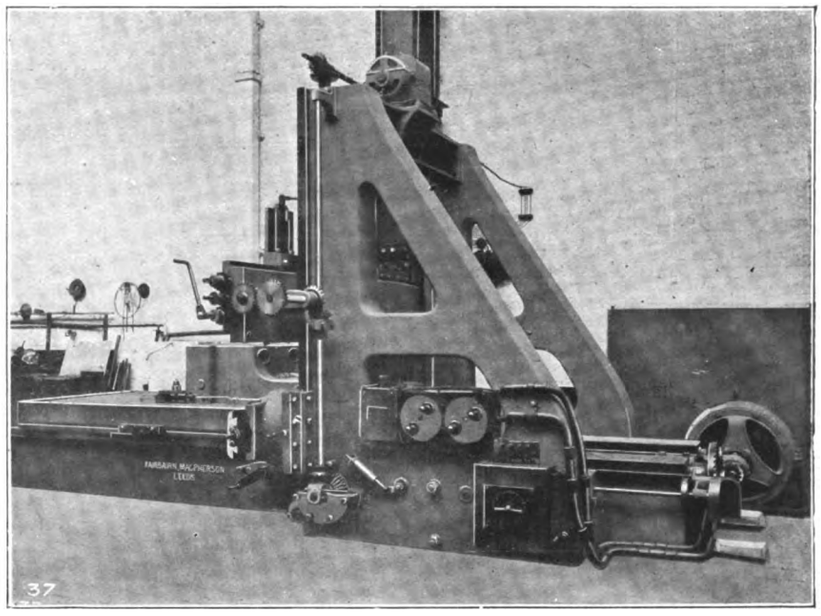
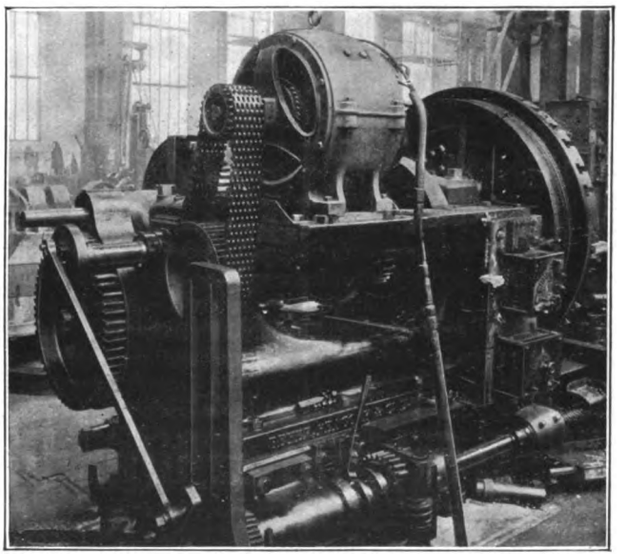
produced a type of power agent which designers and builders of machine tools cannot overlook. The development of the variable speed interpole direct-current motor has taken place in spite of, rather than by the aid of, tool makers. Not that the latter are opposed to the electric drive, or have been at any time. Their attitude has been one of detached interest. Circumstances seemed to make them involuntary spectators of a state of change in which they ultimately were compelled to participate.

It must be admitted that machine tool makers have taken kindly to the electric motor, particularly for the heavy types of tool and medium-weight portable tools. With these some of the most remarkable changes, all attributable to the electric motor, have been introduced. Planers may be selected as an admirable example to illustrate this. The two motions of the table—that is, the cutting stroke and the return stroke, are performed at different speeds. When running against the tool the table is driven slowly forward; on its return it is accelerated to save all time possible in making what is, in fact, an idle stroke. Planers driven from line shafting can only be actuated at these widely varying speeds by the introduction of complicated belt and jockey pulley "fakements," which are clumsy in the extreme and are costly to maintain and operate. The running of one of these machines must be jarring to the nerves of any true mechanic, and is trying to the patience of a good engineer. The whole thing is obviously a confession of the inflexibility and weakness of mechanical power transmission. The early "electric planers" pandered in a way to the depraved tastes of their predecessors, and one found constant-speed, non-reversing motors driving the old rig of belts and pulleys. Perhaps this was to be expected. The right motor and the right method were not hit upon at once. But they were not unduly long in coming. As will be seen by the illustrations accompanying this article an electrically-driven planer is on the market which is operated by motors coupled direct to the table and tool carriage motions. The former is the more important, because in it are embodied the improvements by which all the earlier driving complications have been removed. The motor is reversible and is accelerated during the idle stroke. The table itself, in moving backwards and forwards, actuates switches which reverse the motor at the end of each stroke, so that once the machine is started it continues running automatically.



Large Planer operated by Direct-geared Motors without Belts and Jockey Pulleys.
The electrical controlling and reversing gear is attached to one of the columns in the foreground.
(Vickers, Sons & Maxim.)



Screw-cutting and Sliding Lathe driven through Renold Chain by 20 H.P. Variable Speed Motor.
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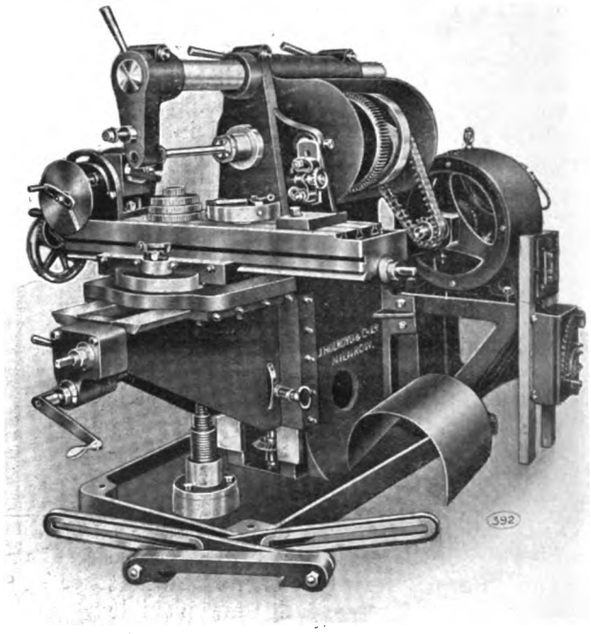
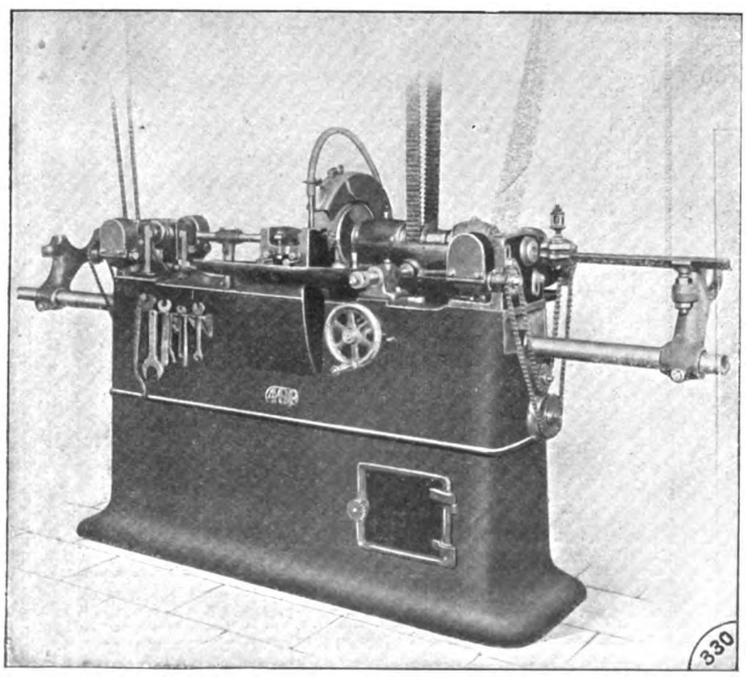
Lathes form another class of machine tool on which the electric motor is exercising its influence. At one time speed cones and stepped pulleys were the only available means of control over the lathe speed from countershafting running at a constant speed. Through several stages the electric motor has gradually been adapted to the individual operation of lathes. In the modern tool the motor is a part of the lathe bed, and controllable as to its speed by electrical means, thus dispensing with reducing pulleys and a certain amount of gearing. Some special lathes are fitted with motors directly built on the main spindle, the desired speed regulation being obtained by control of the shunt circuit. This application of motors to lathes is, however, the exception rather than the rule.



2½ H.P. Motor driving Universal Milling Machine through Renold Silent Chain.

The motor speed is variable between 200 and 1,200 revs. per min. Observe the compact arrangement of the starting gear.

Another interesting development in tool driving is to be met with in shipyards and steel works, where motor-operated tools are used in the open, irrespective of weather. Shears, punches, rolls, drills and other tools, can, with electric power, be dotted about amongst the raw material on which they are required to operate with a convenience and efficiency known only to electric driving. In each case the motor is either mounted on the machine or is placed close to it in a suitable housing from which it is connected by belt to the tool. This system removes at a stroke the need for transporting the raw material to the machine shop, and re-handling it there. The work required can be done, under electrical conditions, at the point of storage, and one process of rehandling is saved.



An Example of Chain Driving of a Special Grinding Machine by Renold Silent Chain.

With 7 ft. 0·325 in. diameter rods the output is 50 to 60 per hour. With 0·5 in. and 0·75 in. rods the same length the output is 25 to 45 per hour.

Side by side with the development of the machine tool motor has proceeded the improvement of starting and controlling devices. These have gradually tended to become iron-clad, and much in the same way as the motor was brought nearer to the tool, has the starter reached the stage in which it may be regarded as part of the motor itself. To avoid straggling cable connections and remove the liability of damage to conductors the motor starting switch and resistance were combined and, in suitable iron cases, secured to the machine on or near which the motor is placed.

In its up-to-date guise the electric motor and accessories as built for machine tool service are as near perfection as they well can be. In so

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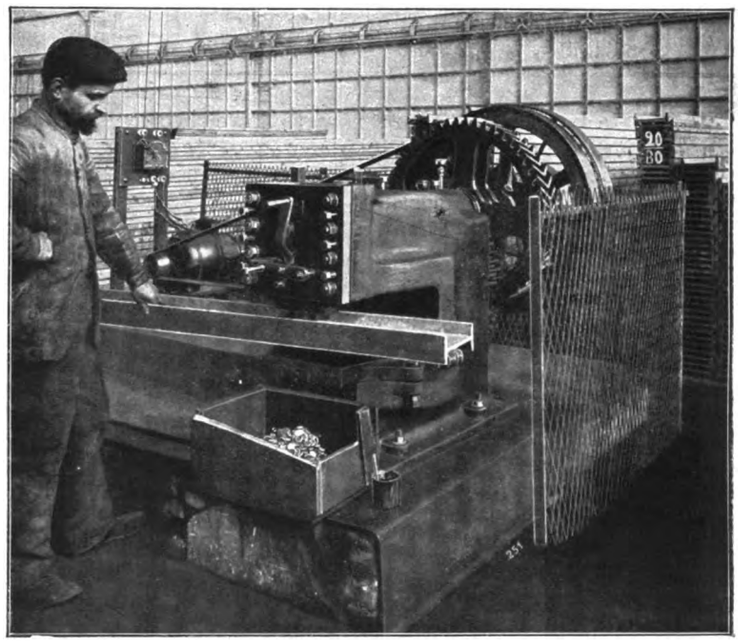
reliable and efficient a power agent the tool builder can realise his ideal in the design and construction of each type of tool which admits of individual electrical operation. The machine can be regarded as a distinct unit with its peculiar characteristics and functions, all of which may be given play without reference to any other tool.

In a word, then, the electric drive confers advantages on machine tool users which by no other known method could be experienced in engineering circles. We have not yet observed any limit to the use of individual motors (save it be that of excessive cost, an unlikely contingency) and there appears, at the moment, to be no end to the possibilities which present themselves in company with the extension of our experience of electric power applications in this interesting field.

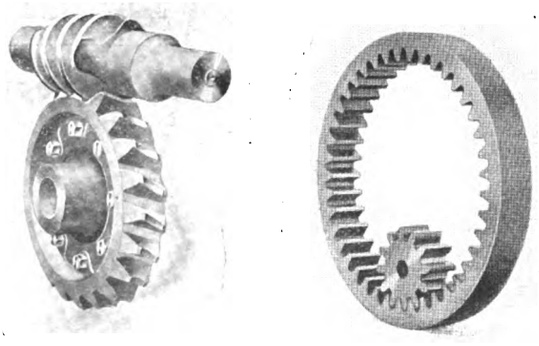
The introduction of high-speed steel contemporaneously with electric motor driving is a matter which is often regarded as a mere coincidence. Without wishing to claim undue credit for the part played by the electric motor in the working of high-speed steel, we think there is little doubt that its application to machine tools was a distinct assistance to metallurgists and acted as an additional inducement to them to proceed with their experiments. Such heavy cuts as are now made on lathes, in the turning of high-speed steel, require a great amount of power, and unless the energy needed is available, practically at the tool itself, success cannot be assured. Belts and countershafting are wasteful in the transmission of power and when employed for heavy tools lower the operating efficiency to such an extent that they become useless for deep cuts and high speeds. Without the electric motor machine tool, then, the engineer would not enjoy the advantages of high-speed steel. The building of our "Dreadnoughts" and "Lusitanias" would be matters of years instead of months without high-speed steel and electric tools, and it is for this acceleration of industrial operations that the electric motor claims precedence over other forms of power agents.

The future of the machine tool under the influence of electric power appears very promising. The supply of electrical energy in industrial areas has now become so general that the chief obstacle to electric driving in the early days is now entirely removed. The manufacturer need not, unless the circumstances are specially adaptable to his case, lay down generating plant for the production of the necessary energy for electrical operation of his works. All his requirements, both as to lighting and power, can be met with complete satisfaction by the electric service.



Electrically-driven Punching Machine, with Motor and Starting Gear placed near the machine, which is operated by belt. The Tool is at work amongst the stacks of Girders.

(Union Electric.)



Typical examples of Worm and Gear Drives, as introduced for the application of Electric Motors to Machine Tools.

(David Brown & Sons, Ltd.)

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Electric Drills and Pulley Blocks.

THE electric drill appears now to have become a recognised tool in the industrial world. Its development is practically parallel with that of electric power distribution in engineering workshops. The motors for drill work are so small and light that they can be supplied from an ordinary lampholder and where electric

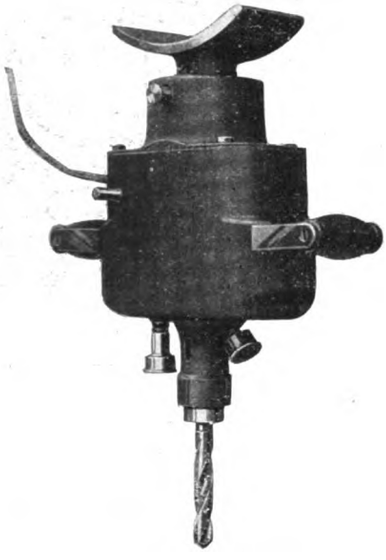

Fig. 1.—"Slick" Electric Drill.

lighting is installed the use of these power drills is much facilitated.

There are numerous types of electric drills on the market, a standard range being manufactured by Kramos Limited, Bath, who have specialised in the production of electric drills for some years past. It has been a prime

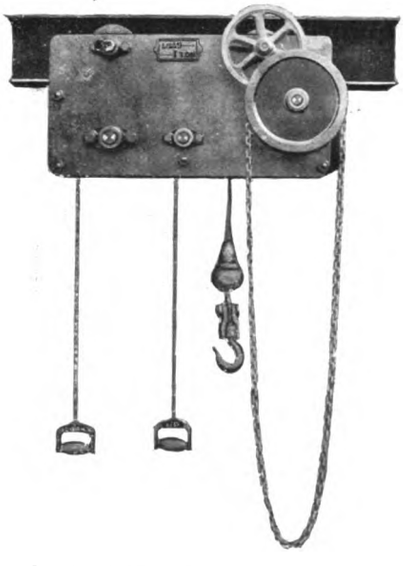

Fig. 3.—Overhead Mono-Rail Electric Pulley Block.

consideration with this firm to construct a type of electric drill which might rank in solidity of construction, mechanically and electrically, with ordinary machine tools. This standard, so we understand, is acted up to with all the tools manufactured.

An illustration of one of the leading types of drill, known as "The Slick," is given in Fig. 1, which only weighs 30 lb. This handy machine will drill up to $\frac{7}{8}$in. holes in steel, at 80 revs. per min. with a consumption of 480 watts on a 110 volt circuit. The motor is series wound to allow of a wide speed variation being obtained. Speed-reducing gear is dispensed with, the speed variation being effected electrically. By this means a more gradual increase or decrease of speed can be obtained than when gears giving one or two fixed speeds are used. To reduce the deadweight of these drills aluminium is used wherever possible, as in the motor cases. The motors also are enclosed to exclude dust from the bearings and windings.

In Fig. 2 we illustrate the largest type of drill made by Kramos Limited. This is designated, evidently not without good reason, the "Runthru." It is depicted in use with a magnetic drill pillar by means of which the adjustment of the drill previous to running is easily made without recourse to clamps and bolts being needed. This drill is

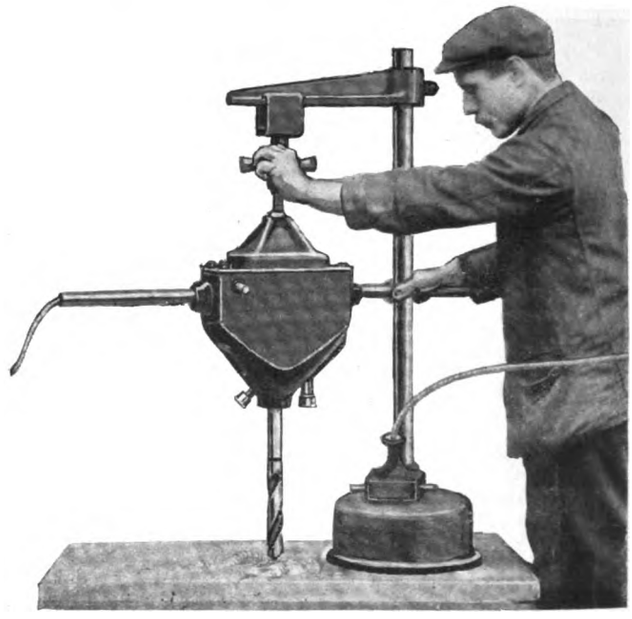

Fig. 2.—"Runthru" Electric Drill and Magnetic Drill Pillar.

made for holes up to $1\frac{1}{4}$ in. diameter at 90 revs. per min. Its full load consumption of electrical energy is 630 watts at 100 volts and the machine complete weighs 60 lb. The drill pillar is made in various sizes and, in addition to being suited to working in a vertical position, it can be supplied for horizontal use.

Another Kramos speciality is an electric pulley block for use on an overhead mono-rail. An example of the latest pattern is represented in Fig. 3, from which the general design will be at once clear. The power supply, and with it the operation of the device, is controlled from ground level through the medium of ropes and pull rods. The traveller hangs perfectly plumb at all loads. Upward of 50 types are made by the firm for hook suspension, hand travelling and electric power travelling. The machines are built up to a maximum of 5 tons lift. We understand that a cement transporter is at present being built by the firm for some East Coast contractors. Skips carrying 5 tons will be employed on this particular conveyor handling cement.

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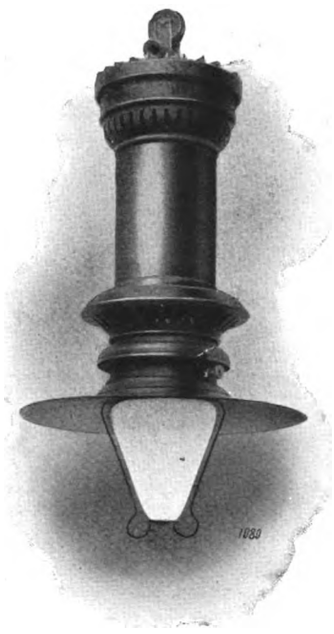

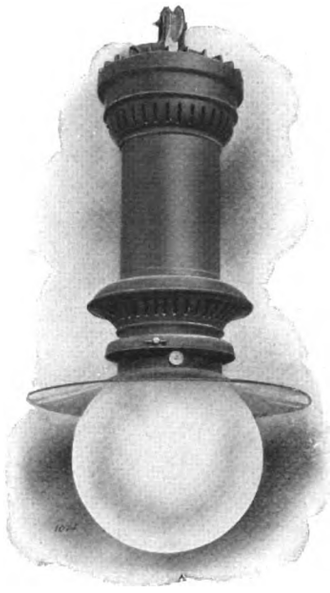

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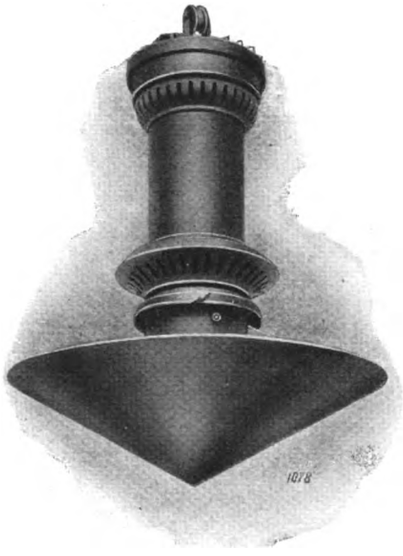

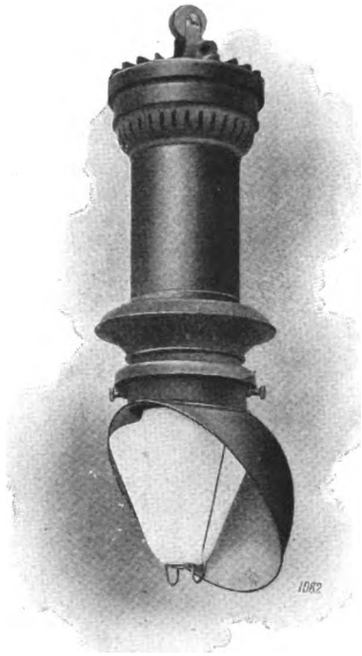

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Induction Motor Applications.

WE hear little now of the relative merits of alternating and direct-current motors for industrial power work. Each appears to have found its particular "niche," and is filling it admirably. The battle of the systems is a thing of the past in so far as electrical distribution is concerned. Matters have so far settled themselves that both direct and alternating-current motors can be utilised almost indifferently for most industrial work. In mining, of course, the induction motor has its exclusive domain which the commutator motor will never usurp. It has proved its reliability in a remarkable degree for service equally as arduous, and on account of its simplicity is greatly appreciated where unskilled labour is regularly employed.

The design of induction motors is a matter which does not admit of much variation, though much will depend upon the method of manufacture and the general construction of the machine. The British Electric Plant Co., Alloa, N.B., build a standard line of induction motors with either short-circuited or slip-ring rotors. Punched sheet-iron laminæ form the rotor core, which is keyed on to a cast-iron spider. Adequate ventilation is secured through longitudinal and radial channels by which cool air is conducted to the rotor core. Such an important member as the shaft receives special attention. Of high grade steel, it is turned to limit gauges, and subsequently ground true on its bearing surfaces and those portions on which the spider is fitted. These operations ensure true running in the main bearings. The windings are protected from any oil which may creep along the shaft by splasher discs, these throwing out the oil by centrifugal action against the inside of the bearing. A feature of the construction is the provision for removing the shaft from the rotor without disturbing the windings. The stator core is built up with insulated iron laminæ, slotted in the usual way on the internal periphery for the windings. The bearings are ring oiling, and have large diameter and ample supporting surface for the shaft. All the stator and rotor windings are well insulated and vacuum stove-dried before inserting in their respective slots.

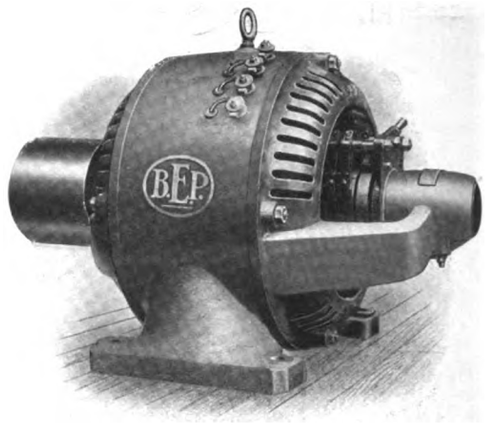

Fig. 1.—B.E.P. Standard Slip-ring Motor.

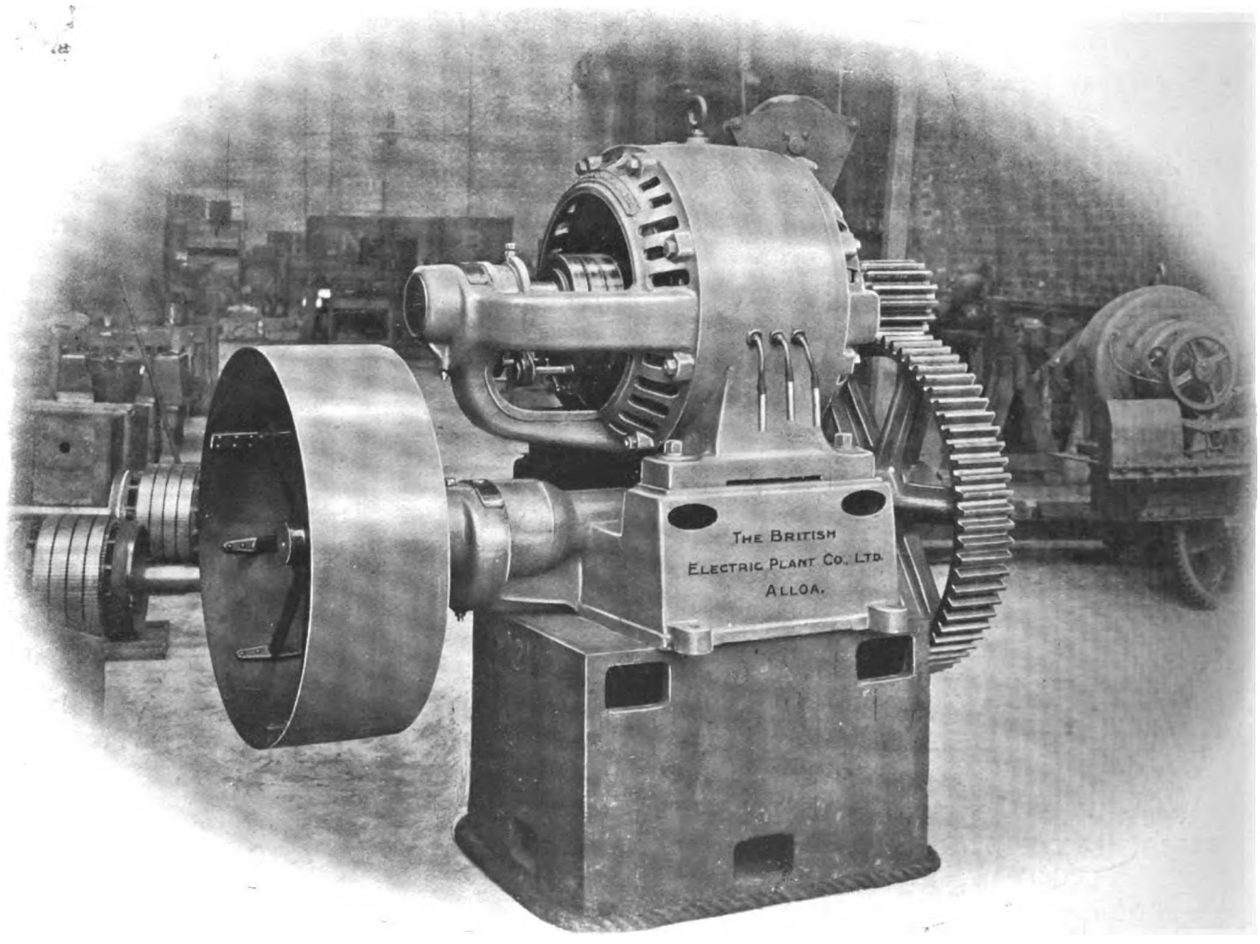

Fig. 2.—70 B.H.P. Three-phase Back-geared Motor for Industrial Service.

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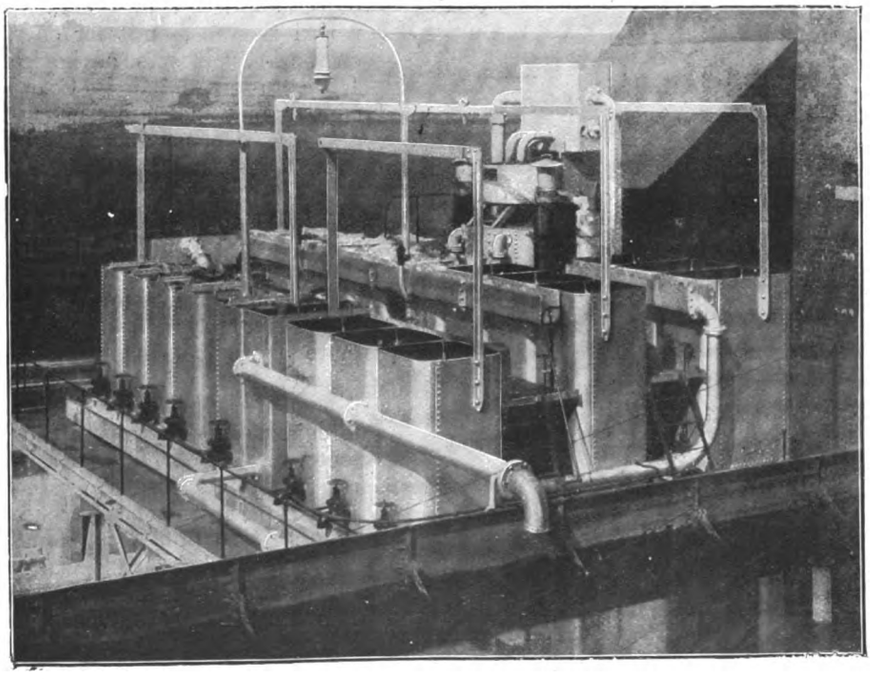

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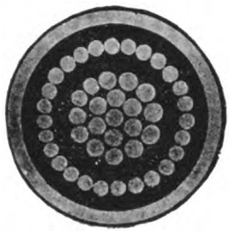

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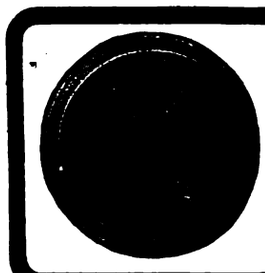

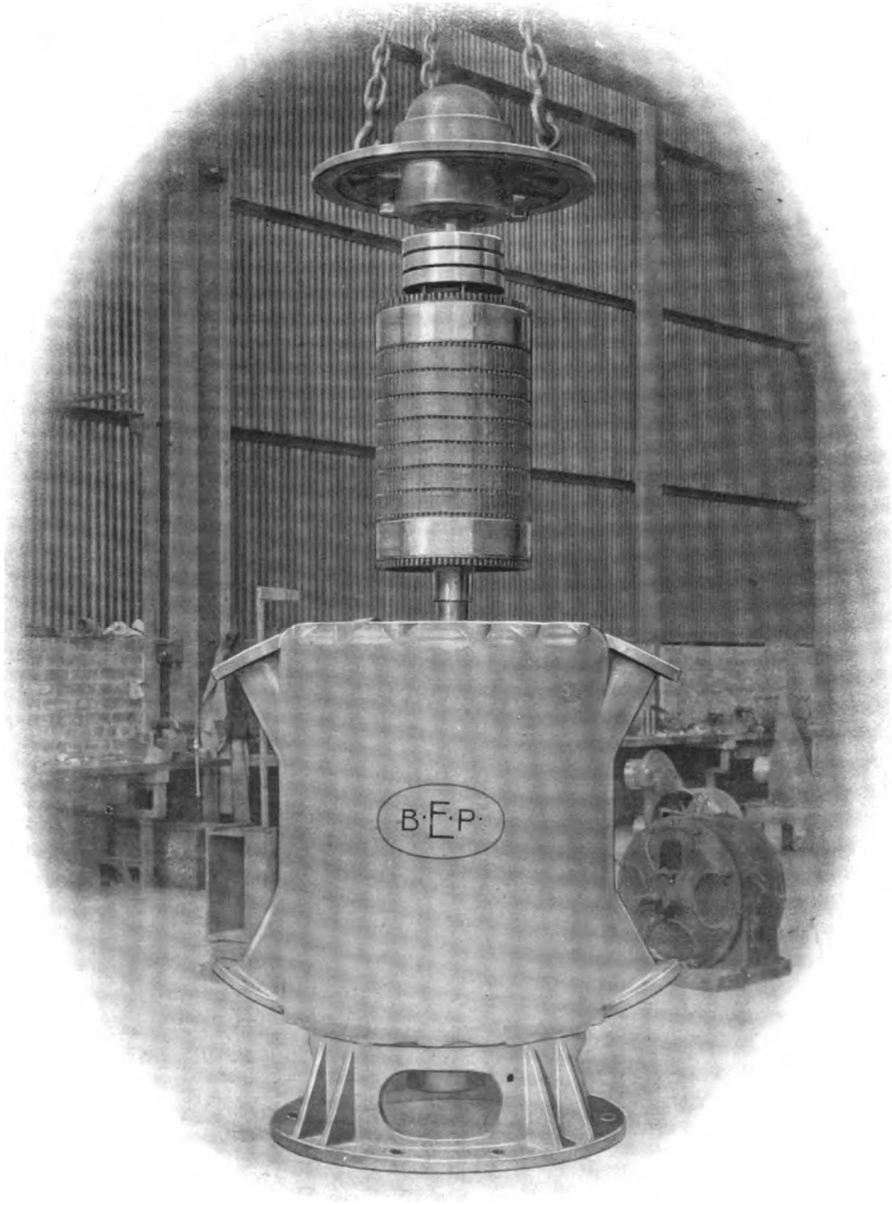

Fig. 3.—Vertical Type 300 B.H.P. Induction Motor for Pumping in Copper Mine.

The insulation of the windings is subjected to a test pressure of at least three times the working voltage and a minimum of 1,000 volts alternating current. It is interesting to note that all machines are painted with two coats of approved colour before delivery. The makers give an undertaking to replace any defect appearing in a machine within twelve months after delivery free of all cost to the purchaser, subject, of course, to the usual condition that the machine has received proper treatment, and that the damaged part is returned to the works.

The squirrel cage or short-circuited rotor type of machine is built for two and three-phase circuits, 50 periods, and any voltage up to 500, in sizes from 4 H.P. to 120 H.P. Slip-ring machines are also made, and they can, if required, be fitted with automatic or hand-operated short-circuiting and brush-raising device.

We illustrate in Fig. 1 a standard B.E.P. three-phase motor of 50 B.H.P., provided with slip-rings and short-circuiting arrangement. This will serve to convey a general idea of the machine. In Fig. 2 is depicted a back-geared motor of 70 B.H.P., also of the slip-ring type. This is a 50 period machine, built for operating on the 440 volt mains of the Scottish House-to-House Supply Co. Four similar machines are in operation driving a rivet-making plant.

A vertical pattern induction motor is illustrated in Fig. 3, and this is somewhat unique in design in that the water from the pump, to which the machine is direct connected, is taken round the motor and is thus utilised for cooling the machine. The motor develops 300 B.H.P. at a speed of 450 revs. per min. and it is operated from a 50 cycle 440 volt three-phase circuit. The design admits of the motor being bolted direct to the pump case, thereby ensuring a water-tight joint as far as the motor is concerned. A flexible coupling is used between the motor and the pump shaft. The duty of the pump is 1,450 gallons per minute against a 450 ft. head, and the equipment is installed in a copper mine. We understand that the design has proved so satisfactory that orders for two similar pumping units have been received. The British Electric Plant Co. are also makers of alternators and direct-current dynamo-electric machinery.

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Machine Tool Motor Control.

THE design and construction of controlling apparatus for machine tool motors have undergone many changes of recent years. When the individual driving of tools was little more than a name, the controlling gear for the motors was badly designed and ill-adapted to the standard of service required in a workshop. The starters and regulators were usually made separate and were coupled by insulated wires allowed to hang loosely about the machine. These connections frequently gave trouble and brought electric driving under the ban of the works manager accustomed to steam or some other driving method. Its outstanding merits have, of course, given electrical operation the ascendency, but much annoyance might have been spared in the early days had more care been taken with the controlling gear. Experience is, however, rectifying these early mistakes. Specialists in switch and starter gears have devoted time and thought to the problems involved, and their efforts are now bringing definite results. It is gratifying to notice the advances made in motor starting and controlling gear for machine tools particularly. The trend of modern designs is in the direction of complete iron-clad gears which serve all the purposes of the machine controlled. Starting switch, circuit breaker, fuses and regulator can now be found enclosed within a single housing and self-contained with resistances. These designs are a striking contrast to the earlier patterns. The compressing of what were previously separate control units within the compass of one enclosing case has done away with cable connections between parts and straggling leads to resistance boxes. The use of iron covers, and, in fact, iron-clad gears generally, at once suggests the placing of the incoming cables in steel conduit, and this practice is becoming more generally followed. These tendencies not only make for efficiency in control, but also they influence favourably the price of the controlling apparatus. This latter is one which directly concerns the power user. He does not want to find that the controlling apparatus for the motor is likely to prove more costly than the motor itself. If manufacturers of starting apparatus continue to simplify their designs in the way they are at present doing the results will reflect beneficially on the extension of electric power developments.

Another interesting phase in the progress of machine-tool motor control is the employment of solenoid switches and starters for distance control. Those types of heavy machine tools, such as planers, boring mills, &c., which are semi-automatic in action, are best controlled by solenoid operated switch-gear. The need for running heavy cables to the machine is done away with, and a costly item in insulated connections is thus got rid of. Small control wires and light switches operated by tappets or push buttons on the tool bed do all the work formerly entrusted to heavy switches with special blow-out or carbon breaking devices. The solenoid starter enables the control of the motor to be centralised, in so far as the gear is concerned, Further, it is not a complicated mechanism, is unlikely to give trouble and may be adapted to an almost infinite variety of control conditions. With machine tools it is advantageous because it enables electrical equipment to be removed from proximity to the tool and takes away, also, any temptation there may be to the workman to tamper with it, either deliberately or out of curiosity.

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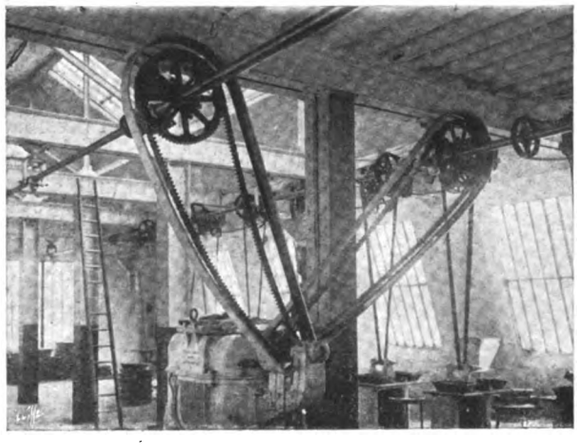

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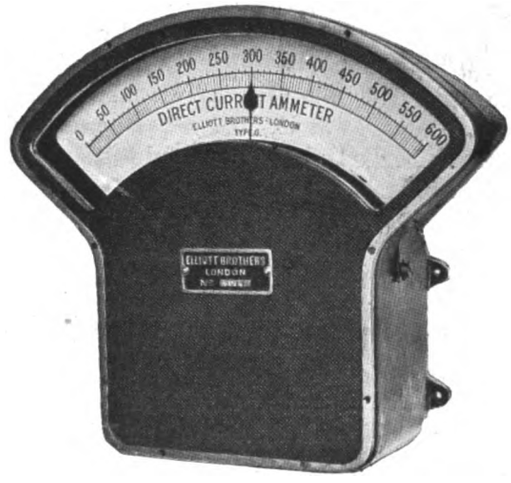

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Editorial.

The Olympia Engineering Exhibition.

The second Engineering and Machinery Exhibition, opened yesterday, is not essentially an electrical show, though electricity will be found to play a prominent part in its proceedings. Apart from the lighting of the building, which has never lost the brilliance of the Electrical Exhibition of 1905, electric power is being utilised to a large extent on those stands showing machinery in motion. Last year machine tools were much in evidence, and group-driving from large motors was generally resorted to. Several fine examples of individually-operated machines were also included in the exhibits. From a preliminary inspection of the present exhibition the portable electric tool appears to be well represented, and it should create a good deal of interest. These little machines have been made the object of a specialised design and manufacture, and in this way have been made more efficient and reliable. The fact that they will be exhibited under actual operating conditions should increase the interest of visitors and prove an additional inducement to business with engineers and contractors requiring tools of this class. We hope that from an electrical point of view, in directing attention to the utility of electric driving of machine tools, the Exhibition will do much good.

Ancient Workshops.

One is apt to associate the story of the inventor who by royal command was privileged to experience the delights of the machine he had devised for capital punishment, with certain industrial establishments producing modern labour-saving appliances. From our experience of British workshops and from descriptions which have appeared of those abroad, only the very large workshops are equipped with up-to-date machinery and latest means of driving it. Most of the smaller undertakings rely on gas or steam for power and retain old types of tools as long as there is any work to be got out of them. Without being in a position to analyse all the facts it is difficult to explain this adherence of manufacturers of modern plant and apparatus to particularly ancient methods. Not every quack has faith in his own nostrum; not every manufacturer can use his own products. Still there are instances of factories in which the introduction of a few of the articles manufactured about the shops would, to say the least, improve the appearance of things. What could be more mystifying to the purchaser of an electric motor, for instance, than to find that the works of the maker are driven by a gas or steam engine, through line shafting and all the old wasteful rig which he has been persuaded to do away with by adopting electric power. Similarly with other devices which, designed to economise time and save labour, are constructed under time and labour-wasting conditions. Obviously the manufacturer cannot be always adopting his own devices in his works, but in his own interests he should see that there is not too wide a divergence between his shop methods and the type of product he is engaged in manufacturing.

In the Beginning.

In his address to the Engineering Section of the British Association given recently, the President reviewed the progress of electrical engineering from quite early times. Some extracts from this make instructive reading in these days of electric driving in the great industries. "Antonio Pacinotti in 1864 described a machine of his own devising, having a specially wound revolving ring magnet placed between the poles of a stationary magnet which, while it would serve as an admirable generator of electric currents if mechanically driven, would also serve as an excellent electric motor if supplied with electric currents from a battery. He thereupon laid down the principle of reversibility of action—a principle more or less dimly foreseen by others, but never before so clearly enunciated as by him. There was a notion abroad—and it persisted into the '80's—that no electric motor could possibly have an efficiency higher that 50 per cent. This notion, based on an erroneous understanding of the theoretical investigations of Jacobi, certainly delayed the progress of events." "Ever since 1891, when, at the Frankfort Exhibition there was shown the tour de force of transmitting 100 H.P. to a distance of 100 miles with an inclusive efficiency of 75 per cent., the commercial possibility of the electric transmission of power on a large scale was assured. The modern developments of this branch of engineering and the erection of great power stations for the economic distribution of electric power generated by large steam plants or by water turbines are known to all engineers. The history of the electric motor is probably without parallel in the lessons it affords of the commercia and industrial importance of science." When the pioneer work of the electrical industry is surveyed in these days of its expansion and development one is apt to wonder how the importance of electric driving ever met with recognition at the hands of engineers. The preliminary difficulties seem so great compared with subsequent achievements that it is hard to recognise the one as the outcome of the other.

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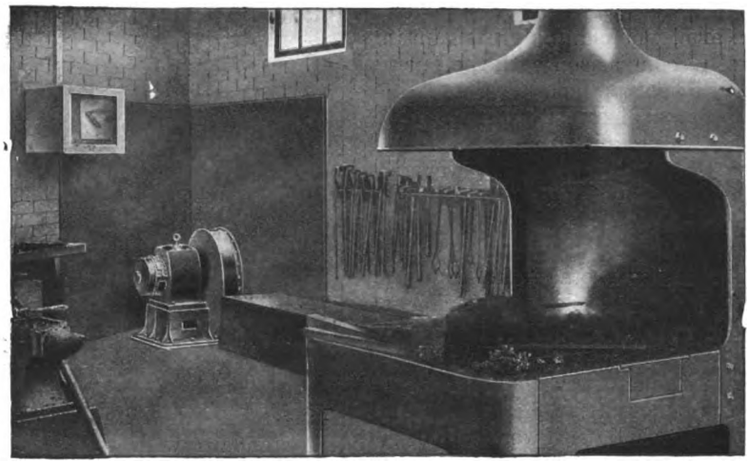

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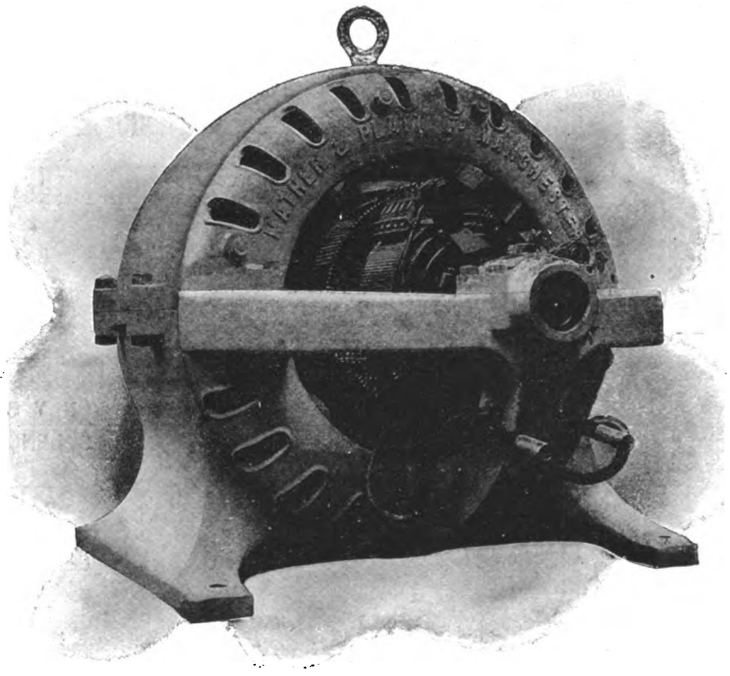

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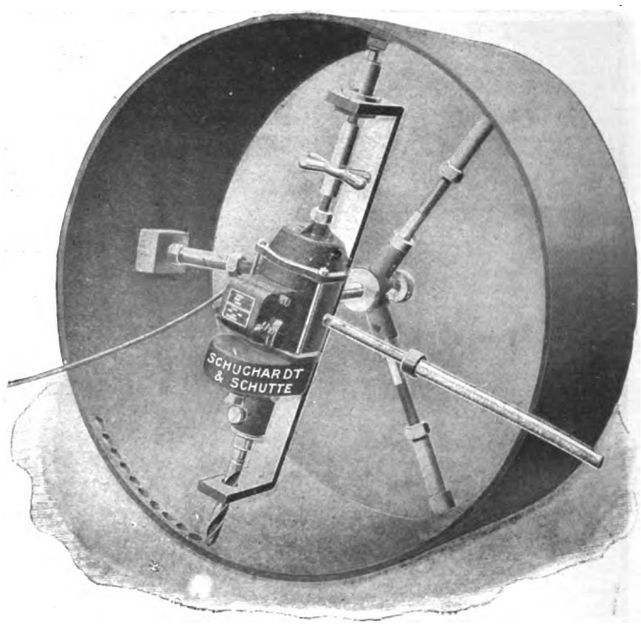
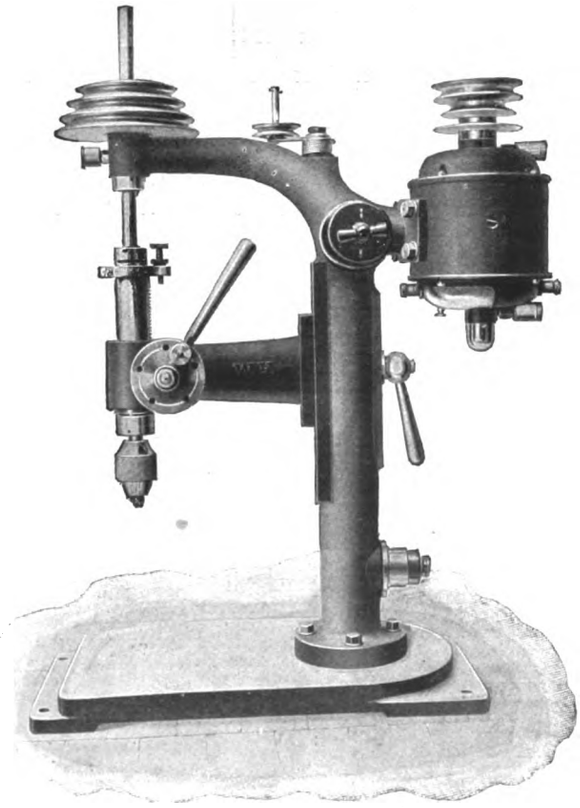
Some New Electric Tools.

AMONGST their extensive exhibit of electric tools at the Engineering and Machinery Exhibition at Olympia, Messrs. Schuchardt & Schutte have included typical examples of electrically operated tools, such as drills, grinders, polishers, &c. These are being shown in motion at the stand, so that visitors will be afforded opportunities of witnessing the capabilities of a drill and also of testing it for themselves. A complete line of portable electric tools is carried by this firm, who claim a great gain in efficiency for their machines in comparison with the pneumatic tool. They state in a recent publication that "the ratio of power consumption of an electrically driven drill as against a pneumatically driven one is as about 1 to 10." The motors on the smaller S. & S. tools have a reversing switch which is enclosed within the body of the tool. Motors are wound for continuous or alternating currents, the former being series wound, and the latter arranged for one or two speeds. The machines are totally enclosed, and consequently are recommended for outdoor work. For work up to $\frac{3}{8}$ in. diameter the tools are made for hand use. Above this size fixed pillars with screw feed are recommended. We illustrate one of the latter, adapted for drilling holes in circular tanks and boiler shells. An adjustable three-arm fixture is placed in the shell, with wooden blocks at the foot of each leg. The nuts are tightened to secure the fixture in a central position. A wrought-iron bracket with right-angled ends is pivoted to the fixture, and serves to hold the drill in position for its work. The bracket is also pivoted, so that it may be swung round as the work of drilling proceeds. This method ensures the holes being in accurate alignment.

Another interesting electric tool is the bench pattern drill, illustrated herewith. In this design the motor is arranged for belt driving, and is bolted to the back of the drill standard with the spindle in a vertical position. Stepped pulleys are fitted to the motor and drill spindle, and a spring-controlled "idler" pulley keeps the belt taut. These drills are supplied in a variety of sizes for drilling different diameters of holes. A pattern is also made in



An Example of the Application of Portable Electric Drill to Tank or Boiler Shell Work.



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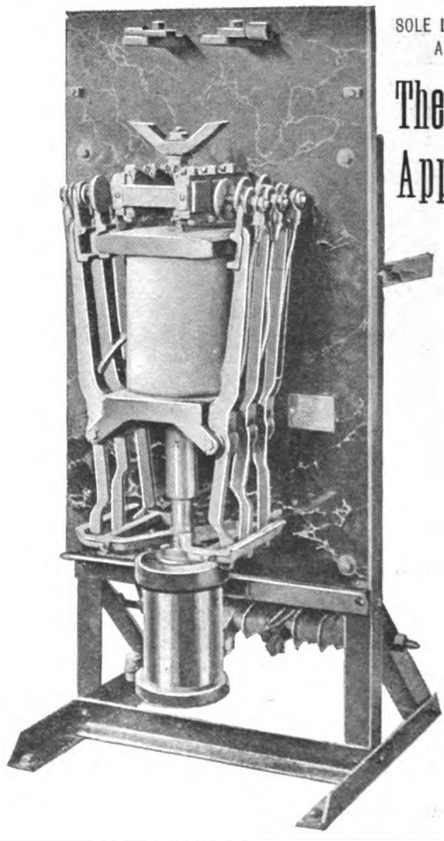

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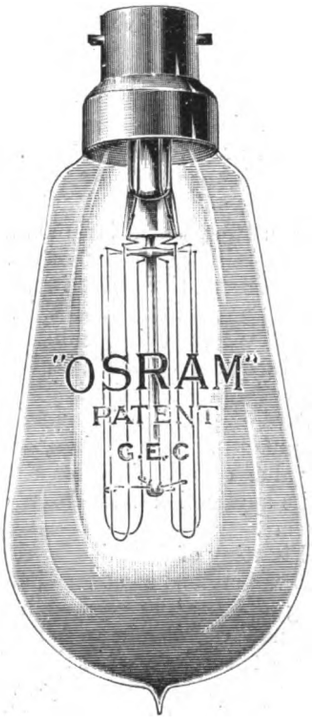

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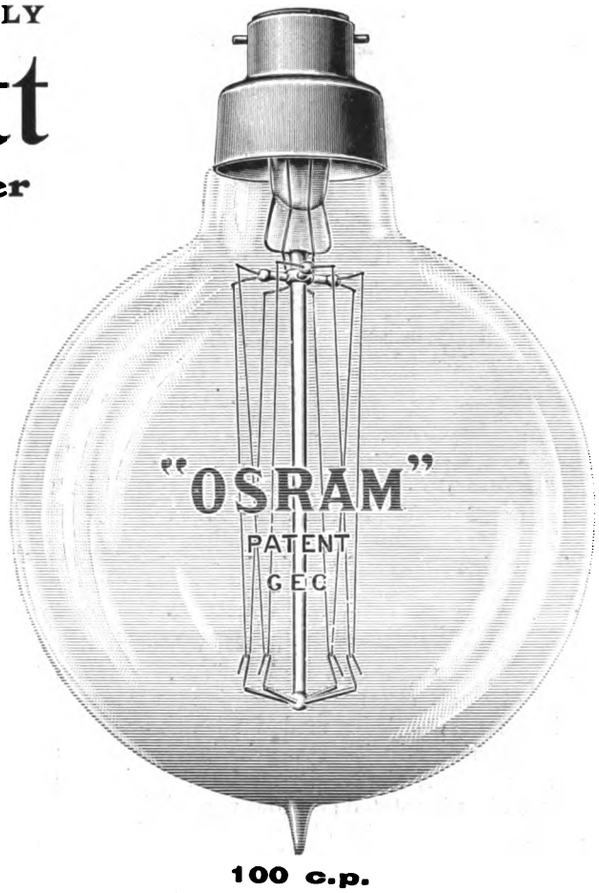

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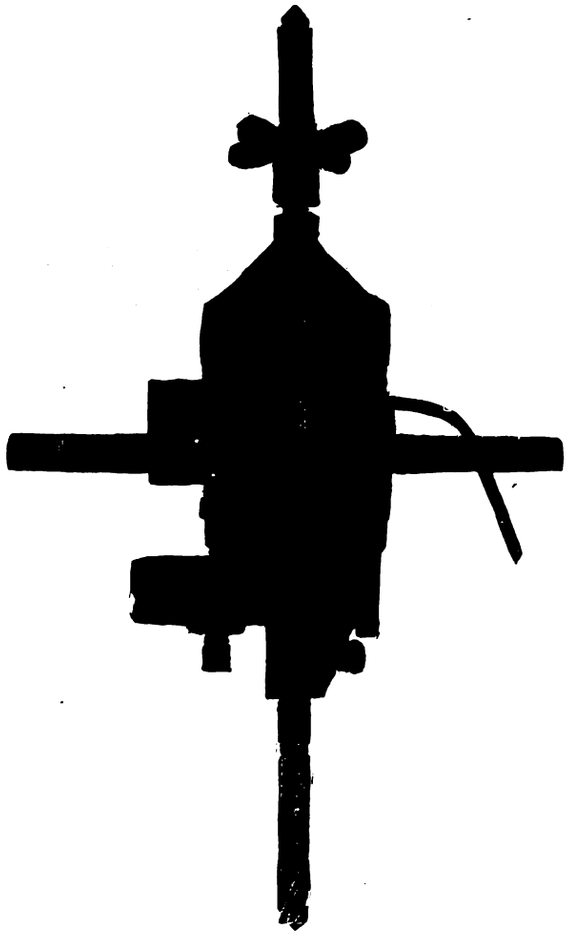
which the motor is direct-coupled to the drill spindle, and its speed may be varied by electrical means.

We also give an illustration of a portable drill with screw feed adjustment. These are made in sizes to drill holes from $\frac{1}{4}$ in. to $1\frac{1}{8}$ in. diameter, and have two speeds, one high and the other normal. The lightest machine for continuous current weighs 9 lb. and the heaviest 38 lb.; corresponding weights for drills with alternate-current motors are 10 lb. and 55 lb. respectively. The outputs of the motors for these limit sizes—largest and smallest—is $\frac{1}{15}$ H.P. and $\frac{3}{4}$ H.P. respectively. Magnetic pillars are suitable for use on these drills, and Messrs. Schuchardt & Schutte supply these for continuous-current circuits in three sizes for 110, 220 and 500 volts. The small pattern of motor employed for electric tools is also frequently found useful for other work. The above-mentioned firm supplies these



Totally Enclosed Type Portable Electric Drill, with Reduction Gear and Controlling Switch within Motor Casing.

machines either ungeared or single and double geared for direct-current and alternating-current circuits and sizes ranging from $\frac{1}{12}$ H.P. to 1 H.P. These motors are suitable for applying to existing tools or for operation of drills, grinders, &c., by means of a flexible shaft.

A line of small electric grinders is also carried by this firm, these machines being made for bench or pedestal use. One pattern is fitted with two grinding discs, one at each end of the armature shaft. By means of gearing the larger of the two discs is rotated at a lower speed than the smaller disc. A useful adaptation of a small motor is the fitting of a winding reel to the armature shaft. Coils of wire or other material can be quickly wound with this machine. A reversing switch and revolution counter are fitted, and the motor is mounted on a swivel base which can be locked in any position.

Industrial Topics. . .

Electric Heat in Workshops.

A MODERN industrial establishment is now equipped both for the electric driving of its tools and the lighting of its workshops. Small shops buy energy from an outside source when it is available, and large shops generate on the premises. Having regard to the fact that electrical energy can be utilised for so many purposes—light, heat and power—there is some justification for consideration of the adoption of electric heating devices in certain shops. Gas is largely used in workshops for blow pipes, tool-heating furnaces, melting glue, water boiling, &c., and appears to be appreciated. Still, while electrical energy is "on tap" and devices are obtainable for its conversion into heat, some good use should be made of such apparatus. Take, for instance, the electric soldering iron. There are many trades in which this could well take the place of gas or coke-heated irons both with improvement in the work done and decreased time in doing it. A case is recorded of a maker of oil lanterns who, after using electric soldering irons, reduced the percentage of leaky oil cans from 5 to $\frac{1}{2}$ per cent., and increased the output 5 per cent. per man, compared with work done by gas-heated tools. Metal trades accustomed to work with irons heated by gas or other means would experience some such improvement as this if electrically-heated bits were used. Then there is the electric stove for heating tools previous to hardening. These are now built in convenient sizes; they have every appearance of reliability and are not very costly. They can be turned off when not in use, thereby economising energy. Another useful electrically-heated device is the "brander," or packing-case marker, which is a modification of the soldering bit. In the packing department of a large factory these tools would soon earn their cost in the time saved by their use. Branding methods are, as a rule, primitive in the extreme, but they have this peculiarity, that a single brander is required for many thousands of packing cases, so that the cost of the electrical device is justified by the extensive employment of the article in question. It does not appear that manufacturers, as a class, have yet come to appreciate the value of electric heat about the works. Yet devices for its application have been on the market for a number of years.

The question of general heating of factories by electrical means will not of course bear serious consideration at the present time. Ventilating and heating equipments combined in a single unit are now obtainable which place all idea of competition from electrical sources in the category of the absurd. With electrical energy so readily available and applied for other duties in his shops, the manufacturer must still, of necessity, utilize coal or coke, or, much the same thing, steam, for heating his shops. This disability of electrical energy to economically solve the heating problem for the factory owner should not, however, place an embargo on electrically-heated tools for which many manufacturers might find a legitimate use. The experiment in many cases would, at any rate, be worth making.

CORRECTION.—We regret that in our last issue we attributed, in error, the illustrations of motor grinder slide rest, pedestal type motor grinder and electric drill for rail work on pages 128, 129 and 130 respectively, to S. Wolf & Co. These illustrations depict the standard apparatus of the Consolidated Pneumatic Tool Co., Bridge Street, Westminster, S.W., who specialise in electric tool production, and have an extensive exhibit of their machines on Stand 119 at the Olympia Engineering Exhibition.

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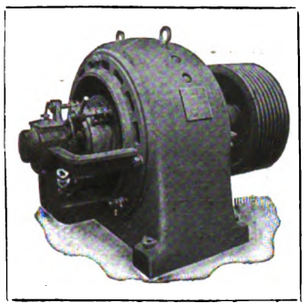
THE ELECTRIC CONSTRUCTION Co. LTD.



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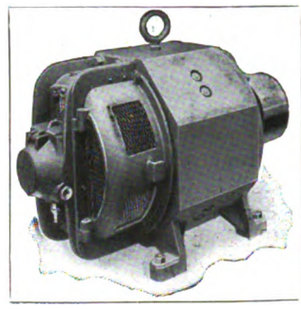
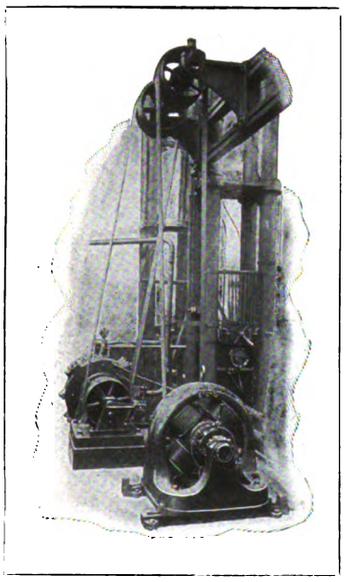
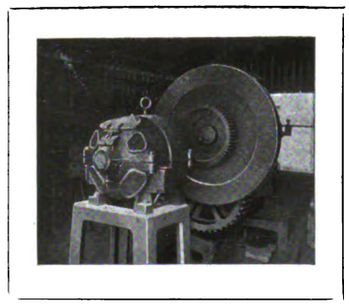


Continuous-Current Enclosed Ventilated Motor

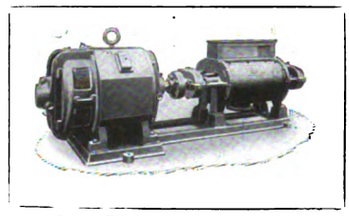


Motor Driving Shafting by Belt.

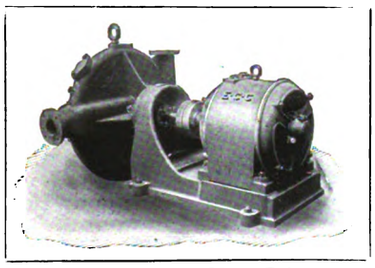
E.C.C.



Motor Driving Cold Shear in Steel Works.



Motor Direct-Coupled to Root's Blower.



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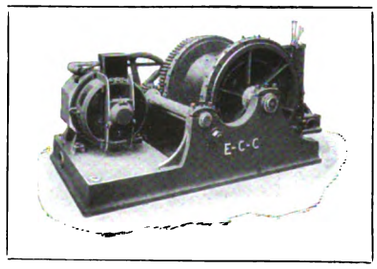

Motor-Driven Winch.

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Industrial Power Transmission.

THE statistics of present-day electric power transmission schemes indicate that a preponderating number of polyphase stations, as compared with other systems, are in actual operation. The American stations cannot claim credit for a single high-voltage direct-current undertaking, and in other parts of the world outside the continent of Europe the same may also be said for electric power plants whether water, gas or steam driven. In Great Britain there are several direct-current equipments operating at a comparatively high voltage, but these are mainly engaged in giving a lighting, traction and small power service and, moreover, they are designed for parallel circuit operation. In many ways they are complicated and, further, as they do not transmit over any distance, they cannot be included in the category of transmission schemes. Their establishment in Great Britain may, however, be noted *en passant*. On the Continent, for the past 20 years, M. Thury has achieved success with a high-voltage d.c. series system which is in operation in over a score of Continental power plants mostly driven by water turbines. The raising of the transmission voltage to the limits reached in three-phase work has attracted considerable attention from electrical men, and the system appears to be gaining advocates in this country while it also is exciting comment in the United States. Mr. Highfield's recent Institution Paper and a pamphlet on the subject published by Messrs. Dick, Kerr & Co. (Ltd.) have excited a great deal of interest which in the early days of power transmission would probably have been ridicule. The *Electrical World* of New York has recently given an opinion on the system. "In broad outline," it says, "the Thury direct-current transmission system resembles the ordinary constant direct-current arc light system, except that instead of lamps, motors are operated in series and instead of a constant current of 8-10 amperes flowing under a pressure of a few kilovolts, there is a constant current of 150 amperes under a pressure of many kilovolts. To supply this pressure a variable number of 2,200 volt generators are connected in series at the generating station, and a similar number of 2,000 volt motors are connected in series at the receiving station." It is then pointed out that a source of trouble with the system is experienced from lightning, though admission is at once made that no reasons exist for supposing the trouble to be any greater than with polyphase lines. Commutation is also regarded as a weak spot, and the fact that only small units can be employed. Proceeding with the list of weaknesses, our contemporary says: "The system is not adapted for distribution but only for transmission of energy in bulk. A.C. systems always admit of being tapped locally at the mere cost of installing a stationary step-down transformer, but the d.c. system requires a motor-generator and men to watch it. The efficiency of the system is thus naturally lower than that of the corresponding a.c. system, even allowing for losses in the transformers peculiar to the latter." The conclusion reached is that economical advances in line construction and insulation for a.c. working will damage the prospects of the d.c. series system, but on the contrary it is stated that "if the insulation along the line could not be commercially maintained with an adequate margin of safety then the d.c. system is capable of becoming a dangerous rival of the a.c. system." To all this we can only remark *Qui vivra, verra.*

Commercial Development of Central Stations. . . . .

DURING the winter season there is every excuse for expenditure of some kind on display advertising. Pamphleteering is quite another matter and requires separate consideration. But the insertion of display announcements in the local press, the use of every available public spot, and generally launching into prominence of the electric service, all these are part of the autumn and winter programme of an electricity undertaking. Of course, a large sum of money can be absolutely wasted in this way unless the means and media for publicity are properly selected and utilised. On the other hand, a judiciously laid-out sum will produce gratifying results. The matter is one for what is known as making a "splash" at the time when evenings draw in and days get colder. If something in the nature of discontent with existing lighting and heating methods can be created among tradesmen and householders by a month's display advertising, the outlay involved will not have been in vain. There is not enough use made of "dissatisfaction" campaigns against gas for power, lighting and heating at a time of year when the circumstances justify it. This should be the key-note of advertisements of the electric service. A policy of "sheer bluff" will fail dismally in this country as compared with the United States although the tall talk of the gas folks—and the presumption of some of these tall stories almost takes one's breath away—is allowed uncontroverted circulation in many places where a different policy should obtain. Britishers are, however, on the whole, too stolid by nature to swallow the coated publicity pill without enquiry as to its after effects. Indeed, station managers themselves are apt to be too chary of advertising methods, believing them to be of little value in securing customers. This is undoubtedly a mistake. Much money is devoted to canvassers for personal solicitation of prospective consumers, but this might with advantage be allocated partly to canvassers and partly to display advertising. Each is essential to the other, and it is difficult to see how either can be run independently. The advertisement awakens interest and brings the enquiry.

Advertising Again.

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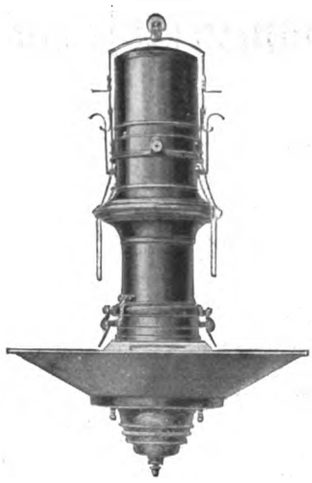

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CONTINUITY WITH SOCKET JOINT CONDUITS.

SIMPLEX "**PIN**" CONTACT SYSTEM.

By means of our New Pin Contact Device our Socket Joint Conduits may now be erected electrically and mechanically continuous at practically **no increase in cost** over an ordinary Socket Joint Installation. A small Slot, as shown in the illustration, is left in the lip of all socket fittings, and when the enamelled tubing is socketed home in the ordinary way, a small hardened metal Pin or Dowel is inserted and hammered sharply home. This Pin cuts its way into the fitting and into the skin of the tube, and being under great pressure makes **efficient** and **lasting contact** without the necessity of scraping or injuring the enamel in any way. The projecting part of the Pin may subsequently be filed off flush. A particular advantage in connection with this system is that existing installations can be made continuous at a very slight cost.

FITTINGS FOR USE ON THIS SYSTEM TO BE OBTAINED ONLY FROM—

SIMPLEX CONDUITS LIMITED,

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BIRMINGHAM.

LONDON.—20, Bucklersbury, E.C.
MANCHESTER.—6, Bull's Head Yard, Corporation St.
GLASGOW.—165a, West George Street.
LIVERPOOL.—37, Moorfields.

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Electric Rock Drills.

ELECTRIC power has invaded so many domains of industry that the list of processes to which it has not been applied will soon become very small indeed. The ordinary tools of everyday manufacture are already adapted for direct operation by electric motors, and no factory of repute, whether old established or but newly founded, conducts its operations other than with the electric drive. Small wonder then that work which is classified as outside the boundaries of organised manufacture should come to be performed by electrical means rather than by any other power agency. Mining operations have long been conducted by the aid of some form of power. The most important of all its processes, that of drilling, is still very largely given over to compressed air-power. But this is now seriously challenged by an electrical competitor which has all the prospects of ultimately supplanting its rival. In a way the transition from the pneumatic to the air type of drill will be evolutionary rather than revolutionary. The intermediate process may be described as electro-pneumatic in that the majority of air drills are supplied with compressed air from electrically-driven compressors. This happens where electric power is distributed about a mine and electric drills are not in use. Under these conditions the pneumatic drill is tolerated as a mere appenage of the electric-power system. Obviously there is but one step further to complete the process of change with economy and simplicity as its object—that is, the use of the direct electric drill.

This transition is now made possible by the Sandycroft-Marvin electric rock drill which is represented in section in Fig. 1. It will be observed that there is only one moving part in the drill, this being the plunger (1), having an enlarged portion (2), which is free to reciprocate within the solenoids (3), through a bearing (5) at the drill end. The shank (4) is also part of the plunger and carries the enlarged tool holder (6) in which the drill is inserted. The back stroke of the plunger is checked by the powerful helicoidal spring (7) which also assists the return stroke. The rifled ratchet rod (8) has a ratchet wheel in the back head (9) and fits a rifled nut in the back end of the plunger. The solenoids are built up of square section bare copper wound on mica sleeves which effectually insulate the turns and layers. This construction makes the solenoids practically a solid mass of mica and copper, impenetrable by water and absolutely fireproof. The "bobbin" on which the solenoids are wound is of steel tube with steel end flanges and over these latter is slipped a steel jacket which is securely riveted into place. Connection to the external circuit is made through the brass plugs (10) projecting through the enclosing outer case.

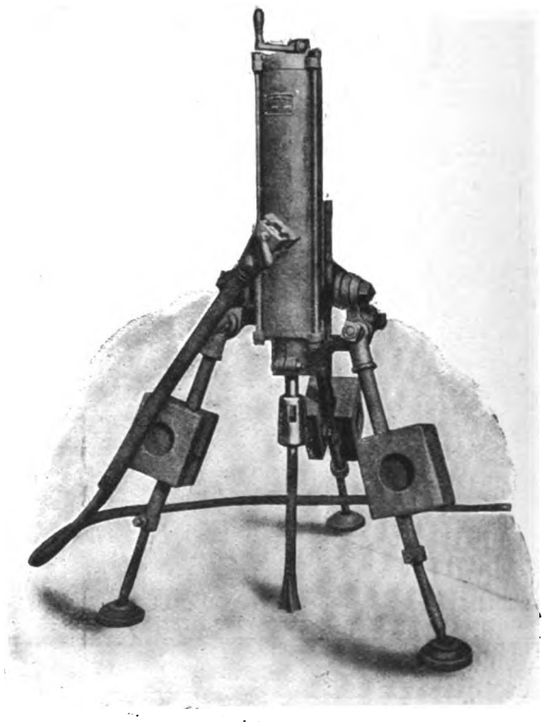

Fig. 2.—Sandycroft-Marvin Electric Rock Drill, complete on Tripod.

A view of the drill complete is depicted in Fig. 2 which shows also the tripod mounting. The action of the drill is extremely simple. By means of an alternating current of low frequency the value of the current in the two halves of the solenoid is varied so that at the moment it is at its maximum in one it is at a minimum in the other, the net result being a pulsating magnetic effect which causes the

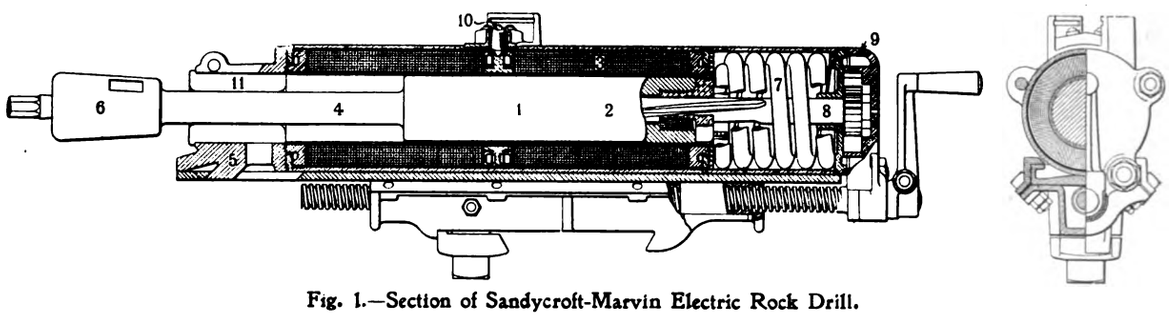

Fig. 1.—Section of Sandycroft-Marvin Electric Rock Drill.

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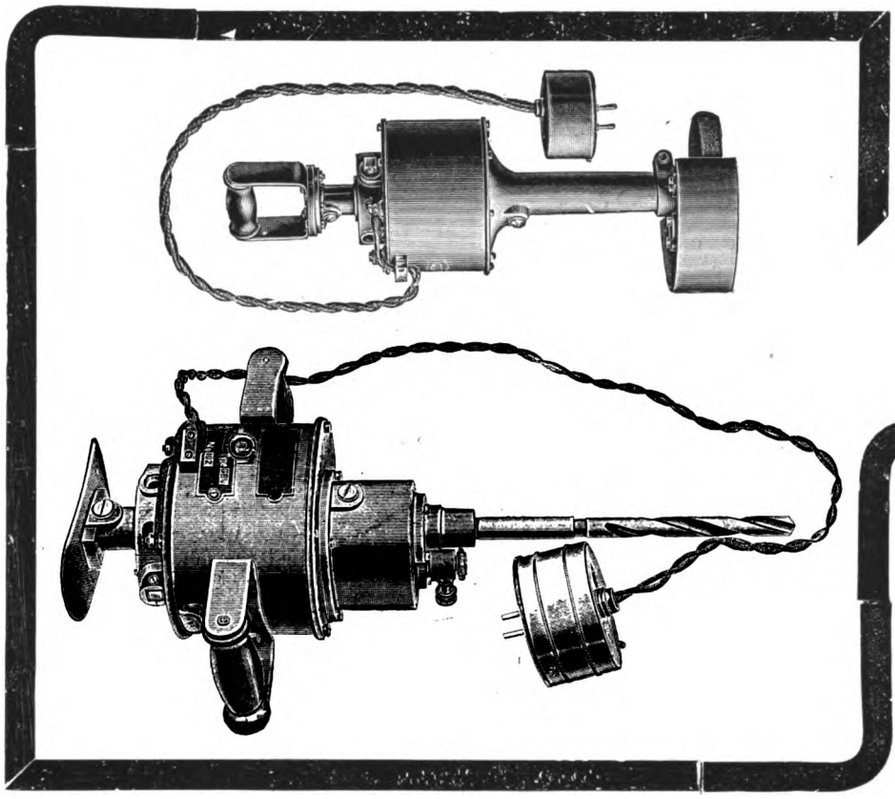
Don't drill your holes in the slow, old-fashioned way—in the way that suited the period of your grandfathers—
"it doesn't pay"!

Don't waste your time in carting heavy castings to your tools when you can carry the tool to the casting,—
"so much cheaper"!



Try "LITTLE-HUSTLER" Drills and Grinders,—"modern tools of unequalled efficiency and reliability,"—"tools to suit modern requirements."

Sole Makers:—THE ARMORDUCT CO.
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Farringdon Avenue, London, E.C.

steel plunger to reciprocate between the two coils, carrying with it the drill at its outer extremity. Fig. 3 illustrates the main parts of the drill "dissembled" and this view generally indicates the simplicity of the design. The voltage of the machine is purposely kept low—140 volts—to eliminate all possible risk of shocks to workmen. This alternating current is supplied by a special generator, which is usually driven from any convenient shafting or by a motor direct connected to it. A general view of one of these machines is given in Fig. 4, the type of generator depicted being built for belt driving. It also represents a later design, which is much lighter than those at first used, and is, in addition, so the makers inform us, more efficient. The machine, one of the Sandycroft standard d.c. pattern, is provided with slip rings and commutators by which the current produced is "shaped" to the requirements of the drill solenoids. These slip rings overhang one of the bearings on an insulated extension of the shaft and the ordinary commutator is within the enclosing end piece. From this commutator current can be taken for lighting and other purposes. The machine produces a current wave every half-revolution, and the net result is 435 impulses per minute at the drill, the generator running at the same number of revolutions per minute. By varying the speed of the generator the drill impulses can also be varied. We have made it clear that the construction of the drill is simplicity itself. In operation we understand that the horse-power required is about half that needed for pneumatic drills. The maximum stroke is 8 in., but this is variable down to a minimum of 4 in. by the

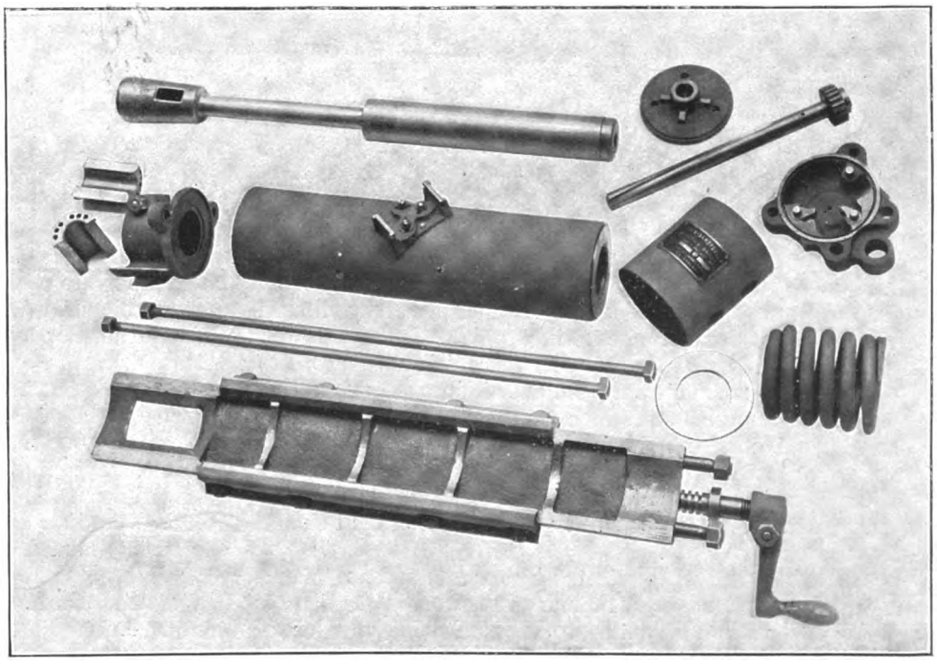

Fig. 3.—Electric Rock Drill taken to pieces to show Constructional Details.

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A real Fuel Saver of Great Value to all Steam Users.
Interesting Literature Free on Application
SANDERS, REHDERS & CO., LTD.,
108, Fenchurch Street, LONDON, E.C.
Hundreds of Installations Prove its Value.

adjustment of the feed screw shown in Fig. 1. This minimum feed is very useful when starting a hole. We are informed that the drill is capable of standing up to a lot of careless handling, its simple and solid construction being accountable mainly for this. When it is considered that the greater part of the labour employed in mining work is unskilled, this feature of the drill is an important one. In comparing the generator with an air compressor, as may quite reasonably be done, it should be borne in mind that the latter has an abundance of valves, requires expensive foundations, has a low efficiency and high first cost—in fact, it is generally undesirable as an accessory in mining work. The electric generator, on the other hand, is very efficient, takes up little room, and is inexpensive to instal. In addition, its construction and operation are matters of extreme simplicity. In quarries and mining operations in which electric power is at present infrequently employed the generator may be driven from the existing power system, the method usually followed being the belt drive from shafting.

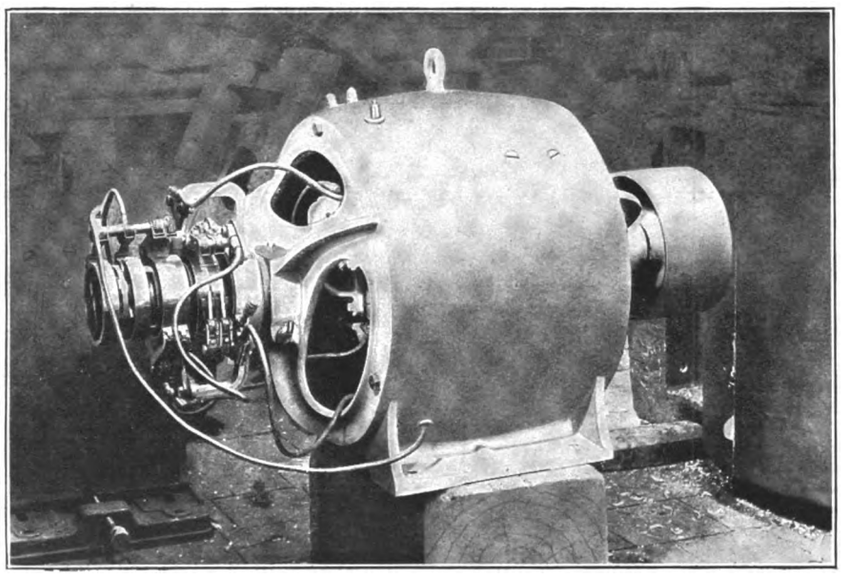

Fig. 4.—Generator for Sandycroft-Marvin Electric Rock Drill showing Special Collecting Rings.

In conclusion we may add that these drills will work to a depth of 25 ft., and a large number is in use both in this country, in America and other countries. Tests comparing the general efficiency with that of air drills have, so the makers of the Marvin drill state, indicated the superiority of the electrical machine. Now that electric power supply is so general in mining operations this form of drill should come into regular use.

The drills are fully protected by patents and are manufactured at the Sandycroft Foundry Co.'s works near Chester under modern conditions as to shop methods and labour organisation. We may mention also that the firm are specialists in the design and construction of mining machinery.

Lifting Electromagnets.

WE have on various occasions directed attention to the industrial value of the lifting electromagnet, intimating that its merits were not widely enough known or they would be more extensively appreciated. The Cutler-Hammer Clutch Co., of Milwaukee, U.S.A., have recently published some interesting data on the subject of a special line of lifting magnets which they manufacture, and which appear to have been favourably received "on the other side." The size and capacity of these magnets varies considerably, but the range extends from a 10 in. size up to a 52 in. size, designed respectively for dealing with plates, rails and small castings and pig iron scrap, or a 10 ton mass of metal. The largest size weighs about 5,000 lb. and comprises a hollow steel casting containing the magnet coil. Alternate layers of copper and asbestos make up this coil which is further insulated from the frame by sheet mica. The fireproof nature of this insulation may be gathered from the fact that under test the coils were heated without injury to 470°F. A corrugated construction has been adopted for the enclosing case and the bolts clamping up the under plate are deeply recessed to protect them from injury. The magnet has a central opening for the circulation of cool air to carry away the heat radiated from the coil. The amount of lift of which these magnets are capable varies in accordance with the form of the material handled. Plates, rails, tubes and long narrow pieces of metal are picked up by two rectangular magnets attached to a balancing bar suspended centrally from the crane hook. Pig iron, scrap and loose material is best raised by circular magnets having a greater lifting capacity, and provided with a concave under surface, this being suitable for irregular shapes. By closing the central ventilating aperture with an auxiliary steel pole the magnets are capable of lifting heavy masses with plain surfaces. This additional pole will also allow of a magnet being lowered within about 3ft. of a heap of scrap, not directly in contact, when the pieces will be attracted as soon as the current is turned on. Under favourable conditions a 50in. magnet will raise 20,000 lb., and a 75 lb. magnet will lift an 800 lb. dynamo. It is interesting to note that these magnets are successfully used in foundries and rolling mills to raise metal pieces in a heated condition, which does not allow of their being moved under ordinary conditions with rope and chain slings. The convenience of being able to drop the magnet on to the heated metal from above, without approaching it for the adjustment or placing of a chain, is a strong argument in favour of the use of lifting magnets for this purpose.

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Notes and Observations.

XII.—A Holiday Episode.

I HAD emerged from my bathing box on the pier head at Ramscombe and was contemplating a delightful post-luncheon dip, when who should appear in the doorway of a box three doors oft but old Fliston, the flour mill proprietor of M——. We had not met since the opening of the new power station in his district, and I had recollections, doubtfully pleasant, of a conversation we had then on electric driving in general and flour mill operation in particular.

His genial smile, however, and warm greeting quite changed my opinion of him.

"Going round the mile buoy?" he inquired, slapping his chest like most portly bathers do.

"That's my morning trip down here," I replied, imitating his slapping example, but on my legs. I generally paddle out and have ten minutes or so on the buoy and then come back at a good pace. I can then enjoy a square meal; not one of the sandwich and coffee variety.

"Suppose we begin the first half of the journey," he suggested, and almost at once we took the 15ft header from the pier. I followed him, because I like to see goodly round bodies such as his making progress in the water. My! What a hole he made in the sea as he plunged! His bald head seemed to appear in the middle of the hole before his toes had gone under, and the effect reminded me of an instrument jewel in its socket.

He was an excellent swimmer and was quite comfortable in his strokes on the way to the buoy. We reached it together and clambered in at the door which on calm mornings always faced the beach. In rough weather we used to watch it from the shore, turning and tossing in the waves.

We lay on the top of the buoy and for a time there was an unbroken silence.

"Where did I see you last?" he yawned. "I have a good memory for faces, but can't always locate them."

"Opening of the D—— power house of the ——shire Power Company some months ago. I sat next you at the luncheon and was mean enough to talk about electric driving in flour mills."

His face fell.

"Oh! Um! Ah! Quite slipped my memory, and to think we meet again—here, like this." He waved his hand round the buoy and finished with a tap on his bathing suit.

I made no remark. He seemed rather sorry he had swum out with me. In fact I was convinced he thought me someone else when we had met on the pier. I turned the conversation, by an effort, to swimming and found he was a keen sportsman in the natatory art. Following up my advantage I recited tales of river and sea bathes and polo, until we must have got through half an hour on the buoy. He did his share as well and we both laughed away the feelings of that irksome re-introduction.

"Do you know," he said, "I've felt quite concerned about you since we met at that luncheon. I meant to hurt your feelings, and I did not spare you. Although I was a guest of the company I felt after your first few words on flour

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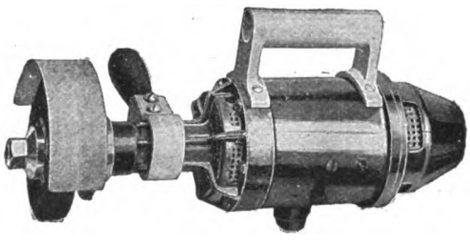

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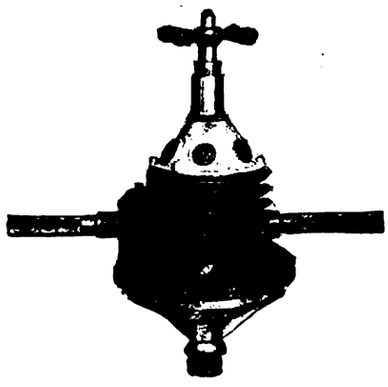

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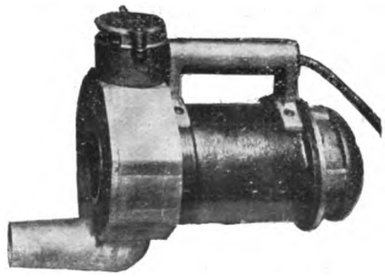

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mills that I had been invited there for a purpose. You were set to pluck me as a fat goose. I resented it, and as you remember I was not slow to show it. But I was sorry afterwards. You were so deadly in earnest and I had taken so cruel a delight in snubbing you that it reacted on me, and I wanted to apologise. Funny, though, on the pier I took you for an acquaintance."

I gave him time to clear his conscience of its load, and then went on—

"My dear sir, no apology is needed. I did feel a bit cut up at the time, but somehow I had a presentiment that you would come round afterwards. Naturally, I have been giving you time. I did not call on you to press the claims of the electric service, though I have not been idle in the meantime."

"Your duties——" he interposed.

"Took me into the nooks and crannies of your flour mill," I cut in, "and I have made many interesting notes thereon."

"But how did you get in," he asked, not disguising his astonishment.

"Perfectly fair means," I answered. "I went up the hoist as a sack of human wheat and emerged as a sack of human flour."

"The deuce you did? Well, that's plucky anyway. And now you are more convinced than ever that I should come on the electric power mains I suppose?"

He stood up and leaned against the door of the buoy.

"Well, sir, I am not only convinced that it is expedient, but I now know that you can well afford the capital outlay. Besides, you know, the output of the present equipment will be increased."

I hate talking "shop" on holidays, but here I found myself in university bathing dress marching round an anchored buoy interviewing a prospective power consumer for the supply station 100 miles away. The opportunity was too good to lose.

Fliston stood some minutes looking towards the land. Suddenly he turned on me.

"Look here," he cried, "I've got an idea. You've guessed I'm a bit of a sportsman, and you're right. On shore I can show you a case of medals I got for swimming 15 years ago. I feel fit still, and though you are some years younger I'll race you to the beach a mile or more away. If you can beat me, come round to my office at the mill when you get back with a blank order for the electric power service."

"But——" I started.

"But me no buts," he said, excitedly. "Do you accept?"

"Decidedly," I replied without hesitation. "I merely wish to protest against so improper a test of the value of electric power applications to your flour mill machinery."

"Get ready," was his answer.

I clipped the edge of the buoy with my toes.

"Go!" said he.

We took the water together, he with a powerful breast stroke, I upon my back. He began to head off. I let him go, for I had already seen that he had only the stroke he was using. The "trudgeon" was unknown to him and I had not used it on the way to the buoy. Of course, he knew of it, but when I say the stroke was unknown to him, I mean that he had not learnt it.

It was an exciting struggle, and I cannot give you all the details of the way I played my man. At the half-mile buoy I had him well in hand, though he was in front of me by 30 yards. In the last quarter mile he still led, but then I began to "trudge," and passing him struck ground 20 yards to the good. As soon as he could "bottom," I shouted did he want a hand, but he waved me aside and paddled up the beach.

"The deuce," he panted. "You could have given me 30 yards, and I believed myself game enough for a scratch race. I must compliment you on your stroke though. I believe you were playing me all the time."

"We must get back to the pier head," I reminded him, when he had recovered his breath. So we swam back and had a good rub down before dressing.

I made no mention of the bet nor did he. He returned the next day and I saw no more of him until I was once more going my rounds for the ——shire Power Co.

I waited a fortnight and then called on Fliston with one of our official power contract forms filled up as to its details and with signature blank only.

I have the pleasantest recollections of that interview. We did not talk electric power at all. The old chap insisted on living over again some of his swimming records, and made me examine all his medals. He had got them down at the office awaiting my return, so he told me.

When we had finished, he took up his pen.

"Where's that blank form we had the race for," and he reached out his hand.

It was out and signed without another word. Then he handed me a small envelope, remarking laconically, that he hoped that we should not be long in getting in the power service, and bidding me good-day.

I opened that package late at night. I felt that it was some gift from my friend, for such I now counted him. It was a gold scarf pin modelled to resemble a buoy—our buoy off Ramscombe.

W. E. W.

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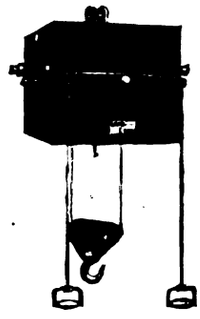

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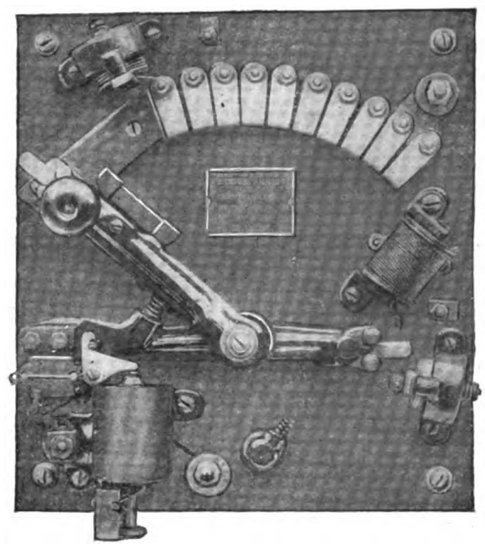
"Fool-Proof" Motor Starters.

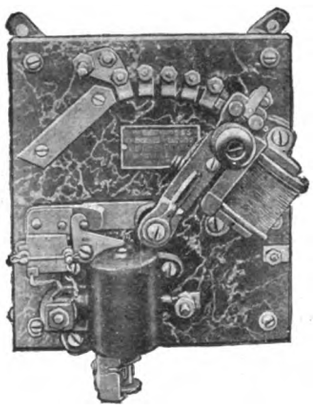
THE importance of the starter for machine-tool motors cannot be overestimated, seeing that mechanics are usually careless in the way in which they handle electrical apparatus of any kind. Some interest therefore attaches to a line of improved motor starters of the Ward-Leonard type which Messrs. Geipel & Lange are introducing.

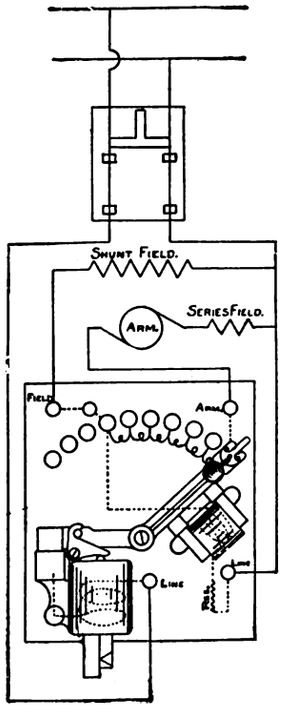
The special feature of the "Fool-Proof" type of starter is an overload release so interlocked with the arm of the starter that, should an overload occur during the starting operation, the circuit is opened by a circuit-breaker independently of the starting lever, and thus prevents damage to both starter and motor. It further provides protection while starting by preventing a too rapid cutting out of resistance and renders it impossible to start the motor when the connections are incorrect or too great an overload exists. A time limit can be fitted to this circuit-breaker if required.

A further new improvement consists in the use of a no-voltage release which is not usually dependent on the field strength for its efficiency in holding the contact arm in the running position. The coil is connected directly across the mains, so that it holds the arm of the starter regardless of the strength of the field; at the same time it is arranged to release when the armature falls below half-speed. This overcomes the objection where motors are regulated by inserting resistance into the field circuit, which often causes excessive weakening of the no-voltage coil.



Open-type Motor Starter for Control of 15 H.P. 500 volt Machine.





2 H.P. 200 volt Starter and Connection Diagram for Compound Motor. For Series Motor omit Field Connection and Series Field for Shunt Motor.

Renewable contacts are fitted to every size; effective magnetic blow-outs are fitted on the contact and circuit-breaker arms of starters above 10 H.P.; efficient leading fingers and spark takers are arranged, to avoid any possibility of deterioration to the working contacts of starters below 10 H.P. One of the main features of the Ward-Leonard starter is the protection afforded to the resistance material, this being enclosed in a hermetically sealed case and embedded in sand, which, whilst providing a protection against corrosion and oxidation, affords an effective means of cooling the resistance material rapidly, thus enabling heavy overloads to be carried for short periods without the slightest injury.

These starters are manufactured in two types, "SU" and "SK." The "SU" pattern have no-voltage release with coil independent of shunt field, and are made in sizes from ½ to 40 H.P. and pressures ranging between 125 and 500 volts inclusive. The "SK" type are known as "fool proof" and are fitted with overload circuit-breaker, time device (Statter) if required and no-voltage release. The illustrations herewith are of this last-mentioned type and include a connection diagram in which the circuit-breaker coil and other parts are shown. This pattern is built up in the same sizes and for the same voltages as the "SU" starters. We understand that the sizes mentioned are kept stocked by Messrs. Geipel & Lange, in London.

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Norwegian Hydro-Electric Developments.

MOUNTAINOUS countries of comparatively small size appear to the electrical engineer as a species of happy hunting ground in which he may spend his time on the development of water power schemes. Norway, Sweden and Switzerland are the best European examples of countries which may, and no doubt will, be "run by electricity." The waterfalls are so numerous, the difficulties of catchment few and the civil engineering, compared with some schemes, light and inexpensive, that once the work of establishing a national electric service is seriously undertaken it would appear that but a few years only would witness its completion. The important developments proceeding in these countries point to the existence of sanguine hopes among hydro-electrical engineers of carrying their schemes to successful issues to the general advantage of the industries of their respective countries. The hydraulic resources of the three countries mentioned are not by any means entirely utilized for electric power transmission, though many large works are in operation. In Norway and Sweden at present a number of extensive works are in hand. According to *Engineering*, something in the nature of a "boom" in water power is being at present experienced. Municipalities, private enterprise and even Government departments are in competition for the acquisition and utilisation of water powers. The Norwegian Storthing during its present session has voted £22,300 for the purchase of all the waterfalls on the Numedalslaagen between Tunhöodfjord and the Sporan Bridge, a distance of 5½ miles in which there is a considerable fall. An interesting engineering problem is presented in connection with this proposal. The water of eight lakes lying at a height varying from 2,800 to 4,220 ft. can be utilised, and the work of damming them is not difficult. When completed it will considerably increase the power available at the falls. Two schemes are suggested, one for building two dams at Tunhöodfjord and Paalsbufjord of 33 ft. and 16½ ft. which will increase the effective horse-power to 100,000, and another for the construction in addition to the two dams mentioned, of smaller dams in the remaining lakes, which will give an aggregate increase of 150,000 H.P. to the falls between the limit points already mentioned. The cost is placed at £55,000 or a matter of 7s. 4d. per horse-power, but a contribution towards this is expected from manufacturers lower down the Laagen who will materially benefit by the developments in question. Further, hydraulic works, such as a distributing basin and a tunnel 2½ miles long would have to be undertaken to complete the scheme for water impounding. The total cost including power-house, turbines, generators and equipment is estimated at £85,000, including 10 per cent. for unforeseen expenses, or £5. 10s. per horse-power installed. In this figure the turbines and penstocks are estimated to cost 33s. per horse-power, and the generators, switch gear and transformer equipment £2 per horse-power; buildings are not included and are calculated separately at 6s. 8d. per horse-power. No particulars are supplied of the system to be adopted for the transmission, whether alternate or direct current, though it is probable that no radical departure from standard polyphase working will be attempted. Copper mines are situated within the range of distribution but it is expected that the bulk of the power generated will be transmitted to the coast, to the Bergen railway some 20 miles distant, to Drammen 60 miles, to Christiania about 90 miles. It is estimated that energy can be sold at the most distant places at 28s. to 33s. per horse-power-year, a figure which, compared with steam, is remarkably low. These developments point to very considerable industrial activity within the region of the water power and they will act as an incentive to the release of further capital, either private or public, for embarking on similar enterprises.

The Swedish Government is by no means tardy in recognising the national value of water power development and from the same source we gather that over a quarter of a million was voted by the legislature for the purchase of water falls. Our readers will doubtless recollect that the same government carried out some interesting experiments with one-phase traction about two years ago, with the object of converting the State railways to electric working, the energy being transmitted from waterfalls inland. Doubtless this vote of so large a sum is connected in some way with these tests in electric traction. The progress of these hydro-electric schemes in other countries should be followed closely by British engineers as opportunities will soon be afforded of comparing their operating costs with those obtained in steam practice. Up to the present hydro-electric transmission systems have not been regarded as serious competitors of steam as their installation is more costly, and they cannot be placed conveniently near the centre of distribution. However it is reasonable to expect that as such stations become more numerous their competition with steam will be more severely felt. Hydro-electrics still remain the "dark horses" of electric power.

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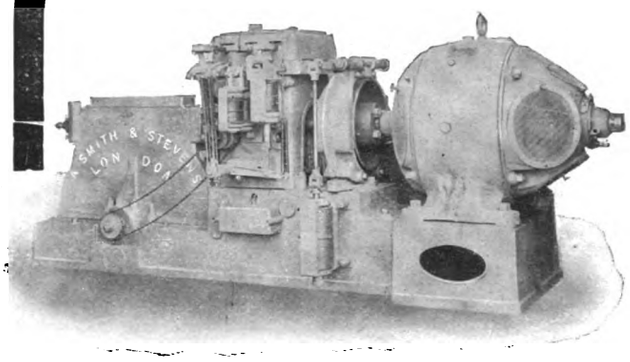

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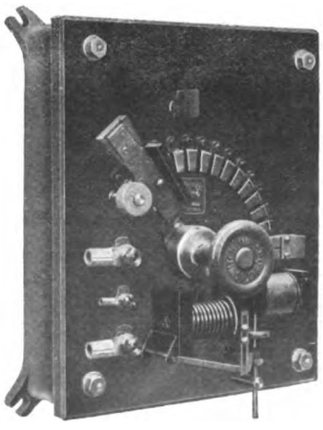
New Motor Starters.

ALTHOUGH motor starters may appear to the casual observer to be very much alike, yet there is a great difference in the details of the design of starters by different makers. The standard motor starters of Siemens Bros. Dynamo Works (Ltd.) range from ⅔ H.P. to 80 H.P. for any standard voltage, and each size is made in two types, open and enclosed. Each starter comprises a multiway switch, resistance and (except in the smallest size) no-voltage and overload releases. A hand trip is provided for short-circuiting the shunt coil, to stop the motor.

The resistance consists of a strip bent into folds, with pure mica as insulation between each fold. This is termed a "resistance element," a number of which are packed in a cast-iron case and insulated therefrom by a micanite trough. No soldered connections are used, and the cases are completely air and water-tight. All the resistances are tested with an alternating pressure of 2,000 volts between live parts and body before leaving the works.

The no-voltage release consists of a magnet wound with copper wire and connected in series with the motor field, and a copper-plated iron armature which is carried on the switch arm. When the field circuit is closed the coil is energised, and when the switch arm is moved on to the last contact the pull exerted by the magnet on its armature is sufficient to overcome the tension of the centre spring, so that the switch arm is firmly held in the "On" position. Should the field circuit be broken, or the no-voltage coil be short-circuited by the hand trip previously mentioned, the magnet fails to hold its armature and the switch flies back to the "Off" position, being stopped by an indiarubber buffer.



Open Type Motor Starter, with No Volt and Overload Release Coils.

The overload release consists of a magnet wound with copper wire or strip and an armature placed underneath the magnet and pivoted to it at one end. This magnet is energised by the main current, and when an overload

Motor Starter enclosed in Cast-iron Cover.

occurs its armature is raised and bridges two contacts, thus short-circuiting the no-voltage coil and causing the switch to be released. In the larger sizes of starters the overload release, in addition to short-circuiting the no-voltage coil, actuates a simple mechanism which forces the switch-arm away from the no-voltage coil, thus assisting the spring in overcoming any slight residual magnetism which may exist in the iron of the magnet. This overload release has yet another function: it prevents the motor from being started up too rapidly by locking the switch arm and preventing it from being moved any further as long as the starting current exceeds a predetermined value. The switch arm is specially designed to withstand the rough treatment to which motor starters are not infrequently exposed. In the larger sizes the arc on breaking is taken up by a carbon block which engages with a "flicker" carbon contact. The largest size has a brass arm fitted with a leaf copper brush moving over solid copper block contacts, and a copper pilot brush to prevent damage by sparking.

All sizes of starters, with the exception of the smallest, are provided with contacts which are renewable from the front; the smallest size has button contacts. The connections between switch contacts and resistance are made with lead-covered copper strand, and no soldered connections are used. The steps of the starter are graduated in such a manner as to give a minimum fluctuation of current when passing from step to step. If the switch is worked properly the current will never exceed twice the load current—that is, twice the current required during the start, irrespective of that required for acceleration.

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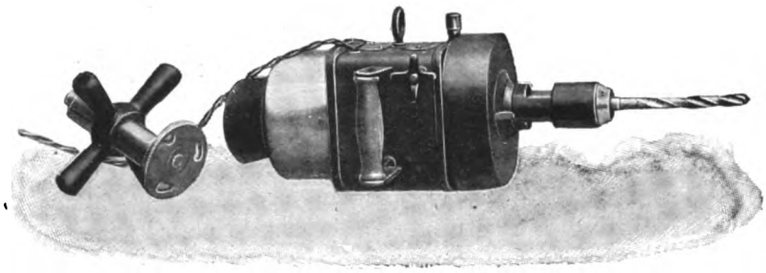
Light Electric Tools.

WE have referred elsewhere in this issue to the show of electric tools being made at the Olympia Engineering and Machinery Exhibition. Among the exhibits of this class, that of S. Wolf & Co., Southwark Street, London, S.E., will be found of interest. This firm makes a speciality, among other machine tools, of light portable electric drills and grinders. The motors of these handy little machines are wound for operation on direct and alternate current circuits, the latter including a line of single-phase machines. These are also built for various pressures up to 500 volts, so that they can be operated for any electricity supply mains. We illustrate an electric drill which is fitted with a three-speed gear and is suitable for drilling, reaming or tapping in any metal. The parts of the motor, gears and controlling switch are all enclosed within a single case, and the gears are interchangeable and may be easily renewed. This is made in four sizes for drilling holes $\frac{9}{16}$ in., $\frac{7}{8}$ in., $1\frac{3}{8}$ in. and 2 in. diameter respectively. The weight of these drills is given by the makers as 22, 35, 65 and 112 lb. for the four respective sizes. The figures of the energy consumption are of interest, being 180 watts for the $\frac{9}{16}$ in. drill, 300 for the $\frac{7}{8}$ in., 650 for the $1\frac{3}{8}$ in., and 1,150 for the 2 in. A useful series of very light drills, known as the "Featherweight," is also being exhibited at the firm's stand. These machines are wound for all classes of circuits and for pressures up to 500 volts. Four sizes are supplied for $\frac{1}{8}$ in., $\frac{3}{16}$ in., $\frac{7}{32}$ in. and $\frac{1}{4}$ in. holes; the approximate weight being 8 lb. for the smallest size and 10 lb. for the others. The energy consumed in each case is 5 watts. The machines are supplied with and without gearing, and have self-centring chuck starting switch and flexible cord.



Portable Electric Drill with Three-speed Gear made for Direct and Alternate-Current Circuits.

Pedestal Type Electric Grinder with Twist Drill Grinding Attachment.

Messrs. Wolf & Co. also specialise in electric sensitive bench drills with movable and fixed tables, and with direct or gear drive. Motor-operated grinders and polishers are being exhibited in addition to the above-mentioned tools. An illustration is given herewith of a special pillar type grinder with tool rest and other fitments. A tool of this description is most useful in a workshop, and its very compactness in dispensing with shafting and belts is one of its strongest recommendations. Grinders for attachment to lathe slide rests, planer beds, &c., are also reckoned among the interesting light electric tools which Messrs. Wolf & Co. are showing at Olympia. Other machines on the same stand are flexible shaft drilling machines for drilling holes in confined spaces, and portable drills mounted on carriage with electric drill for holes up to 4 in. diameter. This latter is fitted with a three-speed gear and is a handy light-pattern tool.

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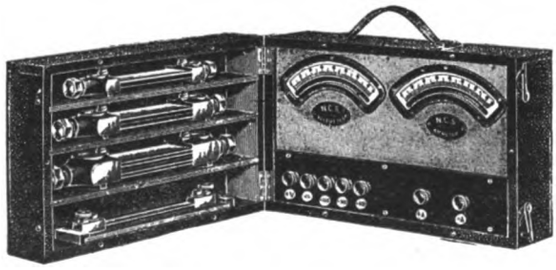

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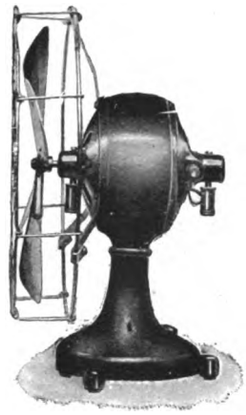

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NOTES.

Atlantic Wireless Telegraphy.

WE are face to face with another attempt to anticipate events in regard to wireless telegraphy. A great deal of space in the Daily Press is being devoted to the subject of transmitting wireless telegraph messages across the Atlantic, and the man in the street is becoming alive to the idea that in precisely so many days' time not only will trans-Atlantic wireless messages be an accomplished fact, but that the rate for such messages will be less than half that hitherto in force for the older method of telegraphing. We are disposed to question, however, whether we are any nearer Mr. MARCONI's entry into the commercial world of telegraphy than was the case when similar claims were made for him three years ago, and when the famous letter S first hurtled through space.

THERE is, however, one aspect of this business which deserves attention. About three years ago the Post Office decided to accept messages from the general public for transmission to ships within certain zones, but the Department carefully guarded itself against responsibility. If the message did not reach its destination no claim could be made on the Post Office, and no guarantee was given that the money paid by the public would be refunded. This action of the Post Office undoubtedly was very acceptable to the Marconi Company, and we think that encouragement by linking up any well-established wireless system is well deserved; but we do not think that the Post Office should have taken up the uncommercial attitude of accepting no risk. Popular opinion does not discriminate in these matters, and if within the next few weeks the Post Office were to announce that they were prepared to accept messages for America to be transmitted by wireless means on terms similar to those adopted on the former occasion, the man in the street would at once conclude that the occupation of the submarine cables to America was gone, and that the telegraph cable companies were doomed to failure. This opinion would be immaterial if it were not that the value of financial securities is affected very easily by statements of this kind, which are echoed with the greatest readiness by the Daily Press. The result, so far, in the present instance has been that the shares in the undertakings of the Atlantic cable companies have fallen in value very considerably, while those of the Marconi Company have risen in value—or, at any rate, are reported to have risen, although we have failed to obtain any confirmation of this report from the Stock Exchange. It is, perhaps, significant that the annual meeting of the Marconi Company will be held in a fortnight's time, and that these great developments in wireless telegraphy are promised by Mr. MARCONI at the end of three weeks.

Coal Costs.

IN a recent issue our contemporary, the *Journal of Gas Lighting*, describes the effect which the threatened increase in the price of coal will have on the works costs, the price of electricity, and the financial returns of the electricity undertakings of this country. As might be expected, the prophetic picture is in somewhat mournful colours. The subject is one, however, which it must have needed a considerable amount of courage on the part of our contemporary to tackle, for it is surely obvious that the gas undertakings will feel the effects of a rise in the price of coal much more severely than their electrical competitors. In fact, the South Metropolitan Gas Co. has already found it necessary to increase the price of gas by 3d. per 1,000 cubic ft., and the Mitcham Gas Co. has followed suit with a rise of 2d., while that great gas undertaking, the Gas Light & Coke Co., which supplies half London, has resorted to the expedient of charging meter rentals. Coal is responsible for only a small proportion of the total costs of electricity supply. As

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typical examples of this fact we might instance Manchester, where the cost per unit for coal is 0·21d. out of a total cost of supply, including capital charges, of 1·62d.—*i.e.*, about one-eighth; and Glasgow, where coal accounts for 0·245d. out of a total of 2·02d.; or, the case of a Metropolitan undertaking, St. Pancras, where the fuel cost is 0·48d. out of a total of 2·2d. Similar proportions to these will be found if the published figures for other electricity undertakings are considered. In the case of the gas undertakings, however, coal plays a much more important part—say, about three-fourths of the manufacturing costs, or more than half of the total costs (including capital charges). It is evident, therefore, that a rise in the price of coal must affect the gas industry considerably more than the electrical, and consequently electrical engineers will gladly allow their gas competitors all the satisfaction they can obtain from such a rise.

THERE are, however, some cases in which the price of coal will have a considerable effect on the cost of electricity supply—namely, where the price per unit has been based principally on running charges—*i.e.*, where it has been assumed that stand-by and capital charges are less important. As an instance in point, we may mention restricted-hour supply, to which we have referred on several occasions recently. In such a case the coal costs would probably account for more than one-half of the total cost of supply, and it would be advisable to insert in any agreement with such consumers for a supply of electricity over a lengthy period a provision whereby the price charged per unit would be controlled by the prevailing price of coal. Serious objection to such an arrangement could not be taken by the consumer, for generally the effect of an increased price of coal would be felt less in the increased price for electrical power than if the consumer had his own power plant. Another case where an increase in the price of coal will be felt will be in the supply of power by the so-called power companies, because in their case the output is large per £ of invested capital. In short, the higher the load factor the greater the effect of a rise in the price of coal, and the more necessary is it to quote prices for electricity supply dependent upon a coal clause. In the case of companies, the coal will only affect dividends, but in the case of municipal undertakings working with only a small margin of profit—and, by the way, most of these undertakings desire to keep this margin small—the profit may be converted into a loss, as pointed out by our contemporary. Even if such evil days should come, it will still be possible to revise prices, as our gas friends are now doing, and such revision will be much less marked than with gas. It is better, however, to work with a larger margin of profit, which may be dissipated in the form of varying discounts, than to have an occasional revision of the tariff or an appeal to the rates.

Gas v. Electricity.

THE *London County Council Gazette* is scarcely a journal in which one would look for statements regarding the relative values of gas and electricity on health, yet on the front page of the current issue we notice an advertisement by the Gas Light & Coke Co. quoting a paragraph from the *Lancet* to the effect that the incandescent electric lamp is wearying to the eyes and gives rise to headache. The natural moral, as pointed out by the Gas Light & Coke Co., is that, if you desire to preserve your eyesight and that of your children, gas light should be adopted. By now, however, we should have thought it was well recognised that the electric light, when properly applied, is the most healthy form of illumination obtainable, and probably it is for this reason that it has been found necessary to go so far back as 1904 for the verdict quoted by the *Lancet*. Most people realise that vivid contrasts must be fatiguing to the eyes, and that if the filament of an electric glow lamp is continually in the field of view the effect on the eyes must be bad. Ignorance on the part of some people nevertheless permits illumination of this kind. These people would not dream of staring at the sun at noon-day, and even if they did so, and suffered the inevitable consequences, they would not forthwith declare that sunlight was a natural evil to be avoided, yet they will look closely at the glowing filament of an incandescent lamp and feel they have a moral grievance as well as optical discomfort. The average gas burner is less in the field of view because it is less adaptable. But undoubtedly electric light, when properly utilised, is far and away preferable, from the point of view of health, to any form of illumination which pollutes the atmosphere, and most of us know by experience that a polluted atmosphere is a ready source of headache.

Municipal Tramways Association.

IT is just possible that during the great boom in electric tramways in this country some few years ago American practice was followed too closely. This, at any rate, is the opinion of Mr. R. L. ACLAND, as will be seen from the Paper which he read this week before the Municipal Tramways Association, a report of whose Convention is given elsewhere in this issue. The opinion has generally been held that 7 ft. was the limiting length of wheel base for a single truck; Mr. ACLAND, however, considers that 8 ft. 6 in. to 10 ft. will ultimately come into favour. One thing, however, is very noticeable about most of the tramcars now in use, and that is the noise and vibration arising whenever the cars are running at anything above the lowest speeds. Most tramway managers are finding their repairs and maintenance accounts very heavy, and will welcome any suggestions for decreasing the same, but we do not think that long rigid wheel bases will offer much improvement in that respect.

Birmingham & District Electric Club.—The opening meeting of this club for the session 1907-8 will take place on Saturday evening next, September 28th, when a smoking concert will be held at which the President (Mr. W. H. Whitehouse) will take the chair.

Cable Interruptions.	Date of Interruption.
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Brest—Dakar	July 22, 1907
Grand Canary—Lanzarote	Sept. 18, 1906
Midway Islands—Guam	Sept. 22, 1907
Fort de France—Paramaribo	Sept. 26, 1907

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Wireless Telegraph Notes.—It is reported that Japan and Russia are arranging for the establishment of wireless connection with Siberia. Japan is connecting Vladivostok and Tsuruga on the west side of the island of Hondo.

Telephones for the Deaf.—The American Consul at Gothenberg reports on a miniature telephone which has been invented by the chief of the Swedish Government Telephone Bureau. It is expected to be of great convenience to employés at telephone stations, and also to persons with defective hearing. In front of the diaphragm of this telephone, the dimensions of which are 0·472 in. and 0·630 in., is screwed a cover with an elongation of hard rubber suitable for inserting into the ear. When in use this receiver is put into the auditory passage of the ear, and the connection consists of a fine cord resting on or behind the ear, in the same way as pencils or eyeglass cords are sometimes carried, and no helmet or extra fixtures are needed. It is suggested that this small telephone may also be very useful to persons with dull hearing, who are usually better able to carry on a telephone conversation than an ordinary one.

Ionic Medication.—In a Paper under this title, read by Prof. Stéphane Leduc, professor of medical physics in the Medical School of Nantes, before the electro-therapeutic section of the British Medical Association at Exeter, the author refers to the fact that the discovery of electricity was due to Dr. Gilbert, an English physician. He then pays a glowing tribute to the pioneer work of English scientists in electro-chemistry, and recalls Priestley's oxidisation of nitrogen by electrical discharge, and the discovery of the decomposability of water by Nicholson and Carlisle. He also mentions the electrolytical investigations of Sir Humphry Davy and Faraday, as well as the latter's researches in magnetism. The author then discusses the methods by which substances in solution can be introduced by electrolytic means into the human body, and the precautions which must be observed in carrying out these operations. He concludes by congratulating the section of electro-therapeutics on their choice of Dr. H. Lewis Jones as president.

British Weights and Measures Association.—The question of the compulsory adoption of the metric system in the British Empire comes up for discussion from time to time, and various societies have been formed to promote its introduction. The system also has its opponents, however, and among them may be mentioned the British Weights and Measures Association, whose objects are to oppose legislation destined to abolish any of the existing fundamental units or to introduce the compulsory use of the metre and its derivatives. The Association seeks to legalise the use of decimal divisions of the existing imperial units and the weight of a cubic inch of water, and to simplify weighing and measuring operations by eliminating useless and standardising useful weights and measures. Some inquiries have been made by the Association as to the working of the metric system in countries where it has been adopted, and we have received from them papers showing the results thus obtained. One of these is a reprint of a circular issued by the French Minister of Commerce, showing that, in spite of the efforts of the inspectors to suppress illegal weights and measures, these are still used, and it is thought that the strict application of the law dealing with this point is no longer possible. The Minister, therefore, appeals to the Chambers of Commerce to use their influence in the suppression of these practices.

"**The Central.**"—We have received the September number of this journal together with a list of members of the Central Technical College Old Students' Association. The editors announce that the use to be made of the Unwin Fund during the coming year has been settled, although, owing to the uncertainty, due to the changes in constitution, connected with the formation of the Imperial College of Science and Technology, no permanent method of perpetuating Prof. Unwin's name has been determined. An Unwin Memorial scholar will, however, be admitted to the college during the present session, and the holder of the scholarship must be a fourth-year student in one of the departments. It is hoped that full particulars of the scheme will shortly be announced, and that old students will continue to send in contributions, as it is felt that another £50 should be raised. The present number contains articles on "The Cyanide Process for the Extraction of Gold and Silver from Their Ores," by Mr. R. Krall; and "Some Notes on the Running of Turbo-Generators," while Mr. T. Mather has compiled some Notes on the research work carried out during the past session in the electrical engineering department. There are the usual number of Old Student Notes, and a plea is made for the development of the social side of the Association. The Paper is got up in excellent style, though we notice that in two places "Behr-Eschenberg" is printed for "Behn-Eschenberg."

Technical Training and Modernised Apprenticeship.—We have received from the Committee on Industrial Education (London), a communication to the following effect:—

There is a tendency just now, thanks to the efforts of this committee and similar bodies, to recognise that greater attention should be paid to what a lad is going to do when he leaves school. In Gloucester, Bootle, Wigan and other centres, and in London, pre-apprenticeship schools are established where lads may be sent at 13 or 14 to receive a course of manual instruction, combined with a deepening of the work of the elementary school course on industrial lines. These efforts are fully appreciated by the parents, traders and other sections of the community. It might be well if in all school districts all over the country such schools were established, where the lads of the small farmers and tradesmen could be taught for a couple of years before being apprenticed, for no school can supersede workshop practice such as an apprentice receives. The parents of such lads would prefer to send their sons to these pre-apprenticeship schools rather than to the small grammar schools in the neighbourhood as the teaching would be on the right lines for the work to follow. The authorities throughout the land might well address themselves to the task of providing such instruction and reduce the number of classes in which fancy instruction is being given. After such a course the young apprentice would come to his work with hand and eye and brain trained to work in unison and more direct interest would be taken in his work to the benefit of all concerned. In a system of modernised apprenticeship for the skilled trades the technical evening classes are a most important feature, but to be of the greatest practical use they should be largely superintended by employers of labour and skilled workmen from the trades represented. It is largely because employers and skilled workmen have not been taken into confidence as much as possible in regard to the conduct of technical classes that they have such a poor attendance in many cases. These classes should also, if possible, be taught by men who come fresh to the work, and not by those who have been teaching all day.

Electrical Laboratories of the University of Pennsylvania.—*The Railway and Engineering Review* gives a detailed description of the new electrical laboratories which have recently been opened by the University of Pennsylvania. There are in all five rooms which are used for practical electrical work. Each of them is amply lighted and all have concrete floors. In every case provision is made so that any one experiment can be carried on independently of any other. The instrument laboratory is very completely equipped for all kinds of measuring work, and so arranged that each group of students has its own switchboard and storage battery. Current is supplied at any voltage between 2 and 160, and any source of current can be connected to the instruments of any group. In this laboratory is a large assortment of apparatus for calibrating and adjusting instruments, for measuring E.M.Fs., capacities, &c., and for testing the magnetic properties of iron. The direct-current dynamo laboratory contains a number of raised concrete foundations of varying sizes. Wooden runners which are laid on these are crossed by iron straps to which the machines under test are bolted. Each bed has a test table quite near, on which are arranged the necessary instruments and rheostats. A switchboard, similar to that mentioned above, allows current at an appropriate voltage to be transmitted to any bed. The alternating-current laboratory is arranged in a similar way. Very complete tests on a variety of machines form an essential part of the course. Two rooms have been specially built for photometrical work. Lumner-Brodhun and Bunsen screens are provided, and there is also a flicker photometer. An adequate number of instruments is assigned for use in this room.

ARRANGEMENTS FOR THE WEEK.

THURSDAY, October 3rd.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

8 *p.m.* Meeting at Caxton Hall, Westminster. Presidential Address by Mr. W. N. Twelvetrees.

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ON THE ELEMENTARY THEORY OF ELECTRIC OSCILLATORS.

BY J. A. FLEMING, D.SC., F.R.S.

In view of modern applications in wireless telegraphy, there are many points in connection with the production of electric waves by electric oscillations in wires which are of great practical interest. The accepted theory has been established by the labours of eminent physicists, but the mathematical analysis, as presented in the writings of Hertz, J. J. Thomson, M. Abraham, Love, H. M. Macdonald, Pearson and others, is undoubtedly a little difficult for students to follow. It seems to the writer that some service may be rendered to workers in connection with electric-wave telegraphy by an endeavour to elucidate the theory of the oscillator for a few of the simple and most practically important forms of open and closed radiating circuit.

There are only a few forms of oscillator which we can easily subject to mathematical discussion with the object of predicting or accounting for their behaviour. The theoretical treatment of the problem of electrical oscillations on a conducting sphere, ellipsoid and, as a limiting case, a rod, has, for example, engaged the attention of several mathematicians. Prof. J. J. Thomson has given ("Recent Researches in Electricity and Magnetism," §308, p. 361) a full discussion of the spherical oscillator, and shown that the natural time period of electrical oscillation of the charge on a conducting sphere of diameter D cms. is given by the expression $T=\frac{2\pi D}{u\sqrt{3}}$, where u is the velocity of radiation. Hence the fundamental wave-length of the emitted radiation is 3·63 times the diameter of the sphere. Also Thomson shows that the logarithmic decrement of the oscillations per complete period is $2\pi/\sqrt{3}=3{\cdot}63$, so that the oscillations are damped out with enormous rapidity. This large decrement is solely due to the fact that such an oscillating sphere is an energetic radiator.* The case of the ellipsoid of revolution has been discussed by M. Abraham (*Annalen der Physik*, 1898, vol. LXVI., p. 435) as a means of arriving at the theory of a thin straight rod oscillator of circular cross-section viewed as a limiting instance of the prolate ellipsoid of revolution.

If l is the length of the thin rod and d is its diameter, and e stands for the function $1/4\ log_e \frac{2l}{d}$, then Abraham shows that the length λ, of the waves emitted by the rod oscillator corresponding to its fundamental oscillation is given by $\lambda=2l(1+5{\cdot}6e^2)$, and the logarithmic decrement of these oscillations per complete period by $\delta=9{\cdot}74e$.

For a wire of the dimensions usually employed as a radiator in wireless telegraphy the ratio of length to diameter would be such as to make the above quantity e of the order of 0.02 to 0·03, or even less, so that λ would by this theory be nearly equal to twice the length of the oscillator, and δ equal to something of the order of 0·25.

An experimental determination of the ratio of the emitted wave length to the length of a Hertzian rod oscillator has been made by J. A. Pollock (see *Journal of Roy. Soc. of New South Wales*, 1903, Vol. XXXVII., p. 198), and he found that the ratio λ/l for such an oscillator lay between 2·3 and 2·45.

In the case of a single-wire plain Marconi antenna, which may be considered to be a semi-Hertzian rod oscillator when in action, the writer has always found that the ratio λ/l approximates to the value 5, which is equivalent to 2·5 for a complete Hertzian rod oscillator. Mr. Macdonald (see *Electric Waves*, p. 3) has proved that for any wire resonator of length l the ratio λ/l for the fundamental oscillation is 2·53, and confirms it by comparing the results of the observations of MM. Sarasin and de la Rive with the dimensions of the resonators given by them. Hence, when we are dealing with the case of the fundamental oscillations set up in a perfectly insulated straight rod of length l large compared with its diameter, d, we may say that both experiment and recent theory show that waves are emitted having a wave-length more nearly 2·5 times than twice the length of the rod. Similarly in the case of a simple, straight vertical wire in which oscillations are set up by means of a spark-gap between its lower end and the earth, the wave-length of the fundamental emitted wave is more nearly five than four times the length of this antenna. In such cases the author's cymometer may be conveniently employed to verify the ratio. Thus at University College the writer erected a single wire antenna 73 ft. high and set up oscillations in it by means of a spark-gap inserted near the earth end. The waves radiated were found to have a length as determined by the cymometer of 360 ft., and $360=73\times4{\cdot}93$.

It need hardly be said that the above rule does not apply if there are any coils or turns in the wire, and a great error would be committed if it were assumed that an antenna having an inductance coil inserted in its length emitted a wave of length equal to five times the total length of wire. The above ratio for λ/l is, however, indicated by theory and confirmed by measurements for the simple single thin wire straight oscillator of the Hertzian type when free fundamental oscillations are excited in it by a spark-gap.

We may then consider the nature of the effects taking place in the space outside such a rod oscillator. If electric oscillations or periodic movements of electricity are taking place on the surface of a conductor, it follows that periodic changes are also taking place in a distribution of magnetic force or flux, and electric force or strain in the space around it. It is found that a space filled with pure air differs so extremely little from the best vacuum we can produce in respect of magnetic permeability and dielectric constant that we are justified in neglecting, at least in laboratory experiments, any effects due to the presence of air, and considering the space around the oscillator to be occupied with the æther or electromagnetic medium only.

This assumption is, however, by no means valid when we are dealing with long electric waves in very large atmospheric spaces, as in trans-oceanic electric wave telegraphy. The actual terrestrial atmosphere, especially that portion facing the sun, is in a state of partial ionisation, and contains positive and negative ions or free electric point charges in large numbers.

Recent researches by A. S. Eve (see *Phil. Mag.*, February, 1907, Vol. XIII., p. 248) on this point are instructive. Using an Ebert apparatus, Boltzmann had found during an Atlantic voyage from Dover to New York that the number of electric ions present in the Atlantic atmosphere was 1,150 positive and 800 negative per cubic centimetre. During a voyage from Montreal to Liverpool Eve found from 600 to 1,400 positive and 500 to 1,000 negative ions per cubic centimetre in the atmosphere, the ratio varying from 1·04 to 1·83. These numbers do not greatly differ from those found over land areas of large continents, such as Germany or Canada. From the data given by Strutt as to the amount of radium in sea water and in various sedimentary and igneous rocks, Eve draws the conclusion that this ionisation cannot be wholly accounted for by radio-activity of the sea or soil. Knowing, however, that ultra-violet light is a cause of ionisation, and perhaps the penetration of the upper layers of the atmosphere by cosmical matter carrying electric charges, we may no doubt assign to these last agencies some share in the atmospheric ionisation. In any case the terrestrial atmosphere, when we are concerned with large volumes of it traversed by light, cannot be considered as equivalent to matter-free æther. Maxwell's theory, therefore, as far as it disregards the effects due to the presence of free electric charges in the medium, starts with certain limitations, which must in practice be subject to correction. Its fundamental postulate is that in a region occupied only by a perfect

* In connection with the problem of determining the wave-length of radiation emitted by electric oscillations on a sphere, it may be remarked that the solution affords an indication that visible light cannot be the result merely of the oscillations of electric charges residing on atoms, if these are assumed to be charges on spherical conductors. For suppose a conducting sphere having a diameter of the order of atomic diameters, viz., 10^{-8} cm., to carry an electric charge which is set in oscillation. Then the wave-length of the emitted radiation would be of the order of $3{\cdot}6\times10^{-8}$. But the wave-length of visible light is from 500 to 1,000 times greater than this length. Hence we cannot assume that light is due merely to the oscillations of electric charges carried on atoms as if they were charged spheres. (Cf. Larmor, *Aether and Matter*, Chap. xiv., p. 225.)

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dielectric—viz., the æther—the state called electric strain or displacement whilst changing constitutes an electric current and produces, therefore, magnetic force. Hence, as in the case of conduction currents, the line integral of magnetic force round an element of area is numerically equal to 4π times the time rate of change of the electric strain or displacement through that area. When dealing with unit area this line integral is called the curl of the magnetic force. In the next place, from Faraday's law of induction, we derive the conclusion that the line integral of electric force round unit area, or the curl of the electric force is numerically equal to the time rate of change of the magnetic flux through that area.

If D stands for electric strain or displacement, and B for magnetic flux normally through unit of area, and E and H are the electric and magnetic forces, and K and μ the dielectric constant and permeability, the above statements are mathematically expressed by the equations,

$$4\pi\frac{dD}{dt} = \text{Curl H}$$

$$-\frac{dB}{dt} = \text{Curl E},$$

Whilst by definition the magnetic flux B and the electric strain D are related to the corresponding forces by the equations $B=\mu H$ and $4\pi D=KE$. The 4π makes its appearance in this last equation because we define the unit electric strain or displacement to be that taking place through the unit of area, rather than the displacement through the whole surface of a sphere of unit radius surrounding a unit of electric quantity, which is the most rational definition of it.

Suppose then that we apply these expressions to the case of a rod oscillator. Let the rod have its centre at the origin

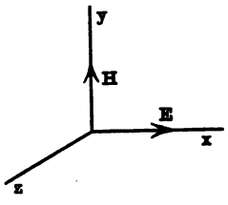

Fig. 1.

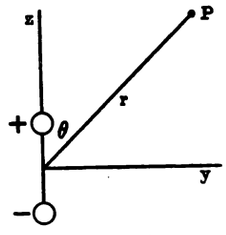

Fig. 2.

of co-ordinates, and let the x axis be in the direction of the rod, and the y and z axes at right angles to it. Then it is plain that at distances large, compared with the length of the oscillator and at points on the z axis, the electric force due to the charges on the rod must be parallel to the axis of x and the magnetic force at that point must be parallel to the axis of y, and also that these forces must decrease as we move away from the origin along the axis of z. (*See* Fig 1.)

Consider the plane of xz. The electric force along x through the origin is E, and at a distance dz, and in the same direction it is $E-\frac{dE}{dz}dz$, whilst x is zero in directions at right angles. Hence for the plane of xz the curl of E is dE/dz. Similarly for the yz plane, the curl of the magnetic force in that plane is $-dH/dz$. The last quantity has the negative sign because in taking the line integralsround the are as $dxdy$ and $dydz$, we must travel in similarly directed directions, and have regard to the fact that the line integral is negative for that part of the journey made against the direction of the force. Accordingly, from the previous equations, we have

$$4\pi\frac{dD}{dt} = K\frac{dE}{dt} = -\frac{dH}{dz} \quad \ldots\ldots (1)$$

$$-\frac{dB}{dt} = -\mu\frac{dH}{dt} = \frac{dE}{dz} \quad \ldots\ldots (2)$$

and by differentiating (1) with respect to t, and (2) with respect to z, and vice versa and equating the results we have

$$\frac{d^2E}{dt^2} = \frac{1}{\mu K}\frac{d^2E}{dz^2} \quad \ldots\ldots (3)$$

$$\frac{d^2H}{dt^2} = \frac{1}{\mu K}\frac{d^2H}{dz^2} \quad \ldots\ldots (4)$$

These equations must be satisfied by any function which can properly represent the variation of E and H along the z axis with time and distance.

If there are oscillations in the rod it is clear that the forces vary periodically, and as a first approximation the amplitude of the oscillations may be taken to vary as a sine function of the time.

If, then, we take such expressions as

$$E = A\sin(pt-qz) \quad \ldots\ldots (5)$$

$$H = B\cos(pt-qz) \quad \ldots\ldots (6)$$

we shall find by actual differentiation that they satisfy the above equations, (3), (4), provided that $p^2/q^2 = 1/\mu K$.

In order that this may be the case we must take $2\pi/T=p$ and $2\pi/\lambda=q$, where T is the periodic time and λ the wavelength, and we then find that E and H can be represented by functions of the form $A\sin\left(\frac{2\pi}{T}t-\frac{2\pi}{\lambda}z\right)$, or $B\cos\left(\frac{2\pi}{T}t-\frac{2\pi}{\lambda}z\right)$, which both satisfy the equations (3), (4), provided that $\frac{1}{\sqrt{\mu K}}=\frac{\lambda}{T}=u$. But these periodic functions of t and z represent wave motions propagated with a velocity, u. For the criterion of a wave motion is that it is repeated cyclically both in space and time, and hence if we consider the state of affairs at any point z, and any time t, we shall find that the same condition is repeated at a time $t+t'$ and at a distance $z+z'$ provided that $z'=ut'$ where u is the velocity of the wave; for we see that

$$\frac{2\pi}{T}(t+t')-\frac{2\pi}{\lambda}(z+z') = \frac{2\pi}{T}t-\frac{2\pi}{\lambda}z,$$

provided that $t'/T-z'/\lambda=0$ or $z'=\frac{\lambda}{T}t'=ut'$.

It is clear, therefore, that the oscillations in the rod set up an undulatory state in the medium in which alternations of electric and magnetic force are repeated at each point and periodically distributed in space and time. The above discussion deals, however, with a limited case—viz., the condition of things along the z axis and at great distances from the oscillator.

We may obtain a more complete solution of the problem for all points in space round the oscillator, provided that we make another reservation. The problem of determining the field at all points round the rod oscillator has been solved, as already observed by M. Abraham, and delineations of that field have been given by F. Hack* for various epochs.

The difficulties of the analysis are, however, enormously increased if we have to consider the case in which the current in the rod varies from point to point at any instant. The matter becomes very simple if we assume the oscillator to consist of a pair of spheres or discs connected by a rod, the discs having such capacity that we may consider the current in the rod to be the same at all points in the rod at the same instant. Such an oscillator is often called a dumb-bell or Hertzian oscillator. The field around can then be calculated when we have determined the electric or scalar potential and the magnetic or vector potential at every point in space.

The scalar and vector potentials are quantities whose space rates of variation in particular ways gives us the electric and magnetic forces. The scalar potential at any point in space is obtained by adding together all the quantities obtained by dividing each element of the electric charge on the body by its distance at the point in question.

In the same way the vector potential is obtained by summing all the quotients of elements of electric current in the body by their distance from that point.

Let us apply this to the case of the dumb-bell oscillator.

Let the oscillator be placed with its rod in the direction of the axis of z. Then it is clear that everything must be symmetrical round this axis, and it will suffice to calculate the field at any point in one plane, say the yz plane (*see* Fig. 2).

* Reproductions of diagrams by F. Hack showing the electric field round a rod oscillator at various epochs are given in Plate 6 at the end of Chapter V. of the author's treatise on "The Principles of Electric Wave Telegraphy" (Longmans).

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Take any point, P, in this plane at a distance, r, from the origin, and let Q be the maximum charge on each end or ball of the oscillator in electrostatic units and C the capacity of these balls with respect to each other. Also, let V be their maximum P.D. Let I be the maximum current flowing in the connecting rod, and let it be the same at all points of the rod at the same instant. Let N be the frequency of the oscillations or T the periodic time, and $n = 2\pi N = 2\pi/T$. Also let λ be the wave-length, and let $m = 2\pi/\lambda$. Let δz denote the length of the oscillator. If, then, the charges on the oscillator balls were constant, the potential at P due to a charge $+Q$ at the origin would be Q/r. But since the + and − charges are varying in accordance with a sine function of the time, and since the electrical effect takes time to be propagated through space, the potential at P at any time due to a charge at the origin whose value at that instant is $Q \sin nt$ is $\frac{Q \sin (mr - nt)}{r}$. We have, however, to consider that the charges at the ends of the oscillator at any instant are of opposite sign, and are separated by a distance δz. If any function has a value F, corresponding to an abscissa z; then for an abscissa $z + \delta z$, it has a value $F + \frac{dF}{dz}\delta z$. It is easy, therefore, to see that the scalar potential at the point P, due to the positive and negative charges on the ends of the oscillator at any instant, has a value at any time t, and distance r, given by $-\frac{d}{dz}\left(\frac{\sin (mr - nt)}{r}\right) Q\delta z$.

The product $Q\delta z$ is called the maximum *electric moment* of the oscillator and we shall denote it by ϕ. Also the quantity $\sin (mr - nt)/r$ will be denoted by Π. Hence if ψ denotes this scalar potential at P, due to the oscillating charges, we have

$$\psi = -\phi \frac{d\Pi}{dz}.$$

In the next place we have to consider the vector potential. If i is the current, reckoned in electromagnetic units, in an element of length dz of a circuit, then the vector potential at a point at a distance r is parallel to the elements and has a value $i\delta z/r$.

In the case of this oscillator, the current varies as a sine function of the time, and has its maximum value when the electric charges at the ends have zero value and vice versa. Hence if I is the maximum value of the current, we have $I = cVn/u = Qn/u$ and $I\delta z = \phi n/u$. The symbol u stands for the velocity of radiation, and therefore the ratio of the electromagnetic unit of current to the electrostatic unit. Accordingly the component H of the vector potential parallel to the z-axis, due to the current in the oscillator at any point P, is $\frac{\phi}{u}\frac{\cos (mr - nt)}{r} = \frac{\phi}{u}\frac{d\Pi}{dt}$.

The components F and G—parallel to the x and y axes—are zero. We find, then, for the scalar and vector potentials of the oscillator in question at any point P at any time,

$$\psi = -\phi \frac{d\Pi}{dz} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$H = A\phi \frac{d\Pi}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where A is written for $1/u$.

Now, Maxwell showed that if F, G and H are the axial components of the vector potential, and ψ is the scalar potential, the axial components of the electric force (P, Q, R) and of the magnetic force (a, b, c) are given by the equations

$$\left.\begin{aligned} P &= -\frac{dF}{dt} - \frac{d\psi}{dx} \\ Q &= -\frac{dG}{dt} - \frac{d\psi}{dy} \\ R &= -\frac{dH}{dt} - \frac{d\psi}{dz} \end{aligned}\right\} \quad . \quad . \quad (7) \qquad \left.\begin{aligned} a &= \frac{dH}{dy} - \frac{dG}{dz} \\ b &= \frac{dF}{dz} - \frac{dH}{dx} \\ c &= \frac{dG}{dx} - \frac{dF}{dy} \end{aligned}\right\} \quad . \quad . \quad (8)$$

Hence we have the means of finding the electric force and magnetic force at all points.

If then we submit the equations (5) and (6) to the operations defined by (7) and (8) we arrive easily at the following values for the components of the electric and magnetic forces at points around the oscillator.

$$\left.\begin{aligned} P &= \phi \frac{d^2\Pi}{dxdz} \\ Q &= \phi \frac{d^2\Pi}{dydz} \\ R &= -\phi\left(\frac{d^2\Pi}{dx^2} + \frac{d^2\Pi}{dy^2}\right) \end{aligned}\right\} \quad . \quad (9) \qquad \left.\begin{aligned} a &= A\phi \frac{d^2\Pi}{dydt} \\ b &= -A\phi \frac{d^2\Pi}{dxdt} \\ c &= 0 \end{aligned}\right\} \quad . \quad (10)$$

We may leave to the reader the task of forming the various differential coefficients of $\Pi = \sin (mr - nt)/r$, and simply confine ourselves to giving the values for the plane of yz, which are identical with the values for every plane passing through the axis of the oscillator. For brevity write χ for $(mr - nt)$ and $\sin\theta$ for y/r and $\cos\theta$ for $2/r$. Then we have

$$R = \frac{\phi}{r^3}\{(2\sin\chi - 2mr\cos\chi) + \sin^2\theta(m^2r^2\sin\chi + 3mr\cos\chi - 3\sin\chi)\}$$

$$Q = \frac{\phi}{r^3}\{3\sin\chi - m^2r^2\sin\chi - 3mr\cos\chi\}\ \sin\theta\cos\theta$$

$$a = \frac{A\phi n}{r^2}\{mr\sin\chi + \cos\chi\}\ \sin\theta$$

These equations show that the magnetic force is distributed in circles round the oscillator, having their centres on the axis of z.

At points not very near the oscillator, for which mr is a quantity large compared with unity, the above equations reduce to,

$$\left.\begin{aligned} R &= \frac{\phi m^2}{r}\sin\chi\sin^2\theta \\ Q &= -\frac{\phi m^2}{r}\sin\chi\sin\theta\cos\theta \\ a &= \frac{A\phi mn}{r}\sin\chi\sin\theta \end{aligned}\right\} \quad . \quad . \quad . \quad (11)$$

These last equations are identical with those given by Hertz in his solution of the problem. They show that at large distances both the forces vary inversely as the distance from the oscillator, a fact which has been approximately confirmed by experiments by Messrs. Taylor and Duddell.

To obtain the equations for the lines of electric force we note that these lines have the same form in every meridional plane passing through the axis of z. It is, therefore, convenient to substitute for the components P, Q and R two components, viz.—R along the z axis and $S = \sqrt{P^2 + Q^2}$ along the direction of a vector, $\rho = \sqrt{x^2 + y^2}$, perpendicular to the axis of z. It is then quite easy by differentiation to show that

$$\frac{d^2\Pi}{dx^2} + \frac{d^2\Pi}{dy^2} = \frac{1}{\rho}\frac{d}{d\rho}\left(\rho\frac{d\Pi}{d\rho}\right)$$

and hence we have

$$R = -\frac{\phi}{\rho}\frac{d}{d\rho}\left(\rho\frac{d\Pi}{d\rho}\right) \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Again, since $S = P\frac{dx}{d\rho} + Q\frac{dy}{d\rho}$

and $P = \phi\frac{d^2\Pi}{dxdz} \qquad Q = \phi\frac{d^2\Pi}{dydz}$

it follows that

$$S = \frac{\phi}{\rho}\frac{d}{dz}\left(\rho\frac{d\Pi}{d\rho}\right) \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Now, the equation to a line of force in the plane of ρ and z is $Rd\rho - Sdz = 0$. For this is the mathematical expression of the fact that the resultant force is directed along the line of force.

Substituting, then, in this last equation the values of R and S from equations (12) and (13), we have

$$\frac{d}{d\rho}\left(\rho\frac{d\Pi}{d\rho}\right)d\rho + \frac{d}{dz}\left(\rho\frac{d\Pi}{d\rho}\right)dz = 0$$

and integrating we have $\rho\frac{d\Pi}{d\rho} = \text{Constant} = c$.

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Accordingly this last is the equation to a line of electric force in any meridional plane of the oscillator. In the plane of yz we have $\rho = y$, and hence $y\frac{d\Pi}{dy} = c$ is the equation for that plane.

But $\Pi = \frac{\sin(mr-nt)}{r}$ and $\frac{d\Pi}{dy} = \frac{mr\cos(mr-nt) - \sin(mr-nt)}{r^3}y$

Therefore, finally, we have for the equation of the lines of electric force the expression

$$\cos(mr-nt) - \frac{\sin(mr-nt)}{mr} = \frac{c}{m\sin^2\theta} \quad . \quad . \quad . \quad (14)$$

We can give to t any required value and thus determine a family of curves for a given epoch. This we can do by assigning certain values to the constant c and also to $m = 2\pi/\lambda$ and to θ and then determining the corresponding value of r. This is best achieved by plotting a graph of the function $\left(\cos mr - \frac{\sin mr}{mr}\right) = f$. Suppose we give to r various values in terms of λ, then it is easily seen that for large values of mr, that is, when r is many times λ, the part $\sin mr/mr$ becomes negligible in comparison with $\cos mr$.

If we construct a curve representing the function $\cos mr - \frac{\sin mr}{mr} = f$, we find that it is a periodic curve which after the first two or three periods becomes a simple cosine curve. The ordinates of the curve are the values of $c/m\sin^2\theta$, and the abscissæ are the corresponding multiple values of r.

Hence for all points beyond a wave-length or two from the oscillator we may say that the equations to the lines of electric force are given by the very simple expression,

$$\cos(mr-nt) = c/m\sin^2\theta,$$

and it suffices to give various values to t and to θ to determine a series of values of r, which are the distances along the radius vector at which the curves of electric force cut it. Accordingly, for any particular value of θ there are multiple-pairs of values of r.

Thus we select any desired values of θ and m and such a value for c that $f = c/m\sin^2\theta$ is not greater than unity for the least value of θ chosen. We then select any other larger values of θ and find the corresponding values of r from a curve drawn for the function $\cos(mr-nt) - \frac{\sin(mr-nt)}{mr}$ as above.

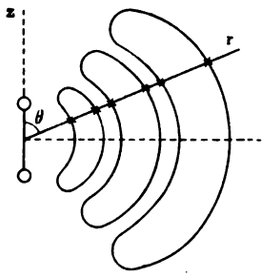

FIG. 3.

This process gives us a set of pairs of points on the radius vector r drawn at an angle θ to the z-axis through which the lines of electric force will pass. In this manner we may find a number of points delineating sets of curves which were drawn first by Hertz, and subsequently by Prof. Pearson and Miss Lee for the field of a dumb-bell oscillator.

These curves at points not very near the oscillator take the form of closed loops bent towards the oscillator and becoming larger as we proceed away from it. (See Fig. 3.)

(To be continued.)

THE ELECTRICAL EQUIPMENT OF THE SS. "MAURETANIA."

Summary.—The equipment of the ss. "Mauretania," the latest addition to the fleet of the Cunard Co., is an excellent example of the varied uses to which electrical power can be put on a modern liner. In this issue the system of power distribution, electrical generating plant, fans, motors for dismantling the turbines, cranes, lifts, &c., are described, whilst in our next issue we hope to describe the lighting, refrigerating plant, the telephone installation and the means adopted for measuring the power of the turbines.

Nowhere is the flexibility, safety and general convenience of electricity as a motive power shown to such advantage as on a modern liner, and the extension of its use for this purpose has proceeded with a rapidity surprising even in an industry of such mushroom growth as the electrical one. It was, therefore, to be expected that the ss. "Mauretania," which is the last word in present-day shipbuilding, would possess some interesting and remarkable features in connection with its electrical equipment, and we are not deceived in this supposition. From the first it had been intended that everything within reason should be accomplished by electricity, and that this has been well carried out will be evident from the following description. So extensive, indeed, is the electrical plant that in any mention of the boat itself the remarkable size of this plant is almost invariably alluded to—a justifiable allusion when it is stated that the generating plant is considerably larger than that in the generating stations of many a small town.

Distribution.—At sea, safety is above all things essential, so that, in the choice of a system of distribution, but little scope is allowable, direct current at low voltage alone being possible—naturally expensive and uneconomical owing to the heavy cables necessitated, but quite unalterable under the circumstances. In the "Mauretania" the voltage is 115, allowing a 5 volt drop to the motors and lamps, which all work at 110 volts. The almost perfect balance of load on the port and starboard sides of a ship allows what is practically a duplicate system of wiring to be adopted, without materially increasing the cost of cables required, yet securing complete immunity from any serious breakdown. The generating sets, of which there are four, are placed in two rooms separated by a water-tight bulkhead, and each room, containing two sets, has its own switchboard quite independent of the other, but capable, by means of a connecting bar and switch, of being joined up in parallel. From these two rooms, which are port and starboard, the cables are led all over the boat, those supplying power to the starboard side from the starboard generating room and those to the port side from the port generating room. The port and starboard sides of the ship are thus completely isolated from each other, and any mishap to the one leaves the other unaffected. The main cables on leaving the generating rooms go direct to their various distribution boards (some 10 or 11 on each side), and each of these boards is connected by a heavy cable through a switch to the corresponding board on the other side of the boat. In the event, then, of a breakdown on the machines or in the cables any of the distribution boxes can be cross-connected and take power from the other side. Indeed, one might safely say that the boat would have to be on the point of sinking before the supply failed—so complete is the system of duplication and isolation. As might be expected, the cables are of large dimensions, the maximum current being 15,000 amperes. They are laid as far as possible on the side of the ship and carried between porcelain insulators, the positive cables on one frame and the negative on another. In passing through water-tight bulkheads, each cable is fitted in a gland, being insulated from the gland by fibre packing.

The two switchboards are quite similar, and each consists of three vertical panels, the two outsides being generator panels and the inside a feeder panel. There is also a horizontal division of the board, the top being negative and the bottom positive. The arrangement is, of course, extremely simple owing to the very elementary system adopted, the generator panel being fitted only with a circuit-breaker, field ammeter

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and voltmeter. It will be noticed, however, by the diagram in Fig. 1, that each of the generators is connected to a maximum reverse-current and time-limit relay, while each feeder has a maximum-current time-limit relay. These, of course, can be set to any required overload up to 25 per cent. and to any required time up to 15 seconds.

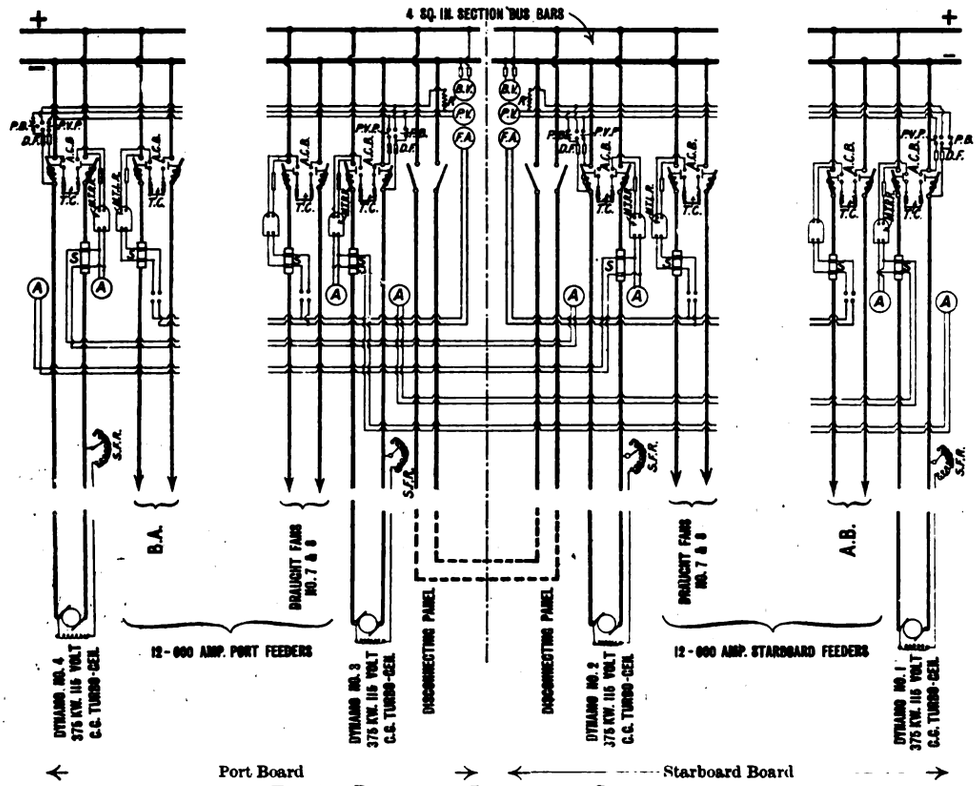
4 SQ. IN. SECTION BUS BARS
B.A.
A.B.
12-000 AMP. PORT FEEDERS
12-000 AMP. STARBOARD FEEDERS
DRAUGHT FANS NO. 7 & 8
DRAUGHT FANS NO. 7 & 8
DISCONNECTING PANEL
DISCONNECTING PANEL
DYNAMO NO. 4 375 KW. 115 VOLT C.C. TURBO-GEN.
DYNAMO NO. 3 375 KW. 115 VOLT C.C. TURBO-GEN.
DYNAMO NO. 2 375 KW. 115 VOLT C.C. TURBO-GEN.
DYNAMO NO. 1 375 KW. 115 VOLT C.C. TURBO-GEN.
Port Board
Starboard Board

FIG. 1.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

A Ammeter. FA Feeder ammeter. BV 'bus bar voltmeter. PVP Paralleling voltmeter plugs. MTRR Maximum time-limit and reverse-current relay. MTLR Maximum time-limit relay. S Shunt. SFR Shunt field regulator. ACB Automati ccircuit-breaker. DF Damper fuse. TC Trip coils. R Resistance in series with voltmeter. PB Push button for short-circuiting voltmeter resistance.

Each of the main feeders is isolated on the board, being joined on to the 'bus bars through positive and negative switches of a particularly substantial type, both switches being connected to the automatic time-limit cut-out mentioned above, so that the possibility of a disastrous overload is small. Besides this time-limit relay, which is practically a Ferranti clock meter in principle and is a shunt instrument, each switch can also be thrown out by a series trip coil, which, however, would only come into play with a much heavier load.

The generator switches are also very strongly made and are operated by long handles connected by a system of levers at the back of the board, the switches themselves being at the top and well clear of the attendant. The break and make of all the switches is taken by renewable carbon contacts so that no severe arcing across can take place between the copper surfaces.

The paralleling of two machines is rendered very simple by an ingenious arrangement. On running up a generator to be paralleled with one already on load, the main positive switch is closed, which completes the paralleling voltmeter circuit, this voltmeter then giving the reading between the negative 'bus bar and the machine side of the negative switch—*i.e.*, the difference in voltage of the two machines. As the incoming generator excites, this voltage gradually reduces and finally becomes zero, a very accurate adjustment being obtained by a small push plug which short-circuits the voltmeter resistance, the whole range of the voltmeter then being from zero to 12 volts. When the pointer is exactly at zero the two generators are at the same voltage, the negative switch is closed and the machines are in parallel.

Another somewhat novel idea in an installation of this kind is the arrangement for determining the current in any one of the feeder circuits by the use of a single ammeter. Each feeder passes through a shunt whose ends are connected to two small sockets in the middle of the panel. By means of a four-fanged plug these two sockets can be joined up to two others, coupled to the feeder ammeter and rendered common to the whole board by two small copper bars running its entire length. This arrangement is more important and necessary than might appear at first sight, since it will enable a reliable check to be kept on the current used in all the circuits, and affords a means of ascertaining if the boilers are being efficiently stoked, since the power required for the forced-draught fans in any of the boiler rooms can be continually noted.

The boards, which were manufactured by Messrs. Ferranti Limited, are of a more handsome design than one usually associates with ship construction.

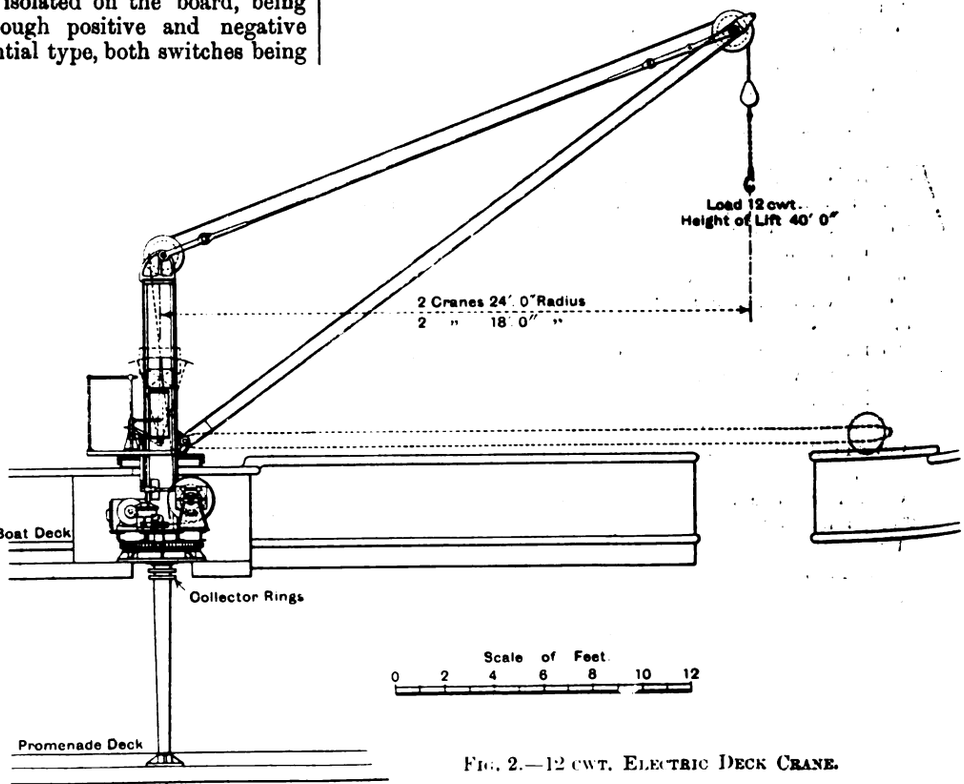

FIG. 2.—12 CWT. ELECTRIC DECK CRANE.

Generating Plant.—The Cunard Company have been con-

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sistent in their adoption of the turbine principle, for not only is the ship propelled by turbines, but the electric power is obtained from four turbo-generators. These have been manufactured by Messrs. C. A. Parsons & Co, and vary in some points from the ordinary type built by that firm. They have a normal output of 375 kw. each, but, like all turbine machinery, are capable of large overloads for extended periods. The full power has to be developed, moreover, with a back pressure of 5 lb. above atmosphere, since the exhaust steam is used in the feed heater, so that it is obvious that nearly double this power could be obtained when working on a good vacuum. Auxiliary condensers are installed for use when the machines are running condensing. Owing to the necessity of avoiding gyroscopic action, the speed of the turbines had to be kept down to 1,200 revs. per min., which is, of course, very much slower than usual for turbos of this power. The dynamos present some interesting points in design owing to the extremely heavy current developed (nearly 4,000 amperes) and the restricted length and diameter of the commutator. By the use of a wide air gap, with a correspondingly strong field, and the usual Parsons compensating winding, however, the generators have been made to run quite sparklessly and without any large rise of temperature The commutators are cooled by a ventilating trough (a branch from the main ventilator of the generating rooms), the mouth of which is brought under the deck directly beneath the commutator.

Forced Draught Motor-driven Fans.—It is, perhaps, somewhat surprising that the chief call for power (and the most constant one) comes from the fans for producing a forced draught in the furnace of the boilers, on the Howden principle. The arrangement is as follows: There are four sets of boilers (25 in all), each set, or stokehold, being isolated by watertight bulkheads. For each stokehold there are two fan rooms directly over the boilers they operate, being well ventilated by a 5 H.P. series motor. The system of ventilation, here as

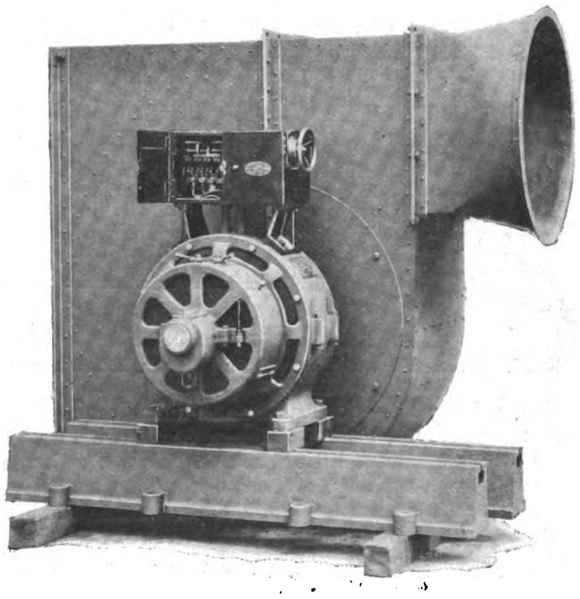

FIG. 3.—SEMI-ENCLOSED MOTOR DRIVING 35IN. FAN.

throughout, consists of an air duct right round the room with gratings at intervals fitted with movable shutters. In each fan room there are two absolutely separate fan motors (port and starboard), independently wired as usual, each motor driving two fans, the leads for the ventilating motor being tapped off the main fan leads, on alternate sides of the room in alternate rooms. The fans take the air directly from the top of the boilers, so that it is already heated before being delivered into the furnace. These fans, by W. H. Allen, Son & Co., are illustrated in Fig. 4. The motors are shunt wound, capable of giving 50 H.P. at full speed (450 revs. per min.), and are totally enclosed, but ventilated in an ingenious manner by a small fan on the same shaft and

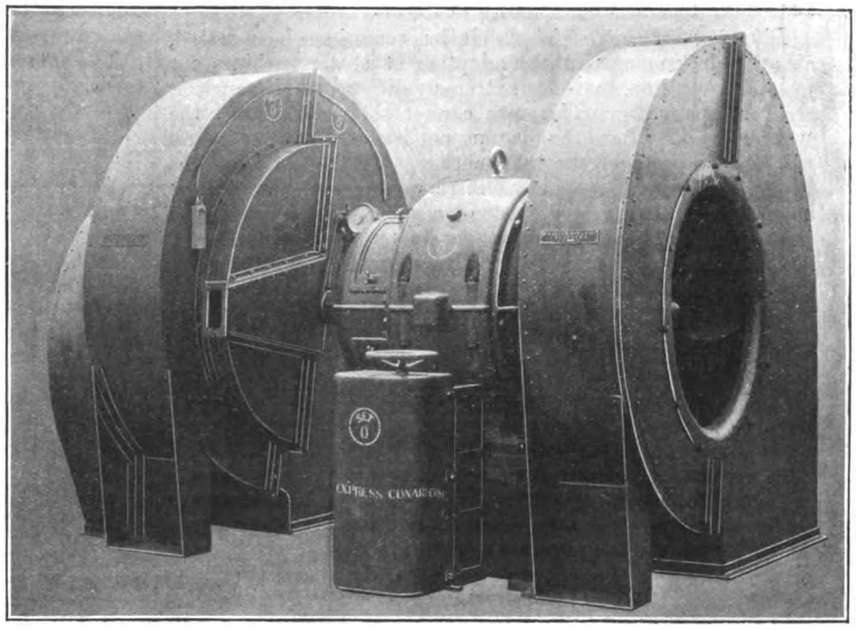

FIG. 4.—MOTOR-DRIVEN FORCED DRAUGHT FANS.

connected to the motor by an air duct. The motors thus run very cool and are protected from dust and dirt and in every way are placed under ideal conditions; they will undoubtedly give the highest satisfaction, and it is to be hoped that their success will cause the Admiralty to reconsider their decision to revert to the use of steam-driven fans, the failure of motor-driven fans on battleships being undoubtedly due to carelessness in choosing their position. Obviously it is folly to suspend a motor in an atmosphere of coal-dust and a temperature of 120°F. and expect efficient results, yet this has been done on more than one battleship. The motors are controlled from the stokehold by levers, which mechanically operate the controller handle in the fan room. The fans are designed to give the normal draught ($2\frac{1}{2}$ in. of water) at considerably less than full speed, so that in the ordinary way a resistance will be in circuit. A very fine adjustment of the speed is thus possible and ample margin is left for high steaming in case of necessity, the fans at full speed giving nearly $3\frac{1}{2}$ in. of water draught. There are in all 16 motors with a maximum load of 800 H.P., but, naturally, under normal conditions, nothing like this power will be required, 400 H.P. being a more probable figure, it being absolutely essential to have a very large reserve.

Ventilation.—The system of cooling and heating the saloons and berths is an original and effective one, in which electricity plays again an important part. At various points on the ship, and notably on the top deck, are placed a number of thermo tanks, some 60 in all. Each of these tanks contains many tubes, around which is a large air space, from which air ducts are led to the cabins, saloons, &c. In the air space is a motor-driven fan, which forces the air around the tubes into the distributing trough. When it is required to heat the ship live steam is passed into the tubes, heating the air all around, so that warm air is delivered; for cooling, the steam is shut off and a supply of fresh air is allowed to enter the tank, and this is likewise carried by the fan to its destination. The object of having so many tanks on the top deck is obvious, since the rooms can thus be filled with absolutely the purest air possible. The motors vary in size with the dimensions of the tanks, averaging from 3 H.P. to 8 H.P., and are shunt wound, capable of speed adjustment, so that practically any desired tempera-

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ture can be maintained in the rooms. For the ventilation of the engine room, all auxiliary machinery rooms and various other parts of the boat, motor-driven fans are used, which draw cool air down the ventilating shaft and distribute it through gratings with movable shutters around the various rooms. The motors for this purpose are shunt wound and from 5 H.P. to 10 H.P. A view of one of the ventilating motors, by Laurence, Scott & Co., is shown in Fig. 3.

Lifting and Turning Motors.—It has sometimes been stated, as an objection against the adoption of steam turbines for marine propulsion, that it is extremely difficult to dismantle at sea for repairs, &c. This plea cannot be urged against the "Mauretania," where the opening out is a matter of comparative ease in spite of the mammoth size of the turbines, the lifting gear being operated by electric motors with the greatest smoothness. This gear consists of a substantial metal sheath at each end of the turbine, working in two vertical guides of circular section, and capable of being coupled to the lifting bar by a pin joint. The vertical lifting bar, which is screwed for the greater part of its length, gears into the interior of a spur wheel of large dimensions supported in a footstep bearing on girders some 12 ft. above the turbine. The exterior of the wheel meshes with a worm on the motor-driven shaft, which runs the whole length of the machine and operates both ends simultaneously.

On starting the motor the sheaths at each end rise, carrying the cover with them, owing to the large projection cast on. When it has risen to a sufficient height the cover is supported by six steel stanchions with spigots fitting in the bolt holes; the sheaths are then lowered and bolted on to the corresponding half-sheaths underneath the projecting shaft of the motor, the two thus forming a tight-fitting bearing on the shaft. The gear is once more raised and the spindle hoisted right up into the cover, since there can be no longitudinal movement whatever. The whole gear works smoothly and rapidly, hoisting at about the rate of 2½ in. per minute.

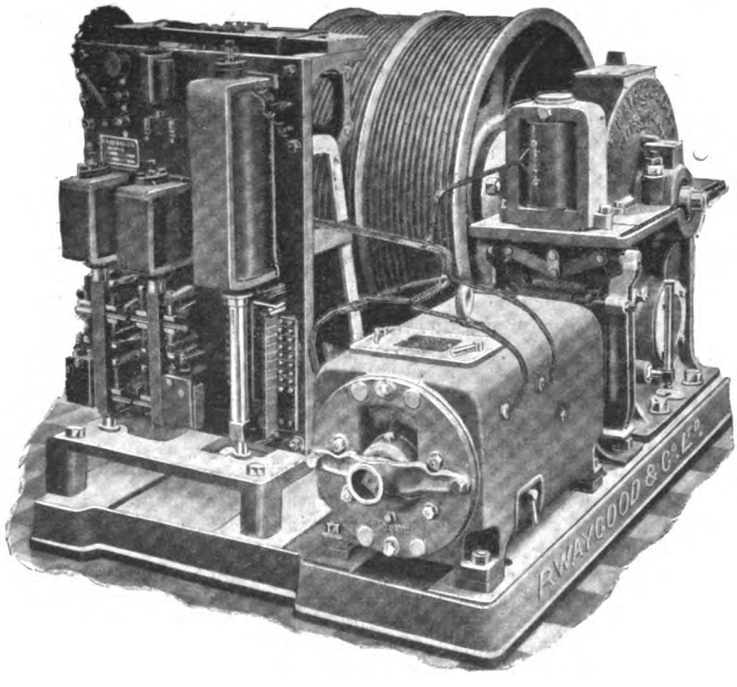

FIG. 5.—LIFT MOTOR AND GEAR, BY MESSRS. R. WAYGOOD & CO.

For various purposes it is necessary to have a means of turning the motor without putting steam in the cylinders—for coupling up the shafting, examining the journals and thrust block, &c., and to accomplish this a large spur-wheel is fixed on each shaft just in front of the first coupling, and driven through very largely reduced gearing by motors similar to those used for lifting.

These motors, as well as several more, used for driving ventilating fans, are manufactured by the Lancashire Motor & Dynamo Co., and possess some advantages which make them very suitable for ship work where conditions are so unfavourable. Many of them have to be run in a very heated atmosphere, and hence the fan blades, which are fitted on all the armatures, will be of great value in ensuring cool working, the small blades forcing air right through the spider and up the ventilating spaces. The armatures, moreover, are built up on sleeves which are forced on the shafts by pressure, and hence the removal of the armature can be effected without disturbing the gear to which the shaft is coupled.

The motors are compound wound and operated by controllers of the tramway type, allowing a fair variation of speed.

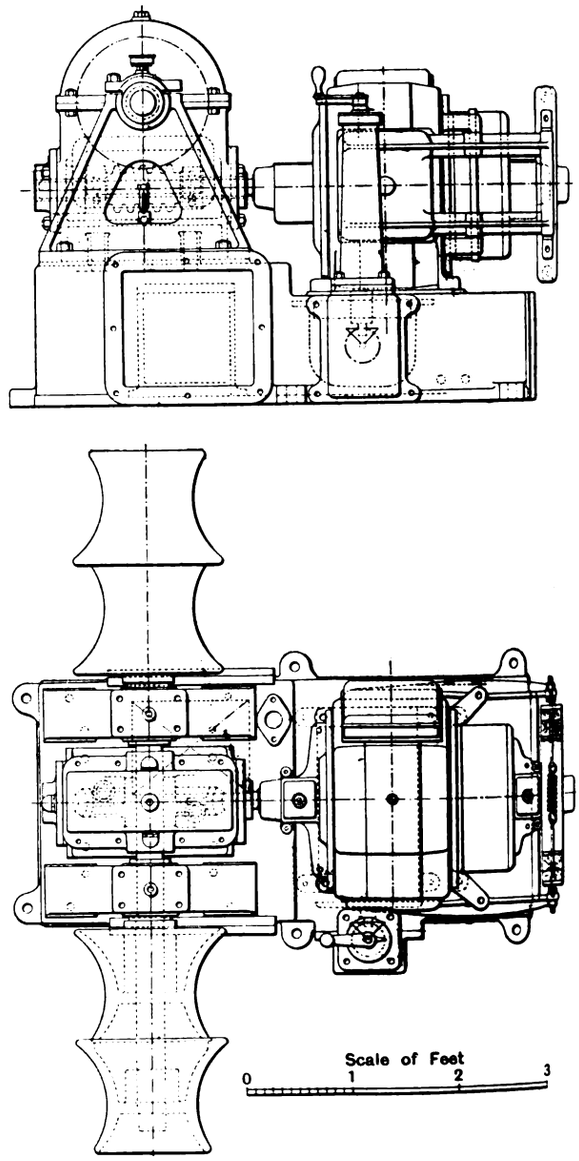

FIG. 6.—ELECTRIC BOAT HOIST, TO LIFT 12 CWT. 250 FEET PER MIN.

Cranes, Lifts, &c.—For loading and unloading baggage, &c., four electric cranes, made by Messrs. Stothert & Pitt, are provided, each capable of lifting 12 cwt. They are designed to work with great rapidity. When hoisting they travel at 200 ft. per minute, when turning at 300 ft. per minute, the lift being 40 ft., and the swinging radius 24 ft. for two of the cranes and 18 ft. for the other two. Details of these are shown in Fig. 2.

Electric lifts and hoists are, of course, used, operated on the press-button relay principle—a type now becoming very popular in hotels on account of its simplicity and reliability.

The lifts and hoists are chiefly remarkable for the great precautions adopted to ensure absolute safety. For instance, with the passenger lifts the electromechanical brake automatically comes into play directly the current is switched off, and drops off when the current comes on. The operating handle (the passenger lifts are not of the press-button type) is fitted with

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a spring so that if it is released by the attendant it automatically flys back to its original position and cuts off the current. Even if it is held on too long another automatic switch attached to the drum shaft comes into play and stops the car at the top or bottom. Should the car be accidently stopped and the cable become slack, the current is again cut off and the brakes applied. The entrance doors to the lifts are fitted with electric locks arranged so that they cannot be opened except when the lift is opposite to them and the car moreover cannot leave until the doors are closed. An illustration of Waygood & Co.'s lift motor and gear appears in Fig. 5

The motor-driven winches present no particular points of interest, except for their neat and compact appearance compared with the old steam-driven type.

The electric boat hoists, which are somewhat original in construction and necessitated considerable care in design, were manufactured by Messrs. Laurence, Scott & Co. They are to lift 20 cwt. at a speed of 250 ft. per minute, and as this pull has to be distributed over four ropes two warping drums are provided on each side. The gear consists of a forged steel worm carried on the extension of the armature shaft gearing into another wheel with a machined gunmetal rim mounted on the slow speed shaft, as shown in Fig. 6.

The motor is 14 H.P. at 600 revs. strongly constructed and made watertight. It is series wound in order to adapt its speed to various loads, and is fitted with a patent flapper brake to prevent excessive speed. This brake depends for its action on the field of the motor itself, part of the metal round the root of the pole being cut away so that most of the flux has to pass through steel plates or flappers connected to the brake blocks by pivot arms. The flappers thus experience a pull (tending to close them on the side of the motor frame) which varies with the strength of the field—*i.e.*, the load. The brakes are right off with ordinary work, and come into action gradually and prevent high speed when running light.

The armature is built up independent of the main shaft and is secured by a long feather key, so that it may be withdrawn without disturbing the gear, forming a very compact arrangement. The controller is of the tramway type, and is placed under the motor, being operated by a handle beside the hoist through bevel gear.

Sluice Valve Motors.—All the sluice valves are naturally electrically operated, the only complication arising from the necessity of provision for manœuvring the boat. The astern and low-pressure turbines all exhaust straight into the condenser, but the high-pressure turbines may either deliver steam straight to the low-pressure turbos or to the condenser for manœuvring purposes, so that two valves for each are necessary. These are actuated by 15 H.P. motors, in each case geared down, but closing the valves fairly rapidly. They are enclosed vertical motors operated by levers from the engine room, being themselves well above the turbines in a cool and open position.

(To be concluded.)

BROWN BOVERI TURBO-ALTERNATORS AND TURBO-DYNAMOS.

(*Concluded from page 907.*)

Turbo-Dynamos.—The building of turbo-dynamos, especially when they are of large size, presents very considerable difficulties to the constructor, for not only are the mechanical difficulties considerably greater than is the case with turbo-alternators, but the question of successful commutation at high speeds largely enters into the problem. Messrs. Brown, Boveri & Co. is the only firm which has turbo-dynamos of over 1,000 kw. individual output in successful operation, and the building of these larger turbo-dynamo units is, nowadays, one of their leading specialities, over 80,000 kw. having been delivered, or taken on order, to date.

Quite a special type of dynamo has been evolved by this firm and standardised in all sizes from 100 kw. to 1,800 kw. individual output. As far as the general construction and the system of ventilation are concerned, the type generally resembles the turbo-alternators already described, inasmuch as these dynamos are totally enclosed (apart from the commutator) and are provided with forced ventilation generally similar to that described above. The field system, too, is practically smooth all round (it having no polar projections), although, of course, in this case the field system is stationary; moreover, these direct-current machines (just as is the case

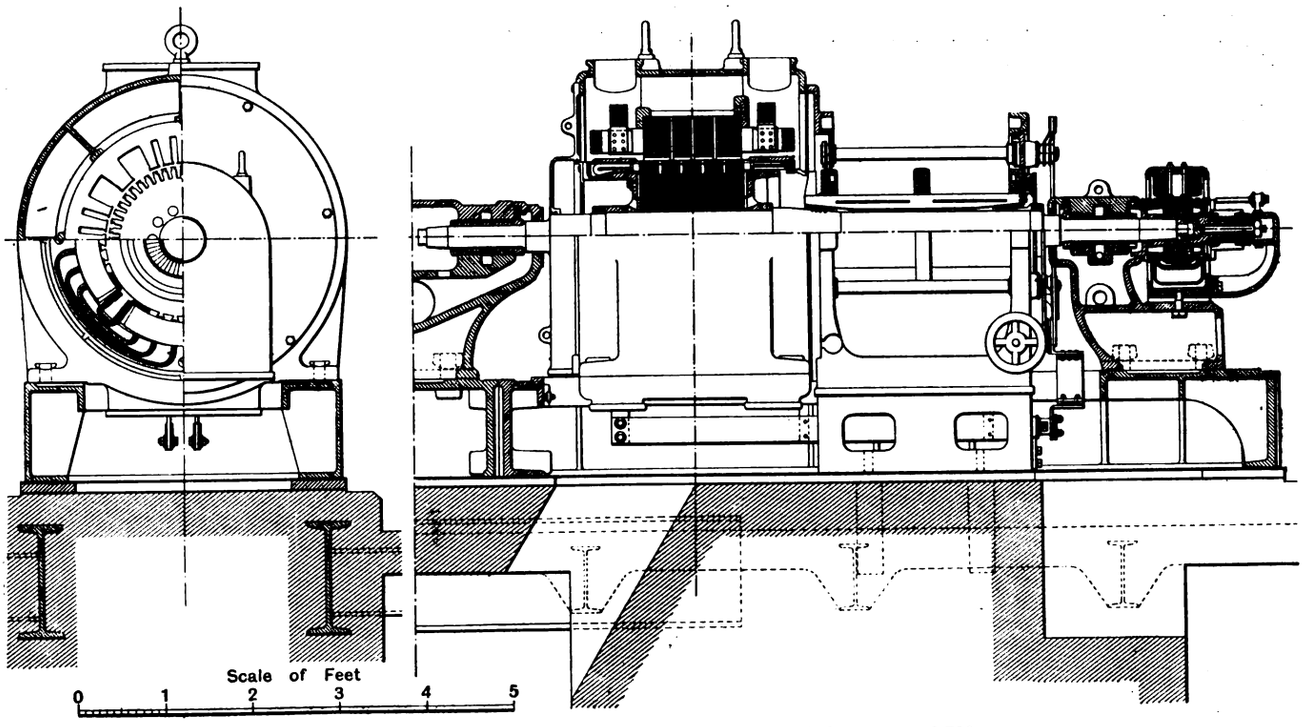

FIG. 6.—GENERAL ARRANGEMENT OF A TURBO-DYNAMO OF 250 KW., 150 VOLTS, AT 2,700 REVS. PER MIN.

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with the alternators) are provided with separate direct-coupled exciters. The general design of the Brown-Boveri turbo-dynamos is indicated in Fig. 6, although certain details—notably in respect to the design of the field-magnet casing—have been modified since the particular machine illustrated was built. As will be seen, the dynamo is totally enclosed, with forced ventilation, the cooling air entering at the centre of the machine through an air trunk on the side remote from the commutator, which air, after being circulated right through the armature and field-magnet system, is ejected at the top through chimney-shaped openings.

The field system is of the Brown Boveri-Deri type, as specially evolved for machines of this class. The principle of this method of field winding is illustrated diagrammatically in Fig. 7, while Figs. 6 and 8 show how it is carried out in

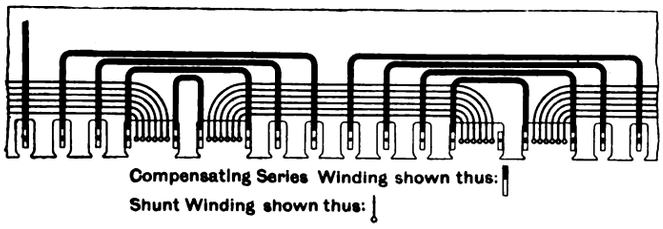

FIG. 7.—DIAGRAMMATIC REPRESENTATION OF THE BROWN BOVERI-DERI FIELD SYSTEM FOR TURBO-DYNAMOS.

practice. As will be seen, the field structure is very similar to that of the stator of an induction motor, it being built up of stampings provided with slots spaced around the inner periphery; there are two sizes of slot, into which the main windings and compensating windings are respectively placed.

The main windings consist of former-wound coils, and they are placed in the larger slots, into which they are secured by means of metal wedges; the compensating windings consist of copper strip, placed edgewise in the smaller slots, and also secured therein by wedges.

The field distribution so obtained (both in respect to the main field and the compensating and commutating field) is such that, with the proportions adopted by the makers for both the armature and field systems, perfectly satisfactory commutation is obtained at all loads, with a fixed position of the brushes. Of course, the dimensions of the commutator and the nature and arrangement of the brush gear have an important bearing on the commutation of any given machine, but the experience the makers have gained in respect to these matters is such as to ensure the proper performance of the machines in regard to commutation and commutator behaviour, under all conditions of working.

Fig. 9 shows the construction of the armature for a 1,500 kw. dynamo. The ventilators at the ends of the armature can be clearly seen from these illustrations, as well as the general method of commutator construction. The complete armature is balanced by means of screws in the end caps both before and after coupling to the turbine, while a groove is cut in the shrinking rings of the commutator, and

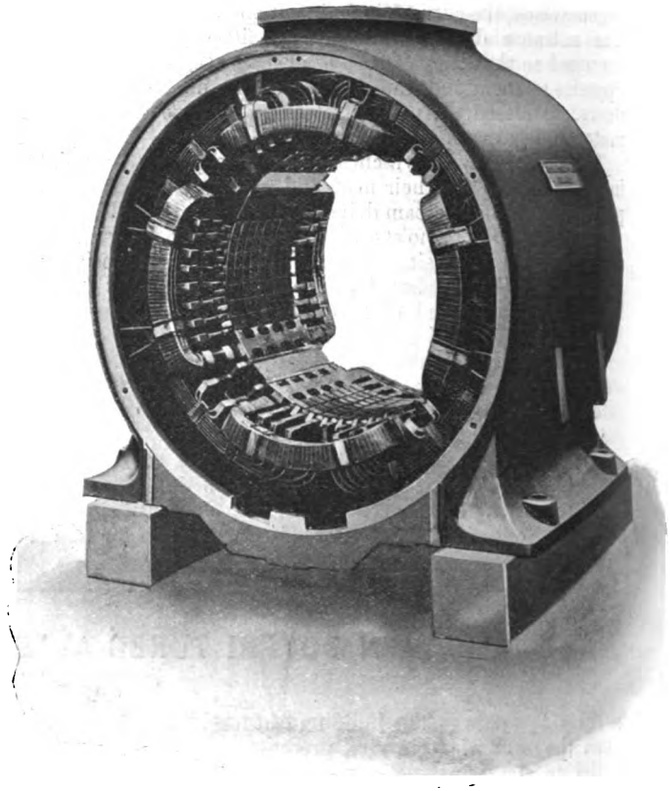

FIG. 8.—FIELD SYSTEM OF A TURBO-DYNAMO OF 380 KW., 240 VOLTS, AT 2,400 REVS. PER MIN.

small steel plates screwed inside the same, in order to obtain perfect balance of this part, this being a very important point in the construction.

The brush-holder rods are rigidly held at each end in order that they may be as rigid as possible, it being essential that vibrations should not be communicated to the brushes. The latter are held in massive holders in a specially elastic manner, so that they remain continuously in good contact with the commutator, and are not thrown off. Special compound carbon and metallic brushes are employed, the carbon acting as a lubricant for the commutator, and ensuring sweet running at all loads and minimum wear of the commutator. From measurements taken on dynamos that have been several years

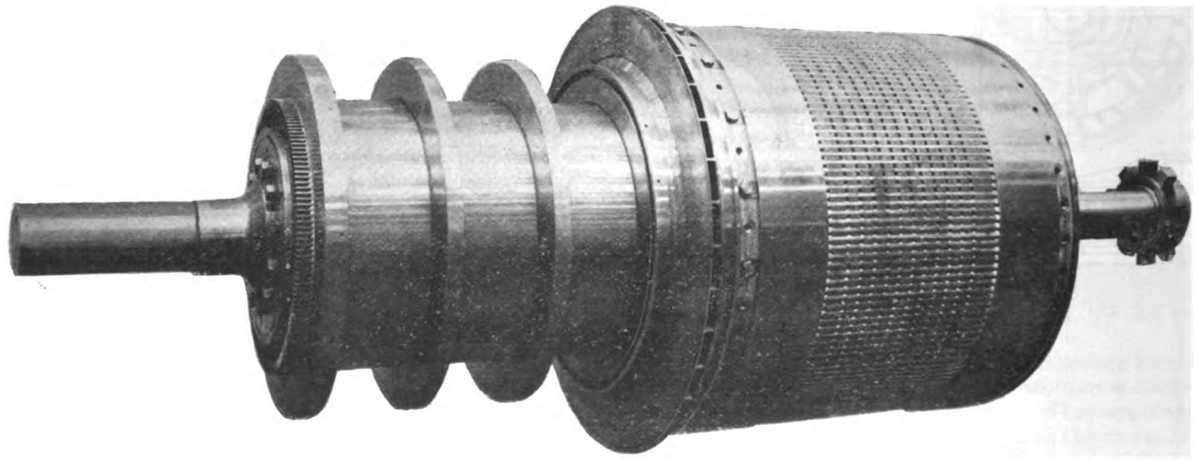

FIG. 9.—ARMATURE OF ONE OF THE 1,500 KW. TURBO-DYNAMOS AT THE ROTTERDAM ELECTRICITY WORKS. PRESSURE 550—650 VOLTS, SPEED 1,000 REVS. PER MIN.

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at work the average wear of the commutator has been found to be 0·02 in. per 1,000 hours of running.

The makers state that flashing over at the commutator during short-circuits or excessive overloads is unknown with these machines, only one case of this kind having occurred in their whole experience, the cause of which was speedily ascertained and removed.

The complete closing in of the machine, and the continuous inner cylindrical surface of the field system, ensure silent running, while the total enclosure of the windings has the further advantage that it prevents any copper dust being drawn into them from the commutator.

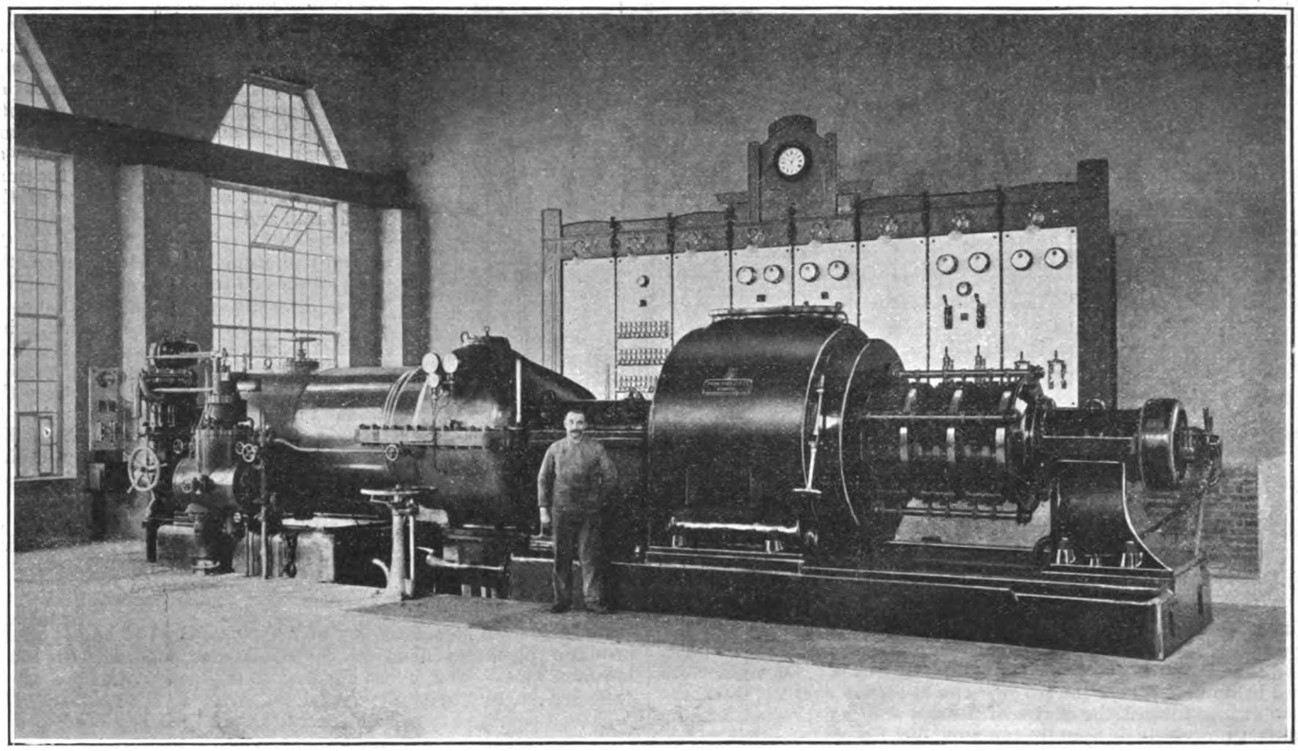

FIG. 10.—TURBO-DYNAMO OF 1,100 KW., 550 VOLTS, AND 1,250 REVS. PER MIN. INSTALLED IN THE MANNESMANN TUBE WORKS.

As already indicated above, the Brown Boveri turbo-dynamos are supplied with separate direct-coupled exciters, as shown in Figs. 6 and 10, for the purpose of providing the exciting current for what have been referred to above as the "main windings." The object of such separate excitation is to ensure a constant direction of field when the dynamo is operating in parallel with others, for it must be remembered that in machines of this class the number of compensating ampere turns is relatively large, and should a reversal of the main field take place, the possibility of the machine attaining a dangerous speed would be present. This is altogether eliminated by the employment of separate exciters as used for the Brown Boveri dynamos, for, in addition to ensuring non-reversal of the main field, this latter increases in strength with any increase of speed, and hence, by reason of the additional losses thrown on the machine, has a strong tendency to prevent excessive speed being attained, should any accident occur.

Fig. 10 shows the general appearance of one of the larger Brown Boveri turbo-dynamos, with its direct-coupled exciter, and gives a good idea of the enclosed construction and of the brush gear.

General.—The foregoing description and illustration give a fair idea of the standard turbo-alternators and turbo-dynamos built by Messrs. Brown, Boveri & Co., and we hope to supplement them before long by a description of the 11,000 H.P. sets for the Boca central station at Buenos Ayres which this firm has now in hand, and which will be the largest sets of their kind yet built.

A characteristic feature of the turbo-alternator and turbo-constructions of this firm is their uniformity, the same principles of design being employed for the largest as for the smallest machines. It is, moreover, very noteworthy that the principles of design embodied in the present-day machines of the firm are precisely those which were put forward six years ago by Mr. C. E. L. Brown when he took up the question of turbo machinery, and in particular this applies to the features of total enclosure, forced ventilation and cylindrical field systems which have been described above, and which are nowadays gradually finding their way into the constructions of other makers of turbo-generators.

We are indebted to Messrs. Brown, Boveri & Co. for placing these particulars at our disposal.

SOME FACTS AND PROBLEMS BEARING ON ELECTRIC TRUNK-LINE OPERATION.*

BY F. J. SPRAGUE.

(*Continued from page 918.*)

Summary.—In this Paper the author makes a vigorous and detailed attack upon single-phase traction for trunk railways. The various parts of the electrical equipment are considered in turn. Conductors, when used for alternate currents, suffer loss of current capacity through impedance. Single-phase motors, although effective, are much heavier than continuous-current motors of the same capacity when considered on a thermal basis, and the weight of the complete single-phase equipment for a locomotive comes out to be about double. The differences between single-phase and continuous-current motors are given in some detail. Polyphase motors also are considered by the author to be unsuitable. After considering the pros and cons of electric braking, the author discusses the various systems of working conductors at present available, and describes an improved form of under-contact third-rail, designed by Mr. Wilgus and himself. Recent suggestions to use 15 cycles instead of 25 cycles show some advantages, but the total weight of single-phase apparatus on a car will remain much the same. After describing recent examples of locomotives, and considering some minor points, the author concludes that the field of the single-phase system is on roads with sparse traffic, and that where the traffic is dense a comparatively high-pressure continuous-current system is to be preferred.

An ingenious method of making contact with an overhead single-trolley line is that developed by the Oerlikon company under the direction of Mr. Huber. In this system the trolley is stretched with

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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comparative rigidity on top of insulators supported on posts alongside the track, with cross-overs where needed. In place of the ordinary wheel and bow trolleys, a curved hinged arm of fair length, and sweeping over nearly one-half a circle in a plane transverse to the line of track, is supported on insulators on the side of the car Normally, this bow rests on top of the wire, pressing lightly on it, and thus avoiding the under formation of icicles. On cross-overs and in tunnels, where the trolley wire is carried over the track, the arm swings toward the centre of the car, and is depressed, making contact progressively from the top around to the side and then underneath the trolley wire. In addition, the saddle which carries the bow is movable laterally, increasing the radius of action. Of course, two bows can be used. I believe that in some of the experiments a roller has been tried. Two difficulties present themselves: one, the fact that the wire is pressed down from the top, the strain of the weight being added to by the pressure of the contact bar, which can be, and I believe has been on one test minimised by having the wire supported by and above two catenaries, just the reverse of the New Haven practice; the other objection is that at cross-overs the trolley wire is very close to the top of the car. The system is somewhat similar to one originally proposed in my earlier trolley work, where two vertical rollers with universal flexiblo support made contact, one on each side of a trolley wire, and at crossings one was deflected below it. This was not put into practice.

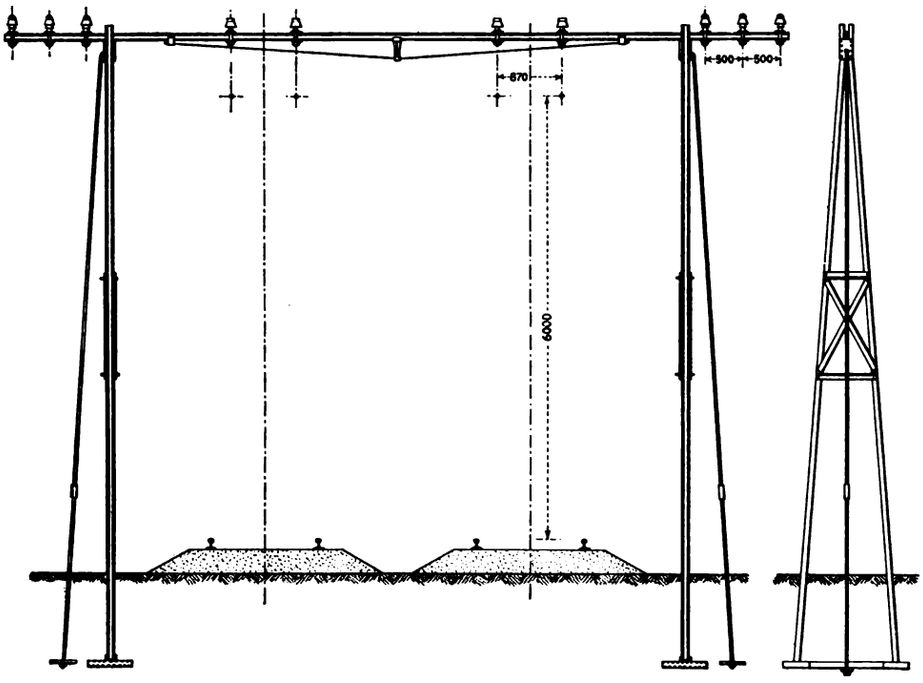

FIG. 4.—GANZ OVERHEAD TROLLEY SUPPORT.
Poles and Overhead Three-phase Line Construction used on Line from Pontedecimo to Busalla.

A very neat structure for the overhead trolley, whether of the ordinary or catenary suspension, is that designed by Mr. C. de Kando, of the Ganz Company (Fig. 4).

The alternative type of working conductor is the third rail, already adopted on about 40 roads, some of considerable extent, most of them with heavy passenger traffic, and operated under greatly varying conditions. A large proportion of these roads have used the ordinary type of top-contact rail, carried by insulators on the ties, sometimes entirely exposed, and again partly guarded by side boards, as on the Manhattan Elevated, or by a wooden shield carried by yokes from the rail itself, as on the Interborough. While this is the simplest form of third-rail construction, and has given good service for years, it has certain disadvantages. If exposed, it is a constant menace, especially in yards; and, even when guarded, it cannot be wholly protected from snow and ice. The lower part is only about 4 in. above the tie, while the holding clips generally used reduce even this clearance, so that the danger of earthing from accumulation of wet snow, ashes and from flooding is increased. In the latter case, over-all flooding has the whole rail surface for leakage.

These various objections led to the abandonment of the top-contact rail in connection with the New York Central work, and the development by Mr. Wilgus and myself of a new type—an under-contact sheathed rail—supported by insulators from brackets carried on the ties, and with the body of the rail about 9 in. clear (Figs. 5-8). The results have been so satisfactory that this type of rail has been adopted for the 285 miles of track under electrification, as well as on a number of other roads. It differs from the top-contact rail in that it affords far greater safety, more certainty of continuous operation, and can be used with higher potentials.

The structure consists, briefly, of a series of iron brackets carried on the ties, to the tongued vertical face of which are clamped non-charing moisture-proof insulator blocks which loosely embrace the head of the rail. Intermediate between the insulators the rail carries an insulating sheathing, which embraces the head and reaches down nearly to the bottom face of the rail, but extends outward from the web to form a petticoat protection against snow and sleet. The position of the rail depends primarily upon the clearance requirements. To meet those of ordinary trunk-line rolling stock, the bracket height is made so that the under-contact surface of the third rail is 2·75 in. above the surface of the traffic rail, and the centre of the rail 27·25 in. from traffic rail gauge line (Fig. 7). On account of using the under contact, the body of the rail is, of course, considerably higher from ties and ballast than that common in top contact rail construction, being about 5 in. more. On crossings, the horizontally extending flipper-shoe, pressed upwards by a spring, lifts and clears the traffic rail by a fairly safe margin. At switches, to accommodate the lateral displacement of a locomotive when taking the siding, while not reducing the clearance from the protective sheathing on the straight track, the lower head of the rail is specially formed; similar construction is necessary for engaging the shoe when entering a straight track from an angle.

For moderate potentials, say of 600 volts, the two halves of the insulator blocks are alike, but for the higher potentials the inner insulator block—that is, the one next to the face of the bracket—is extended so as partly to shroud the head of the bracket. The sheathing between the insulator blocks, depending upon local conditions and price of materials, as well as potential used, is formed of three wooden strips, one grooved on the under side and enclosing the head of the rail, and the other two, attached to and dependent from it, reaching in towards the web of the rail. Where good wood is not available, an alternative protection, costing about the same

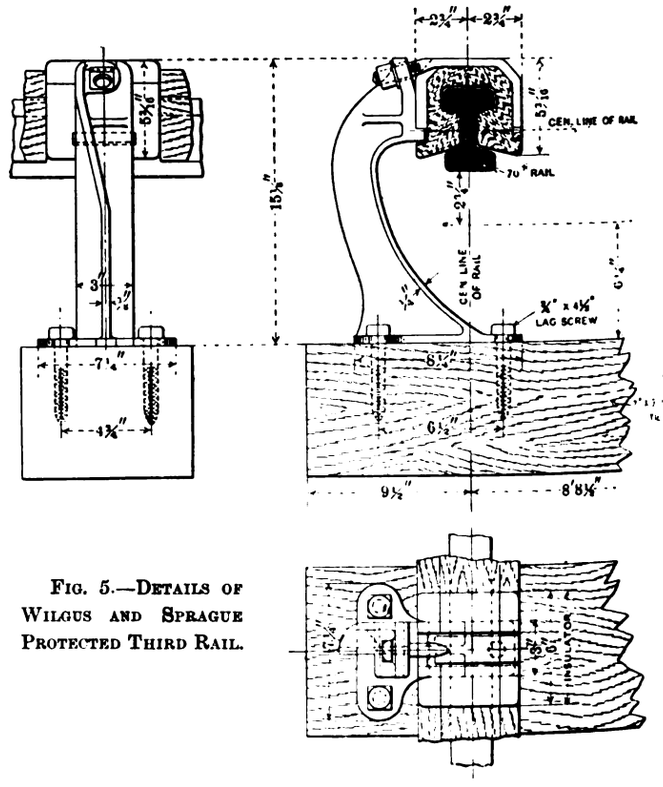

FIG. 5.—DETAILS OF WILGUS AND SPRAGUE PROTECTED THIRD RAIL.

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and having a higher electrical resistance, although not quite so good a mechanical one, is a semi-flexible shell of indurated fibre conformed to the rail-section. To get the highest protection, both mechanically and electrically, the two methods of sheathing can be used, or in place of the inner sheathing of indurated fibre the wood sheathing can be carried slightly removed from the rail surface by non-hygroscopic saddles; this leaves an air space between the wood and rail, prevents warping and affords the necessary physical support for rigidity. At passenger stations, where special precaution may be deemed advisable, and in freight yards the double protection can be used, and any required thickness of insulation adopted without reducing clearances by reducing the cross-section of the rail at these points. The conductivity will, of course, be made up by the number of rail circuits in parallel at these points.

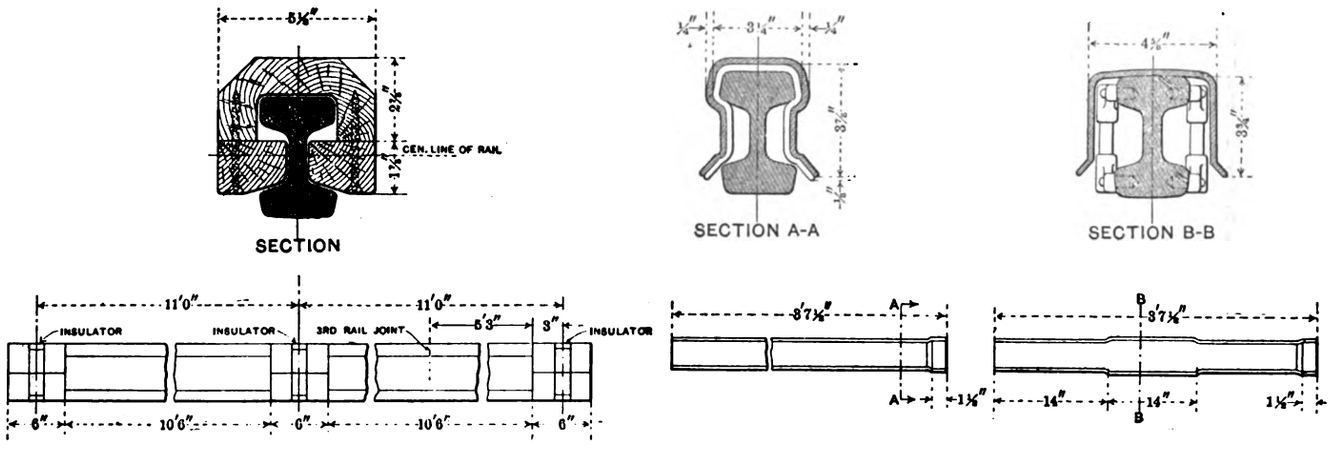

FIG. 6.—DETAILS OF WILGUS AND SPRAGUE THIRD-RAIL.

This protection is of such character that passengers, as well as employés, in the normal discharge of their duties are fully protected. In sleet storms none reaches the contact surface, small icicles only forming at the edge of the petticoats, and these are easily broken off by the passing shoe. Of course there is no packing of snow between the protection and contact rail, and the increased distance from the ground reduces the tendency to leakage. An incidental advantage is a reduction of the tendency to creep and buckle because of less abrupt and wide changes in temperature.

General Comparison of Working Conductors.—All working conductors are in many ways objectionable, but since they are a necessary connecting link between the source of supply and the motors some comparisons may be made of the two kinds, the under-contact protected type of third rail and the overhead trolley, as affected by construction and operation.

The third rail is an inert structure; it can be aligned accurately with the track, is not under strain, and its expansion can be readily taken care of. The overhead trolley is necessarily a system under strain, and where permanency is desired and high potentials are used it must be carried by one or more catenary cables, which on roads of high curvature makes the construction more difficult. Its

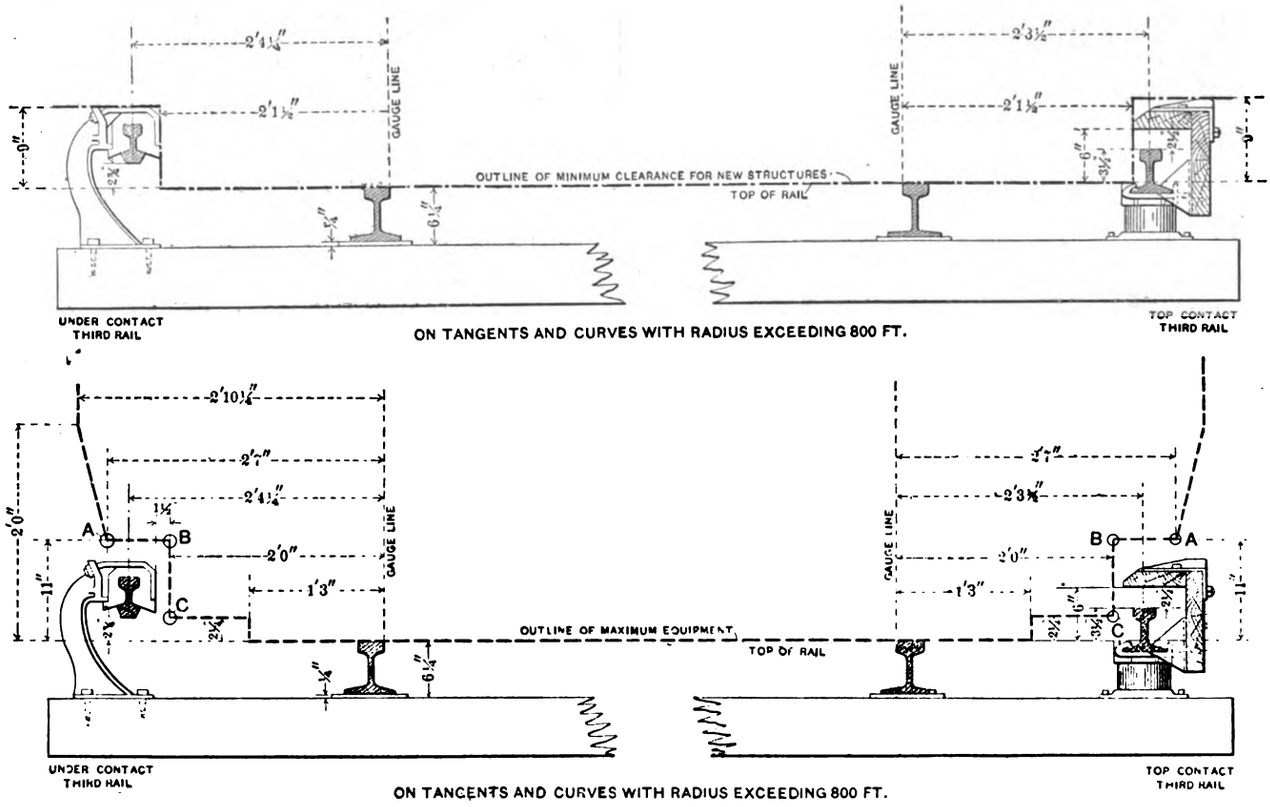
GAUGE LINE
OUTLINE OF MINIMUM CLEARANCE FOR NEW STRUCTURES
TOP OF RAIL
UNDER CONTACT THIRD RAIL
TOP CONTACT THIRD RAIL
ON TANGENTS AND CURVES WITH RADIUS EXCEEDING 800 FT.
OUTLINE OF MAXIMUM EQUIPMENT
TOP OF RAIL
UNDER CONTACT THIRD RAIL
TOP CONTACT THIRD RAIL
ON TANGENTS AND CURVES WITH RADIUS EXCEEDING 800 FT.

FIG. 7.—CLEARANCE DIAGRAMS—EQUIPMENT AND THIRD RAILS.

alignment in the latter case does not correspond with the line of track, and, as ordinarily constructed, it is subject to extreme variations of tension on account of weather changes. The third rail offers some hindrance to the ordinary maintenance of track; but overhead construction is inelastic, and the laying of additional tracks or changes in grades or alignment require radical and expensive alterations or additions in permanent overhead structures. Derail-

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ments will crush one form of conductor to the ground, forming a short-circuit which will cut off the section; but they may also knock down the supporting structures of the other, and, where there is a plurality of tracks, put them all out of service. In wrecking, the third rail offers some obstruction to the throwing of the equipment to one side; but on the other hand, overhead conductors may interfere with the operation of the crane-booms of the wrecking car. Where there are two or more tracks snow cannot be piled up between them if the third rails are located there; but, on the other hand, overhead conductors are a source of danger to train men, to snow-shed and tunnel repairers, and in the open are subject to troubles of sleet formation. The third rail will oftentimes be covered with snow, but is unaffected by sleet. Very thorough tests made in connection with the New York Central work show satisfactory operation, not only in sleet storms but with the rail buried in snow. With regard to frogs and switches, there are no problems which cannot be solved with this type of third rail, with an occasional overhead section, and any required amount of power can be collected at operative speeds.

As to danger to passengers or employés, this is largely overcome where the under-contact third rail is properly protected, and is designed with due regard to equipment clearances. With an overhead high-tension trolley there is, on trunk railways, where there are overhead street or highway bridges, tunnels and snow-sheds, great possibilities of danger because of rearing equipment in case of derailments or collision, and the physical necessity of often bringing the trolley within a short distance of the cars. Then there are corrosion and soot deposits when steam and electric operation are maintained over the same track, and where the steel supporting

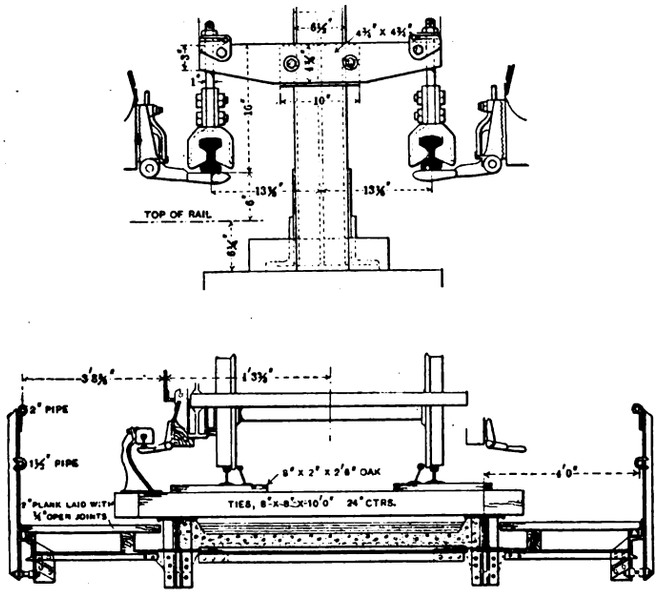

FIG. 8.—DETAILS OF WILGUS AND SPRAGUE PROTECTED THIRD-RAIL ON PHILADELPHIA RAPID-TRANSIT RAILWAY.

bridges also carry signals there is increased danger to men engaged in cleaning, painting or repairing overhead structures, and taking care of signals; and also a possible interception of the train operator's view of signals because of dips in the railroad grades bringing overhead bridges in front of the semaphores.

In the matter of inspection, that of the third-rail can probably be carried on by the regular section hands, and ordinary repairs made without interfering with traffic. Repairs of an overhead system on a main trunk-line present some special difficulties. It will often require judgment and experience to determine just where trouble may exist, and in any case that particular section of the line must be absolutely cut out and made dead. If the repairs be other than at a rigid cross-suspension, it would seem that they would have to be made from the top of a structure running on, and for the time being occupying, the rails and propelled by its own power.

In the overhead system it seems vital in the interests of general safety that every crossing bridge and every supporting structure should be mechanically and permanently connected with the return circuit of the rails, to avoid the possibility of such structures being in partial or complete contact with the overhead conductors and not absolutely earthed, and at all crossings and highways both the catenaries and the trolley wire should be thoroughly shielded from either accidental or wilful interference. Also, where single-phase alternating currents are used, the magnetic and static inductive effects on telephone and telegraph circuits cannot be ignored nor the danger of interference with signal systems disregarded.

Relative Direct-Current Potentials in Overhead Trolley and Third-Rail.—Engineers have generally proceeded on the assumption that the use of a sufficiently high potential for practical purposes is possible only with overhead conductors. In the Siemens-Schuckert installation at Mazières, where 2,000 volt direct current are used, the current is taken from two trolley wires of like potential supported by cross-wire catenaries from side poles of the same construction as is commonly used to carry the warning tickler. Again, the third-wire system has been proposed, as on the Krizik road, and on a recent installation with many grades and heavy tunnels in the Iselle mining district in France, where two overhead trolley wires are used at 2,400 volts, with the track as a neutral, and with the motors grouped in series of two, current being supplied by two Thury generators in series and earthed in the middle. A comparison of potential relations giving the same losses on three systems is interesting. The systems are: (1) Three-wire, with two No. 0000 trolleys and 75 lb. bonded single track; (2) two wire, with same trolley wires and track return; (3) third-rail, 70 lb. special, and with same track return. The following table gives the comparisons:—

System.	Resistance per double mile.	Ratio of resistance.	$\sqrt{\text{Ratio.}}$	Comparative voltages.	
No. 1	0·52 ohms	6·6667	2·58	2,400	3,100
No. 2	0·165 ,,	2·1154	1·45	1,350	1,740
No. 3	0·078 ,,	1·0000	1·00	930	1,200

On such a showing there is little excuse for departing from the lower potentials and the simpler systems, and being handicapped with the higher voltage problems and complication of switches in the three-wire system. If any smaller trolley wire be used, then the disparity between No. 1 or No. 2 and No. 3 would be emphasised. The relation of potentials indicated in this table raises the question whether, in view of the disparity of current-conducting capacity between an overhead system and the third-rail, it is not also possible that a sufficiently high potential can be used on the latter if from a practical railroad standpoint the balance of advantages and objections should be sufficiently in its favour to warrant its material extension.

Some time ago I stated that in my opinion it was practicable to operate at double the ordinary potentials with a properly-protected under-contact sheathed third-rail. I am glad to be now able definitely to announce that it seems possible to construct and operate at these increased potentials with a degree of safety hitherto deemed doubtful. The details of the particular construction necessary must for practical reasons be withheld for the present.

Fifteen-Cycle Operation.—The principal object sought, and certainly a most desirable one in the use of higher potentials, whether direct current or alternating current, is not now so much reduced cost of working conductors on a trunk line system—for practice has shown that this cost is not materially affected—but lessened feeder investment, increase of sub-station distances, reduction of total sub-station capacity and, in the single-phase system, the abolition of moving machinery in the sub-stations. The raising of the potential on direct-current equipments will not be without some objections, not so much, as I have indicated, in the actual construction or use of the third-rail or the overhead trolley, nor because of difficulties in the matter of commutating and earthing, but rather on account of some reduction of capacity because of less slot and winding efficiency where the motors are individually constructed for the higher potentials, this feature being less important if two machines are operated in series. The controlling systems present some added difficulties, but nothing insuperable.

The 25-cycle motor (hitherto the only frequency actually installed for single-phase equipments) has proved inadequate, and it has been proposed to adopt 15 cycles as a standard of operation This number of cycles has been under consideration for some time. It is successfully used by the Ganz Company in its polyphase installations, it has been proposed by the General Electric and Westinghouse Companies for important work, and has lately been urged as a standard by a number of engineers. Considered solely from the standpoint of the series commutator type of railway motor, a reduction from 25 to some lower compromise number of cycles—15, if you please—has certain distinct advantages; for it should make possible the use of higher field induction, larger air-gap, higher armature potential, slower armature speed, and less sparking—all making for increase of motor capacity for any given weight, and affording greater mechanical freedom in construction and operation. It likewise increases the capacity of trolley and track circuits, and raises the power-factor both of the line and the motor; but against this is an unavoidable increase in the weight of transformers, which, according to such facts as I have at hand, about offsets the saving in motor weight. It appears, then, that the total weight of single-phase apparatus on a car for a given capacity is approximately the same within a very wide range of variation of the number of cycles. There are, in addition, special objections in the matter of turbine and generator construction, as well as in other directions.

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It is difficult to establish exact comparison of equipment weights unless one personally conducts tests, or has complete technical reports which have been made on identical bases; but the following table is one comparison of early estimated weights of complete equipments of two recent typical types of like nominal capacity.

Weight of 4-Motor Alternating-Current Equipments.

	A		B
Motor			
Cycles	15		25
Nominal capacity per motor	75 H.P.		75 H.P.
Individual Weights:			
Armature	1,333 lb.		1,146 lb.
Field	2,414 ,,		2,646 ,,
Gear, case and pinion	398 ,,		407 ,,
Total motor	4,145 ,,		4,199 ,,
Car Equipment:			
Four motors	16,580 lb.		16,796 lb.
Transformer and rheostat	6,750 ,,		4,325 ,,
Controller and adjuncts	1,000 ,,		1,200 ,,
Trolley	500 ,,		500 ,,
Wiring, switches, &c. (?)	1,950 ,,		1,239 ,,
	26,780 ,,		24,060 ,,
Excess A over B	2,720 ,,		

Allowing for such changes and corrections as seem reasonable, not only is no actual saving in A over B probable, but the excess of nearly a ton and a-half against the 15 cycle equipment will remain in some makes. On the other hand, the manufacturers of B hope to show about 10 per cent. total saving in the weight of a 15 cycle equipment, but this hope is based upon theoretical estimates, not actual performance. On other sizes it is probable that these relative differences will vary somewhat, but a comparison of the weight coefficients of large 15 cycle motors and direct-current motors of like weight show a ratio of two to one in favour of the direct-current machine.

(*To be continued.*)

THE SIMULTANEOUS MEASUREMENT OF THE CAPACITY AND POWER FACTOR OF CONDENSERS.*

BY FREDERICK W. GROVER.

In a condenser having absorption, the angle of advance between the current and the electromotive force is less than 90 deg. by a small angle θ, the power factor being equal to sin θ. A condenser having absorption is equivalent, therefore, in its effect on the phase of the current, to a capacity in series with a small resistance r of such a value that $\tan\theta = pCr$ (where $p = 2\pi$ times the frequency) or to a capacity in parallel with a large resistance R such that $\tan\theta = 1/pCR$.

The power factor of condenser is more accurately measured by determining this small angle θ than by direct measurement of the energy loss itself. Such measurements of the phase difference have been made by Potts † using one of Rowland's electrodynamometer methods, and by Rosa,‡ who has developed a number of dynamometer methods, and shown that they give results in good agreement with one another, and with his results on the same condensers by a calorimetric method.§

In 1891 Max Wien || gave several alternating-current bridge methods for the measurement of inductances and capacities. Among these is one where the absorption of the condenser to be tested, which he represented by a resistance in parallel with a capacity, is compensated for by an adjustable resistance in series with the standard capacity. The absorption of the latter is assumed to be zero. An elaborate investigation of the energy losses in the dielectric of cables has been published, since the work in this Paper was begun by Monacsh,¶ in which Wien's method was successfully used.

The following three bridge methods have been found satisfactory. In the first three, each side of the bridge consists as usual of a capacity in series with one of the ratio coils. The phases of the currents in the two sides of the bridge are brought into unison.

1. By an adjustable resistance in series with the standard condenser.

2. By an adjustable resistance in parallel with the standard condenser.

3. By a variable inductance in series with that ratio arm which is adjacent to the condenser to be tested.

Method I.—This is the same in principle as that of Wien described above, except that, whereas he derived the formula on the assumption that the resistance representing the absorption was in parallel with the condenser, the author has adopted the assumption that it is in series with the condenser. Physically it is, of course, immaterial which assumption is adopted, since we are only concerned with the change in the phase of the current due to the presence of the absorption.

It is more convenient in practice to introduce a series resistance ρ into each condenser arm. Then

$$\frac{C_1}{C_2} = \frac{R_2}{R_1}$$

$$\tan(\theta_1 - \theta_2) = pC_2\rho_2 - pC_1\rho_1.$$

Method II.—To avoid the necessity of working with resistances of several megohms it is best to put a resistance ρ in parallel with each of the condensers. Then

$$\frac{C_1}{C_2} = \frac{R_2}{R_1}$$

$$\tan(\theta_1 - \theta_2) = \frac{1}{pC_2\rho_2} - \frac{1}{pC_1\rho_1}.$$

This method is not so good as the other two, since the sensible electrostatic capacities, inseparable from such large resistances, must be added to the capacities of the condensers. The power factor measurement is not, however, affected by these capacities.

Method III.—In practice a fixed inductance L_2 is inserted in one arm and a variable inductance L_1 in the other. Then

$$\frac{C_2}{C_1} = \frac{R_1}{R_2}$$

$$\tan(\theta_1 - \theta_2) = \frac{pL_1}{R_1} - \frac{pL_2}{R_2}.$$

This method has the advantage that nothing is placed in the arms with the condensers. It is, therefore, especially adapted to the comparison of capacities as small as 0 001 mfd., where in Method I. the errors due to capacity of the large resistances r, required with such small capacities, may become appreciable.

To obtain the most precise results with these three methods, the condensers should be nearly equal in capacity and power factor, and it is best to balance each of the two capacities against that of a third auxiliary condenser. This procedure has the following advantages:—

1. Errors due to electrostatic induction between the bridge and its surroundings are practically eliminated.

2. The ratio of the two capacities is proportional to the two nearly equal settings of the same resistance box, making an accurate determination of the actual values of the coils unnecessary.

The following method has been found satisfactory and is especially valuable as a check on those already given, since it is very different in principle.

Method IV.—It has been shown* that in the comparison of an inductance with a capacity by Anderson's method, the effect of the absorption of the condenser on the value of the inductance obtained is in all ordinary cases extremely small. The difference in the actual value of the resistance Q′ of the arm containing the inductance from the value Q with direct current, due to the absorption of the condenser, may become very appreciable.

$$Q' = Q + pL\tan\theta$$

$$\therefore \quad \tan\theta = \frac{Q' - Q}{pL} \qquad \text{(A)}$$

If settings be made with first one condenser, and then with the other,

$$\tan(\theta_1 - \theta_2) = \frac{\Delta Q'}{pL},$$

where $\Delta Q'$ is the difference between the values of Q′ in the two cases, and

$$\frac{C_1}{C_2} = \frac{2r_2 + P}{2r_1 + P}$$

if the ratio arms P and R are equal.

This is inherently a substitution method, and by properly choosing L so as to give a satisfactorily large value to ΔQ, good results have been obtained.

The absolute values of the power factor of a condenser follows at once from measurements with these methods, if some standard of reference is at hand. For capacities of 0·1 mfd. and smaller, comparisons were made directly with air condensers of negligible leakage. The values for the larger capacities were obtained by stepping up from 0·1 mfd., using the relation that the resultant power factor

* Abstract of a Paper presented at the Washington meeting of the American Physical Society, April 19-20, 1907.

† Amer. *Jour. Sci.* (4), 10, p. 91, 1900; *Phys. Zs.*, 2, p. 301, 1901.

‡ *Bulletin* of Bureau of Standards, 1, p. 383, 1905.

§ Rosa, *Phys. Rev.*, Feb., 1899.

|| *Wied. Annalen*, 44, p. 681, 1891.

¶ Inaugural Dissertation, Dantzig, 1906.

* Rosa and Grover, *Bulletin* of Bureau of Standards, 1, p. 312, 1905.

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f of the two condensers of capacities C_1 and C_2 and of power factors f_1 and f_2 is given by

$$f=\frac{C_1f_1+C_2f_2}{C_1+C_2}.$$

As a check on this process, the power factor of a 1 mfd. condenser was determined by using a formula (A) of Method IV., the observed value of $(Q'-Q)$ being corrected for the effect of the known residual inductances and capacities of the arms of the bridge. The result agreed closely with that given by stepping up from the 0·1 mfd. air condenser. Care must be taken in using formula (A) that the change in resistance of the coil L with the frequency is negligible, otherwise it must be determined and allowed for.

Results.

These four methods have been tested by measurements on a large number of condensers, at frequencies between 30 and 1,000 cycles (using vibration galvanometers to balance the bridge). The capacity ratios obtained by the different methods agree to a few parts in 100,000, while the differences $(\theta_1-\theta_2)$ do not differ more than can be explained by the errors in the setting of the bridge. It has been found :—

1. For good mica condensers the angles θ may be as small as 0′ 30″ and as large as 4′. Poorer mica condensers, especially if their capacity is small, may give values of θ as large as 30′ or even more.

2. Good condensers with paraffined paper for a dielectric have a value of from 5′ to 20′; for poor telephone condensers angles as large as 10 deg. have been observed!

3. For all the mica condensers examined the angle θ diminishes slowly as the frequency rises.

4. The same result was observed with all the poorer paper condensers, but with some of the better paper condensers the effect was in the opposite direction. The changes are all greater than in the case of mica condensers.

5. Above 20 deg. the power factor increases with rise of temperature both in mica and in paper condensers, the effect being small for the former and very large for some of the poorer paper condensers.

Since the power factor depends primarily on the absorption, the leakage having but a small effect, the value of the power factor would be expected to give a relative indication of the magnitude of those effects which depend on absorption—viz., residual charges, change of capacity with the frequency, dependence of the apparent capacity on the time of charge and discharge, &c. Ballistic measurements show that this hypothesis is substantiated qualitatively and, approximately, quantitatively. A measurement of the power factor gives, therefore, valuable information as to the quality of the condenser.

These effects of changes of frequency and temperature are being more thoroughly investigated.

ENGINEERING EXHIBITION AT OLYMPIA.—II.

A more detailed examination of the exhibits at the Engineering and Machinery Exhibition confirms the opinion we expressed last week that electrically-driven machine tools predominate in the tool section of the show. Where group driving has been adopted on certain stands photographs and particulars of individually operated motors are also obtainable. The attitude of machine tool makers as a general rule is favourable to the separate motor drive for large and medium sized tools and group driving of small machines. During an exhibition like the present the individual motor scores heavily over shafting and belts. The latter take so much time and trouble to get into position, and when erected are far from artistic, that the improved appearance of the stand and the greater convenience of operating, &c., are well worth what extra expense may be involved by separate motors. Some machine tool makers have faith enough in the electric motor to incorporate it in the supporting columns of the machine. Messrs. J. Stirk & Sons, of Halifax, may be taken as representing this class. We illustrate in Fig. 1 a 30 in. boring and turning mill in which the motor is an integral part of the tool. The four steel poles are fastened against special faced surfaces within the main column by studs which are screwed up from the outside. The end plate and ventilated doors giving access to the brushes are clearly shown in the illustration. The machine has a capacity of 2½ H.P. at any speed between 800 and 1,600 revs. per min., obtained by shunt regulation alone. By the use of a change gear box and the motor variation the range of speed of the revolving table extends from 4 to 200 revs. per min. The motor drive is communicated by chain and belts to the table and tool carrier, though the illustration does not show the belt in position. The tool is electrically complete in another respect, the starting rheostat and main switch, both iron enclosed, are fixed to the column, and the cables are run in steel conduit, giving a neat finish to the whole. Another machine on the same stand is a 3 ft. 6 in. radial drilling machine, driven through Renold chain by a 16 H.P. Lancashire motor The motor (*see* Fig. 2) is mounted on

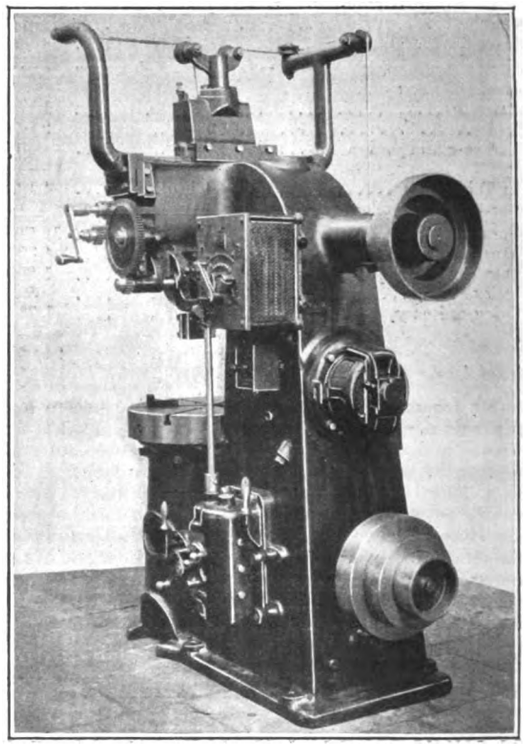

Fig. 1.—Boring and Turning Mill with Self-contained Motor, by Stirk & Sons.

four screwed legs, which may be adjusted in a vertical plane for taking up chain wear. The tool has 18 speeds, with 16 and 530 revs. per min. as the lower and upper limits. We witnessed this tool in operation and saw a 1 in. drill driven through cast iron at the rate

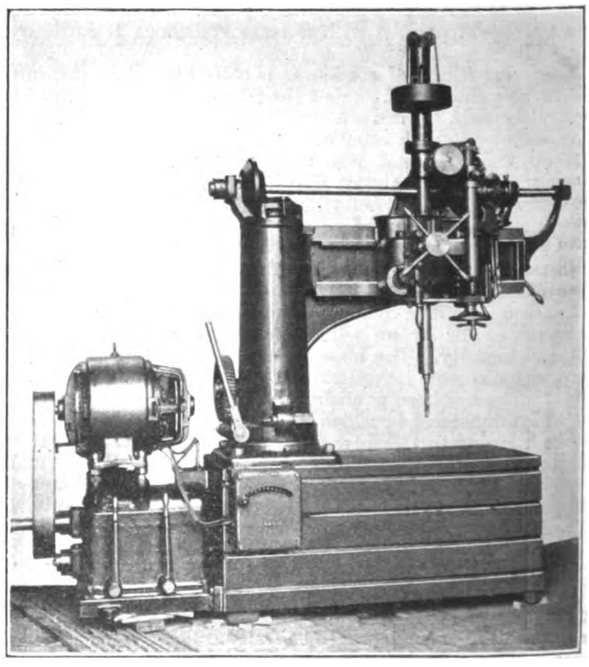

Fig. 2.—Electrically Driven Radial Drill, by Stirk & Sons.

of 11 in. per minute. Another of Messrs. Stirk's tools exhibited is a 12 in. high-speed lathe direct-driven by a 35 H.P Lancashire motor operating at speeds between 460 and 600 revs. per min. A speed-box is also fitted. The motor drives the main spindle of the lathe

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through a friction clutch, and to this also is attached a pulley for belt drive. Cuts up to 15½ in. by ⅛in. can be made in mild steel on this lathe at 75 ft. per minute. The machine is suitable for tapping as well as drilling.

The PHŒNIX DYNAMO & MOTOR Co., in addition to exhibiting a number of grinders and drills from their electric tool department, have on view a special motor grinder for internal work. We remarked last week on a machine capable of working up to 17 in. in

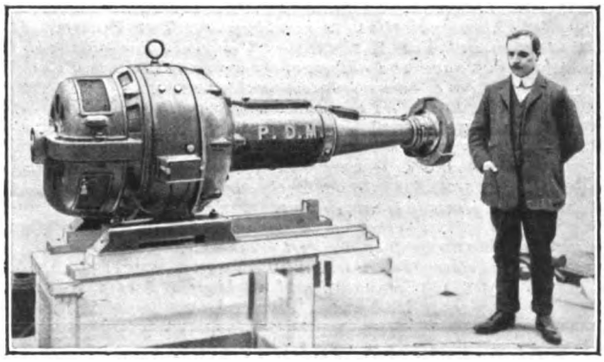

FIG. 3.—P.D.M. ELECTRIC GRINDER FOR LARGE WORK.

depth in a 2¼ in. hole. We give an illustration (Fig. 3) of a much larger pattern grinder, also direct motor operated. This tool we are informed is the largest electric internal grinder yet built. The motor is a standard "P.D.M." machine, with a specially extended shaft and outer bearing. A flange coupling serves to attach the extension shaft to the motor shaft, but this coupling is within the conical housing, as shown in Fig. 4. The normal speed of the

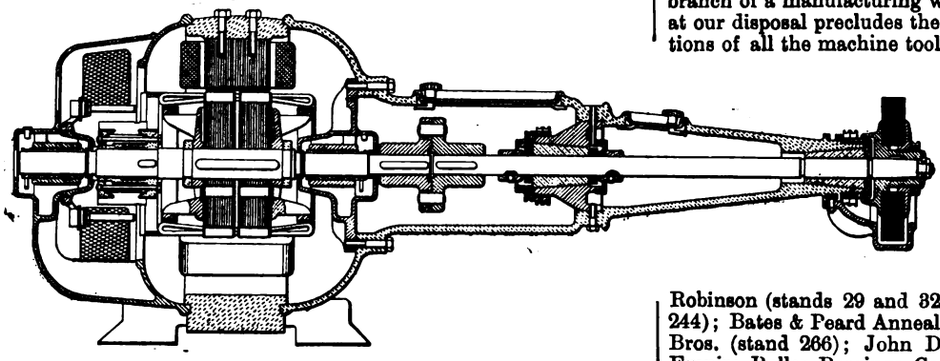

FIG. 4.—SECTION OF P.D.M. ELECTRIC GRINDER.

machine, which has interpoles, is 1,500 revs. per min., but this can be varied in the ratio of 3 to 1. The grinder will work either 24 in. holes to a depth of 4 ft., or 13 in. holes to a depth of 3 ft. This is a good example of direct motor application to machine tools.

On the stand of Messrs. CUNLIFFE & CROOM is a motor-driven planer type milling machine, which is of some interest. The planer bed carries the work to be tooled under a circular milling cutter which is revolved by suitable gearing in the body of the machine. The spindle of the cutter is supported in a sliding carrier which is given an automatic transverse travel while cutting is in progress. The table also has an auto-traverse in both directions. The motor is an 8 H.P. machine and is direct geared to the shafts operating the table and the carrier. Feeds up to 20 in. per minute at a cutting speed of 500 revs. per min., can be made in aluminium. The table is 5 ft. long by 2 ft. 6½ in. wide, and the depth under the cutter nose is 1 ft. 10 in. Two electrically driven planers are also in operation at this stand.

There are many other machine tool exhibits in which individual motors are used. Messrs. POLLOCK & MACNAB show several motor-operated lathes, drilling machines, shapers, &c., driven by motors by Electromotors Ltd. of the constant speed type. One of these is a 6 ft. radial drilling machine driven by a motor through a Renold chain. Since the coming of the automobile the demand for reliable change speed gears has been instrumental in introducing gear hobbing machines on which gear wheel teeth are accurately cut. Messrs. HUMPAGE & HARDY exhibit a high-speed automatic machine driven direct by a 2 H.P. Westinghouse motor. One hob cuts all numbers of teeth having the same pitch, and we understand that a steel pinion with 12 teeth 2 in. pitch ($1\frac{9}{16}$ in. circular pitch) and 3½ in. face, has been cut out in 54 minutes, the same pinion in cast-iron was worked in 30 minutes, a carbon steel hob being used in each case. These hobbing machines are interesting to electrical engineers in so far as they concern tramcar gears and the many patterns of pinions and spur wheels required in industrial electric power applications.

Accurate gears naturally tend to economise power in both these classes of electric drive. Messrs. C. CHURCHILL & Co., A. HERBERT (Ltd.) and SCHUCHARDT & SCHUTTE also exhibited interesting patterns of hobbing machines which were shown in operation. Most of these machines operate on what is known as the "generating" principle, the shape of the tooth being decided by the setting of the machine and not by the introduction of a new form of cutter.

Central station engineers who carry out the bulk of their own repairs will find in the exhibition many new tools which will bear careful examination. Screw cutting and turret lathes, drilling machines both vertical spindle and radial arm, grinders, small hoists, &c. A survey of the tools at present in use in the station workshop and their comparison with more modern types as exhibited at Olympia might well result in the replacement of the older machines, with subsequent economy in the repair department. Similarly station managers will find at Olympia many advances in methods of keeping tools in good order. Grinders, gauges and labour-saving attachments to tool setting appliances by which accuracy is obtained by simple mechanical means, these and many other devices too numerous to mention will be found among the exhibits to interest station engineers. The electrical manufacturer, of course, visits an exhibition of this kind to inquire into new methods and designs which will be of advantage to and in production departments of his works. The numerous types of shaft-grinding machines on view will doubtless be inspected with interest, for although motor and dynamo shafts have been ground true for several years past, improvements are constantly being embodied in the tools for this useful process. Then from the engineer's point of view there are examples of store bins, trays, shelves, lockers, designed for compactness, and fireproof by reason of their iron construction. Stores organisation has been made the subject of much study and the results are admirably reflected in the useful systems devised for dealing with what is undoubtedly an important branch of a manufacturing works or electricity station. The space at our disposal precludes the possibility of giving detailed descriptions of all the machine tool exhibits, but we can recommend our engineer readers to visit the exhibition and inspect these themselves.

Among the exhibitors at Olympia whose stands are of great interest to engineers and electricians may be mentioned those of Messrs. Clarke, Chapman & Co. (stands 91 and 106); W. H. Allen, Son & Co. (stands 92 and 105); Willans & Robinson (stands 29 and 32); W. H. Bailey & Co. (stands 237 and 244); Bates & Peard Annealing Furnace Co. (stand 273); Crossley Bros. (stand 266); John Dugdill & Co. (stands 50 and 83); the Empire Roller Bearings Co. (stands 229 and 251); Greenwood & Batley (stand 150); E. S. Hindley & Sons (stands 233 and 248); Selig, Sonnenthal & Co. (stands 118 and 129); S. Wolf & Co. (stands 57 and 76); and the stands of the Typewriter Co., where Bar-lock typewriters and typewriter accessories are displayed; and that of J. J. Stockall & Sons, where an excellent show of time recorders for use in works and offices can be inspected.

Extra High-tension Transformers.—The *Engineering News* gives a description of two 300,000 volt transformers which have recently been built by the General Electric Co. for testing purposes. They are oil-insulated and of the core type, the core consisting of two vertical legs joined at the top and bottom by horizontal yokes. The primary winding is placed directly on the core, and consists of one strip of copper wound in a single layer. The secondary is divided into 50 separately wound and insulated coils, having a total of about 16,000 turns. The insulation between layers and between turns of the end coils is reinforced so as to stand a continuously-applied voltage of 10,000. The bushings for the high-tension leads are hollow cylinders filled with oil, a construction which has proved superior to solid material. In these transformers the bushings have been subjected to potentials of 500,000 volts for long periods without breaking down. The characteristics of the transformers are: Frequency, 60 cycles; capacity, 300 kw.; primary voltage, 2,300-4,600; primary current, 65 amperes; secondary voltage, 300,000; secondary current, 1 ampere; full-load efficiency, 97·4 per cent.

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STUDENT TOPICS.

In a recent issue of the *Electrical World* some figures are given of the number of students graduating from the electro-technical schools in the United States. The figures apply to 96 schools, and it appears that the total number of graduates enrolled to date from the time when technical education was seriously taken up is 11,000, and that the number of graduates for the present year is 1,358. These figures are remarkable, but even more remarkable is the opinion expressed by our contemporary that the schools are not turning out nearly as many men as could be utilised with benefit to the electrical industry and with profit to the graduates themselves. Certainly when, as recorded in our last issue, a company like the General Electric Company of America find it possible to give employment in a single year to 248 graduates at their Schenectady works it would appear that such graduates have no difficulty in obtaining employment. In the United States, however, the electrical industry is in a very much more flourishing condition than in this country, and it is quite possible that the demand for such students is brisk. But, apart from the electro-technical field, our contemporary is of opinion that the technical graduate is ideal raw material from which to recruit every branch of the industry; that the day is

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passed when the holder of a technical college certificate is put to merely technical duties; and that it has been found that the graduate is equally well qualified for duties in a non-technical branch of the industry, as far as raw material is concerned, and becomes more quickly efficient.

There is some difficulty, however, in broadening the basis for which the technical student is available, unless the syllabus offered by technical colleges is also considerably broadened. This, to some extent, is already being done by certain colleges, so that the student need not feel himself bound to an engineering course pure and simple, but may carry engineering knowledge into some other field. Apart from the unintentional broadening of the field, due to the unsuitability of certain students who, after taking a course of technical instruction, are apt to adopt the church, or the stage, or some other profession in which to gain their livelihood, there may be a distinct advantage in carrying more technical knowledge into commercial work. It may be doubted, however, if this end will be attained so well by adding commercial training to technical schools as by giving students in a commercial school a chance of studying electrotechnics.

It is not often that any very revolutionary method of teaching is suggested. Mr. KARAPETOFF, however, in a Paper recently read before the American Institute of Electrical Engineers, describes what he terms the "concentric" method of teaching electrical engineering. The title in itself is sufficiently startling. Briefly, the idea seems to be to start with a nucleus of popular ideas and to surround them year by year with a circle of more theoretical matter, thus gradually widening the mental horizon of the student. The author's contention is that hitherto the custom has been to proceed from theory to practice, whereas in his system he would proceed from practice to theory. The author's objection to the present system is that during the first two years of his studies the student is burdened with auxiliary sciences, of which he may fail to see the utility, and that, consequently, his ready co-operation is not secured. In the concentric system a student would start with a popular outline of electrical engineering, popular experiments, lectures on the general character of engineering work, and historical sketches of the development of the electrical industry. The second year would comprise a sort of experimental teaching of engineering, including the handling of machines and apparatus, so as to induce practical familiarity. In the third year details would be considered, numerical relations would be studied, and the study of auxiliary sciences would be taken up seriously, since it would now be evident to the student that such sciences were of value. The fourth (and final) year would be devoted mostly to the theory of electric and magnetic phenomena on the basis of previously-established experimental relations.

Such a scheme is interesting, but it appears to us somewhat impracticable. Doubtless there is much to be said in favour of becoming familiar with a subject before studying its theory. A technical college, however, is scarcely the place to become very practically familiar with an engineering subject. No doubt it would be an advantage for a man to go through the shops before starting a college course at all (thus gaining a practical insight into engineering methods) if it were not that his theoretical knowledge is apt to suffer considerably by so doing before taking up serious study at a college. This defect is largely met by the "sandwich" system. In the system suggested the element of time seems to have been forgotten, since the system would necessitate a good deal of repetition. It is also difficult to see how the study of electrical phenomena can be carried on without the simultaneous study of auxiliary sciences; for example, in dealing with electrical effects simple integration is frequently required, but according to Mr. KARAPETOFF'S scheme it would appear that integration would not be reached until, probably, the fourth year.

With some of the author's statements, however, we distinctly sympathise. The more a student can be brought into touch with the applications of theory the better, and for this reason the statement that the study of mathematics should be taught by an engineer, and from the standpoint of engineering applications, is undoubtedly correct. There is also some truth in the author's criticism that colleges are apt to prepare students not for ordinary commercial work, but for special research work. It is necessary to remember, in the words of the author, "that we are supposed to prepare, not future professors, but men for industrial work, and that our first aim should be to comply with the needs of the industry." We think these needs, however, can be met quite as well by the old system as by the suggested system of Mr. KARAPETOFF, and with less expenditure of time, provided always that due attention is paid to practical applications.

REVIEWS.

(Copies of the undermentioned work can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

The Construction of Dynamos. (Alternating and Direct Current.) By T. SEWELL. (London: Crosby, Lockwood & Son.) 7s. 6d. net.

The title of this book is somewhat misleading, as, apart from the construction of dynamos, the author attempts to deal "in a single volume of handy size with the theory, design and construction of dynamos, both alternating and direct current." In certain parts the matter relating to the construction is good, but, on the other hand, there is a considerable amount of antiquated descriptive matter which tends to make the book defeat its own object. The chapters dealing with the theory and principles are lucid, although certain parts might with advantage have been dealt with more completely.

Chapter II. deals with the magnetic field in a comprehensive manner, although it would be clearer to the elementary student to have a definition of "permeability" given at the outset, and the use of this term then dispensed with in favour of straightforward calculations direct from the density and ampere-turns curve. At the end of the chapter reference is made to iron-testing methods, and a description is given of only one apparatus, that of Fischer-Hinnen. There are many modern pieces of apparatus, such as those of Epstein and of Drysdale, which should have been referred to at this point.

Chapter III. introduces the subject of commutation and develops a simple ring winding for this purpose. The treatment should have been extended to drum windings, as the ring winding is practically obsolete. In Fig. 23 the flux paths need completion to make it an intelligible diagram of a homopolar dynamo.

Chapters VII., VIII. and IX. are devoted entirely to bipolar dynamos, and the subject matter deals almost exclusively with old-fashioned types. If the intention of the book were to extend the treatment from the theory and design of bipolars to multipolars, this plan would have been admissible; but, as it is, the chapters on multipolar dynamos are more or less dissociated from the previous ones on bipolars.

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Chapter VII., which should have been placed after Chapters VIII. and IX., would be much improved if the subject matter were classified under headings. Most of the line diagrams in the text in this chapter and elsewhere in the book represent impracticable constructions, but the drawings and illustrations of the products of the various firms are good instances of typical constructions. None of the commutators in Figs. 65 to 67 are on modern lines. On p. 110 we read that closed slots "assist somewhat in procuring sparkless commutation."

Chapter VIII. deals with the theory of bipolars. As much of the theory is common to multipolar machines also, the two would better have been taken together. The chapter on design of bipolar dynamos suffers from a lack of systematic procedure. Thus, for a given rating, the design is set about on such crude assumptions as "Armature reaction limits the largest size of bipolar armatures to something like 2 ft. in diameter, and it may be taken that the smaller the diameter the better." As a matter of fact, so far as commutation is concerned, the larger the diameter within wide limits the better the design.

Chapter X., on "Multipolar Dynamo Construction," is much better, but the examples given relate almost exclusively to the products of a single manufacturing firm. The chapter on multipolar design exhibits the same lack of method as that on bipolar design.

A design is commenced for a 400 kw. 550 volt machine, but no speed is assigned. This is fixed ultimately, during the course of the design, as 100 revs. per min., from peripheral speed considerations. In practice almost every case has to be designed to a prescribed speed, so that such treatment cannot but confuse the elementary student.

The sections relating to alternators are on the whole good, except that there is absence of dimensional data in the examples of machines. The antiquated inductor and copper types of alternator given in Figs. 200 to 206 might well have given place to a more adequate treatment of high-speed alternators. In the design of alternators the starting point is that of practically constant pole pitch and peripheral speed. This rule is now no longer adequate, especially with turbo-alternators, and a much more scientific line of design could well have been followed. We come in several instances across such far from general statements as "It is now becoming the usual practice to employ six slots per pole per phase, whether for one, two or three-phase machines." Such a figure is far too high for slow-speed machines, which are chiefly the type with which the author deals, although it is of the right order for turbo-alternators.

One fault throughout the book to which attention should be drawn relates to the use of far too many significant figures. This is a matter which needs attention, especially among the class of readers for which this book is intended. As an instance, on p. 206 a flux is given as 11, 167, 815 lines, and on p. 209 a flux density as 6,779 lines per square centimetre, and on p. 214 a bearing and air-friction loss as 4,344 watts. Having regard to the comparatively low degree of accuracy attainable in dynamo calculations, the use of such numbers of significant figures is preposterous.

Another matter which is confusing, especially to the elementary student, is the manner in which the magnetic calculations are carried out. The flux densities and magnetic lengths are first obtained in inch units, and these are then converted into centimetre units and the ampere turns obtained from the B.H. curve, the latter being in centimetre units.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

"A Text-Book of Electrical Engineering." Translated from the German of Dr. Adolf Thomälen. By George W. O. Howe. (London: Edward Arnold.) 15s. net.

"Searchlights: Their Theory, Construction and Applications." By F. Nern. Translated by Charles Rodgers. (London: Archibald Constable & Co.) 7s. 6d. net.

"Guide to the Engineering Profession." By W. Galloway Duncan. (Dundee: James P. Mathew & Co.) 3s. net.

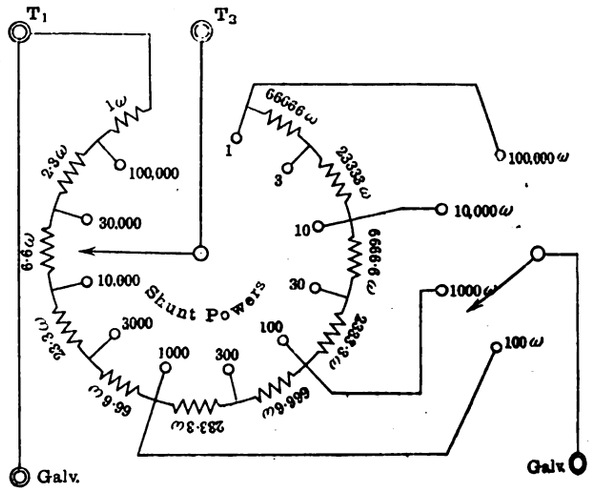
AN IMPROVED UNIVERSAL SHUNT-BOX.

BY PROF. J. K. A. WERTHEIM SALOMONSON.

A sensitive galvanometer is generally used with an appropriate shunt-box, allowing only a definite fraction of the current which is to be measured to be sent through the galvanometer.

Prof. W. E. Ayrton and Mr. T. Mather designed their well-known universal shunt box, which can be applied to any galvanometer. It contains a resistance connected across the terminals of the galvanometer. The current to be measured flows through the tenth, the hundredth or the thousandth part of this resistance. It can easily be proved that the sensitiveness of the galvanometer combined with the shunt is reduced in exactly the same proportion. As this holds good for any instrument, whatever be its resistance, one would expect that one universal shunt-box could be used with advantage for every galvanometer. But this is not the case, as the total resistance of the shunt-box should be neither too large nor too small as compared with the galvanometer resistance. This circumstance is particularly felt when a moving-coil instrument is used, as the damping is strongly influenced by the external resistance. For dead-beat deflections the external resistance should be much reduced, whereas periodic deflections are only to be obtained with a large external resistance. Practically, we want at least one shunt-box for every galvanometer of this kind.

In order to be able to use the same universal shunt-box for every galvanometer, I have modified it slightly. The arrangement will readily be understood by a glance at the accompanying figure. It shows the ordinary universal shunt-box with a dial switch to alter the shunting power. But a second dial switch is added, permitting part of the resistance to be cut out of the galvanometer circuit, so as to reduce its total resistance.



In the shunt-box constructed for me by Mr. Robt. W. Paul the total resistance amounts to 100,000 ohms. The 11 shunt powers are 1, 3, 10, 30, 100, 300, 1,000, 3,000, 10,000, 30,000 and 100,000. By means of the right-hand dial switch the total resistance can be reduced from 100,000 ohms to 10,000, 1,000 or 100 ohms. If the box is used with one of the lower resistances, the shunt powers are reduced in the same proportion. The number of the useful shunt powers is, of course, also modified when the right-hand pointer does not point to the largest resistance. With 10,000 ohms nine shunt powers are available, with 1,000 ohms seven, with 100 ohms we have five shunt powers left.

This modified universal shunt is particularly useful with moving-coil instruments, as it allows the absolute sensitiveness as well as the damping to be modified. Every galvanometer of this kind provided with it can be used with a periodic or an aperiodic movement of the coil. A critical damping can always be obtained, but necessitates the introduction of a suitable additional resistance, the amount of which depends on the external resistance.

I use it in connection with an Einthoven string galvanometer and also with the Place galvanometer. With the terminals connected in the wrong way I use it as a combined shunt and ballast resistance for the Place galvanometer used as a wattmeter.

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RESISTANCE COILS AND COMPARISONS.*

BY C. V. DRYSDALE, D.SC.

Summary.—The author gives a survey of resistance coils, showing their evolution up to the present time and the methods used in accurate measurements of resistance. Results of tests on a number of resistance-alloys are given. The desirable features and temperature compensation of resistance coils are then discussed, and the author describes attempts which he has made at compensation by electro-depositing films of suitable thickness of certain metals on the resistance wires. In conclusion, the methods of standardising coils and bridges are considered, and a modified form of Carey Foster bridge, due to the author, is described.

Few measurements have attained to greater accuracy than that of electrical resistance, and considerable attention has been given both to the construction of resistance coils and to their standardisation. Nevertheless an examination of the various forms of coils and of standardising bridges which have been employed reveals considerable differences, and it has appeared possible that forms might be devised in which the advantages of the existing types might be combined, while eliminating their disadvantages. In the present Paper, therefore, a brief account of the principal types of coils and methods of measurement is given, followed by a description of some new forms which it is hoped may prove advantageous.

The first serious attempt at producing a permanent standard was made by the Electrical committee of the British Association in

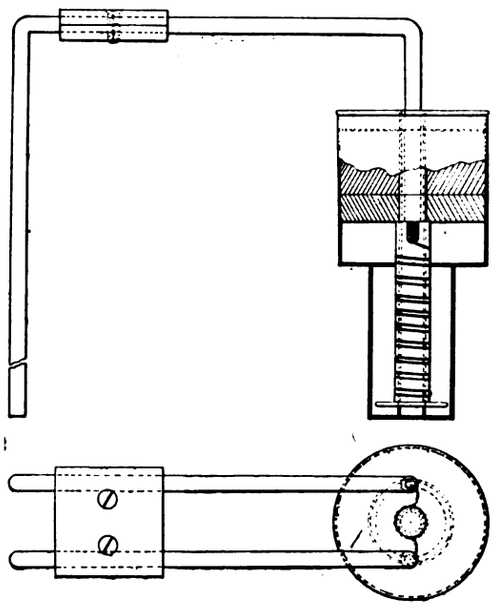

FIG. 1.—B.A. PATTERN, 1865. One-third full size.

1865,† after a long research on the value of the ohm and on the properties of alloys, and until about 15 years ago this coil was in almost universal use. As is well known it consisted of a metal bobbin $\frac{5}{8}$ in. diameter, 8 in. long, with an ebonite crosspiece above (Fig. 1), through which two long copper rods, about $\frac{1}{4}$ in. diameter, passed, and which were bent over to form electrodes. The wire consisted of platinum-silver in the proportion of 1 to 2, having a temperature coefficient of about 0·025 per cent. per 1°C., and was soldered to the ends of the copper leads. After adjusting, it was slipped into an outer case, which was in the form of a double cylinder, and this was sealed up solid with paraffin wax. When the coil was placed in a tank the water surrounded the coil on the outside and entered the centre tube, in which a thermometer was fixed.

As soon, however, as standards of resistance were in great demand and required to be frequently measured, it was found that measurements to a much greater accuracy than 1 in 10,000 were both tedious and difficult. The wire being separated from the water on the outside by a considerable air space, and on the inside by the insulation on the bobbin, the two tubes and the air space between took a considerable time to attain the exact temperature of the water bath, while at the same time any heat developed in the coil by the passage of the testing current was unable to quickly escape. The testing current had therefore to be kept very low and this reduced the sensitiveness of the test.

The first step in the direction of overcoming these difficulties was made by Prof. Fleming in 1889,* who adopted a hollow ring of flat form and about 5 in. diameter (Fig. 2). This ring was of cast brass in two halves screwed together and the copper terminal rods were brought out from it through ebonite bushes in vertical brass tubes.

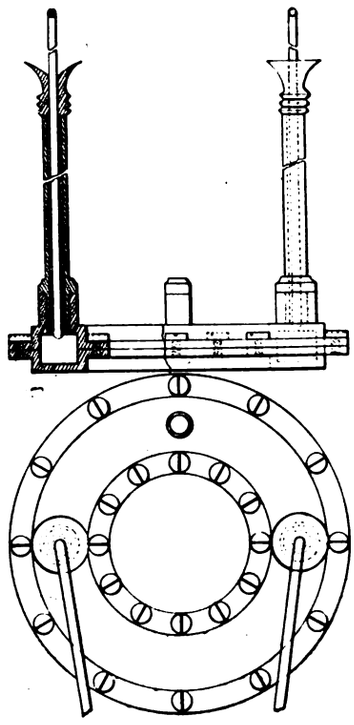

FIG. 2.—J. A. FLEMING, 1889. One-third full size.

The water is thus able to circulate all round the coil, and the difficulty of stratification of the water is eliminated by the flat form.

Other coils on nearly the same lines were brought out by different firms about this time. Messrs. Nalders adopted a form (Fig. 3), introduced by them in 1894, in which a short vertical bobbin about

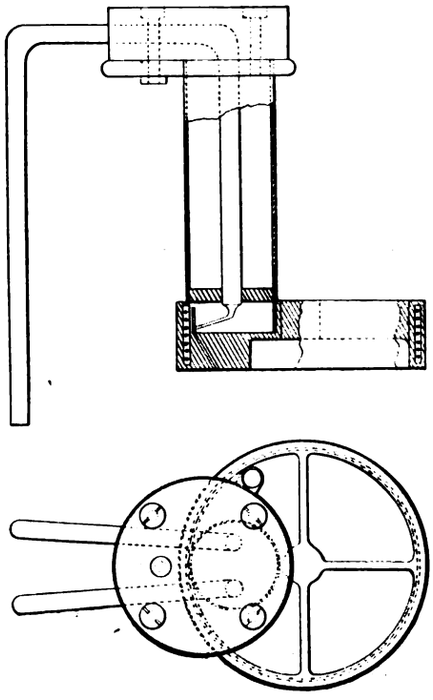

FIG. 3.—NALDER BROS. & Co., 1894. One-third full size.

4 in. diameter was cast of thin brass, and this communicated with a vertical brass tube with ebonite top, through which the somewhat thicker electrodes were brought. The coil having been adjusted, a thin brass band was slipped over the coil and soldered up.

* Paper read before the British Association at Leicester, August, 1907.

† B. A. Report, Birmingham, 1865, p. 308.

* J. A. Fleming, *Phil. Mag.*, 1889.

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Messrs. Paul have modified the flat pattern of Prof. Fleming, as shown in Fig. 4*. Here the flat ring is replaced by a hollow disc from the centre of which rises a brass tube containing the electrodes.

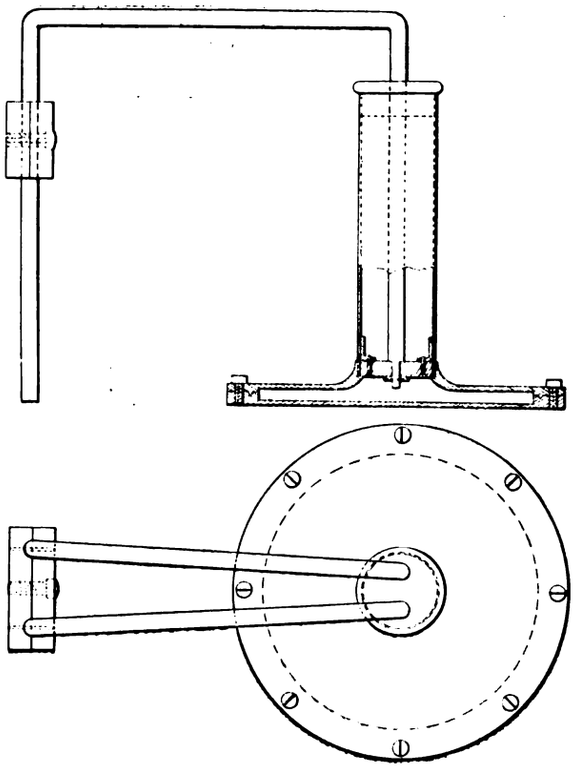

FIG. 4.—R. W. PAUL, 1892. One-third full size.

The advantage of the flat form is thus preserved without so much difficulty in keeping a water-tight joint.

All the above coils may be spoken of as being of the enclosed or

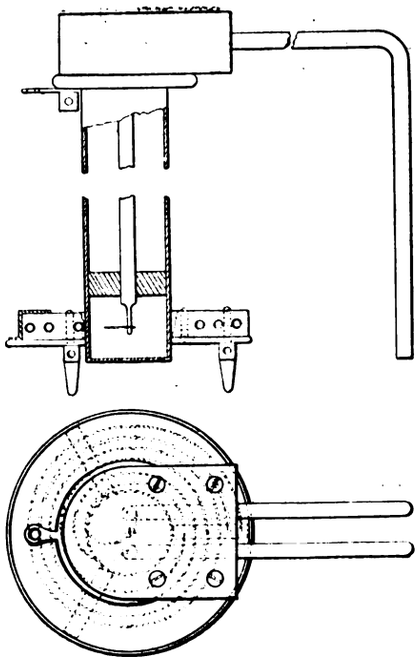

FIG. 5.—A. D. HUGHSON, 1896. One-third full size.

protected type, the working wire being entirely enclosed in a sealed metal case, and being therefore protected from the atmosphere and from the liquid used in the bath. Of this type perhaps the most perfect is that of Mr. A. D. Hughson (Fig. 5),† who threads the doubled silk-covered wire into a thin, small, spirally wound copper tube, which communicates with a larger tube containing the electrodes, as in the patterns of Messrs. Nalder and Paul. By this means probably the most perfect heat radiation possible in a protected pattern of coil is secured, but its use is naturally confined to coils of 1 or at most 10 ohms, owing to the difficulty of threading the wire.

While these improvements were being made in England progress was being made in Germany in two directions: firstly, in securing a coil of lower temperature coefficient, and secondly, in obtaining a greater heat radiation.* For the first purpose experiments were made with the alloy of copper and manganese which had been discovered by Weston in 1889, and this was developed by Dr. Lindeck into an alloy which greatly surpassed those in previous use as

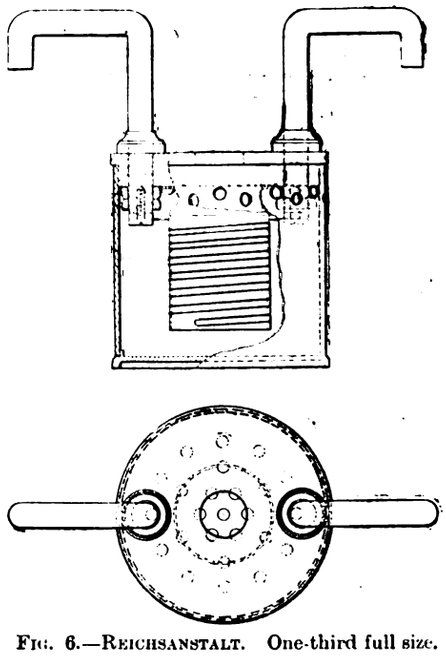

FIG. 6.—REICHSANSTALT. One-third full size.

regards temperature variation, and was found to be very satisfactory as regards permanency.† This wire was simply silk-covered, wound on a metal bobbin, coated with shellac and baked, and the coil was then immersed in petroleum. At the same time, considerable improvement was made in the terminals, the long, thin, bent rods of the English forms being replaced by short arms of double the section, and the wire being silver-soldered instead of soft-soldered to the terminals. Shortly after, the use of separate current and potential terminals was adopted. Figs. 6, 7 and 8 show three forms of standard 1 ohm or 0·1 ohm coil of the Reichsanstalt as

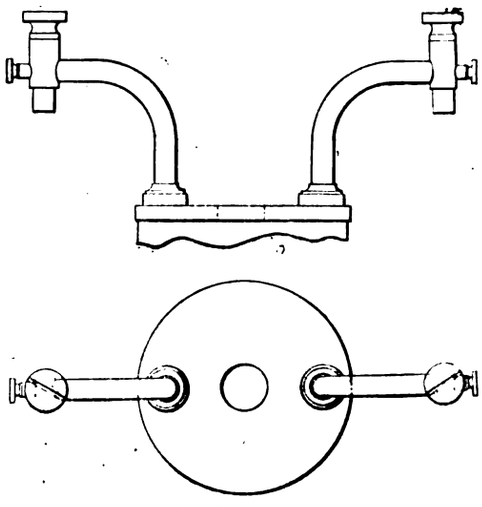

FIG. 7.—REICHSANSTALT.

made by Messrs. O. Wolff, while other firms in Germany‡ have constructed nearly identical forms.

* R. W. Paul, *Proc.* Phys. Soc., March, 1892.
† British Patent No. 4,371, 1896.

* "Die Konstruction der Elektrischen Normalwiderstände der Physikalisch Technische Reichsanstalt." K. Feussner, *Zeit. für Inst.*, X., p. 6, 1890. "Der Elektrischen Normal Drahtwiderstände der Physikalisch Technischen Reichsanstalt." K. Feussner und St. Lindeck. *Zeit. für Inst.*, XV., pp. 394 and 425, 1895.
† "Ueber die Konstanz von Normalwiderstände aus Manganin," *Zeit. für Inst.*, p. 67, 1898.
‡ "Ueber neue Normalwiderstände der Firma Siemens and Halske." A. Raps, *Zeit. für Inst.*, XVI., p. 22, 1896.

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In England the Cambridge Scientific Instrument Co. have made the Reichsanstalt form of coil, while Messrs. Elliotts have modified it as shown in Fig. 9, potential contacts being attached to the sides of the main lugs.

Owing to the extreme importance of good heat radiation and of exact knowledge of the temperature, the coil shown in Fig. 10 was

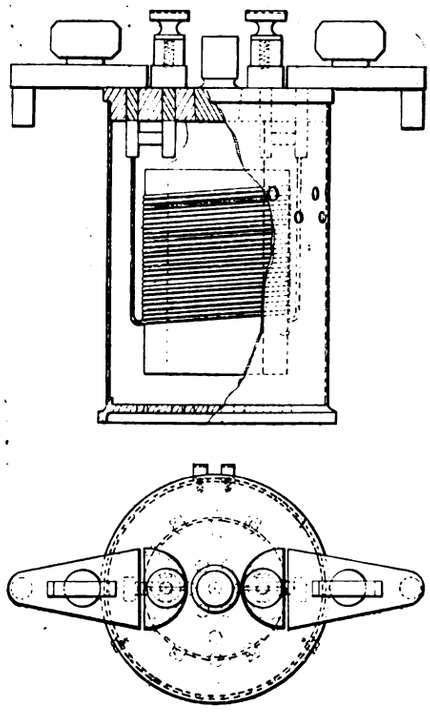

Fig. 8.—Reichsanstalt, 1 ohm.
One-third full size.

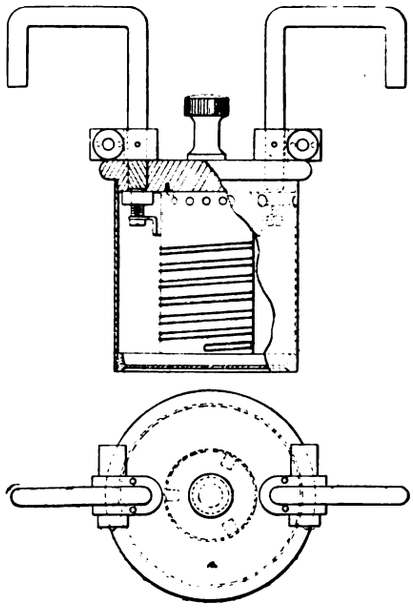

Fig. 9.—Elliott Bros.
One-third full size.

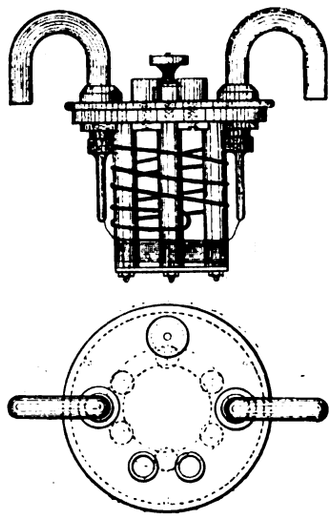

Fig. 10.—C. V. Drysdale, 1900.
One-third full size.

devised by the writer in 1900, and three of these coils were made by Messrs. Everett & Co. It consisted of an ebonite cover supporting two short, thick copper terminals. These were squared on passing through the cover and screwed up by lock nuts underneath. The principal coil consisted of an alloy obtained from Messrs. Nalder Bros. under the title of "new metal," and having a negative temperature coefficient of about 0·003 per cent. per degree centigrade.

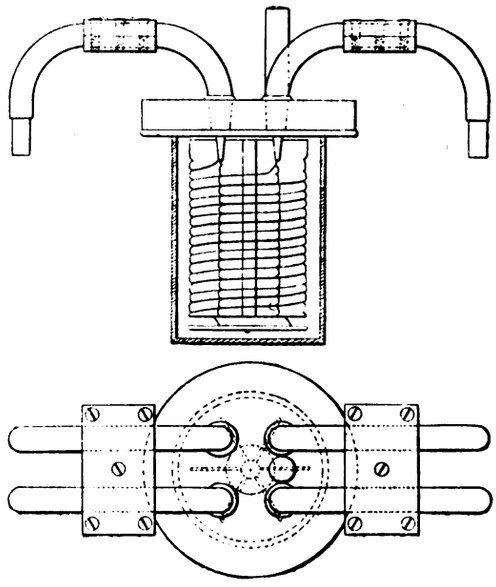

Fig. 11.—F. W. Burstall. One-third full size.

This was silver-soldered to small copper washers, which were tinned, bolted up and soldered to the ends of the copper lugs. The coil was adjusted to be about 0·8 per cent. high, and a shunt of about 130 ohms of thin copper wire was soldered to prolongations of the main lugs left for the purpose. Both the main and shunt coils were wound on a frame of six corrugated glass or ebonite pillars, and they were adjusted to give the required resistance and at the same time to approximately eliminate the temperature variation, which it was found possible to make less than one part in a million for 1°C. over a range of about 7 deg. or 8 deg. In order, however, to determine the temperature with accuracy, two other coils, each of about 10Ω, were wound side by side in between the turns of the main coil. One of these coils was of platinum, the other of "new metal," thus giving a large difference of coefficient, and their junction was connected to a terminal, while the other two ends terminated in mercury cups in the cover. By means of an auxiliary pair of ratio coils and slide wire the mean temperature of the coil was readily determinable. The whole was enclosed in a perforated brass cover and immersed in a tank which was electrically heated by coils wound near the bottom of the tank.

About the same time Prof. F. W. Burstall* described a coil on the same lines (Fig. 11), which has been put on the market by the Cambridge Scientific Instrument Co.† The working wire—in this case of platinum silver—was wound in notches on mica strips and was hard-soldered to short, thick terminal rods. For the purpose of determining the temperature a platinum coil was wound between the turns of the main coil and soldered to a second similar pair of

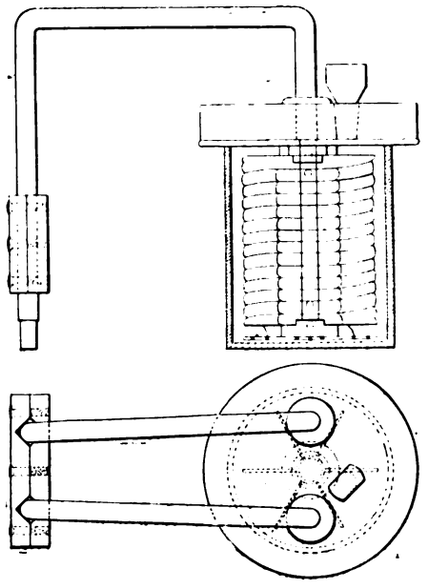

Fig. 12.—Cambridge Scientific Instrument Co. One-third full size.

terminals. The whole coil was immersed in a glass vessel filled with petroleum. A similar form of coil, but without the platinum thermometer coil (Fig. 12), has also been made by the Cambridge Company.

* "On the Use of Bare Wire for Resistance Coils." *Proc.* Phys. Soc., Vol. XIV., p. 286.

† "Standard Resistance Coil." R. S. Whipple, B.A., 1900. *The Electrician*, Vol. XIV., p. 772, 1900.

(*To be continued.*)

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ON THE DISAPPEARANCE OF MAGNETISM.*

BY MARTIN GILDEMEISTER.

When iron is placed in a magnetic field whose intensity increases or decreases suddenly, it does not immediately assume the corresponding magnetic state, but only after a few minutes. This fact was demonstrated by Ewing and Lord Rayleigh. According to Martens, Klemencic and others the change occurring seems to consist of two parts, one of which takes place very rapidly, and the other slowly, with a pause between them. The second part has been profoundly studied, but about the first we have very little material.

Helmholtz found in 1851 that in a vanishing magnetic field thin wires (0·028 cm.) of soft iron assume a state of magnetic equilibrium in the course of an "immeasurably short period of time." From his data we must conclude that this "immeasurable" period is less than 0 0001 second.

Holborn,† on the other hand, investigated the generation of magnetism after the closing of the electric circuit. He concluded that magnetisation was complete when the current had attained its full strength—*i.e.*, after 1/200th second. But it appeared probable that the magnetism follows the force even during much smaller intervals. Both investigators failed to discover the subsequent slow changes of induction, since they used ballistic methods.

The present investigation is concerned with the *cessation* of magnetisation after the removal of the magnetising field, within 1/2000th second after break. The method used is the same as that employed by Helmholtz. Its principle is the following :—

To eliminate eddy currents bundles of thin iron wire are used. These are surrounded by a coil traversed by an electric current. If this is interrupted, and at the same moment the coil is connected up with a ballistic galvanometer, a current traverses the latter, which consists of three parts: (1) The break-current of the coil; (2) the current induced by the disappearing magnetism of the iron; and (3) a current due to the capacity of the coil.

If now a very small interval of time, θ, is allowed to elapse between the instant of break and the connection with the galvanometer, the sum of the three currents passing through the latter becomes smaller. That value of θ, for which the galvanometer ceases to indicate anything, is the time required for the disappearance of the magnetisation (except the slowly-changing and the remanent magnetisation).

The only difficulty lies in the fact that between the opening of one circuit and the closing of the other a very small and accurately measurable interval must elapse. This was attained by means of a Helmholtz pendulum of great precision, made by Edelmann in Munich. One of the contacts was stationary. The other was displaced by means of a micrometer screw with a head divided in 100 divisions. A displacement of one division made a difference of 1/600000th second, and this interval was taken as the unit.

The galvanometer was a Siemens moving-coil galvanometer, showing about 1,000 scale divisions per microcoulomb, and possessing an inductance of 3×10^7 cm.

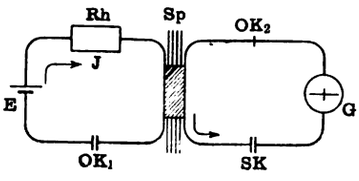
The cylindrical wire bundles were longer than the magnetising coil, which was wound in two layers on a glass tube. Four bundles were used, whose constants were as follows :—

	Length.	Diameter.	Weight.	Thickness of wire.
I.	12·5 cm.	0·55 cm.	13 gr.	0·0185 cm.
II.	34·0 cm.	1·45 cm.	288 gr.	0·0185 cm.
III.	32·0 cm.	0·90 cm.	80 gr.	0·028 cm.
IV.	38·5 cm.	1·25 cm.	224 gr.	0·118 cm.

The arrangement is sketched in the diagram. E is the accumulator cell, Rh a rheostat, Sp the coil, G the galvanometer, OK is the break contact, SK the make contact of the pendulum. The magnetising current J was limited above by the heating of the break contact, and below by the sensitiveness of the galvanometer. The results obtained with bundle II. are given in the table :—

θ	Mean deflection.	θ	Mean deflection.
0	5·45	6	0·25
2	4·10	8	0·05
4	3·65	11	0

The small deflections obtained led to a modification of the arrangement for the smaller coils. Another break contact was inserted at OK_2, and this was opened shortly after the closing of SK. It was found that the readings were increased by reducing the resistance in the galvanometer circuit. This would damp the instrument to an undesirable extent, but not in the new arrangement. The table also shows that the magnetisation had disappeared after 10 units (or 1/60000th second).



As regards the theory of the experiments, which the author gives in full, it may be remarked that the application of Kirchhoffs' laws is quite unexceptionable, since in the shortest interval in question (1/600000th second) electricity traverses more than 500 metres in wires, whereas here the length of wire does not exceed 50-100 metres.

The conclusions arrived at from the results of the experiments are the following :—

In 1/300000th second the magnetisation falls to less than half its initial value. If only the best results are counted, the time may be reduced to two-thirds or one-half the above. In 1/150000th second the magnetisation falls to less than one-tenth its initial value, and after 1/50000th second it has totally disappeared. In the interval between 1/50000th and 1/2000th second the magnetisation does not fall perceptibly. The slow demagnetisation evidently does not set in till 1/2000th second has been exceeded.

The wire bundles used were tested some days or weeks after annealing.

* Abstract from the *Annalen der Physik*, No. 8, 1907.
† *Berliner Ber.*, 11, p. 173, 1896.

MUNICIPAL TRAMWAYS ASSOCIATION SIXTH ANNUAL CONFERENCE.

Wednesday, September 25th.

There was a good attendance at the opening of this Conference at the Town Hall, Manchester, on Wednesday. After meetings of the Executive Committee and Managers Section, the members attending the Convention were officially welcomed by the Lord Mayor of Manchester (Councillor J. Harrop), who expressed pleasure in seeing so large a gathering of tramway men in a "tramway city" such as Manchester. A vote of thanks to the Lord Mayor, proposed and seconded respectively by Sir J. Baxter Ellis (Newcastle tramways) and Ald. Durnsford (Southampton), was carried with acclamation.

Mr. J. M. McElroy, general manager Manchester Corporation tramways, and President for the current year of the Association, then delivered his address. After referring to the prosperity and usefulness of the Association, and to its rapid growth from small beginnings, Mr. McElroy turned to the vexed question of municipal versus private ownership. Naturally enough, he had a decided bias in favour of the former, though he admitted that there *were* difficulties and dangers inseparable from municipal operation, even under the best conditions prevailing to-day. He desired that a fair and impartial account should be put forward on this subject by some person whose qualifications for the task were unmistakable.

With regard to the Tramways Act of 1870, he denied that it had any "strangling" effect on the tramway industry, as contended by anti-municipal traders, but, on the contrary, its "regulating" effect was, in the eyes of municipal advocates, in the end beneficial to all concerned, though the results were, possibly, unsatisfactory towards the end of the companies' ownership. The municipal trader could point to the fact that in practically all the cities and towns in the kingdom the tramways had now been taken over and were operated by the municipalities, and that the benefits accruing to the travelling public, the ratepayers and the tramway employés had been enormous. In the case of unrestricted private enterprise, such as was found abroad, however, the undertakings were not up to the high efficiency to be found in many cities in this country.

In the opinion of anti-municipal traders the Standing Orders, which obliged tramway promoters to obtain the permission of the local authority through whose district it was proposed to construct the line, had retarded the development of the industry, and this clause had, moreover, in some cases proved a thorn in the side of the municipalities themselves, when, as in the case of some of the larger systems, they had desired to extend their systems outside their own boundaries; they had then found themselves in the unenviable position of private promoters. Mr. McElroy contended that this matter was deserving of serious consideration, as it might retard progress by preventing the spreading of the population to outlying areas.

Referring to the extension of tramways to country districts,

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the speaker compared the two methods of procedure in this country and in America. In the former case the district was developed before the tramways were constructed, while in the latter the tramway preceded the population.

There were, however, difficulties to be met with even under municipal control. The political influence which might be exerted by the employés was a disconcerting feature and might lead to slack and inefficient service to the public. Another danger was the tendency to look for a reduction in the rates from the proceeds of the trading departments. Great caution was needed in this matter, and the provision of an adequate fund for depreciation and renewals, in addition to the usual capital charges, was of great importance.

The address concluded with a reference to the report of the American Commission on municipal ownership which visited this country last year, and a summary was given of the various points of interest. This subject has already been referred to in *The Electrician* of September 13th.

Mr. J. B. Hamilton (Leeds) Past-President and Mr. J. B. Aldworth (Nottingham) Vice-President of the Association, respectively proposed and seconded a hearty vote of thanks to the President for his address. Mr. R. L. Acland (tramways manager, Chesterfield tramways) was then called upon to read his paper on :—

LONG WHEEL-BASE TRUCKS.

At the spring meeting of the Municipal Tramways Association the relative qualities of cars mounted on double bogies and single short wheel-base trucks were advocated respectively by Messrs. Mozley and Dalrymple, and many valuable expressions of opinion were elicited from other tramway experts on this subject, but little was said as to the merits of the third alternative, namely, the long wheel-base single truck, which, in the opinion of the author, is superior to either of the older types, and further, he considers that before long it will be very much more largely adopted in this country as is already being done in Germany, where its advantages have been realised as compared with the short wheel-base trucks previously in use, particularly in Nuremburg, Vienna, and Buda Pesth, where cars with wheel-centres varying from 8 ft. 2in. to 11 ft. 10 in. are being used.

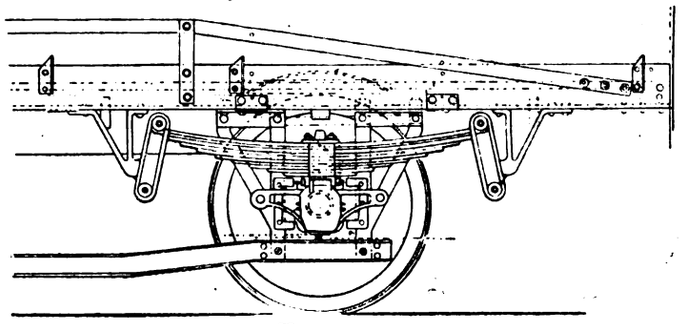
The standard single truck double-deck car as used in this country, carrying from 50 to 56 passengers, 22 inside and the remainder on the top deck, leaves nothing to be desired from the traffic manager's point of view, as it is a size which can be loaded and unloaded rapidly, provided an efficient stairway to the top deck is used, and not one of the inconvenient and awkward arrangements known as the "Reverse" staircase which causes the inside and outside passengers to struggle as to who is to get on or off first, and further, a single conductor can easily manage to collect all his fares with a mixed complement of long and short stage passengers on board ; a high average speed with stops can be maintained ; and with a top deck cover, this is an ideal car for all weathers.

From the engineering point of view, however, to run a self-propelled vehicle weighing with a full load of passengers and top-deck cover about 12 tons, spread over a length of some 30 ft. on a wheel-base not exceeding 6 ft. 6 in., at speeds up to 16 miles per hour, is certainly very contrary to what has been found from experience to give the best results on other forms of rolling stock. This type is a legacy from the old horse-car days, when very much smaller and lighter cars mounted on short wheel-base trucks were used in order to take as much work as possible off the long-suffering animals when dragging them round fairly sharp curves ; but with the rapid development of electric traction, and the quick change that was made on some of the old horse systems, it was only considered necessary to use a similar truck of stronger build which would carry the motors and other equipment, the wheel-base remaining the same as before. This was all very well with the smaller type of electric cars first used, or when the old horse-car body was simply mounted on the heavier bogie, but car bodies began to grow and extend lengthwise, and it would seem only reasonable to expect that the wheel-base should have been increased in something like proportion, which has, however, not been the case.

The result of this unequal growth of body and wheel-base can now be seen on many systems, where cars are running with bent backs and drooping platforms, caused by excessive overhang and pull on the brake chain fixed to the extreme end of same. the trucks also are strained and thrown out of square, for a car of this type when running on a straight track at high speed, in addition to pitching heavily, oscillates from side to side. due to the unevenness of the rail and other causes, the ends of the platforms describing part of a circle about the truck as a centre, with the result that the wheels are constantly running askew in the grooves in either direction, whereby heavy wear and tear takes place on the flanges which are worn into all sorts of extraordinary shapes by having to guide the car under such severe conditions, and the constant slipping and grinding of the tyres must help to wear the rail head into a corrugated surface, and it would seem to an increased degree when steel tyred wheels are used instead of chilled iron.

When a car runs through a pair of points at the entrance of a loop, the whole mass has to be set revolving in one direction and immediately afterwards in the opposite direction by reason of the short S curve, for which work an abnormal force has to be applied to the wheel flange in order to steer the car round the curve and to draw it out of the line of its momentum into a new direction, both of which are increased in proportion to the overhang of the body. These conditions are worse the shorter the radii of the points, and further, when a runaway car of this type approaches a simple curve at high speed, the flanges have not the same chance to give the car the necessary steering force to get it safely round the curve, and to overcome its momentum travelling in a straight line, as they would if the wheel-base was longer and the leverage of the unsupported portion of the car body upon them thus reduced.

Rail joints, when they begin to go, as all mechanical joints will do, get most unmercifully pounded, for a car that is pitching heavily endways will often have very much more than half the weight on one pair of wheels, when they drop into the bad place. This is given as one of the chief reasons why the European cities above-mentioned have so largely adopted the long wheel-base truck, the majority of the track being in a somewhat shaky condition.



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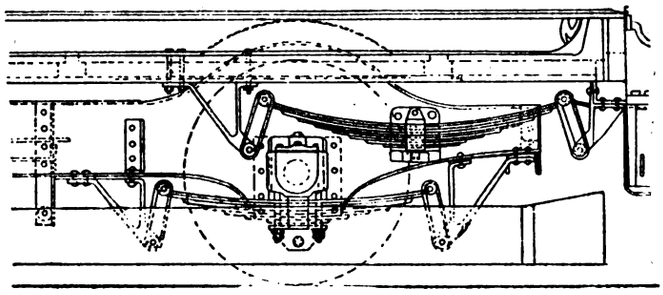

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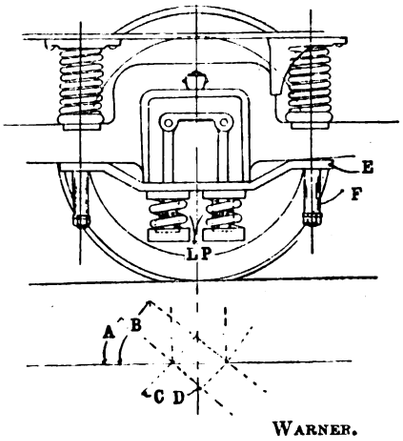

A, B, Angles of lower pins L P.
C, D, Path of swing of links and of slots in yoke bridge.
E, Yoke bridge.
F, W. H. springs here ; M. E. T distance barrel. Axle box not shown.

WARNER.

The bogie car is in the author's opinion only suitable for interurban transit, or in large towns where both types of cars are used, when they are useful for loading up at crush hours with the long distance or "through" passengers, but to continually stop and start a car carrying between 80 and 90 passengers for the accommodation of general traffic is certainly not leading towards the greatest economy, for the average speed is considerably less, time keeping not so good, and the likelihood of all fares being collected is reduced, as compared with the use of two small cars on the same service. A further result of discrimination in car functions on a large system as outlined above, is that the comfort of the passenger and loading speed capacity will be in proportion to the length of the journey, for the small short stage City car with fore and aft seats provides ample space for standing room, facilities for rapid loading and moderate comforts, as compared with the bogie car, which, with comfortable cross seats, centre aisles and minimum of standing accommodation, offers an attractive method of transit to the long stage or interurban passenger as compared with the higher speed and varying comfort of a competing railroad.

From an engineering point of view the bogie car is a considerable improvement on the single-truck type, as the wear and tear on the car body is not as great, nor are such violent strains imposed upon the truck frames, wheel flanges and track, but still the oscillation of the bogies upon their respective centres, with the consequent skewing

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of the wheels in the grooves, will give the same conditions conducive to flange wear, rail corrugation, &c., as those belonging to the short wheel-base truck, but in a less degree, for the bogie truck is not acted on by any direct force tending to throw it out of square, and to set itself in line with the track has only to overcome the direct downward pressure of the car body upon the centre of the bolster.

When most tramway lines were operated with steam locos. and trailers mounted on bogies corrugation was practically unknown, for the cars were being hauled, and not self-propelled, and the steam locos. which did the hauling had a wheel-base proportional to their overall length, and further, they were held practically square in the rail grooves by the weight of the trailer. A locomotive type of crank axle on the driving wheels hitched up to the trailing wheels by means of coupling rods gave practically an even turning moment on all four wheels, which making therefore the same number of revolutions would tend to keep all the tyres the same diameter, and also reduce the slip when accelerating and rounding curves, whereas the two motors running independently and gear driving on to the extreme end of each axle, torsional strains are set up on the axles themselves, cross strains on the trucks and cross-corner wear on the tyre-flanges, with a consequent extra wear and tear on the track which did not exist before.

This argument is supported by experience on steam railroads, where a comparatively small amount of corrugation has so far been found when the train is hauled by a single locomotive in front, but with the advent of electric traction and multiple-unit system with numerous driving wheels on four-wheeled bogies dispersed throughout the length of the train corrugation has developed largely, also wheel-flange and rail head wear, owing, apparently, to the insufficient length of wheel-base in proportion to the rail gauge, as pointed out recently in the *Tramway and Railway World*. Some steam railroads are adopting six-wheel bogies on main-line rolling stock, and it would be interesting to know whether this increased wheel-base, or the use of coupling rods connecting the driving wheels would tend to reduce these troubles.

In 1904, when advising the Corporation as to the type of truck to adopt on the Chesterfield tramways, the author held the same opinion of the faults existing in the bogie and short wheel-base trucks as he has endeavoured to lay before you to-day. He wanted the standard two-deck body mounted on a single truck with a long wheel-base, and recommended the adoption of the only one at that time on the market, certainly not without some misgivings, for, while the advantages were very apparent, the disadvantages would only develop in working, and no other corporation had at that time adopted them, from whose experience any information could be obtained. The result, however, of nearly three years' working with this type of truck has clearly demonstrated that a car mounted on a long wheel-base gives the most comfortable riding owing to the great reduction of pitching and side oscillation, the body is also held in line being supported practically throughout its length, and can in consequence be of lighter construction, the strain on body, truck and track, when running through points or round curves, is largely reduced, and no case of derailment has occurred on this system unless through an obstruction on the track, and not a single axle has been broken.

The long wheel-base trucks mostly in use in this country are called "radial" trucks; a better name would be "flexible" trucks, because they do not radiate, in the geometrical sense of the word, and the author considers that in designing these the necessity for a minimum amount of flange friction on short radius curves has been made too much of, with the result that the trucks have been rendered unsuitable for high speed on a straight truck. On all these cars the tractive force is applied at the centre of the truck frame through king pins, which are fixed only a short distance to the front and rear of the diagonal centre of same instead of at the axles, and the inner truck carrying these motors and break gear, together with the axle, are free to move about these pins as centres, subject to the controlling effect of springs or inclined planes, the result of which is that any end oscillation of the body and main frame, or tendency of the trailing motor to do more work than the leading motor, will move the king pins off the central line of the track and put both axles out of square with the rails, in which position they will often remain with disastrous results to the tyre flanges. To get over this latter trouble a link suspension with gravity control has been recently put on the market, and is being tried on several lines, which certainly seems to fulfil its claims in this respect; but with such a delicate method of hanging the car body the axles are more likely to be constantly slightly deflected, with the result that while the flange wear may be reduced, the constant grinding slip on the rail head will be increased.

Experiments are also being made with locking the inner trucks completely, and thus using an 8 ft. 6 in. rigid wheel-base, and on one line having curves of 40 ft. radius, cars with chilled wheels have been running successfully for some time with much better results in the way of wheel flange wear than when the axles were free to move, and, it is stated, without any appreciable increase of wear of the check rail on curves. The author is also experimenting in the same direction at Chesterfield, using a special V-shaped flange on the wheels, and is inclined to think that this will be the ultimate form of the long wheel-base truck with wheel centres spaced from 8 ft. 6 in. to 10 ft.

No industry in modern times has attained such huge proportions in a few years as has been the case with electric traction in this country; every town wanted to be equipped at once in order to be up to date, with the consequence that there has been no time for one line to carefully investigate the results of faulty designs on its forerunners, to improve on these and benefit thereby. One of the fallacies that has grown and flourished under these conditions in the past was that tramway trucks could only be built in America, because it has been easier for tramway engineers simply to specify a certain make of American truck already in use rather than to seek out the good and bad points of these, to design an improved one and have it built in this country, so that details could be discussed with the makers. We can turn out some of the finest locomotives and rolling stock in the world, so that surely we are capable of building a good tramway truck, and more of the leading firms would give this all-important matter their attention, provided tramway authorities are prepared to pay a reasonable price for a good article. The rush of constructing new lines is over for a while, and now is the time for engineers to carefully consider what improvements can be made in truck design, as many of those running at present are not only knocking themselves to pieces, but the track also. One of the chief results of such investigation will be, in the author's opinion, a greatly extended use of the long wheel-base truck.

DISCUSSION.

Mr. R. C. BULLOUGH (Colchester) remarked that in Colchester it would be impossible to put long wheel-base cars on the sharp curves existing in the track there. He thought that the title of the Paper should have been flexible or radial trucks, and not that adopted by Mr. Acland. The long wheel-base car, he agreed, was conducive to smooth running; he thought that the cost of the maintenance of flexible trucks should have been included in the Paper.

Mr. P. FISHER (Dundee) asked for information as to whether steel-tyred or chilled wheels produced corrugations the more.

Mr. H. MOZLEY (Burnley) said that in Burnley they were experimenting with a special car which had been designed for two-motor equipment and a long wheel-base. The design, as far as he was aware, was quite novel, as it embodied several important points, and he gave the following description:—

This truck, which is known as the Simpson & Park radial truck, has been designed to meet the following requirements: (1) To prevent oscillation of the car under any conditions, by providing a sufficiently long wheel-base. (2) To enable a long and heavy car to be carried on two axles, and so render the whole weight of the car available for obtaining the maximum adhesion. This gives rapid acceleration and more efficient braking, making it unnecessary to use maximum traction trucks, in which only a portion of the weight comes on the driving wheels; also doing away with the necessity of adopting four motor equipments on heavy cars used for ascending steep gradients. The car body is supported on two single-axle trucks, the centres of which are separated to give a wheel-base proportional to the length of the car. Each truck is entirely independent of the other, the only connection being the brake rigging as in the case of all types of bogie trucks. Each truck is pivoted at a point in the centre line of the axle, the thrust being taken entirely by the king pin and bracket attached to the car body underframe. Rollers of suitable design running in an oil bath are interposed between the car body and the truck, to enable the latter to swing readily round the king pins. The springing is carried out in the same manner as on maximum traction trucks. The wheel brake is very effective, the blocks being hung as near to the centre line of the wheel as possible instead of below same. A differential gear is fitted to each axle which, with the usual gear-wheel, is compact in itself, only taking up on the axle about 1¼ in. more space than the ordinary gear, and only requires a small change to the standard gear case. This gearing enables each wheel when passing round a curve to work independently of the other, and so prevents slipping, binding and waste of energy and wear of wheels and rails, and also facilitates the movement of the truck into the correct radial position. It will be seen a flexible truck is obtained in which the wheels are allowed to follow the rails, the axles swinging round when taking a curve, this movement being facilitated by eliminating as far as possible the friction due to the weight of the car on the truck, which tends to hinder the angular movement of the trucks, also by the adoption of the differential gear.

Advantages claimed for this truck are as follows: (1) A wide range of angular movement. (2) The length of the wheel-base is only limited by the length of the car. (3) Reduction of wear between wheel flanges and rails. (4) The tendency to unequal wear between the diameters of the two wheels on one axle greatly diminished. (5) Reduction of twisting strains on the axles. (6) Differential action will lessen corrugation. (7) Reduction of weight of car. (8) Less sand required for accelerating. (9) A saving in current consumption.

Alderman SMITH (Liverpool) asked if Mr. Acland's unfavourable opinion of reversed stairways was based on experience. At Liverpool they tended to attract passengers rather than otherwise. Upwards of 700 million people had been carried and there had been no accidents. Experiments were now being made in Liverpool with trucks having 7 ft. 6 in. wheel base.

Mr. HILL (assistant manager, Birmingham) considered that the rail grooves at all sharp curves should be widened. In Birmingham they had experience of the running of maximum traction, rigid and so-called radial trucks. He gave comparative maintenance costs of the three types. These were: for 20 maximum traction trucks £5 6s. per car (trucks in use 3½ years), 150 radial trucks £1 16s. per car, and 100 rigid trucks 7s., the two last mentioned having been in service since the beginning of 1907. These figures did not include any expenditure on wheels. The average life of steel-tyred wheels on radial trucks was 20,000 miles, which corresponded more or less with the maker's figure of 5,000 miles per ⅛ in. of depth.

Mr. J. DALRYMPLE (Glasgow) said that experiments were at present being made in Glasgow with longer wheel-base trucks. He asked for information as to the renewal of track in Nuremberg. If the long wheel-base truck shortened the life of the track, its advantages of smooth running would be too dearly bought. He knew that 6 ft. 6 in. centred wheels would not go round the Glasgow curves.

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Mr. MOFFATT (Rotherham) considered that with the new top cover cars a longer wheel-base was needed. His experience of radial trucks was that they would not radiate. If it were possible to start afresh in car and truck design he thought that the best plan would be to do away with the double-deck car. Top covers practically did away with the outside "fresh air" passenger, so that longer single deck cars might be adopted with advantage. The tyre life of wheels on radial trucks was, in his experience, about 18,000 to 30,000 miles, using top-covered cars; with single-deck cars the life rose to 55,000 to 60,000 miles.

Mr. BLACKMAN (Belfast), who had not time to speak at length, had sent in a written contribution to the discussion, and expressed an opinion strongly in favour of the rigid truck.

Mr. ACLAND, in reply, said that his object was to advocate the use of a longer wheel-base truck, hence the title to his Paper, and whether rigid or flexible trucks were used was a matter for tramway managers to decide. His information as to corrugations and chilled tyred wheels had been supplied by several tramway managers, and was not taken from his own experience. The life of the first batch of tyres used at Chesterfield was about 46,000 to 50,000 miles, and the second batch had been running longer.

A hearty vote of thanks was then accorded to Mr. Acland, and the next Paper was read by Mr. A. BAKER (Birmingham Corporation tramways) on

HOURS OF LABOUR AND RATES OF PAY.

The Paper is accompanied by a detailed tabular statement of the hours of labour and rates of pay of inspectors, motormen and conductors employed on 83 municipal tramway undertakings in the United Kingdom. After referring to his previous Papers on the same subject, especially one at the Glasgow conference in June, 1903, in which he pointed out that during the preceding five years the wages of tramway men had increased by 42 per cent. and their hours decreased by 48 per cent., the author states that there has been a further increase of about 5 per cent. in wages since 1903 in the 34 towns then under consideration. In the schedules presented to the meeting there are several additional features not included in previous schedules. These are: "Time allowances," "Actual time men are on cars," "Actual time men are paid for," "Annual value of holidays," "Annual value of uniforms," and "Average rate of pay taking value of holidays and uniforms into consideration." The author's remarks with regard to these are as follows:—

With regard to "Time allowances," some few years ago a man's pay was always reckoned from the time he was actually on his car, nothing being allowed for the time occupied in "looking round" his car in order to see that it was equipped with everything necessary to meet all contingencies while it was on the road, or in seeing it safely stored away on its return to the shed. But this to a large extent has been altered, and "time allowances" are now made and paid for. Thus, when we say that a man works 60 hours a week, it does not always follow that he has been actually on his car 60 hours. In some cases you will observe that he is paid for as many as six hours in which he has been occupied in the way I have mentioned. It has been felt that this fact should not be lost sight of when our various committees are discussing this important question of rates of pay and hours of labour.

A striking feature to be noted is the change which has taken place with regard to Sunday work. In 1903 there were only two towns which paid anything in excess of ordinary pay for Sunday work. To-day 21 towns, or 25 per cent. of those included in the schedules, give their men extra remuneration for Sunday labour, the rate adopted being generally time-and-a-quarter. The question of Sunday pay is one which has disturbed the minds of a good many tramway committees for a long time, and there is a considerable division of opinion as to whether tramway employés who only work six days out of seven are entitled to extra pay for Sunday labour, it being held in some quarters that Sunday work is incidental to tramway business, and that having regard to the fact that the men get one rest-day in seven, and to the generally excellent conditions under which they are employed, no extra remuneration is necessary. In several cases the concession has been made voluntarily, while in others the matter is now under consideration, and therefore I do not think it advisable to express any opinion on the matter.

I think I may next call attention to the system which has recently come into practice of giving bonuses beyond their ordinary pay to motormen who have been free from blamable accidents during certain periods. Nearly half the towns have adopted this practice with, I believe, good results. It will be seen that in Leeds a half-penny per hour is paid to all motormen who during any calendar month have been free from blame in the matter of accidents, and it will be remembered that in the illustrated article in the *Tramway and Railway World* dealing with the Leeds system, in September of last year, it was stated that no less than 97½ per cent. of the men had qualified for the bonuses, and as indicating the value of the arrangement the amount paid in compensation during one financial year only equalled ½ per cent. of the receipts. I am not able to speak from personal experience of the value of the system, which has also recently been adopted in Birmingham, but I am strongly in favour of it. Of course, no extra remuneration should be necessary to make a motorman diligent, cautious and alert at all times, but while human nature is as it is, I am afraid that, with the majority of the men engaged in tramway work, an extra inducement, beyond the ordinary satisfaction a man gets out of doing his duty "for duty's sake," is necessary. There is one good feature about the business, and that is the adoption of the system advertises the fact that the management is anxious to avoid accidents, desirous that the cars shall be driven with due regard to the lives and property of the public, and willing to adopt special means towards securing this end.

With regard to "Uniform and holiday allowances." I have given the annual value of these and have, for the purpose of estimating the real value of a tramway man's job, worked out the weekly value and added it on to his wages. It seems to me only fair that these things should be taken into consideration, and when this is done I think we shall be pretty unanimous in the conclusion that in municipal service a tramway man's lot is not a particularly unhappy one, but that on the contrary it compares favourably with that of any unskilled labourer in the kingdom. Personally I am very glad that tramway labour is so well looked after, and I should be the last in the world to deal ungenerously with the men. Still, as I pointed out in 1903, it behoves us, as far as lies in our power, to prevent the pendulum from swinging too far. As I then said, "I think that, having regard to the peculiar nature of the work, tramway men should be generously treated; but there are limits, and as soon as these limits are passed, so soon will the work in which we are all engaged be seriously prejudiced." I think that if those words applied in 1903 they apply with perhaps more force to-day when the "Burden of the rates" is the universal cry. It is not for me to say what the limit shall be. Every town must settle the matter for itself, but I do seriously suggest that in the matter of hours of labour and rates of pay, tramway managers and committees should be careful, in perhaps the first flush of their success, not to fix rates out of proportion to the value of the work performed. This only leads to demands being made for similar treatment in other cities, which are difficult to resist when the men can point to some other place where specially favourable conditions exist. It is with the object of showing what is being done in various towns that the schedules have been prepared, and I hope the members of our association will find them of value in that direction.

The discussion on Mr. Baker's Paper was postponed until Thursday.

At the close of the meeting the members were entertained to luncheon in the Town Hall by the Tramways committee of the Manchester Corporation, the Lord Mayor presiding over a large gathering. The chief speakers were Alderman Wilson (Manchester), Mr. McElroy (president of the Association), Bailie Macfarlane (Glasgow) and Alderman Wainwright (Manchester).

The afternoon was pleasantly spent in weather which was a record for Manchester, at the Hyde-road car depot and works of the Tramways committee and the Stuart-street generating station of the electricity department.

In the evening a reception was held by the Lord Mayor and Lady Mayoress at the Town Hall, where entertainments were also given.

Thursday, September 26th.

The business meeting of the Association was held this morning at 10 a.m. in the Lord Mayor's Parlour. After the various reports had been presented Mr. McElroy proposed Mr. J. Aldworth (general manager Nottingham Corporation tramways) as president; this was seconded by Councillor Flint (Leicester) and carried. Mr. A. L. C. Fell (London) was then elected vice-president on the proposal of Councillor Fenton (Sheffield); and Mr. A. R. Fearnley (Sheffield) again consented to act as secretary. Nottingham was selected as the place for next year's meeting. The Conference was resumed at 11.30 a.m. In introducing the subject of

STAFF ORGANISATION

MR. JAMES DALRYMPLE (general manager, Glasgow Corporation tramways) deplored the impossibility of laying down a scheme adaptable to all tramways. This was due to a variety of reasons. The size of the undertaking was an influential factor, while in two systems of equal magnitude the method in which the primary organisation was carried out was of great importance. For instance, the internal economy of the department has in some cases been decided before the appointment of the tramways manager, with the result that many essential details of upkeep and expenditure have been taken entirely out of his hands. The speaker contended that the full control of the expenditure on all work connected with his department should be given to the manager, although it might not in all cases be carried out by his staff.

Turning to the actual arrangement of the personnel in the department, the author placed the general manager in sole

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charge, with a chief engineer, secretary and traffic superintendent controlling their respective groups. These groups were further sub-divided in great detail, but it was admitted that in smaller undertakings many of the duties would be performed by one person.

The question of a separate power station for the tramway department depended entirely on the size of the undertaking, and on smaller systems it was considered that the necessary power should be purchased from the electricity department. On large systems a separate generating station was preferable.

With regard to extensions and maintenance of track work, this should only be carried out by another department when the system was very small, and even then it should be, owing to the great importance of efficient track maintenance, performed entirely to the satisfaction of the tramways manager.

In discussing the question of control of accounting work, the author expressed the opinion that, as long as information could be obtained when required, it was immaterial by whom the work was done, although in large undertakings an accounting staff directly under the charge of the tramways manager was necessary to avoid the duplication that would otherwise arise. The borough accountant was, however, the chief financial officer of a local authority, and all necessary precautions should be taken by him to ensure financial stability.

On the invitation of the Salford Tramways committee, the members of the Association were entertained to lunch in the Town Hall, Salford, after which special cars were provided for conveying the party to Buile Hill Park. The day's entertainment concluded with dinner at the "White City," Old Trafford, on the invitation of Mr. J. C. Brown, managing director, who also furnished the party with tickets of admission to the various side shows.

(To be concluded.)

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant electrical engineer is wanted for the harness and saddlery factory, Cawnpore, India. Age not over 30. Candidates should possess sound engineering and electrical training, with subsequent workshop and central station experience, a working knowledge of steam, ability to erect steam sets, mains and motors, and take charge of such power as may be required. Five years' agreement, with option to Government to extend. Pay to commence at Rs.280 per month, rising annually by Rs.10 per month to Rs.320. On re-engagement Rs.350 per month. Free quarters and medical attendance provided. Second-class passage out and home. Applications to the director-general of stores (Mr. E. Grant Burls), India Office, London, S.W., by Sept. 30.

A chief lecturer in mechanical engineering is required for the Auckland (New Zealand) Technical College. Candidates must have had good workshop experience, and, if possible, possess a diploma or degree in engineering. Salary £300 per annum. Particulars from the director of technical education and manual training (Mr. Geo. George, F.I.C., F.C.S.), c/o the High Commissioner for New Zealand, 13, Victoria-street, London, S.W. Applications by Oct. 8.

The chief engineer of Ipswich electric supply and tramways departments has a vacancy for a premium pupil. See an advertisement.

There is a vacancy for a pupil, without premium, in an electricity station in the south-west of London. See an advertisement.

Armature winders (used to large alternator work) are wanted at once at the Westinghouse Works, Trafford Park, Manchester. See an advertisement.

Mr. Adam S. Barnard, formerly city electrical engineer of Hull, and for the past four years consulting electrical engineer to the Government of Ceylon and to the Colombo Municipal Council, has been appointed borough electrical engineer at Walsall at a commencing salary of £400, rising by £25 each two years to £450 per annum.

Mr. A. H. Stanley has been appointed general manager of the Metropolitan District Railway Co., in place of Mr. Collinson, resigned.

Mr. F. W. E. Jones, engineer and manager of the Midland Electric Light & Power Co., of Leamington, has retired after 15 years' service, and is succeeded by Mr. P. Olver.

Mr. F. W. Windsor, chief assistant at Monmouth, has been appointed resident engineer to take charge of the electricity works under the supervision of the consulting engineer (Mr. A. W. Blake), who has arranged to take over the management at an increased fee.

Mr. A. C. Bostel, of Manchester, has been appointed junior assistant in the business development department of Birmingham Corporation electricity works.

Mr. Hemingway has been appointed teacher to conduct the classes at the Woolwich Polytechnic in motor-car engineering.

EDUCATIONAL NOTICES.

University College, London.—The calendar for the session 1907-8 contains many new features. There is a sketch of the history of University College by Dr. Carey Foster, with a full statement of the statutes and regulations under which the college is governed in its new position as an integral portion of the University of London. A set of plans show the uses to which the extension of buildings are being put. The space now available for university purposes is greater by one-third than it was last session.

Among the features of the new developments are the following: The enlargement of each of the engineering departments and of the drawing office; enlargement of the department of applied mathematics and the provision of special rooms to be known as the Galton research laboratories in connection with the Eugenics Institute founded by Mr. Francis Galton.

The calendar also contains a section setting forth the arrangements for post-graduate courses of lectures and arrangements for research work. For the ordinary undergraduate courses composition fees have been instituted in all faculties. These fees vary from 10 guineas for the complete session's course in the faculty of laws (or 30 guineas or the three sessions) to 45 guineas in the faculty of engineering (or 120 guineas for the three sessions' course). The complete course in science is given for an average fee of between 30 and 35 guineas.

The work of the session begins on Oct. 2. Students should attend either on Monday (Sept. 30) or on Tuesday (Oct. 1) for the purpose of consulting the various deans and professors with regard to their courses.

University College, Bristol.—There are courses at this college for civil, mechanical, electrical and mining engineers and surveyors, and special facilities are offered in the way of college scholarships and engineering works scholarships. A diploma is awarded to students who pass the qualifying examinations, and the associateship of the college is conferred on students who obtain a first-class senior diploma. Applications for vacancies in October should be made to the registrar and secretary (Mr. James Rafter), from whom prospectuses, &c., may be obtained.

There are also lectures on inorganic, organic and physical chemistry, and the laboratories are fitted with the most recent improvements for study and research in chemistry and metallurgy.

Merchant Venturers' Technical College, Bristol.—There are courses at this college for civil, mechanical, electrical and mining engineering and chemists, and students are also prepared for the University of London degrees (including engineering). There are numerous well-equipped laboratories and workshops. Particulars from the Registrar.

Finsbury Technical College.—Although the official opening of the new engineering laboratory by the Lord Mayor does not take place till Oct. 2, the evening classes commence on Sept. 30. In the advanced courses this term Prof. Silvanus Thompson will lecture on Mondays on the "Design of Continuous-Current Machinery," and Mr. H. H. Simmons on the "Designing and Laying-out of Distribution Systems." On Wednesday evenings Mr. Howgrave-Graham will lecture on "Electrical Instruments," and in November Prof. Silvanus Thompson will begin a course of six special lectures on "The Permanent Magnet." There are lectures on and laboratory work in mechanical and electrical engineering, industrial and technical chemistry, applied art (including lectures on domestic furniture, and practical instruction in enamels and art metal work), &c. Programmes may be obtained at the College, Leonard-street, Finsbury, E.C., or at the head offices of the City and Guilds of London Institute, Gresham College, E.C.

Northampton Polytechnic Institute.—The full day courses in the Theory and Practice of Electrical and Mechanical Engineering commence on Sept. 30. These courses include periods spent in commercial workshops and extend over four years; they also prepare for the degree of B.Sc. in engineering at the University of London. Full and part time day courses in all branches of technical optics are given in specially equipped laboratories and lecture rooms.

Evening technical courses in all branches of electrical and mechanical engineering commenced on the 23rd inst. The laboratories are well equipped for both alternate (single and polyphase) and continuous-current work and for all kinds of electrical testing. Particulars as to fees, &c., can be obtained at the Institute, St. John's-street, Clerkenwell, E.C., or on application to the principal, Dr. B. Mullineux Walmsley.

Battersea Polytechnic.—The work of the present session commenced with the re-opening of the secondary day schools on the 17th inst.

The day college and day courses opened on the 23rd inst. Instruction is provided in mechanical and electrical engineering and architec-

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tural and constructional work for youths desiring to enter the engineering and building industries, and also preparative for university and other examinations. The chemistry department offers a course of instruction extending over two or three years to persons desiring to become technological chemists or general analysts, and to those engaged in chemical industries desiring to improve their knowledge or to do research work. The School of Art and Crafts also opened on the same day. This school provides a complete course of instruction in drawing and design as applicable to various industries and practical classes in such subjects as enamelling on metals, carving wood, &c. The evening schools reopen on 30th inst., and will provide courses of instruction for the engineering and building trades, classes in science and commercial subjects and special subjects for women. The special courses offered for men to qualify as chauffeurs and motor-car attendants, which was so largely attended last year, will be continued. The Polytechnic offers numerous scholarships, particulars of which as well as prospectuses of classes may be obtained on application. The reunion meeting usually held at the beginning of each session will be held to-morrow (Saturday) evening, 28th inst.

South-Western Polytechnic (London).—At this polytechnic a complete three years' course is given in electrical engineering during the day and a four years' course in the evening. There are courses of lectures and practical work in elementary, intermediate and advanced electrical engineering, electrical design, instruments and lamps, alternating and polyphase currents, electrical wiring and fitting and the calculus for engineers.

Bradford Technical College.—We have received a copy of the Calendar of the City of Bradford Technical College for the 1907-8 Session, which gives particulars of the courses (day and evening) of instruction in engineering, chemistry, physics, &c.

Tuition by Correspondence.—Prof. Andrew Jamieson, M.Inst.C.E., M.I.E.E. (16, Rosslyn-terrace, Kelvinside, Glasgow), prepares pupils, by correspondence, for all examinations in mechanical, electrical and engineering science. Prof. Jamieson's announcement appears on another page.

Popular Science Lectures.—During the winter a series of penny science lectures will be delivered at the Royal Victoria Hall (termed the People's Palace for South London), Waterloo Bridge-road, S.E., by gentlemen well known in the scientific world. The first lecture will be delivered on Oct. 8. Further particulars from the Hon. Secretary, Miss Cons.

Accrington.—An additional length of electric tramway was opened for traffic on Friday last.

Aldershot.—The Council have increased the salary of the assistant electrical engineer (Mr. Eberl) to £110 per annum.

American Telegraph Strike.—The Western Union Telegraph Co. announces that telegrams for all important points east of Pittsburg and north of Washington are no longer subject to delay.

Angola (Portuguese West Africa).—A number of new overland telegraph lines are being erected in this Portuguese colony, and at June last there were erected and opened for traffic nearly 2,000 miles of telegraph line, and there were 63 telegraph offices opened for business. Angola is connected by cable with Europe, and with South Africa by the cables of the West African and Eastern & South African Telegraph Cos. The companies have a repairing ship permanently located at Loanda, where cable tanks have been erected to provide accommodation for 200 miles of cable.

Loanda is lighted by petroleum, and it is reported that the municipality are endeavouring to negotiate a loan in Paris to enable them to establish electricity supply. Formerly Loanda was lighted by gas, but as the municipality declined to pay more than 9s. 8½d. per 1,000 ft., and the local gas company estimated that gas could not be produced under 15s. 1½d. per 1,000 ft. with coal at £2. 5s. a ton, gas ceased to be used for lighting at Loanda in 1900.

In 1906 a concession was granted to an Italian engineer for the establishment of electricity supply works for Benguella, Catumbella and Lobito. Under this concession electric energy will be generated from falls on the Catumbella River at a point distant about 4 miles from Catumbella. It is reported that a British syndicate has taken over this concession.

Association of Chambers of Commerce.—At the autumnal meeting of this Association last week the following resolutions were passed:—

National Insurance.—A resolution calling upon the Government to take into serious consideration the subject of national insurance against accident, sickness and old age, urging them to extend the terms of reference of the Royal Commission now sitting on the working of the Poor Law so as to include old-age pensions and the working of the system now in operation in Germany.

Legislation by Reference.—A resolution condemning legislation by reference and calling for codification of commercial law.

Smoke Abatement.—A resolution from Manchester urging British manufacturers to use the most effective appliances for economising fuel, and thus incidentally to improve atmospheric conditions in manufacturing centres.

Submarine Signalling.—That in the opinion of the Association it is desirable that a system of submarine signalling should be established on the coast of the British Isles.

Commercial Arbitration.—That as contracts and agreements are frequently made between British and Continental firms or their agents, containing clauses providing for arbitration in event of differences arising thereunder, and whereas the English Arbitration Act, 1889, is in operation abroad, the Association is of opinion that the principal foreign countries should be invited to consider the desirability of establishing an international arbitration code by convention.

Ministry of Commerce.—That whilst acknowledging the recent efforts of the Government to improve the Consular service and the Intelligence department of the Board of Trade, as also the recent declarations of Mr. Lloyd-George in regard to railways and the port of London, this Association nevertheless recognises the increasing difficulty of promoting British trade abroad, owing to the systematic and active assistance given by other Governments to traders of their nation. The executive of the Association is, therefore, requested to urge His Majesty's Government to bring in at an early date, as foreshadowed in the King's Speech in 1905, a measure for the conversion of the Board of Trade into a Ministry of Commerce on modern and representative lines.

Communication with France.—A resolution was passed urging a reduction of the rates charged on postal, telegraphic and telephonic communication between this country and France, and also to urge the desirability of negotiating with the French Government on the subject.

Telephone Charges.—It was agreed to amalgamate a number of resolutions denouncing the imposition of a new tariff by the National Telephone Co. and the Postmaster-General, and urging the retention of the rates now in force. The resolution was then adopted.

Asylum Lighting.—The Alliance Electrical Co. (Ltd.) are putting in an electric lighting installation at the Clonmel lunatic asylum, suction gas plant being employed.

Australasia.—The "Australian Mining Standard" says a water race (costing £5,500) and Pelton waterwheels to generate 363 H.P. are being erected at the Crown Mines, N.Z. The power will be used for pumping. A steam engine will be installed as a stand-by for the dry season.

The common battery system is being adopted in the Government telephone department at Hobart, Tasmania. The work of conversion is being carried out under the superintendence of Mr. J. W. Sutton, assistant electrical engineer on the Queensland Government electrical staff.

Barnstaple.—On Monday the Council considered the report of the accountant (Mr. H. Leicester) on the position of the electricity undertaking.

Mr. Leicester, in his report, stated that there was a deficit (after charging interest on loans and instalments of principal) of £1,830. 13s. 1d. He sugested that provision should be made annually for depreciation. A recommendation was received from the Council in committee that £1,000 on account of the deficit be contributed from the District Council account to the electric light account.

Mr. A. PERRIN, in moving the adoption of the recommendation, pointed out that the money was really to come from the fund accumulated by the ratepayers as a working balance on the urban fund account, and the Council felt that instead of levying a rate to recover the whole of the deficiency they should relieve the ratepayers to that extent, and pay the £1,000 out of their accumulated funds.

Mr. SMALE said that the utilisation of the £1,000 was the alternative to a 9d. rate, but it was not to be forgotten that the accumulation which made it possible had cost the ratepayers 5d. in the £.

Mr. G. W. LANDSLEY said it was not a question of the wisdom of paying the money out of the rates—it was an absolute necessity. They had up to March 31 accumulated nearly £2,000 by over-rating, and from that sum they had taken £300 for reducing the rate for the current half-year.

Mr. H. BARRETT, chairman of the Electric Light committee, said he had no reason to retract anything he had said in the reports of the progress of the electricity undertaking from time to time. The works were opened on Jan. 28, 1903, and if they referred to the net revenue account on Dec. 31 of that year they would find the debit balance (after payment of £1,288 for interest and redemption of capital) amounted to £950. To that they must add the accrued interest upon the first loan from Aug. 11 to Dec. 31, 1903, making a total of £1,261, which had been due to the treasurer ever since, and (with interest) amounted to about £1,461. Therefore, no less than £1,461 out of the total deficiency of £1,830 (which included £270 transferred by Mr. Leicester from capital to revenue, but some of this was questionable) arose within the first 11 months of the working of the undertaking. For nearly six months prior to the opening of the works interest was being incurred in respect of the £21,600 loan without a penny being earned. It, therefore, followed that during the past 3¼ years the profits had been sufficient within £369 to pay for redemption of capital during that period. Had the concern belonged to a company, the profits would have been sufficient to pay annual dividends of 5 per cent. for 3¼ years, ending March 31. Those figures were practically borne out by Mr. Leicester's audited accounts to Dec. 31, 1906. The deficiency which he then showed was only £436, but he did not then take into account the accrued interest upon the loans as he had now. The sum had been increased to £1,830 in three months by adding deficiency at Dec. 31, 1906 (£436), interest accrued but not paid to March 31, 1907 (£633), additions and renewals to accumulators (£289), loss by Mr. Jordan (£78), transferred from capital to revenue (£270), revenue liabilities omitted (£31), total £1,740. He entirely disagreed with Mr. Leicester's contention with regard to depreciation. They might rely upon it that the L.G. Board, in granting loans, took every contingency into consideration. To adopt Mr. Leicester's idea, they would accumulate a vast sum of money, in addition to paying off the loans and handing over the undertaking free after the loans had been paid off. As to the bank overdraft, it must not be forgotten that

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they started without working capital, so that they had to borrow from their bankers to meet the expenses for generating current, but against the overdraft there was always a large sum owing from consumers, besides the value of the stock.

Mr. F. CHANTER: If something like £900 was lost on the first year's working, was not it the Council's duty to have then levied a rate?

The MAYOR: It was their duty, but the Council did not know it at the time.

Mr. CHANTER: Do I understand that you cannot legally levy a rate for a loss more than six months after the loss is sustained?

The MAYOR: That is so.

The report was ultimately adopted.

Belfast.—The Corporation have received authority to borrow £75,000 for extensions of the electricity works, to be repaid in 25 years.

Belgium.—In an interesting report just issued on the trade of Belgium for 1906 and the first half of 1907 particulars are given of the light railway and tramway services which form important connecting links between the trunk line railway system of Belgium. By means of these light railways and tramways, running in many cases alongside the highways, the surrounding neighbourhoods of all the principal towns in Belgium are placed within easy touch, and the distribution of agricultural and other commodities is, in this way, promptly and economically made. The light railway system belonging to the Société Nationale des Chemins de Fer Vicinaux comprised on Dec. 31 last 1,814 miles of route, and 574 miles additional were under construction at that date. The company owns in all 155 routes, of which 127 are working, and the remaining 28 are under contruction. 118 of these lines are in connection with the heavy railway system of the State for goods and passengers, and there are on the company's system 321 private connections between manufactories and agricultural undertakings. Electric traction has been adopted on 93 miles, and the electrification of 109 miles further is under consideration. The company owns 194 electric cars or motor carriages, 191 trailers and 9 trucks. The capital of the company at Dec. 31 last was about £9,500,000. The State has granted concessions to the company, which is able to borrow on guarantee preference shares at 3 per cent.

The important works on the Termeuzen Canal, which connects Ghent direct with the sea, are being pushed forward. The canal when completed will be lighted throughout its length by electric arc lamps, and the new docks at Ghent will be provided with 15 electric cranes. This is one of the most important works of public utility of the present time progressing in Belgium.

An interesting report on the coal mining industry in Belgium has recently been published, and includes a description of the School of Mines at Mons. This school is subsidised and practically owned by the provincial authorities of Hainaut. The school has a Government subsidy, a subsidy from the town of Mons and a larger subsidy from the province of Hainaut.

In this report, which is very complete, it is stated that many of the mines in Belgium have adopted electricity as the sole motive power in mining and for pumping and ventilation with successful and economical results.

The question of electric versus steam power has been much discussed in technical circles in Belgium of late, and whereas no definite statistical statement has been published showing comparative financial results of the working of the two systems, it is generally agreed that the manipulation of electric power is more simple than that of any other motive power employed in running. This is particularly the case in connection with the operation of the shafts. In Belgium mine owners are compelled to have a secodd operator when shifts of workmen are going up or down the shaft, and it is found that in working the cages by steam the attention of the operators has to be divided between several control levers, whereas by electrical operation of the cages only one main controlling lever is required, and the operator has only to give his attention to this one piece of mechanism. The provision on electrical machinery of automatic devices serves as an additional protection, and brings the risk of accident to a minimum.

Brazil.—The Rio de Janeiro Council have ratified the contract for the unification of the local tramways, and the Rio de Janeiro Tramway, Light & Power Co. have obtained extensions of the period of the concessions, the right to construct extensions in suburbs and other privileges.

The telegraph service in the State of Pernambuco has recently been greatly improved, direct through lines having been erected between Recife and Parahyba, between Recife and Pesqueria, and between Glycerio and Lourenço de Albuquerque.

Negotiations were some time ago proceeding between a British company and the Companhia Ferro Carril de Pernambuco, owners of the principal tramway service of the city, and terms of purchase of the horse lines and provision for the electrification of the lines were agreed upon between the two boards of directors. The contract, however, was subsequently rescinded by a newly-constituted board of the Pernambuco company, and litigation is proceeding between the parties.

Brighouse.—On Wednesday the Council decided to enter into an agreement with the Yorkshire Electric Power Co. for a supply of electricity in bulk. Some particulars of this agreement were given in our issue of Sept. 6.

Brighton.—The recent revision of fares on the tramways, by which 1½d. stages were abolished in favour of 2d. fares, has not resulted as anticipated. While there has been an increase in the number of passengers paying 1d. fares, the total receipts show a decrease. The Tramways committee have decided practically to go back to the old scale of 1d. a mile with a 1½d. rate for distances beyond.

Croydon.—The Corporation have decided to alter the future charge made for electric energy for power to 1½d. per unit for all times except between dusk and 11 p.m., when the charge will be 3d. per unit instead of 5d. as at present.

In future electricity used for lighting factories and workshops will be charged through the same meters as the motors where the time-switch system is in vogue, provided the quantity used for lighting does not exceed 20 per cent. of the total energy taken.

Damascus.—The Damascus Electric Tramway Co. are making rapid progress with their work of construction, and some idea of the extent of the company's service may be gathered from the fact that during 1906 wages to the amount of £25,000 were paid for construction works alone. On Feb. 7 the opening of the company's line was inaugurated. The service connects the two farthest extremities of the cities and is 5,300 metres in length. The rolling stock includes 19 motor cars and six tandem cars, all of Belgian manufacture. Electric power is generated at the waterfalls of Tekiyeh (with a 90 ft. fall), and the minimum of this power is estimated at 1,000 H.P. The falls are situated 19 miles from Damascus. The three turbines employed in the power house are of Swiss manufacture, the remaining portion of the power house equipment being supplied from Belgium. The owning company has its headquarters at Brussels and has a capital of 6,000,000fr., the bulk of this capital being held by the Société Générale de Chemin de Fer Economiques, the Société Générale Belge d'Entreprises Electriques and the Compagnie de Railways et d'Electricité.

Devonport Electrical Exhibition.—So popular has this exhibition been that it has been decided to keep it open for another week.

Messrs. W. C. Heath & Co., of Plymouth, are exhibiting a number of the latest types and patterns of electrical supplies. In addition to an interesting range of Ediswan instruments, desk fans, electric radiators, &c., two of the yellow flame pattern "Ediswan Carbone" flame arc lamps are shown burning, with the remarkable efficiency of 5 c.p. per watt, or ⅕ watt per candle, a figure which, it is claimed, quite casts into the shade any foreign importations. Two of the new 4 ampere "Ediswan radiant" enclosed arc lamps are also shown.

Directory Canvassing.—At the Guildhall (London) last week, in connection with two charges of alleged attempting to obtain money by false pretences, Ald. Sir Geo. Smallmann made some strong observations relative to a system of canvassing for advertisements in certain directories, which for some time in the City of London has been matter for general complaint. It was stated that the system objected to had become a general practice.

In the first case a canvasser named Kirkby was charged with attempting to obtain by false pretences £2. 3s. from Mr. L. W. Hadley, London manager to the Worcester Royal Porcelain Co. Evidence was given to the effect that prisoner called on prosecutor, stating that he was a canvasser for the "A B C Commercial Directory," and asked for payment of £2. 3s. for the insertion of an advertisement. He assured prosecutor, in reply to a question from him, that the Worcester Co. advertised in the previous issue of the directory, and in support of his statement produced what appeared to be a cutting from a directory. When the prosecutor, who had had previous applications of the sort, handed him over to a policeman, he declared that he was only endeavouring to get an order.

Mr. HORACE SIMPSON, manager to the "National Publishing Co." (which, he explained, was controlled by Chambers' Publishing Co., Ltd.), 57 and 58, Chancery-lane, said they published the "A B C Commercial Directory." Prisoner was engaged as canvasser at a nominal salary of 1s. a week—in order to make him legally a servant—and commission. The Worcester Royal Porcelain Co. had never advertised in their directories. The cutting came from "Kelly's Directory."

The MAGISTRATE on this said he did not think the evidence was such that a jury would convict, and prisoner was discharged.

A clerk named Donovan was then charged with attempting to obtain 10s. by false pretences from Mr. Hadley. Similar evidence was given, except that prisoner was still a servant of Chambers' Publishing Co. For the defence in this case it was suggested that prisoner merely stated that he was from Chambers', and was canvassing for advertisements in their directory.

Mr. SIMPSON stated, in reply to the Court, that the copy advertisement shown to Mr. Hadley by accused had, in fact, been cut from some other directory and stuck on their own form. "All the trade do it" he declared

The MAGISTRATE: As I said in the last case, I do not think any jury would convict the prisoner, and he is discharged, but I must express my strong disapproval of this company's methods. Apparently canvassers go into a merchant's office—although the gentleman may never have been what may be called a member of the directory—and producing a form on which is pasted a cutting from another directory, and a figure put against the words "amount due," he is led to suppose that he owes that money. The company is taking a course which might lead to serious consequences, and if the charges before me to-day had been in a different form I might have acted differently.

We have no hesitation in saying that the statement made by the witness Simpson, that "all the directory trade do it" (meaning that

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directory proprietors and conductors adopt such tactics as are above detailed) is a grossly false statement, on a par with the practices it was attempted to excuse.

Dover Naval Harbour.—An additional company of Royal Engineers is to be stationed at Dover, in order to carry out the electrical equipment of the new naval harbour.

Exhibition.—An International Exhibition of Heating and Lighting Appliances will be opened at St. Petersburg on Dec. 14. Further particulars from the Executive committee, Panteleimonskaya No. 2, St. Petersburg, where applications from intending exhibitors will be received up to Oct. 14. The exhibition will remain open two months. Copy of programme and regulations may be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

It has been decided to hold an International Exhibition at Ghent in 1913. The municipality has promised the loan of the whole of the extensive park at Ghent for the purposes of the exhibition.

Extensible Tramcar Axles.—The experimental car which, as we have before stated, has been fitted with an axle adaptable to the 4 ft. 8½ in. gauge of the Leeds tramways, and the 4 ft. gauge of the Bradford system, has now been placed upon the regular service in and between the two cities.

Fatality.—On Saturday last a man named Bowwater was killed at the Lumley Sixth Pit (belonging to the Lambton Collieries Co.) Durham.

Deceased was employed as brakesman at one of the coal-cutting machines, with three mates. The shift was almost completed when Bowwater, noticing that something was wrong, went to the machine, but as soon as he touched it he received a shock and was thrown down on to the haulage rope. The current was at once shut off, and two of his mates, who hold proficiency ambulance certificates, released Bowwater. They tried artificial respiration, but without success, and life was pronounced extinct.

At the inquest it was stated that deceased had charge of the cutting. It was his duty to thoroughly overhaul the machine every hour. The machine was examined after the accident and it was found that the trailing cable had been jammed between a post stone and a nut head on the gear case. Friction had exposed the conductor, and caused a short-circuit, the bare conductor being in contact with the machine. There was no blame attaching to anyone, as the stone had, apparently, been dragged to where it was found by the cable.

Medical evidence was to the effect that deceased had died from electric shock, the fact that his body was very wet having intensified the current.

A verdict of accidental death was returned.

France.—The Minister of Marine has authorised the port of Cherbourg to borrow 1,000,000 frs. (£40,000) for the provision of electric plant for lighting the workshops of the arsenal and for charging accumulators in submarines.

Gloucester.—There were three notices of motion in connection with the tramway undertaking on the agenda of the City Council on Wednesday, but the mayor (Mr. S. Aitken) stated that Mr. Harland-Bowden and himself had been appointed a special committee to inquire into the possibility of leasing the undertaking, and there were negotiations in hand which it would be improper to discuss at this juncture, and which were so delicate that discussion would be detrimental to the interests of the undertaking.

Guatemala.—Trade between the United Kingdom and Guatemala is reported on the decrease, and this country now takes third place with the United States and Germany in this respect. Electrical apparatus and mater al were imported into Guatemala in 1906 to the value of £101 from the United Kingdom, £3,140 from Germany and £5,600 from the United States.

Hamilton.—Edmundson's Electricity Corpn., who operate the local electricity works on lease, have deducted income tax in respect of the half-yearly payments to the Council of 6¼ per cent. on the capital expended; but the Electric Light committee are advised that income tax is not chargeable upon the proportion of the half-yearly payments of the capital advanced, and the town clerks have been instructed to communicate with the company on the matter.

The Secretary for Scotland has adhered to his decision to deduct from the additional borrowing powers of the Council the items expended on free wiring, which amount to about £6,000.

Hemel Hempstead.—The Council decided last week not to consent to the application of the Chesham Electric Light & Power Co. for a provisional electric lighting order.

India.—"Indian Engineering" says one 15 ton and two 5 ton gantry cranes, a 5 ton jib crane, five 7 H.P. electric motors, &c., have been ordered from England for the new riverside warehouse of the East Indian Railway at Howrah.

The "Indian and Eastern Engineer" says an extension of the Stone system of electric train lighting on the South Indian Railway, to cost more than a lakh of rupees (about £6,667), has been ordered. Thirty sets of Stone's apparatus have also been ordered for the Great Indian Peninsula Railway. Nearly all the coaches of this company (1,370 in number) have hitherto been lighted by gas.

Industries and Electricity Supply.—A Nottingham firm recently wished to establish a branch factory at Newark, but, owing to no supply of electricity for lighting and power being available, the firm reconsidered the matter and have now established the branch works at Sleaford.

Interchange of Traffic on Tramway Systems.—West Ham Tramways committee have reported on the decision of the L.C.C. to electrify their lines between Bow Bridge and Commercial Bridge on the "G.B." surface contact system.

The committee point out that this will place a serious obstacle in the way of through running over that portion of the London system and the extra-metropolitan tramway systems, and express the opinion that both the L.C.C. and Stepney Council in approving the surface-contact system could not have been aware of the serious inconvenience which would be caused to the travelling public if through running cannot be arranged. The committee has instructed the town clerk to lay their views before the L.C.C. and Stepney Council, and also to communicate with the adjoining local authorities on the subject. They had further directed the town clerk to bring the matter before the attention of the Board of Trade.

Italy.—At Leghorn a company was established under the title of Società Livornese di Trazione Elettrica in December, 1906, with a capital of 27,000 lire, to establish, equip, maintain and work electric tramways, and one of the company's first operations is the establishment of a new tramway service from Antignano to the foot of Montenero, which completes the circle of the Leghorn tramway system. This line is to be completed during 1907. The same company is engaged upon the Funicular Railway to run from the tramway station at the foot of Montenero to the famous sanctuary near the top. This line will be completed next month.

The extensive works of the Società Italiana per Conduttieri Elettrici Isolati, manufacturers of electric wires and cables, are nearly completed, and it is anticipated that the company will be in full working by the end of 1907.

Kettering.—An unopposed inquiry was held here last week into the Council's application for sanction to borrow £3,500 for the extension of the electricity undertaking.

Kilmarnock.—At a special meeting on Friday last the Town Council decided to reduce the salary of the general manager of the tramways from £380 to £300.

Lambeth (London).—Some time ago the London Electric Supply Corpn. agreed to supply the Council with electricity to the extent of £1,000 a year at 1½d. per unit for lighting public buildings so long as the Lambeth provisional order is held by the company or its assignees, and the libraries committee now suggest that the Tate (Central), West Norwood, Durning and Tate (South Lambeth) libraries should be wired, taking the libraries in the order given, and so far only as may be required to make up the £1,000 a year; but that if the supply to the baths and new town hall and such libraries should not reach £1,000 a year, then that the Carnegie library be added. The report was adopted.

L.C.C. Tramways.—Lambeth Council have approved provisional plans submitted for L.C.C. tramways from West Norwood to the Crystal Palace.

Wandsworth Council have asked the L.C.C. to include in their next Parliamentary bill a scheme for a double line of tramways along Streatham High-road.

During the autumn session, which commences on Oct. 8, the County Council will discuss various proposed extensions and connecting lines estimated to cost £351,000, including street widenings. The extensions include two overhead trolley lines from Forest Hill and West Norwood to the Crystal Palace, and a line from Lower Clapton-road to join up with the overhead trolley lines of Walthamstow Council, which extend to Woodford, &c.

Maidstone.—A satisfactory trial trip was made on the new Loose extension of the tramways on Monday, and the line is expected to be opened on Wednesday next.

Municipal Benefit Funds and Friendly Societies.—On Tuesday Manchester Tramways committee received a deputation, representing the Manchester and Salford United Friendly Societies' Council, who explained objections held by friendly societies to the establishment of a sick and benefit society for the tramway employés on lines suggested in a report recently prepared by Mr. J. M. M'Elroy, the general manager.

Councillor GILCHRIST said the deputation represented some 50,000 friendly society members, and desired to point out that generosity to tramway employés meant injustice to the friendly societies. The action taken by the Friendly Societies' Council had received the unanimous approval of the Manchester and Salford Trades and Labour Council. The proposed scheme was unfair to the men themselves, because in many cases, after leaving the service of the committee, they would probably be too old to join a well-established society. The proposal was also unfair to the citizens. He presumed the superannuation proposals would be based on the model of those in force at Glasgow. Under the Glasgow rules men who had served 15 years could retire upon a superannuation of 10s. a week, 20 years' service entitled them to 15s. a week and 25 years' service to 20s. a week. Glasgow last year paid £2,200 to the funds of the men's society, which showed a surplus of £1,100; but it had to be borne in

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mind that no superannuation allowances had yet come into force, either in Glasgow or at Liverpool, where a similar society existed.

Mr. J. T. TAYLOR (Oddfellows) urged that, while the municipality as employers of labour should be model employers, the deputation were not prepared to admit that a municipal employé should have any claim to privileges which would not be readily conceded to workmen engaged by private firms. The new society was to be recognised and materially subsidised by the committee out of the rates or out of the profits of the tramways undertaking—which, they suggested, amounted to the same thing—to the extent of from 1½d. to 4d. per member per week. The deputation suggested that the existing society must have been founded on an unsound basis, or otherwise it would not now find itself in need of outside financial assistance. They objected to the proposed subsidy in the first place as ratepayers, on the ground that it would be an improper use of the rates. Their second objection was that, as subscribing members of registered friendly societies, it would be most unfair to existing societies in Manchester and the neighbourhood to susidise this particular institution, to the certain disadvantage and prejudice of all other societies.

The Chairman of the committee (Ald. WAINWRIGHT) said the matter was under consideration at present. A special sub-committee had been formed, who would come to a decision upon Mr. M'Elroy's report, but through stress of business they had allowed the matter to stand over. As soon as the elections were over a decision would be arrived at. At the same time there was something to be said for the officials and men who had organised the society in the early days of the committee.

Newcastle-on-Tyne.—Tradesmen in Grey-street have entered into an arrangement with the Newcastle-upon-Tyne Electric Supply Co. for the lighting of the thoroughfare by 40 2,000 c.p. flame arc lamps during the winter months, as it is considered that the extra illumination will attract additional customers.

Overhead Supply Cable.—The Board of Trade have consented to the erection and use by Erith Council of an overhead wire for the supply of energy at 3,000 volts from a sub-station on Belvedere Marshes to the L.C.C. Outfall Works, Crossness, subject to certain conditions. Sanction has been received to a loan of £2,664 for extensions of the electricity undertaking, repayable in 18 years.

Plymouth.—The Tramways committee considered on Tuesday the reports of the borough electrical engineer (Mr. E. G. Okell) and the tramways manager (Mr. C. R. Everson) upon the condition of the tramcars and overhead equipment. Mr. Okell's report was abstracted in our last issue, and we are now able to give extracts from Mr. Everson's report.

Mr. Okell and Mr. Everson were both present at the committee meeting and offered explanations on various points. The different matters specified in the engineer's report were taken seriatim, and at the committee's request, Mr. Okell exhibited parts of the mechanism of cars which he considered defective. Some of the faults revealed were, it is stated, found in cars which had been sent to the shed for overhaul and repair, and the committee were stated to have been satisfied that there was nothing of an alarming character disclosed in the condition of the plant. No resolution was, however, passed, the committee adjourning further consideration of Mr. Okell's report until their next monthly meeting.

Mr. Everson, in his reply to Mr. Okell's report, agrees with Mr. Okell as to the effects which the state of the permanent way, the sharp curves and the steep gradients, were having on the rolling stock generally, but especially on the Peckham type trucks. Those trucks, it was stated, it was almost impossible to keep thoroughly tight on account of the hammering and vibration that took place when the cars passed over the permanent way joints. In most cases the wear was very little, and considering the number of car-miles run the wonder was that the trucks were not showing more signs of wear. Mr. Everson considers that had the Brill type truck, which is a solid frame, been adopted at the outset, the cost of upkeep would not have been nearly so high; but he was not responsible for the Peckham type truck being in use. All cars ordered by him had Brill type trucks. With regard to axle-box springs, Mr. Everson states that he had informed the assistant electrical engineer that, having had a lot of trouble with that detail, they had been trying springs from various makers. Of course the cars were not allowed to run with a broken spring if known, but it was when the cars were in service that a spring broke and not when standing in the car shed. Mr. Everson had been unable to discover any guide bolts of the truck springs bent. The spring steel washers formerly used were being replaced by large flat iron washers made by their own smith. When the specifications for the large Pennycomequick cars were before the committee, he (Mr. Everson) suggested that the suspension beam should be fixed between two spiral springs. That was done, and there had been no trouble from that source on those cars. Other points in Mr. Okell's report are replied to seratim. Mr. Everson states that the brake rods were carefully overhauled every night, and the ends renewed as required. All nuts and bolts were examined nightly. Gear case bolts getting loose was a matter of daily occurrence. They were tightened every night, but owing to continual jumping taking place the lugs of the gear case casting were frequently broken off, or the threads stripped from the bolts. A car in full work ran 100 miles a day, and it was no wonder that nuts got loose occasionally. It was undesirable to lubricate the lifeguards, which were fixed so tenderly that they very often dropped with the vibration of the car. 30 motors had been repaired within the last 18 months, and others would be dealt with in the same way. All the motor cables underneath the cars, which were formerly exposed to the wet and dirt, had been covered with rubber tubing, and since that had been done there had been no trouble from that source. All the earth connections for the motors were overhauled every night. The carbon dust was removed frequently from the cases and armatures with a pair of bellows. In some very large tramway undertakings compressed air plant was used for cleaning out the motors, but no tramway undertaking the size of Plymouth's had such plant. The electrical equipment (continues Mr. Everson) was tested by the assistant electrical engineer, who expressed his surprise at its good condition and the high insulation test, and also at the splendid state of the controllers after so many years' work. Mr. Everson expressed regret that these opinions on really the vital parts of the electrical equipment were entirely omitted from the engineer's report. He finds little fault with Mr. Okell's estimate that the cost of car repairs and upkeep will amount to £3,230 per annum, and points out that the actual cost per car-mile for the past three years has been 0·93d., which on the mileage taken by the engineer works out at £3,016 per annum. To refute the statement that the condition of the cars was responsible for an abnormal consumption of current, Mr. Everson submitted a table which showed that Plymouth, despite its severe gradients, compared favourably with other towns in the item of current consumption. The suggestion that the examination of the overhead equipment is only made at irregular intervals the manager declares would be disproved by an inspection of the wages book. A regular weekly examination was made every Sunday, weather permitting, and at frequent intervals between.

On the remaining points in Mr. Okell's report Mr. Everson offers explanations.

Postal Charges for Oversea Letters, &c.—Some important alterations in postal facilities between Great Britain, the British Colonies, and foreign countries in the Postal Union will come into force on Oct 1.

The charge for letters to the Colonies will be 1d., and to foreign countries 2½d. per ounce instead of per ½ oz. as heretofore, and in the case of foreign countries, each ounce after the first will cost 1½d. Reply postage coupons will be issued here and in foreign countries at 3d. (or its equivalent), and these can, after receipt by the addressee, be exchanged for stamps to the value of 2½d. to affix to the reply. Foreign post cards may, like the present inland cards, have communications written on the left-hand half of the address side, as well as the whole of the reverse side.

Presentation.—The deputy town clerk of Sheffield (Mr. W. E. Hart), who has been appointed solicitor to the National Telephone Co., has been presented by the town clerk and his staff with an embossed silver inkstand as a mark of esteem.

Private Fire Brigades.—In the annual competition for the City fire shield, presented by the Corporation of London, held at the Guildhall on Saturday, the Robertson Fire Brigade lost possession of this shield. Twenty brigades competed, and the Robertson brigade were placed third, only one or two seconds dividing the first three brigades. In the competition for the fire brigade championship, the Robertson brigade held a clear lead of 12 seconds, and in the concluding event, to take place on Oct. 19, it is anticipated that the Robertson brigade will retain the championship.

Railway Carriage Lighting.—On the lines of the Great Western of Brazil Railway Co. electric light has been installed in a large number of the first-class carriages.

Saundersfoot (Pembrokeshire).—A committee of the Parish Council is considering the expediency of adopting electric lighting.

Southend-on-Sea.—The Council have adopted the Light Railway committee's recommendation to apply to the L.G. Board for sanction to a loan of £20,940 for additional generating plant, including a new engine, dynamo, boilers, condensing plant, pumps, &c.

Tighnabruaich (Argyllshire).—A meeting of the Cowal District committee was recently held to consider a requisition to form Tighnabruaich into a special lighting district, and, after considering the particulars available as to the cost of obtaining electric lighting powers, the following resolution was agreed to:—

The committee, looking to the large cost and difficulty involved in forming districts to be lighted by electricity, resolve to recommend the County Council to petition Parliament to amend the acts dealing with the matter, so that local authorities may be empowered to undertake electric lighting under similar provisions as apply to lighting by gas and other illuminants, without the necessity of a provisional order.

Tottenham.—The Metropolitan Electric Tramways (Ltd.) have informed the Council that they cannot construct a tramway from Green-lanes, Harringay, along St. Ann's-road to its junction with Seven Sisters-road, on the ground that there is little or no demand for a service of cars from Harringay to Seven Sisters-corner and Stamford-hill.

Victoria Falls Power Scheme.—The Victoria Falls Power Co. have received advices that the electrical power stations at Germiston and Brakpan on the Rand, purchased respectively from the General Electric Power Co. and the Rand Central Electric Works, are now supplying power to their utmost capacity, and that it has been found necessary to enlarge the capacity of the Germiston station pending the erection of the new 24,000 H.P. central generating station, the machinery for which is in an advanced stage of construction. The Marquis of Winchester (president), Mr. H. Wilson Fox (vice-president) and Mr. Henry Birchenough, C.M.G. (directors of the company) have recently paid visits to both power stations, accompanied by Sir Charles Metcalfe, Bart., Mr. R. D. Mershon (New York) and Mr. Arthur Wright (electrical engineers to the company).

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Wisbech.—The transfer of the Wisbech electric lighting order (1901) to the Wisbech Electric Light & Power Co. has been sealed.

Workhouse Lighting.—The Guardians of North Dublin Union have instructed the clerk of works (Mr. Morris) to supply information to the City Electrical Engineer, so as to enable him to submit an estimate of the cost electric of lighting the workhouse. The medical officers and the master have been instructed to report generally upon the advisability of installing the electric light.

The Sedgefield (co. Durham) Guardians are considering a proposal to adopt electric lighting at the workhouse, electric current being taken from the Durham County Asylum electricity works in the vicinity.

Workmen's Organisations and Labour-Saving Machinery.—Colchester District Trades and Labour Council have passed a resolution protesting against the Corporation adopting mechanical stokers at the electricity works.

Worksop.—An unopposed inquiry was held last week into the application of the Council for sanction to borrow £1,700 for cable extensions.

York.—The Tramways committee unanimously recommend the City Council to apply for a provisional order (or light railway order) to authorise the construction and electrical equipment of four new tramway routes. The City of York Tramway Co. will continue to work the old horse-lines until the Corporation are in a position to purchase the undertaking.

The city electrical engineer (Mr. J. W. Hame) recommends the Electricity committee to establish a showroom for electrical apparatus and fittings in the centre of the city, and a sub-committee has been appointed to consider the matter.

Electro-Harmonic Society.—An excellent programme is provided for the first smoking concert of the 22nd season of this society, which will be given in the King's Hall of the Holborn Restaurant, London, on Friday evening, Oct. 4, at eight o'clock.

ELECTRICITY SUPPLY ACCOUNTS.

Keighley.—The annual accounts of the electricity department for the year ended June 30 were considered by the Council on Tuesday.

Ald. PAGET confessed that hitherto the financial result had not been satisfactory. There had been an increase of capital without a corresponding increase in prosperity. During the past year there had been an additional outlay of £1,217, making the total £57,409. Repayments by sinking fund and the amount in hand represented £7,012. The estimated expenditure had only been exceeded by £45, but the income for current had been £675 less. Adding the deficiency on the previous year (£253) the total deficit was £973. The prospects for power were distinctly encouraging, and there was some ground for hoping that it was only a question of time, patience and labour for the electricity concern to become a paying one. The accounts were passed.

Kingston-on-Thames.—The report of the borough electrical engineer (Mr. J. E. Edgcome), which was presented at the meeting of the Council last week, states that the charge for current for power had been reduced to 1½d. per unit, and there had been a satisfactory increase in the number of motors and radiators connected.

Mr. Edgcome has carried out experiments with metallic filament lamps which have given good results, and he intends to continue these experiments on a larger scale. The total connections and applications for connection are equivalent to 40,741 8 c.p., compared with 35,644 last year. Capital expenditure has reached £98,344 (increase £2,479). Revenue was £11,378, including £9,231 from private consumers, £1,802 for public lighting and £346 sundry sales and receipts. The net result is a debit balance of £8, against a credit balance of £505, partly owing to increased cost of coal and partly to increased amounts required for interest and repayment of capital.

The report was adopted.

Leicester.—After providing for sinking fund and interest the half-year's working of the electricity undertaking to June last shows a net profit of £2,603.

Sheffield.—The receipts of the tramways department for the past quarter are a record, being over £1,000 more than in the June quarter, when the total was £72,430.

Warrington.—The traffic revenue of the electric tramways for the year ended March 31 was £19,204. 9s. 8d. (10·724d. per car-mile), and the total revenue was £19,540. 5s. 11d.

Traffic expenses were £4,995. 13s. 7d., general expenses £1,460. 0s. 2d., repairs and maintenance £2,177. 18s. 3d., power expenses 3,813. 14s. 5d., total £12,446. 16s. 5d. (6·950d. per car-mile), leaving gross profit £7,093. 9s. 6d., which, with £126. 13s. 11d. bank interest, gave a balance of £7,220. 3s. 5d. Interest came to £3,194. 12s. 1d., and sinking fund to £2,715. 13s. 6d.; the balance, £1,309. 17s. 10d., has been carried to reserve. Capital expenditure is £101,615. 6s. 1d., an increase of £452. 5s. 4d. on the year. The total length of track is nearly 6¾ miles. 429,785·8 car-miles were run and 4,965,296 passengers carried. 610,115 units of electrical energy were used (1·42 per car-mile). The percentage of working expenses to receipts was 63·7.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

West Ham Corporation invite tenders for supply and delivery of indiarubber-covered wires and cables for the six months ending March 31. Forms of tender, &c., from the engineer and manager (Mr. A. Hugh Seabrook), 84, Romford-road, Stratford, E. Tenders to the town clerk (Mr. Fred. E. Hilleary), Town Hall, West Ham, E., by 4 p.m. Oct. 3. See also an advertisement.

Hammersmith (London) Council invite tenders for the supply of (*a*) about 8,000 yds. E.H.T. concentric feeder cable, (*b*) about 1,000 yds. E.H.T. three-core cable, and (*c*) joint boxes, &c. Specifications from the borough electrical engineer (Mr. G. Gilbert Bell), 85, Fulham Palace-road, Hammersmith, W. Tenders to the town clerk (Mr. H. Thompson), Town Hall, Hammersmith, W., by 4 p.m. Oct. 2. See also an advertisement.

Tunbridge Wells Corporation invite tenders for the supply, delivery and erection of the work in connection with the installation of a 500 kw. turbo-alternator, condenser and pipe work in sections: (*a*) 500 kw. turbine, (*b*) 500 kw. alternator and exciter, (*c*) surface condenser, with air and circulating pumps and (*d*) pipe work. Specifications (after Oct. 1) from the consulting engineer (Mr. Horace Boot, M.I E.E.), Electricity Works, Tunbridge Wells. Tenders to the town clerk (Mr. W. C. Cripps), Town Hall, Tunbridge Wells, by 10 a.m. Nov. 1. See also an advertisement.

Tenders are invited for the supply of 466 d.c. and 200 a.c. meters for the city of *Melbourne* (Victoria) electricity department. Specifications from the agents for the City Council, McIlwraith, McEacharn & Co. Proprietary (Ltd.), Billiter-square-buildings, London, E.C., to whom tenders by noon Oct. 4. See also an advertisement.

The directors of the *Metropolitan Railway Co.* invite tenders for supply of general stores during 12 months ending Oct. 31, 1908. Manufacturers and others desirous of tendering should apply to the secretary (Mr. R. H. Selbie), 32, Westbourne-terrace, London, W., for forms. The company's requirements include electric wires, cables, lamps, carbons, fuses, ebonite battery jars, zincs, &c. Patterns and samples will be on view from Sept. 30 to Oct. 5 inclusive. Tenders to the Secretary by 10 a.m. Oct. 7.

London County Council invite tenders for the manufacture, delivery and erection of three electrically-driven boiler feed pumps, each of 9,000 gallons per hour capacity, at the tramways electricity station, East Greenwich. Tenders to the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 11 a.m. Oct. 8.

London County Council want tenders by 11 a.m. Oct. 8 for erection of tramways sub-station at Lewisham. Forms of tender from the Architect's Department, 13, Charing-cross, S.W.

Maidstone Corporation want tenders by Oct. 7 for supply and erection of seven electric motors and centrifugal pumps, motor-driven air ejectors, cranes, switchboard, starting switches, &c., and a complete electric-light installation, for the sewage disposal works. Plans from Mr. G. R. Strachan, 9, Victoria-street, London, S.W.

Dublin Lighting committee invite tenders for supply of 500 alternating-current single-phase meters and 100 three-phase meters. Tenders to the Chairman of the Committee, 3, Cork-hill, Dublin, by noon Sept. 30.

Dundee Electricity committee want tenders by first post Sept. 30 for supply of two turbo-alternators, condensing plant, water-tube boilers, mechanical stokers, economisers and coal-handling plant. Specifications from City Electrical Engineer.

Tenders are required by 10 a.m. Oct. 5 for maintenance of wiring, telephones, bells, &c., at the Union Hospital, Horton-lane, *Bradford*. Particulars from Mr. F. Holland, 11, Parkinson's-chambers, Hustlergate, Bradford.

The *East Indian Railway Co.* require tenders by noon Oct. 2 for supply of 600 kw. d.c. generator. Particulars from the Secretary, Nicholas-lane, London, E.C.

Portrush District Council want tenders by 8 p.m. Nov. 2 for an electric (or gas) lighting installation. Specification from Mr. John Woodside, Ocean-buildings, Belfast.

Tenders will be received by the Deputy Postmaster-General, *Sydney* (N.S.W.), until 2.30 p.m. Nov. 6 for supply and delivery at Sydney of 14¼ tons of h.d. copper wire (300 lb. per mile); 4 cwt. copper binding tape (200 lb. per mile and ⅜ in. wide); 3,500 porcelain insulators, 1,000 tallow-wood crossarms, 3 ft. 10 in., with end bolts and straps; 2,500 tallow-wood crossarms, 5 ft. 2 in., with end bolts. Tender forms and specifications from the Australian Commonwealth Offices in London, 72, Victoria-street, S.W.

Tenders are required by 1 p.m. Oct. 7 for supply of four dynamos to the *Odense* (Denmark) Electrical Works. Tenders to the Stadsingeniorens Kontor, Odense. Copies of specification and conditions can be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

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TENDERS RECEIVED AND ACCEPTED.

Hackney (London).—Public Libraries committee have received the following tenders for wiring and fitting the Central Library:—

Tilley Bros. (*conditionally accepted*), (1, steel conduit) **£311. 13s. 7d.**, (2, wood casing) £274. 0s. 1d., (3, lead covering) £277. 8s. 7d.; F. C. Hoskins & Co., (1) £266. 14s. 10d., (2) £246. 3s. 10d., (3) £314. 14s. 6d.; G. Weston & Sons, (1) £317. 11s., (2) £305. 10s., (3) £299. 15s.; Pemberton, Arber & Co., (1) £324. 7s. 6d., (2) £296. 9s. 6d., (3) £282. 15s. 6d.; Smeeton & Page, (1) £325. 15s. 10d., (2) £295. 4s., (3) £290; Roger Dawson, (1) £347. 2s. 4d., (2) £318, (3) £328; E. Probert & Co. (exclusive of fittings), (1) £351. 15s., (2) £301. 15s., (3) —; F. Troy & Co., (1) £358. 3s. 1d., (2) £323. 18s. 1d., (3) £341. 0s. 7d.; H. J. Galliers, (1) £367, (2) £328, (3) —; Vaughan & Cook, (1) £367, (2) £330, (3) —; W. J. Fryer & Co., (1) £382. 10s. 10d., (2) £340, (3) £356; Barlow Bros. & Co., (1) £386, (2) £322, (3) £367; J. H. Golding, (1) £390. 4s. 6d., (2) £301. 14s. 6d., (3) —; F. A. Glover & Co., (1) £391. 3s. 5d., (2) £341. 3s. 5d., (3) £379. 12s. 5d.; Sweet Bros., (1) £396, (2) £272, (3) £358; J. O. Grant & Taylor, (1) £403. 6s. 2d., (2) £368. 6s. 2d., (3) £345. 8s. 6d.; Jackson Bros., (1) £403. 7s. 6d., (2) £352. 5s. 6d., (3) £345. 8s. 6d.; Ward Bros., (1) £414. 13s. 8d., (2) £382, (3) £380; Smith & Co., (1) £451. 6s., (2) £359. 11s., (3) —; Electrical Installations (L'd.), (1) £603. 16s. 3d., (2) £420, (3) £452.

Aldershot District Council have referred the undermentioned tenders received for electric light cables to the Lighting committee:—

St. Helens Cable Co...	£486	9	2	British Insulated & Helsby Cables.....	£466	14	1
Western Electric Co...	482	18	10				
W. T. Glover & Co. ..	475	2	6	Siemens Bros. & Co...	457	5	6
Geipel & Lange	472	9	7	Johnson & Phillips ..	451	19	4
W. T. Henley's Co.....	460	4	5	Callender's Co.	444	18	9

Leyton Council have received the following tenders for an oil eliminator:—

Paterson Engineering Co. (*accepted*) **£160**, William Boby £181. 5s. Lassen & Hjort £195, Davis Perrett (Ltd.) £260.

Leyton Council have placed an order with Frank Pearn & Co. at £90 for a Cameron pump, with F. W. Potter & Co. for wire guards for machines in the tramway fitting shop at £14. 18s. 6d., and with Venner & Co. for two car-meters at £3. 15s. each.

Maidstone Council have accepted the following tenders:—

John Spencer (Ltd.), steel steam pipes, at £106; G. E. Wallis & Sons, extension of electricity station buildings, at £1,294; E. A. Phillips & Co., supply of Leicestershire ½ in. slack for one year, at 12s. 3d. per ton.

Croydon Corporation have accepted the following tenders:—General Electric Co., 100 transformers; Oliver Arc Lamp Co., about 100 flame arc lamps; London Electric Firm, lowering gear (about 100).

Kingston-on-Thames Town Council have accepted the tender of Siemens Bros. & Co. for supply of ¼ mile 1 sq. in. l.t. armoured cable at £123.

Dynamo and Motor Contracts.—The following orders have been recently received by the Phœnix Dynamo Mfg. Co., Bradford:—

From Grimsby Corporation, a 500 kw. P.D.M. generator (coupled to Belliss engine); Wednesbury Corporation, battery booster and feeder booster sets and switchgear; Levinstein (Ltd.), all the variable speed motors for the electrification of Crumpsall Vale Works, Manchester; for a mill at Cleckheaton, 100 kw. generator at 100 revs. per min., motors and switchboards, &c.; for a mill at Dewsbury 100 kw. generator, motors and switchboard; Old Roundwood Colliery, 100 kw. dynamo with Belliss engine and large switchboard; Brown Bayley's Steel Works (Sheffield), 110 kw. dynamo with Allen engine; Kohler Bros., in connection with the printing press equipment for the London "Daily Mail," six 60 B.H.P. and six 10 B.H.P. motors; G. W. Railway Co., further order for variable speed motors for Swindon Works; Hammersmith (London) Council, small motor generator set; Manchester Technical School, South Western Polytechnic (London) and Brighton Technical School, various machines for laboratory and demonstration purposes; Greenock Electricity Works (to order of Horsfall Destructor Co.), seven totally enclosed motors; and for textile mills and works in Bradford district, some 400 B.H.P. of motors.

BUSINESS NOTICES.

On and after 30th inst. the London office of the Western Electric Co. will be at Norfolk House, Victoria Embankment, W.C. The company's P.O. telephone number will remain 2389 Central, but the National number will be Gerrard 5849.

Owing to increase of business, the Concordia Electric Wire Co. have been compelled to take more spacious premises at 64, Salusbury-road, Kilburn, London, N.W. The telegraphic address (*Polianite London*) remains the same, and the telephone number (Bank 8448) will remain in force until further notice.

Messrs. Brecknell, Munro & Rogers, of Bristol, have opened new offices in London (at Finsbury Pavement House, E.C.) under the management of Mr. E. M. Munro, M.I.E.E, M.I.M.E.

Messrs. F. W. Smith & Co. are removing on the 28th inst. from their present Salford address to 12, Tib-lane, Cross-street, Manchester.

W. Mackie, Egerton J. Glyn and A. R. M. Lockwood (trading as W. Mackie & Co.), electrical engineers, 122-124, Golden-lane, London, E.C., have dissolved partnership. Debts by Mr. Glyn.

Wm. J. Crawford and Edmund Draper (trading as Wood & Crawford), electrical and mechanical engineers, Alma Works, Alma-street, Sheffield, have dissolved partnership. Debts by Mr. Crawford.

Messrs. B. Paege & Co, manufacturers of special insulating varnishes and colours, &c., notify that from Oct. 1 their offices and stores will be removed from 14, Kaiserin Augusta Allee, Berlin, N.W.87, to 80-82, Quitzowstrasse, Berlin, N.W.5.

BANKRUPTCIES, LIQUIDATIONS, &c.

A second dividend (1s. 8d.) in the liquidation of McPhail & Simpson's Dry Steam Patents Co. (Ltd.) will be payable on Oct. 2 by Mr. J. W. Close, North British and Mercantile Buildings, East Parade, Leeds.

The City of Wellington Electric Light & Power Co. (Ltd.), New Broad-street House, London, E.C., is being wound up voluntarily. Mr. H. E. Salt is liquidator.

Electro-Chemical Works for Sale.—The extensive buildings, plant and machinery belonging to the Scottish Cyanide Co. (Ltd.), with offices, foremen's houses, and large water power at Leven, Fifeshire, are for sale. The grounds are about 13½ acres, of which 2 acres are covered by buildings, and the water power (about 280 H.P. from the river Leven) can be increased. The machinery has been very little used, and comprises 10 Lancashire boilers, four Willans triple expansion engines (each of 800 H.P.), eight Mather & Platt low-tension alternators, condensing plant, Green's economisers, four "Achilles" water turbines, 15 electric furnaces with mechanical discharge complete, three Dowson gas producers, gas plant, &c., eight filter presses, six vacuum filters and two vacuum evaporators, Linde refrigerating plant, distillation plant, dynamos, electric motors, hoists, blowers, &c. The works have ample railway sidings, and are conveniently situated and compactly arranged. Can be seen at any time by appointment on orders from Messrs. Davidson & Syme, W.S., 28, Charlotte-square, Edinburgh, or Mr. Robert B. Lawrie, manager and secretary of the company, Kirkland Works, Leven, Fife, with either of whom tenders are to be lodged. See also an advertisement.

Business for Sale.—Owing to illness of owner a well-known engineering business in London is offered for sale as a going concern. The business has a well-established connection extending over half a century, and the business includes electrical, general and marine engineering. Freehold land and buildings may be purchased or leased, and the plant and stock taken at valuation. Particulars from the sole agents, Messrs. Wheatley Kirk, Price & Co., 46, Watling-street, London, E.C. See also an advertisement.

Plant for Sale.—Electric lighting plant (including two 45 kw. Willans-E.C.C. sets, one Cottman-Siemens 40 kw. set, three B. & W. boilers fitted with Erith underfeed stokers, one forced draught blower, two Worthington feed pumps, feed-water heater, &c.) is advertised for sale on another page.

Timber for Sale.—Messrs. Remer & Co. (Ltd.), timber importers, Mersey Saw Mills, Liverpool, advertise for sale seasoned ash planks and ash in the round.

CATALOGUES, &c.

Electric Drills.—We have received from the Ingersoll Rand Co., 114, Queen Victoria-street, E.C., copy of an illustrated pamphlet on the Temple-Ingersoll electro-pneumatic drill, for which many advantages are claimed, including simplicity, durability and economy. Either a direct or alternating-current motor may be employed with these drills.

Paul's Instruments.—A new catalogue is in preparation by Mr. R. W. Paul, New Southgate, N., and the first three sections are now being issued. A1 deals with resistance standards, resistance boxes and Wheatstone bridges; E1 with reflecting galvanometers and shunts, and H2 with the Duddell-Mather standard wattmeters and anti-capacity gauze resistances.

We illustrate in Fig. 1 the Duddell-Mather oil-cooled non-inductive resistance, pattern 1826, which is a resistance for extra high-pressure

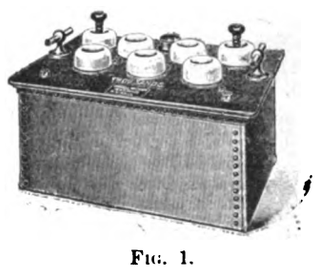

Fig. 1.

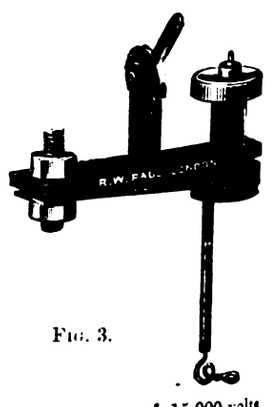

Fig. 3.

circuits and is suitable for a maximum pressure of 15,000 volts. The gauze is strung on to long porcelain insulating rods fixed in frames attached to the cast-iron cover of the oil tank, in which the resistance is immersed. The whole can be lifted out for inspection when desired. The total resistance is 100,000 ohms, suitably

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subdivided, and the wire being immersed in oil is capable of carrying a current of $\frac{1}{100}$th ampere. The overall dimensions are 39 in. by 29 in. by 22 in. and the weight 180 lb. Fig. 2 is a new pattern reflecting galvanometer, and Fig. 3 a detail of the zero adjustment and coil clamp for which several novel points are claimed. This instrument is specially suited to withstand rough usage in a works or students' laboratory, and is claimed to have a sensibility equal to

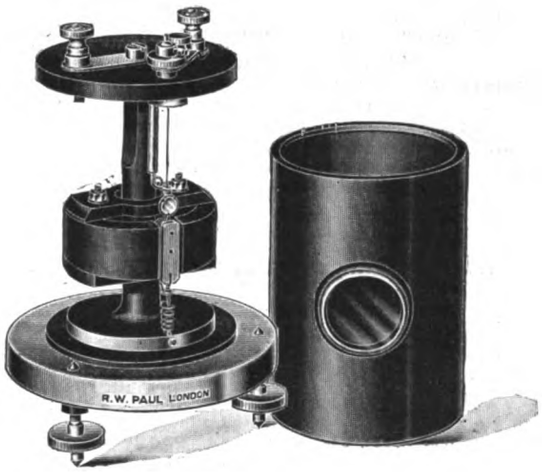

FIG. 2.

the more expensive types. The device for clamping the coil has the advantage of being actuated from outside the instrument, and, while firmly fixing the coil, also relieves the suspension from strain.

Electric Signs.—The Electric Sign and General Advertising Co., 38 and 39, Cowcross-street, E.C., issue a booklet on illuminated advertising signs. The company notify that they have no catalogues of electric signs, as all such signs are made to the special requirements of their clients.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Sept. 18 to Sept. 24, with the ports of destination:—

Africa—Alexandria, £299 (including £22 telegraph material); Beira, £21; Cape Town, £705 (including £147 telegraph material); Delagoa Bay, £1,588; Durban, £1,917 (including £1,406 telegraph material); Kalindini, £187; Lyttelton, £66; Mombasa, £1,435; Mozambique, £533 (telegraph material); Port Said, £127; Port Sudan, £82; Suez, £77. *Argentina*—Buenos Ayres, £1,410 (including £266 telegraph material). *Australasia*—Adelaide, £369; Auckland, £607: Brisbane, £646 (including £600 telegraph material); Christchurch, £20; Melbourne, £3,248; Otago, £180; Perth, £96; Sydney, £2,209; Wellington, £12,506 (including £9,374 submarine cable). *Belgium*—Ghent, £77; Ostend, £13. *Brazil*—Rio Janeiro, £112. *British Guiana*—Demerara, £122. *Burma*—Rangoon, £32. *Canada*—St. John (N.B.), £105; Toronto, £28. *Ceylon*—Colombo, £317. *Channel Islands*, £51. *China*—Shanghai, £840. *Cuba*, £754. *Denmark*—Copenhagen, £148. *France*—Boulogne, £135. *Germany*—Bremen, £1,125; Hamburg, £61. *Gibraltar*, £350. *Holland*—Amsterdam, £444; Rotterdam, £161 (including £20 telegraph material). *Hong Kong*, £164. *India*—Bombay, £3,716; Calcutta, £1,402; Karachi, £410; Madras, £7,691. *Italy*—Leghorn, £150. *Japan*—Nagasaki, £1,732. *Malta*, £59. *North Atlantic*, £150,000 (telegraph cable). *Russia*—Riga, £12; St. Petersburg, £167 (telegraph material). *Siam*—Bangkok, £176. *Straits Settlements*—Singapore, £1,536. *Uruguay*—Monte Video, £21. *U.S.A.*—Boston, £176; New Plymouth, £35; New York, £27. *West Indies*—Jamaica, £20; Port Swettenham, £178; Trinidad, £42 (including £30 telegraph material). *Zanzibar*, £93 (telegraph material). Total, £201,010, against £20,643 in the corresponding week last year (Sept. 19 to 25).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

July 15, 1907.

16,188 BEVIS & CHAPMAN. Fixing terminals and contact-pieces of electrical fittings.
16,191 BARRACLOUGH. Automatic electromagnetic switch for disconnecting charged conductors in overhead traction.
16,227 CORIN. Controlling supply of electricity at a distance.
16,235 PEARS. Electric light and bell fittings.
16,251 HINSKY. Insulating conduits for electric wires.*

July 16, 1907.

16,270 BOWLEY. Steam and other turbines.
16,272 HILLING. Safety attachment for raising sunken submarines and telephoning thereto.
16,276 HIRST & CUMMINGS. Cleaning tramway lines and the like.
16,286 SUTTON & RUDD. Signals on electric vehicles for preventing accidents.
16,301 STEVENSON. Electric lamp for lighthouse apparatus.*
16,315 DOSEK. Generating gases and vapours of such tension that steam engines, turbines and the like may be driven by them.*
16,334 SIEMENS BROS. & CO. & GRIMSTON. Printing-telegraphs.
16,346 TURBAYNE. Electrical systems of distribution. (Date applied for, 25/7/06.)*†
16,360 DE MARTIS & THOMAS. Batteries.
16,364 MAYO & HOULEHAN. Automatic multiple fuse blocks.*
16,366 MAYO & HOULEHAN. Starters for electric motors. (Date applied for, 11/2/07.)*†
16,369 COWPER-COLES. Switches.
16,372 MCPHAIL. Applying insulating material to cables, parts of generators or motors, &c.

July 17, 1907.

1,197A B.T.-H. Co. (G.E. Co., U.S.) Treatment of refractory materials by electricity. (Date applied for, 16/1/07.)
16,383 APPLEYARD & QUIGGIN. Electric light carriers or fittings.
16,386 MATTHEWS. Starting switches for motors.
16,393 MOORE. Appliance for electrical or mechanical massage.
16,409 RICKETS. Telephonic transmitters and translators.
16,429 BURBEY & KERSLEY. Rails for tramways and the like.*
16,431 STEARN & TOPHAM. Incandescence lamps.
16,447 COREY. Switch mechanism. (Date applied for, 18/7/06.)*†

July 18, 1907.

16,450 PETCH, DUNCAN & KING. Electric motor control.
16,461 VARLEY. Devices for making and breaking contacts.
16,467 ZEISS. Telemeters. (Date applied for, 12/6/07.)*†
16,481 IRWIN. Oscillographs.
16,485 LENNER. Regulating or controlling and measuring electric currents.
16,500 LAKE. (Sanford, U.S.) Electric self-winding clocks.*
16,502 WEICHELT. Turbines.*
16,503 DEUTSCHE GASGLÜHLICHT A.-G. Attaching tungsten filaments in glow lamps. (Date applied for, 6/5/07.)*†
16,508 BÉCHERAZ. Mouthpieces for telephones.
16,513 WISE. (MAILLOUX, U.S.) Cooling electric machinery.*
16,523 BROWN, BOVERI & CIE. A.-G. Steam turbines with an impulse and reaction part. (Date applied for, 18/7/06.)*†
16,529 ALLGEMEINE ELEKTRICITÄTS GES. Alternating-current motor of the commutator type. Date applied for, 19/7/06.)*†
16,530 B.T.-H. Co. (G.E. Co., U.S.) Preparation of refractory materials.
16,531 B.T.-H. Co. (G.E. Co., U.S.) Supports for filaments of incandescent lamps.

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

19,704 MORGAN CRUCIBLE CO. & SPIERS. Brushes for dynamo-electric machines.
20,201 ELECTRIC IGNITION CO. & HALL. Switches.
20,395 B.T.-H. Co. (G.E. Co., U.S.) Transformers.
20,639 COWPER-COLES. Removing metallic cylinders from mandrils on which they are electro deposited.
20,716 ROBERTS, ROBERTS, & JAFFRAY. Electrodeposition of metals and alloys.
20,803 B.T.-H. Co. (G.E. Co., U.S.) Electric motor control devices.
21,002 NOEGGERATH. Dynamo-electric machines. (Date applied for, 22/9/05.)
21,253 B.T.-H. Co. (G.E. Co., U.S.) Control of electric motors.
21,299 ROBINSON & WALKER. Preventing spread of fire in connection with electric wiring.
21,391 LUNDBERG, LUNDBERG & LUNDBERG. Wall connections.
21,583 COWPER-COLES. Electrolytic manufacture of metallic wire, strip, or the like.
21,668 B.T.-H. Co. (G.E. Co., U.S.) Terminals for use in incandescent lamps.
22,132 GERSABECK. Electrical cells.
22,347 B.T.-H. Co. (G.E. Co., U.S.) Control of electric motors.
22,497 LANGE. Ventilation of the cores of electrical machines.
22,546 HART. Joints of railway and tramway rails.
22,625 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
22,795 B.T.-H. Co. (G.E. Co., U.S.) Current-collecting devices.
22,863 MILCH. Speed regulation of induction motors.
22,904 B.T.-H. Co. (G.E. Co., U.S.) Dynamo-electric machines.
23,246 RUSSELL & BERRY. Two-phase alternating current distribution.
23,413 LEITNER. Active materials for accumulators.
23,427 THOMPSON. (Schwabe & Co.) Electric lighting devices for theatres.
23,444 B. T.-H. Co. (G.E. Co., U.S.) Brushes for dynamo-electric machines.
23,602 HOOKHAM. Electricity meters.
23,781 JOHNSON. Electrical resistance thermometer.
24,209 GARRARD & FERRANTI LIMITED. Maximum demand indicators.
24,239 MITCHELL. Electrically driving printing and other machines.
24,270 KING'S NORTON METAL CO., BAYLISS & SMITH. Electric vent sealing tubes or primers.
25,027 CASE, HAMPSON & PALMER. Lifeguards.
25,143 LUNDBERG, LUNDBERG & LUNDBERG. Multiple-way switches.
25,877 DE SAINT-ROMAIN. Magneto-electric ignition. (Date applied for, 25/5/06.)

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COMPANIES' MEETINGS AND REPORTS.

DICK, KERR & CO. (LTD.)—At the meeting on Tuesday the chairman (Mr. John Kerr) moved the adoption of the report (given in our last issue) and said that on a calm survey of the business situation, and taking the experience of other similar concerns, he thought they could rejoice that their position had been so well maintained. From the competition which, he referred to last year as keen, they had found little or no amelioration during the last 12 months. They were prepared to take part in the struggle and to endeavour to hold their own, but the directors deprecated the folly of ruinously cutting prices. If they had during the last two years been able to maintain their profits, he trusted that they could look forward to a time when all the energy and capital they had might get a more generous return. Another element affecting the profits had been the great increase in the cost of raw materials. Electrolytic copper, of which they bought a large amount, had been not only high in price but very fluctuating. It was the severe fluctuations that militated against them and made business most difficult. By reason of the stringency in the money market many schemes, where much material they produced would be required, were in a state of suspense. The great shrinkage in capital values of all classes of securities had naturally caused a check on new enterprises. The enormous wastage of capital involved in the South African war, the Russo-Japanese war and the destruction of San Francisco all pointed to a restraint in speculative activity. The Board of Trade returns would give the impression that this country was enjoying a period of boundless prosperity. One or two favoured trades had certainly had a good time, as also some producers of raw material, but a careful study of the true position would, he thought, satisfy most people that the margin of profit had been greatly reduced compared with many years when the Board of Trade figures were of a more modest character. He expressed the directors' thanks to the management and the staff for the whole-hearted manner in which they had, one and all, worked during an arduous 12 months. There was a harmony and an esprit de corps in the company which could not fail to make for success.

The report and accounts were adopted.

ELECTRICAL SECURITIES TRUST (LTD.)—The report to be presented to the statutory meeting states that the number of shares allotted is 52,085, of which 51,578 are allotted as fully paid—namely, 10,000 have been allotted to nominees of the Alliance Trust Co. in consideration for its underwriting an issue of £100,000 of first mortgage debentures; 38,078 have been allotted to Bruce Peebles & Co. as part consideration for certain securities transferred by it to the company; 2,000 have been allotted to the Electric Conversion Synd. as part consideration for certain securities transferred by it to the company, and 1,500 have been allotted to Mr. Arthur Elliott as consideration for certain securities transferred by him to the company. There has been paid in cash on each of the remaining 507 shares £1, making the total cash received in respect of shares issued wholly for cash £507. The estimated amount of preliminary expenses (exclusive of underwriting commission) is £3,000.

SWANSEA IMPROVEMENTS & TRAMWAYS CO. (LTD.)—The report for the half-year ended June 30 states gross receipts of the tramway undertaking to be £22,317, an increase of £613 upon the corresponding period of 1906, and the expenses £18,575, an increase of £63. The profit on the half-year's working is £3,472, added to £2,000 brought forward. After payment of the dividends and putting £1,000 to depreciation £3,442 is carried forward.

UNITED ELECTRIC CAR CO. (LTD.)—At the meeting last week the chairman (Mr. Geo. Richardson) said the directors considered the result of the 12 months' trading very satisfactory, in view of severe competition, the greatly increased cost of all raw materials, and the advance in cost of labour, for with a greatly reduced production compared with the previous year they had made a profit of nearly £7,000 more. With respect to the Hadley and Manchester works, the shareholders would be pleased to hear that the directors had leased the former at a fair rental for three years. The Trafford Park works were unlet, but the directors were doing all they could to secure a tenant or purchaser. As to the policy of absorbing these two places, two very formidable competitors no longer existed, and the absorption had made it possible for them to show a better net result for the past year on a decreased production. For several months past orders had been scarce, but the directors had obtained a fair share of them. At the moment there was something like stagnation in electric traction, but they trusted that, as many schemes of electrical and railway development matured and monetary conditions were more favourable, there would be more work for them.

NEW COMPANIES, STATUTORY RETURNS.

NEW COMPANIES.

CHARLES G. SMITH & CO. (LTD.) (94,973.)—Reg. Sept. 21, capital £1,000 in £1 shares (800 preference), to carry on the business of manufacturers of and dealers in architectural metal work, electrical appliances and fittings, sanitary and electrical engineers, &c. Reg. office, 5, Denmark-street, Soho, London, W.

GENERAL ACOUSTIC (LONDON) SYND (LTD.) (94,797.)—Reg. Sept. 3, capital £10,000 in £10 shares, to acquire option of certain patent rights in connection with an invention known as the "Dictograph," and to carry on the business of manufacturers of and dealers in "dictographs" and other instruments used for telephonic and similar purposes, electrical and mechanical engineers, &c. Reg. office, 3 and 4, Great Winchester-street, London, E.C.

LANGDON-DAVIES MOTORS (CANADA) (LTD.) (94,889).—Reg. Sept. 12, capital £1,000 in £1 shares, to carry on the business of producers of and dealers in electric and other motors, gas, oil, petrol and other engines, motor cars, dynamos, apparatus, accessories, &c. First directors F. B. O. Hawes and A. E. Alston. The Langdon-Davies Motor Co. (Ltd.), of Southwark, London, S.E., have consented to this registration.

B. D. K. CO. (LD.) (94,856)—Reg. Sep. 10, capital £26,525 in 25,000 A preference shares of £1 each, 5,500 B preference and 25,000 ordinary shares of 1s. each, to adopt agreements with the Transcontinental Construction and Contracts Corporation and T. Kirkpatrick and to acquire and work railways, rolling stock, tramways, roadways, electrical generation works, &c. Reg. office, 46, Leadenhall-street, London, E.C.

STATUTORY RETURNS

ACCESSORIES MANUFACTURING CO. (LTD.)—In return to Aug. 14, capital is £10,000 in 5,000 preference and 5,000 ordinary shares of £1 each, of which 2,443 preference and 1,064 ordinary have been taken up. £1 per share has been called up and paid on 7 ordinary. £3,500 is considered as paid on 2,443 preference and 1,057 ordinary. Mortgages and charges, £3,300.

BRAY, MARKHAM & REISS (LTD.)—Return to Aug. 2 gives capital as £20,000 in £1 shares, of which 8,000 have been taken up and paid for in full. Mortgages and charges, nil.

BUENOS AYRES ELECTRIC LIGHT CO. (LTD.)—The capital in return to May 16 is £100,000 in 9,986 shares of £10 each and 70 founders' shares of £2 each, of which 70 founders' have been taken up. No calls have been made. Mortgages and charges nil.

ECUADOR TELEPHONE CO. (LTD.)—According to return to July 25 capital is £100,000 in 20,000 shares of £5 each, of which 5,000 have been taken up. £25,000 has been received. Mortgages and charges, nil.

ELECTRIC & GENERAL INVESTMENT CO. (LTD.)—In return to July 10 capital is £200,000 in £5 shares (20,000 ordinary, 100 founders' and 19,900 preference), all of which have been taken up. £1 per share has been called up on 20,000 ordinary and £5 per share on 100 founders' and 19,900 preference and £120,000 has been received. Mortgages and charges, nil.

ELECTRIC LIGHT POWER & HIRING CO. (LTD.)—The capital in return to July 13 is £15,000 in £1 shares, of which 13,206 have been taken up. 8s. per share has been called up and £5,282. 8s. has been received. Mortgages and charges, nil.

ELECTRIC SUPPLY CORPN. (LTD.)—The capital in return to Aug 14 is £250,000 in £5 shares, of which 42,000 have been taken up. £5 per share has been called up on 35,000 and £174,990 has been received. £35,000 is considered as paid on 7,000. Mortgages and charges, £54,955.

GENERAL ELECTRIC CO. (LTD.)—In return to Aug. 9 capital is £800,000 in 40,000 preference and 40,000 ordinary shares of £10 each, of which 25,000 preference and 34,587 ordinary have been taken up. £10 per share has been called up on 18,000 preference and 9,587 ordinary and £275,870 has been received. £320,000 is considered as paid on 7,000 preference and 25,000 ordinary. Mortgages and charges, £200,000.

SUNBEAM LAMP CO. (LTD.)—Capital in return to Aug. 7 is £25,000 in £10 shares, of which 1,765 have been taken up. £9,080 has been received, and £8,570 is considered as paid. Mortgages and charges, £8,800.

UNITED RIVER PLATE TELEPHONE CO. (LTD.)—According to return to Aug. 6, capital is £1,000,000 in 100,000 ordinary, 40,000 preference and 60,000 unclassified shares of £5 each, of which 100,000 ordinary and 40,000 preference have been taken up. £5 per share has been called up and paid on 84,000 ordinary and 40,000 preference. £80,000 is considered as paid on 16,000 shares. Mortgages and charges, £300,000.

J. G. WHITE & CO. (LTD.)—The capital in return to July 12 is £200,000 in 15,000 preference shares of £10 each and 50,000 ordinary shares of £1 each, all of which have been taken up. £150,000 has been paid on the preference and £50,000 is considered as paid on the ordinary. Mortgages and charges nil.

CITY NOTES.

MEMORANDA (Sept. 26).—Bank rate 4½ per cent. (since Aug. 15, 1907) Price of silver 31⅛—31 5/16d. per oz. Consols 82¼—82⅜ for money, 82 5/16—82 7/16 for account; 2½ per cent. annuities 80½—80¾. Consols Pay Day, Oct. 3; Stocks and Shares Continuation Days, Oct. 9 and 28; Ticket Day, Oct. 10; Pay Days, Sept. 27 and Oct. 11; Mining Share Carry-over Day, Oct. 8.

ANGLO-ARGENTINE TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend to June 30 of 4s. per share on the ordinary shares (Nos. 260,008 to 580,007 inclusive), which under the recent special resolutions become second preference shares, being at the rate of 8 per cent. per annum (tax free), payable Oct. 7.

BABCOCK & WILCOX (LTD.)—The directors recommend a dividend of 8 per cent. for the half-year ended June 30.

BROMLEY (KENT) ELECTRIC LIGHT & POWER CO. (LTD.)—The directors announce an interim dividend of 2 per cent.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have granted quotations to 100,000 10s. fully-paid ordinary and 150,000 £1 fully-paid 6 per cent. preference shares (in lieu of the preferred shares now quoted) of the *Kalgoorlie Electric Power & Lighting Corpn. (Ltd.)*. The committee have been asked to appoint a special settling day in and grant a quotation to 32,000 £10 fully-paid shares of the *Shanghai Electric Construction Co. (Ltd.)*.

WOKING ELECTRIC SUPPLY CO. (LTD.)—An interim dividend on the ordinary shares at the rate of 5 per cent. for the half-year ended June 30 has been declared.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 18	1,592	+ 100	16	25,014	- 346
Airdrie	,, 13	239	- 1	36	8,070	- 54
Anglo-Argentine	,, 23	16,114	+ 580	38	625,449	+ 61,608
Ashton-under-Lyne Corp	,, 14	425	+ 61	26	10,435	+ 1,003
	,, 21	401	+ 38			
Ayr Corporation	,, 21	771	- 74	19	7,834	- 242
Baker St. & Waterloo Ry.	,, 21	2,205	+ 655	12	27,135	+ 10,895
Barnsley	,, 13	175	+ 7	36	6,105	+ 63
Barrow	,, 13	322	+ 27	36	9,530	- 166
Bath Electric Trams, Ltd.	,, 18	934	- 20	38	30,712	- 1,285
Birkenhead Corporation	,, 22	1,084	+ 18	...	...	...
Birmingham Corporation	,, 21	6,286	...	25	151,494	...
Birmingham & Mid.	,, 6	802	- 1	35	28,710	...
Blackburn Corporation	,, 19	1,189	+ 189	¶25	29,023	+ 1,613
Blackpool Corporation	,, 19	1,966	+ 65	24	38,871	- 1,912
Blackpool and Fleetwood	,, 21	1,198	- 143	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 22	2,303	+ 232	25	58,465	+ 3,370
Bournemouth Corporation	,, 18	2,150	+ 186	¶24	47,200	+ 862
Bradford Corporation	,, 21	4,876	+ 391	25	119,105	+ 1,071
Brighton Corporation	,, 22	1,095	+ 43	25	25,451	- 2,681
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 20	5,535	+ 387	11	55,637	- 925
Burnley Corporation	,, 21	1,214	- 28	25	30,397	+ 710
Burton Corporation	,, 22	279	- 7	25	7,506	- 378
Bury Corporation	,, 15	1,283	...	24	27,317	...
Calcutta Tramways Co.	,, 21	R48,434	- R2,094	11	R521,196	+ R31,323
Camborne-Redruth	,, 21	142	+ 9	38	4,654	+ 94
Cardiff Corporation	,, 14	2,324	+ 156	24	54,026	+ 1,795
Cavehill	,, 13	121	- 2	36	3,187	- 110
Central London Railway	,, 21	4,739	- 1,272	12	57,579	- 8,308
Charing C., Euston & H'stead	,, 21	2,465	...	12	30,005	...
Chatham & Dist. Lt. Rys.	,, 19	831	- 8	¶37	27,616	+ 1,716
City & South London Rly.	,, 22	2,765	+ 173	12	36,290	+ 6,607
City of Birmingham	,, 13	2,896	+ 257	36	101,310	...
Colchester Corporation	,, 18	245	+ 5	...	...	...
Cork Electric Trams Co.	,, 17	546	+ 28	38	17,830	- 743
Croydon Corporation	,, 20	1,553	+ 155	25	36,857	- 1,892
Devonport & Dist. Trams	,, 13	516	+ 12	36	16,848	- 180
Dover Corporation	,, 21	259	- 11	25	6,348	- 921
Dublin & Lucan Railway	,, 20	157	+ 20	12	1,892	+ 146
Dublin United	,, 20	7,225	+ 2,108	‡12	59,367	+ 20,538
Dudley Stourbridge	,, 13	1,026	+ 31	36	31,492	- 947
Dundee Corporation	,, 18	1,195	+ 78	18	20,977	+ 489
East Ham Council	,, 21	974	+ 96	25	23,469	- 345
Exeter Corporation	,, 20	378	+ 66	25	8,524	+ 708
Falkirk and District	,, 18	288	...	...	...	...
Gateshead & Dist. Trams	,, 13	1,027	+ 32	36	36,555	+ 874
Glasgow Corporation	,, 21	18,815	+ 920	16	282,999	+ 5,019
Glossop	,, 21	145	- 5	38	5,196	+ 11
Gravesend—Northfleet	,, 13	299	+ 8	36	9,022	- 84
Great Northern & City Rly.	,, 21	1,611	- 74	12	18,988	- 97
Gt. Northern, Piccadilly, &c.	,, 21	3,870	...	12	46,325	...
Greenock & Port Glasgow	,, 13	717	- 83	36	24,297	- 775
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 13	354	+ 13	36	10,715	- 657
Hastings Elec. Trams Co.	,, 19	1,495	+ 502	12	16,286	+ 275
Hong Kong	,, 21	$7,987	+ $1,412	23	$293,364	+ $38,586
Huddersfield	,, 21	1,615	+ 102	25	40,578	+ 2,037
Hull Corporation	,, 21	2,350	+ 106	25	60,131	+ 3,061
Ilford District Council	,, 21	489	+ 36	25	12,352	- 526
Ilkeston District Council	,, 18	164	+ 19	25	3,886	+ 184
Ipswich Corporation	,, 21	467	+ 15	25	11,096	- 891
Isle of Thanet Co.	,, 21	1,010	+ 172	51	30,929	- 555
Jarrow	,, 13	168	...	36	4,495	...
Keighley Corporation	,, 19	165	+ 11	12	2,019	+ 121
Kidderminster & District	,, 13	145	+ 5	36	4,500	- 195
Kilmarnock Corporation	,, 21	157	- 12	18	3,055	- 77
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 19	1,334	+ 379	38	44,663	+ 11,281
Lancashire United	,, 18	1,451	+ 419	38	48,187	+ 12,265
Leamington	,, 13	198	+ 23	36	5,906	- 752
Leeds Corporation	...	...	...	...	...	...
Leicester Corporation	,, 21	2,211	+ 93	12	26,418	- 513
Leith Corporation	,, 21	516	- 31	‡19	10,251	- 57
Lincoln Corporation	,, 21	115	+ 6	25	3,091	+ 77
Liverpool Overhead Rly.	,, 22	1,171	- 2	12	19,913	+ 1,181
Liverpool Corporation	,, 14	11,266	+ 129	37	404,307	+ 6,972
*London County Council	,, 14	32,713	+ 6,650	24	753,773	+ 120,058
London United	,, 20	7,681	+ 1,611	‡38	250,672	+ 9,856
Lowestoft	,, 21	311	+ 19	51	10,606	+ 979
Maidstone Corporation	,, 21	140	+ 19	25	2,886	- 225
Manchester Corporation	,, 21	15,457	+ 1,398	25	375,072	+ 28,081
Mersey Railway	,, 21	1,781	+ 102	12	21,686	+ 1,609
Merthyr	,, 13	225	+ 10	36	7,635	+ 384
Metropolitan Dist. Railway	,, 22	7,347	- 182	12	85,814	+ 416
Metropolitan Elec. Trams	,, 13	5,748	+ 1,769	36	168,668	+ 41,108
Middleton	,, 13	412	+ 7	36	13,064	- 200
Nelson Corporation	,, 21	140	- 7	26	3,899	+ 60
Newcastle-on-Tyne Corp.	,, 21	3,984	- 49	25	103,186	+ 351
Newport (Mon.)	,, 21	691	+ 15	25	18,110	+ 1,611
Northampton Corporation	,, 20	455	+ 11	‡25	11,279	- 523
Oldham, Ashton & Hyde	,, 13	635	+ 47	36	22,088	+ 910
Oldham Corporation	,, 20	1,976	+ 147	26	51,174	+ 3,218
Perth (N.B.) Corporation	,, 18	181	- 1	18	3,171	+ 5
Perth (W.A.) Elec. Trams	...	...	...	...	...	...
Peterborough	,, 13	145	- 3	36	4,660	- 269
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 21	2,279	+ 273	25	54,806	- 2,208
Potteries	,, 13	1,898	+ 47	36	67,900	+ 1,950
Preston Corporation	,, 11	822	+ 18	...	...	...
	,, 18	761	+ 19			
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 19	621	+ 132	‡25	15,067	+ 2,374
Rothesay	,, 13	423	+ 82	36	9,119	- 566
Salford Corporation	,, 23	5,097	+ 281	25	119,120	+ 3,110
Sheerness	,, 11	71	- 1	36	2,188	- 75
Sheffield Corporation	,, 22	5,693	+ 404	26	145,111	+ 6,368
Singapore Trams	,, 21	$8,986	+ $983	25	$235,874	+ $12,474

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days. * Partly electrical. † Minus 5 days. ‡ Minus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	Sept. 18	561	+ 85	25	11,832	- 293
South Metropolitan	,, 13	1,018	+ 504	36	29,916	+ 6,088
Southport Tramways	,, 13	430	+ 77	36	11,385	- 628
South Staffs	,, 13	1,015	+ 69	36	32,715	+ 2,113
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 22	1,416	+ 37	24	36,717	- 424
Sunderland and District	,, 18	480	+ 56	38	17,274	+ 1,964
Swansea Trams	,, 13	1,005	+ 65	36	33,429	+ 2,117
Swindon Corporation	,, 18	187	+ 10	...	...	...
Taunton	,, 13	49	- 3	36	1,613	- 109
Tynemouth and District	,, 13	334	+ 20	36	9,419	- 817
Tyneside Trams Co.	,, 18	505	+ 74	38	17,731	+ 746
Victoria, Elec. Supply Co. of	Aug. 18	737	+ 83	...	...	...
Wallasey District Council	Sept. 21	893	+ 76	25	22,357	+ 514
Walsall Corporation	,, 21	584	+ 75	38	19,522	- 114
Warrington Corporation	...	...	...	...	...	...
West Ham Corporation	,, 19	2,345	+ 168	25	59,508	+ 1,341
Weston-super-Mare	,, 11	337	+ 29	36	5,896	- 569
Wolverhampton Co.	,, 13	498	+ 25	36	16,665	+ 1,000
Wolverhampton Corpn.	,, 18	844	+ 29	9	7,965	+ 56
*Worcester	,, 13	317	+ 21	36	10,438	- 277
Wrexham	,, 13	122	- 8	36	3,767	- 65
Yorkshire W.R. Trams	,, 22	1,227	+ 410	38	44,130	...
Yorkshire Woollen District	,, 13	854	- 70	36	34,619	+ 1,048

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shrs.	Last Dividend	Name.	Price Wed., Sept. 25.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Sept 25. Highest.	Business Week to Sept 25. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
£5	4/0	Anglo-Argentine Ord. Shares	8⅛–8⅜	4 15 6	Ap, Oct	8⅛	8⅛
£5	..	Do. 5½ per Cent. Cum Pref.	5 15/16–6 1/16	4 8 3	Ja, Jul	6 1/16	5 15/16
St.	6¾	Do. Permanent 6% Deb. Stock	131 –134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 –105	4 15 0	Ja, Jul	..	..
£5	2/0	Brisbane Electric Trams. Invest. Ord.	8½–8¾	2 17 0	May ..	..	..
£5	2/6	Do. 5 per Cent. Cum. Pref.	4 7/8–5⅛	4 18 6	My, Nv	..	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 –100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	128 –133	4 17 6	Mr, Spt	132½	129
St.	6%	Do. Pref. Ord. Stock	111 –115	4 7 0	My, Nv	113⅜	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	104 –107	4 13 6	Ja, Jul	..	..
£10	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 –103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102 –104	4 6 6	Ja, Jul	..	..
£5	3/0	Buenos Ayres & Belgrano Ord.	4 1/4–4 1/2	8 9 3	Ap, Oct	4⅝	4½
£5	3/0	Do. 6 per Cent. "A" Cum. Pref.	4½–5½	5 14 0	Ap, Oct	..	..
£5	3/0	Do. "B"	4½–5½	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 –115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	100 –103	4 17 0	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 –97	5 8 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 –103	5 7 0	Ja, Jul	..	..
100	6%	Do. 6 per Cent. 1st Deb. Bonds	100 –105	5 14 6	Ap, Oct	103	..
£5	4/6	Calcutta Tramways (1 to 137,610)	6⅞–7⅛	5 8 6	Mr, Spt	7⅛	7⅛
100	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅛	4 11 0	Ja, Jul	5⅛	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 –106	4 5 0	Ja, Jul	..	..
St.	..	Cape Electric Tram Shares	5 1/16–5 3/16	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 –98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 –87	5 15 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	83 –93	5 6 8	Ja, Jul	..	..
£5	6%	Do. 6 per Cent. "B" Ditto	77 –81	7 8 0	Ja, Jul	..	..
£5	1/0	Lisbon Elec. Trams. Ord.	1 –1¼	4 0 0	July ..	..	..
100	0/7½	Do. 6 per Cent. Cum. Pref.	1 –1¼	4 16 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb.	95 –98	5 2 0	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 –99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 –103	4 7 6	Fb, Aug	..	..
St.	6%	Perth E. Trams. 1st Mt. Db. Stock	101 –105	4 15 0	Ja, Jul	..	..
..	$2	Sao Paulo Tramway, Light & Power Co. $100 Stock	115 –120	6 13 3	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	93¾–95¾	5 5 0	Ju, Dec	94¼	..
		ELECTRICITY SUPPLY.					
£5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½–5	6 0 0	Mr, Spt	..	..
10	4/8⅔	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7½–8	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 –99	4 13 9	Ja, Jul	..	..
£5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6¾–7¼	5 3 3	Ap, Oct	..	..
£5	2/3	Do. (80,001 to 100,000)	6¼–7¼	..	..	..	..
£10	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 –53	4 14 3	Ja, Jul	..	..
£5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½–2¾	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	89½–93½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94 – 96	5 4 0	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	101 –104	5 15 6	Ja, Jul	..	..
1	0/3⅓	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	1⅛–1⅜	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 –97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	⅝–¾	3 6 9	April ..	⅝	..
1	1/2⅔	Do. 6 per Cent. non-Cum. Pref.	⅛–1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 –98	5 2 0	Ja, Jul	..	..
£5	3/0	Rosario Elec. Co. 6% Pref. (1-20,000)	5 –5⅛	5 9 6	Ap, Oct	5 1/16	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds., Scrip	99 –101¼	4 19 0	Ja, Jul	100	99½

* In calculating the yield, allowance has been made for accrued interest but not for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., Sept. 25.	RATE % YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 28. High-est.	Low-est.
		ELECTRICITY SUPPLY.					
10	5/0	Bournemouth & Poole Elec. Sup. Ord...	9⅞—10⅜	0 10 0	Mar, Sept,	10½	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅞—10⅜	4 8 0	Feb, Aug	10⅜	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	9⅞—10⅜	5 17 0	Feb, Aug	10⅜	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ..	99 —102	4 8 0	Jan, July	..	..
5	3/6	Bromley (Kent) El. Lt. & Power Shares	4⅜—5⅛	5 5 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 —100	4 10 0	May, Nov	..	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7⅜—8	6 5 0	March....	..	..
5	3/6	Do. 7 per Cent. Pref.....	7⅛—7⅜	4 5 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	99 —102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross(W.End & City)El.Sup.Co.	2⅝—4⅛	6 3 0	Feb, Aug	3⅛	..
5	2/3	Do. 4½ per Cent. Pref.	3⅛—3⅝	5 16 0	Feb, Aug	3⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 — 99	4 1 0	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜—1⅞	6 2 6	Jan, July	..	..
5	2/0	†Chelsea Electric Supply Ord.	3¼—4⅛	5 8 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ..	102 —105	4 5 9	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 - 9½	6 6 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11 —12	5 0 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.),.....	122 —125	4 0 0	June, Dec	122⅛	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 —100	4 10 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	3⅞—4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜—4⅞	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	6⅞—7⅜	6 9 0	Feb, Aug	7⅛	7⅛
10	6/0	Do. 6 per Cent. Cum. Pref.....	10 —11	5 8 6	Mar, Sept	..	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 —109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	£6 - £9	4 11 0	May, Nov	99	..
5	3/6	Folkestone Electricity Supply Co. Ord.	4⅜—4⅝	5 2 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	£6 - £9	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅞—7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼—9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅜—7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 - 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Kngtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	£9 - £12	3 18 0	April, Oct	..	..
3	2/4½	London Electric Supply Ord.	1⅜—1⅝	6 5 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4¼—4⅝	6 6 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	88 — 92	4 7 0	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	5⅛—5⅜	6 1 6	April, Oct	5⅜	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜—5	4 10 0	Jan, July	4⅝	4⅝
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 —107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	£8 - 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 - £8⅝	4 11 9	June, Dec	..	..
10	6%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9 —9½	4 17 0	Feb, Aug	..	..
100	4½%	Do 4% per Cent. Deb.	93 - £9	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	£8—£8	6 3 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	5 —5⅛	4 17 7	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 - £8	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 —£9	4 11 10	Jan, July	..	..
10	£/0	Notting Hill Electric Ord.....	11 —12	7 10 0	March ..	..	..
5	2/6	†Oxford Electric Ord.	5⅛—6	5 17 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£5 - 97	4 2 6	Jan, July	..	..
5	5.0	St. James' & Pall Mall Elec. Ord.....	7⅜—8	6 5 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	6¾—7⅛	4 17 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	£6—£1	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	¾—1⅛	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 — 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	1⅞—2⅛	6 6 0	April	2	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝—¾	3 6 9	..	..	..
1	6/8⅜	Do. 7 per Cent. Cum. Pref.....	1 —1⅛	5 12 0	Feb, Aug	..	..
St.	4½%	Do. 4½ 1st Db. Stk. Red.....	100 —103	4 7 6	April, Oct	..	..
5	2/6	Urban Electric Supply Ord.	1⅛—2⅛	8 18 0	April, Oct	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	2 - 3	8 6 9	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb.....	£4 - £7	4 12 9	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8½ 9	6 6 0	Mar, Sept	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	5 - 5⅛	4 2 0	Jan, July	5⅛	5⅛
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	£8 —£3	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	3⅛—3⅜	5 7 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	5⅝—5⅞	5 5 0	Jan, July	5⅝	5⅝
St.	4½%	Do. 4½ 1st Mort. Deb. Stock (red.) ..	£3 - £7	4 12 6	April, Oct	..	..
St.	4½%	B'hm & Midland Trams 4½ 1st Db. Stk.	£4 - £7	4 13 0	Jan, July	..	..
10	9½	Bristol Tramways & Carriage Ord.	14 —14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	£8—9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	£8 - 1'0	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2 —2⅛	..	June, Dec	2⅛	2⅛
10	£/0	Do. 6 per Cent. Cum. Pref.....	6 — 6⅛	9 4 6	Feb, Aug	6⅛	6⅛
St.	5%	Do. 5 per Cent. Perpetual Debs.	100 —103	4 17 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	£8 —£1	5 11 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock.....	£3 —£5	5 8 0	Feb, Aug	67	63
St.	4%	Do. 4 per Cent. Pref. Stock	88 - £0	4 9 0	Feb, Aug	£9	88
St.	..	Do. Deferred Stock	47 — 50	8 0 0	Feb	49	41⅜
100	4%	Do. 4 per Cent. Debs.	103 —105	3 16 0	Jan, July	..	..
St.	4%	Charing X. Euston & Hmpstd Pr. Db. Stk.	£1 —£4	4 15 3	Jan, July	£3	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼—4⅝	5 2 6	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	£8 —£1	3 19 0	April, Oct	..	..
St.	2½%	City & South London Rly. Con. Ord. ..	45 — 47	4 17 0	Feb, Aug	46⅛	45
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	116 —119	4 4 0	Feb, Aug	..	..
St.	5%	Do. (1896).....	113 —116	4 6 0	Feb, Aug	..	..
St.	5%	Do. (1901).....	113 —116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	102 —105	3 16 0	May, Nov	104⅜	..
10	6/0	Dublin United Trams. (1896) Ltd, Ord...	13 —14	4 5 9	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Pref.....	12⅜—13⅜	4 7 0	Feb, Aug	..	..
10	0/11½	Gt. Northern & City Rly. Pref. Ord. (4%)	1¼—1⅜	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 —7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	83 — 85	4 14 0	Jan, July	..	..
St.	4½%	Hastings & Dist. Elec. Trams. Co. 4½ Lb. St.	98 —101	4 9 0	April, Oct	..	..
10	9%	‡ Imperial Tramways Ord.....	11 - 12	7 4 0	Mar, Sept	..	..
10	6%	‡ Do. 6 per Cent. Pref.	10⅛—11	5 9 1	Mar, Sept	..	..
St.	4½%	‡ Do. 4½ per Cent. Debs.	97 - £9	4 10 11	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞—1⅛	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	£6 - 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	£4 —97	5 3 0	Jan, July	91⅛	..
10	..	Liverpool Overhead Railway Ord.....	1⅞ - 2	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	7⅛ - 8	6 5 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	£5 - £7	4 12 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	1⅜—1⅝	5 14 3	Jan, July	8⅜	8
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	£2 - £6	4 13 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 —4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 — 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅜—⅝	—	April	½	..
1	0/6	Do. 5 per Cent. Cum. Pref.	⅝—¾	5 8 0	Feb, Aug	¾	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 - 97	4 13 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	½—1⅝	..	May	⅝	..
1	0/8⅓	Potteries Electric Traction Ord.	½—¾	8 0 0	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½—¾	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb Stock	95 - £8	4 11 9	May, Nov	..	..
1	0/4⅜	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	⅞—1	6 0 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	£0 — 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	£4 - £8	5 13 6	Jan, July	..	..
..	5%	Underground Elec. Rys. Co. of London....	£5 - £8	8 12 0	June, Dec	..	..
5	..	Yorkshire (W.R.) Elec. Trams. Ord. ...	1 — 1¼	—	March ..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	£4—£5	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	£7 —10	5 0 0	Jan, July	..	..

SHARE.	LAST DIVIDEND	NAME.	Price Wed., Sept. 25.	RATE % YIELDED. £ s. d.	DIVIDEND DUE.	BUSINESS WEEK TO SEPT. 28. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.					
1	..	Aron Electricity Meter Ord.	⅜—⅝	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜—⅝	8 12 0	April, Oct	..	..
1	2/4½	Babcock & Wilcox Ord.....	3⅜—4	5 0 0	April, Oct	3⅝	3⅜
1	0/7½	Do. Pref.....	1⅜—1⅝	3 14 0	..	..	..
5	4/0	†British Insulated & Helsby Cables Ord.	6⅜—7	7 3 0	July, Feb	6⅞	..
5	3/0	Do. 6 per Cent. Pref.	5⅜—6⅛	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 - -104	4 6 6	Jan, July	..	..
St.	4½%	British Thomson-Houst'n 4½% 1st Mt. Db.	85 — 89	5 1 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 —1⅛	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	62 — 67	5 19 0	Jan, July	65	..
2	..	Brush Electrical Engineering	⅜—⅝	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜—1⅛	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	83 — 86	5 4 6	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	£8 —71	6 7 0	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.	9⅜—10⅜	6 19 0	Jan, July	10⅛	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5⅛—5⅜	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105⅛—107⅛	4 3 6	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅜—1⅝	5 12 6	May, Nov	1⅜	..
2	..	Do. 4½ per Cent. 1st Mort. Deb. (red.).	£7 —102	4 8 0	Feb, Aug	99	..
1	1/2⅝	Chadburn's (Ship) Telegraph Ord.	1⅜—1⅝	7 12 0	March ..	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅜—1⅝	5 1 0	April, Oct	..	..
3	£/3	* Crompton & Co. (Nos. 1 to 56,000)	1⅜—2⅛	7 3 6	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	£6 —£9	5 1 0	Jan, July	..	..
5	2/0	Dick, Kerr & Co. Ord.	1⅝—1⅞	6 3 0	Sept	..	..
5	0/7½	Do. 6 per Cent. Cum. Pref.	1 —1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 — 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" Sh.) (£3 pd.)	1⅛—1⅝	2 12 0	Feb, Aug	..	..
1	4/2	Do. (£5 paid)	2⅛—2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 — 85	4 14 0	June, Dec	..	..
St.	5%	Do. 5 per Cent. 2nd Deb. Stock.....	£9 —92	5 8 6	Mar, Sept	..	..
5	4%	Edmundson's Elec. Corp. Ord.	½—1	10 0 0	Jan, July	..	..
1	3/0	Do. 6 per Cent. Cum. Pref.	1⅛—2	..	May, Nov	..	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 — 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜—⅝	..	Jan, July	..	..
2	..	Do. 7 per Cent. Cum. Pref.	¾—1⅛	..	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 — 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 — 8⅜	5 17 9	June, Dec	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Debs.....	92 — 96	4 4 0	Mar, Sept	..	..
1	5/0	Henley's Telegraph Works Ord.....	11⅛—12⅛	6 2 6	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 —5⅛	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105⅛—107⅛	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14⅛—15⅛	6 9 0	Feb, Aug	15⅛	..
100	4%	† Do. 4 per Cent. Debs. (red.).....	£5 —97	4 2 6	April, Oct	99	..
1	1/2⅝	Richardsons, Westgarth & Co., Ltd. Ord.	⅞—1⅛	7 14 0	Nov	1	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞—1⅛	6 4 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 —£6	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	31 —32	5 10 6	Mar, July	32	..
100	4%	Do. 4 per Cent Deb. Bonds (1909) ...	£5⅛—102⅛	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅝—2⅞	6 7 6	..	..	..
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅜—1⅝	4 5 6	..	..	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	109 —112	4 9 6	..	111⅜	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	105⅛—104⅛	3 16 6	June, Dec	104⅜	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 —103	4 3 3	June, Dec	106⅛	..
10	£/0	J. G. White & Co. 6 per Cent. Cum. Prf.	9½—9⅝	6 3 0	Jan, July	..	..
1	..	Willans & Robinson Ord.	1⅛—1⅜	..	Apr. Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅜—4⅛	..	Apr. Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	76 — 80	5 0 0	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 —3⅛	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 — 88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	£8 —£0	6 7 0	F,My,Ag,N	..	..
St.	£0/0	Do. Preferred	102 —103	5 16 0	F,My,Ag,N	103	..
St.	12%	Do. Deferred	15⅜—16⅛	8 12 0	F,My,Ag,N	15⅜	..
St.	4%	Commercial Cable 4 per Cent. Deb. Stk.	91 —93	4 5 6	Jn,Ap,Jy,O	92	..
10	5/0	Cuba Submarine Ord.....	6⅛—7⅛	6 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞—16⅜	5 19 6	Feb, Aug	..	..
5	2/0	Direct Spanish Ord.....	3⅝—3⅞	5 10 6	April, Oct	..	..
5	5/0	Do. 10 per Cent. Cum. Pref.	9 - 9⅛	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝—103⅝	4 7 3	Jan, July	..	..
20	0/6	Direct United States Cable	14 —14½	6 10 0	Ja,Ap,Jy,O	14⅜	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 —102	4 8 0	June, Dec	102	..
St.	26/0	Eastern Ordinary	128 —136	5 3 0	Ja,Ap,Jy,O	128	..
St.	17/6	Do. 5% per Cent. Pref. Stock	86 —88	3 19 6	Ja,Ap,Jy,O	87⅛	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 —105	3 16 3	May, Nov	104	..
10	2/6	Eastern Extension	12⅞—13⅛	5 2 6	Ja,Ap,Jy,O	13⅛	..
St.	4%	Do. 4 per Cent. Deb. Stock	102⅛—104⅜	3 16 6	Feb, Aug	..	..
100	4%	Eastern & E. African 4% Mort. Deb. 1909	98 —100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	100⅛—102⅜	3 18 0	May, Nov	..	..
10	5/0	G.N. (of Copenhagen), with Coupon 71...	34 —36	6 19 0	Jan, July	34⅜	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 —102	4 8 0	June, Dec	..	..
25	£2/6	Indo-European.....	55 — 57	5 14 0	May, Nov	57⅛	..
100	£1	†Mackay Companies Common	64 — 67	5 19 6	Jan, July	..	..
100	£1	† Do. Preference	64 — 67	5 19 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	1—1⅛	..	April	1	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 —100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 —10⅛	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅛—1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 —100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅞—1	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7⅛—7⅜	7 15 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅜—7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	£9 —102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	13 —13⅛	5 5 9	Mr,Jn,O,D	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	100 —103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 —92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	£9 —102	4 18 0	Mar, Sept	..	..
5	1/0	Chili Telephone	6⅜—7⅛	5 10 6	August ..	..	..
1	0/4⅜	Monte Video Telephone Ord.	1⅜—1⅝	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾—1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	10⅛—107⅛	5 11 6	Feb, Aug	10⅛	..
St.	6%	Do. Def. Stock.....	10⅛—107⅛	5 11 6	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Cum. 1st Pref.	10⅛—12⅛	4 16 0	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Cum. 2nd Pref.	10 —12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	£4—£5	4 13 0	Feb, Aug	..	..
St.	3½%	Do. Deb. Stock 3½ per Cent. (red.) ...	96 —98	3 11 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 — 103	3 17 6	Jan, July	..	..
1	£/9	Oriental	1⅛—1⅜	5 6 6	April, Oct	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛—1⅜	4 10 0	Apr	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 — 94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½ Db. Stk. (red.)	£8 - 101	4 9 0	Jan, July	..	..
1	£/0	United River Plate.....	6⅛—7⅛	6 18 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 — 5⅛	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	2/0	Elec. & Gen. Investment 6% Cum. Pref.	3⅞—4⅛	6 13 3	Jan, July	..	..
10	6/2	Globe Telegraph & Trust.....	10⅛—10⅜	5 4 6	Ja,Ap,Jy,O	..	..
10	4/0	Do. 6 per Cent. Pref.....	13⅛—13⅜	4 9 0	Ja,Ap,Jy,O	..	..
10	6%	Submarine Cables Trust (Cert.).....	127 —130	4 12 0	April, Oct	128	..

* In calculating the yields, allowance has been made for accrued interest but *not* for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote them.

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NOTES.

Electric Power in Building.

THERE still remain many possible fields for electrical power practically untouched. One of these is in connection with the erection of new buildings. Where mechanical power is required—for example, in working mortar mills, &c.—recourse is usually had to steam, but an electric motor would probably be found more convenient, and might also be used for driving a saw when required. It is, however, in connection with the actual building operations that the greatest saving might be obtained. For example, the bricks might be quickly raised to the level where work was in progress at a practically insignificant cost, the output of the motor not being limited by any Trade Union to a certain number of bricks per day. Probably the best instance of the use of electric power in building operations is recorded in a recent issue of the *Western Electrician*. In the case referred to over 1,500 H.P. of electric motors is being employed in the erection of a large building in Chicago. Motors are used in making concrete, and for derricks, belt conveyors, wood-working machinery, &c., the necessary current being obtained from the street mains. Electric mains very often follow new buildings, but there would possibly be considerable benefit to all concerned if they could precede them, provided the builders could be educated to see the advantages of cheap adaptable power.

Rail Corrugation.

THE information contained in Mr. A. L. C. FELL'S Paper on "Rail Corrugation," read last Friday before the Municipal Tramways Association, is very valuable, and we doubt if such a complete analysis of the possible causes of corrugation has previously been compiled. One of the most interesting points brought to light is that conclusive proof exists of the presence of corrugations in the rails as received from the rolling mills, and Mr. FELL'S experience shows that it is of considerable benefit in warding off trouble due to corrugations if the rails are ground smooth with carborundum blocks previous to their use for traffic. If the grinding of all the rail joints were carried out at the same time the smooth running of the cars would be more easily ensured, and considerable saving would eventually result in the repairs and maintenance account. Apart from the question of surface alignment, there is the question of slackness in rail joints—a trouble which does not make itself felt during the early years of a tramway, but if each joint were re-tightened at the end of about six months' running, the outlay would probably be fully justified after a few years. As regards rail corrugations, however, which seem to be prevalent on all the lines operated by the London County Council, though evidently to a varying extent, the suggestions made by Mr. FELL for minimising their production will prove of value to tramway managers of systems where a less frequent service necessarily causes the corrugations to be longer in making their appearance.

Electricity Supply in Small Towns.

POWER supply companies have, not unnaturally, looked to the smaller municipalities and urban districts for providing a load for their plant, which is usually composed of large-sized units with consequently lower capital expenditure per kilowatt and more economical running costs than could be obtained with plant of small capacity, such as would have to be installed in the case of small municipal undertakings. It seems, however, as if the craze for municipalisation is still destined to hinder the development of the large power companies. Thus Wednesbury Corporation, who are at present obtaining their electricity supply from the Midland Electric Corp. for Power Distribution

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recently applied for sanction to a loan of £10,000 for laying down a complete plant, and the Local Government Board inquiry has been held. The Power Company naturally opposed the Corporation's application, and pointed out that if sanction to the loan were given there would be three undertakings with power to supply electricity in the borough—the Mond Gas Co. being the third. Under such circumstances there does not seem any necessity for a municipal power station, even taking into account the fact that it would have the advantage of commencing operations with the existing load on the mains, which are owned by the Corporation; and, although such competition might be welcomed by the electricity consumers, it could hardly produce very satisfactory results for the ratepayers of a town such as Wednesbury, which offers but a poor field for lighting.

Willans & Robinson (Ltd.)

DURING the last few years there has been a pronounced change from the previously popular policy of using high-speed engines, partly because the generators now in use have increased to a size at which the difference in speed between a high-speed and a low-speed set is much less important, and partly because the sizes in general are such that the steam turbine offers marked advantages. This change in policy has, no doubt, been one of the chief causes of the financial difficulties in which Messrs. Willans & Robinson (Ltd.) have found themselves in recent years. We are glad to note, however, that this period of depression is passing over, and that the shareholders, who have throughout shown confidence in their directors, now find their confidence amply justified. The profit balance shown by the half-yearly accounts is not a large one, but it places the company again among the dividend earners, and shows the outlook for the future of the company to be full of promise for a return to its former prosperity. "Willans and Robinson" is a name which stands for good design and good workmanship, and we are heartily glad to record the improvement in the company's finances.

Finsbury Technical College.—A new wing of the City and Guilds Technical College at Finsbury was opened on Wednesday afternoon last by the Lord Mayor. This extension will enable the instruction in mechanical engineering to be carried on entirely within the college; previously work in the drawing office and physical laboratory was conducted in temporary buildings.

The Electrobus.—There are now regularly running on the somewhat exacting route from Victoria Station to Liverpool-street, London, four electrobuses out of the six owned by the Electrobus Co., and we understand also that within the next few days several additional omnibuses are to be put on the same route. The trials made with Tudor accumulators are stated to have proved very successful, and the omnibuses now make four journeys per charge. The public are attracted to the electrobus by its smooth and noiseless running, and there is little doubt that the days of the very noisy, very smelly and very jerky petrol motor omnibus would be numbered if the commercial practicability of the electrobus could be demonstrated.

Cable Interruptions.	Date of Interruption.
Garachico (Teneriffe)—Santa Cruz de la Palma..	July 12, 1906
Brest—Dakar	July 22, 1907
Grand Canary—Lanzarote	Sept. 18, 1906
Midway Islands—Guam	Sept. 22, 1907
Fort de France—Paramaribo	Sept. 26, 1907

Gyroscope Train for India.—It is stated that Mr. Louis Brennan has received a grant of £6,000 from the Indian Government towards the cost of experiments in connection with the mono-rail car (described in *The Electrician*, Vol. LIX., p. 172), which he is building for use in India. The War Office have allowed Mr. Brennan to use the Brennan torpedo factory at Gillingham for this purpose.

Field Telegraph Lines.—A small book, entitled "Instruction in Laying and Maintaining Field Telegraph Lines," forming part of "Instruction in Army Telegraphy and Telephony," has just been issued by command of the Army Council. It is divided into three chapters, the first of which is entitled "Laying Field Cables," and comprises information concerning rate of laying, details of laying, cable drill, pole crossing, tree crossing, bury crossing, reeling up, &c. The second chapter deals with the erection of air lines, and the last one with the maintenance of air lines.

Electric Omnibus Service in Paris.—According to the *Electrical World*, the Municipal Council of Paris has decided to let the omnibus service of the city, provided the concessionaire will employ electric carriages, charge 10 or 20 centimes according to distance, appoint fixed stopping places, and pay the city 4½ per cent. of their gross earnings. Moreover, the new concessionaire must give their employés a share in the profits, but not by way of an increase in salary. The share is to be paid into two funds, the sick and benefit fund and the pensions fund, the former of which will also receive contributions from the company of 6 per cent. of the total wages paid, and from the employés of 2 per cent. of wages received. Salaries are to be paid by the month. The minimum wage is fixed at £6. Each employé is to have four holidays a month and 10 consecutive days' leave each year.

"Siam Engineering."—We have received a copy of the second number of this periodical, which is the journal of the Engineering Society of Siam. Several of the Papers recently read before the Society are published in this issue, among them being one on "A New Method of Railway Traction," by Mr. E. Gollo. This new method consists of an adaptation of the "petrol-electric" idea to main-line working. A turbo-dynamo supplies current to electric motors which drive the train wheels through gearing in the ordinary way. The author has taken the opinion of two eminent Italian professors, who inform him that "the idea is very good and practical"; but we are afraid, in spite of the author's hopes, that this system will not be taken up by English railway engineers. Notwithstanding the high-class subject matter, we regret to say that the general get-up of the paper is somewhat open to criticism, and there are a large number of typographical errors.

Opening of the New Gerrard Exchange.—The adaptation of all telephones within the London area to the central battery system was further extended on Saturday last by the conversion of the well-known Gerrard (London) exchange and the transference of the exchange to a new building. This change-over has naturally necessitated much preliminary work, and has involved a visit to every subscriber's instrument in order that the requisite alterations might be made. The new subscribers' wires were connected in parallel with the old exchange and worked for some days previous to the change-over in this manner. The actual change-over, which took place on Saturday last, only occupied about nine minutes, and consisted in disconnecting at the old switchboard and then pulling out special wooden plugs, which had been temporarily inserted. Connections to the new equipment were also made at the other exchanges, and the whole system was then tested before being brought into the public service.

British Weights and Measures Association.—We have received a pamphlet from this Association entitled "Third Annual Report." The actual report, however, takes up a very small space, and the greater part of the issue is devoted to editorial notes and to excerpts from speeches and articles which may be taken as favourable to the objects of the Association. Two cartoons dealing with the rejection of the

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Weights and Measures (Metric System) Bill afford pictorial support to the Association's ideals. Great prominence is given to the statement, made by Sir David Gill in his presidential address before the British Association, that the metre is only an arbitrary measure and has now no claim to be regarded as a natural standard; while some suggestions by Mr. Howard Cunliffe, Chief Inspector of Weights and Measures for the county borough of Smethwick, for hastening weights and measures reform, are freely commented on, and in some cases endorsed. A list of the principal donors and subscribers to the Association is also given.

Electricity Supply in Paris.—In a leading article which appeared in our issue of June 21st we commented on the position of electricity supply in Paris, and stated that a company was being formed, under the control of the municipal authorities, for the purpose of supplying power throughout the city. According to *L'Electricien*, this company has now been floated and will work to a concession granted by the city of Paris on March 21st, 1907, or to any modifications of this which may be made from time to time. The concession is granted for 99 years. The capital is £2,000,000 and is divided into 200,000 shares of £10 each. These have all been subscribed and a quarter of the total amount has been paid up. The financial year is to begin on January 1st and to end on December 31st, but the first term will consist of the time from the actual registration of the company to December 31, 1908. The net annual profit will be appropriated as follows: 5 per cent. will be placed to reserve, and the shareholders will receive up to 4 per cent., such dividends being increased by any further profits, provided that the City Council does not exact a further payment, in pursuance of its powers, beyond that already agreed upon.

Relative Floor-space Required by Turbines and Reciprocating Engines.—In a recent number of *L'Industrie Electrique* Mr. Dixon gives an interesting table showing the floor-space per kilowatt installed at certain generating stations, where the boilers are arranged on floors above the ground level. The table is as follows :—

Generating stations.	Surface per kw. in sq. metres.	Description of prime mover.	No. of floors.
Long Island (New York) ..	0·12	Parsons' turbines	2
Port Morris (,,) ..	0·12	Curtis turbines.....	1
Manhattan (,,) ..	0·18	Reciprocating engines	2
Rapid Transit (,,) ..	0·21	,, ,,	1
Chelsea (London)	0·12	Parsons' turbines	2
Metropolitan (New York)..	0·115	Reciprocating engines	3
Kingsbridge (,,)..	0·17	,, ,,	2
Waterside, Old (,,)..	0·09	,, ,,	2
Waterside, New (,,)..	0·07	Turbines	2
Edison Co. (Boston)	0·22	Curtis turbines.....	1
Fisk Street (Chicago)	0·22	,, ,, ...	1
Bow (London)	0·26	Reciprocating engines	1

The volume occupied per kilowatt varies from 3·8 cubic metres (Port Morris) to 8·9 cubic metres (Rapid Transit).

Engineering Standards Committee.—Following on the specification for Steel Bars (for use in automatic machines), which was published some months ago, the Engineering Standards Committee have issued a Specification for Copper Bars (for use in automatic machines) on somewhat similar lines. Copies may be obtained from the publishers, Messrs. Crosby Lockwood & Son, or from the offices of the Committee, at 2s. 6d. net. The material for manufacturing the bars is divided into two classes, A and B, depending on whether mechanical tests are required or not. It will be remembered that in their specification for steel bars no mechanical tests are imposed on hexagonal bars of less diameter than $\frac{3}{8}$ in., or on round or square bars of smaller size than $\frac{5}{8}$ in. In the specification under notice, however, tests are imposed for these small-sized bars, though a specially reduced test piece is provided. For all larger sizes the Committee's standard test pieces C and D are to be employed. There is one point in this specification which to us does not seem quite clear. A table of tensile tests for various classes of alloys is given, the different alloys in it being numbered from 1 to 6. But the actual composition of these alloys does not appear to be stated, and although it may have already been given in one of the other specifications, its repetition in this case would be an advantage.

Electric Railway from Cologne to Bonn.—The *Railway and Engineering Review* gives an account of an electric railway about 16 miles long which has lately been opened between Cologne and Bonn. The distinguishing feature of the new line is that it is operated by direct current at nearly double the common voltage. The main line feeder is supplied with direct current at a pressure of 990 volts, the overhead conductors being divided into three sections and the motors so arranged that they may be operated on the 550 volt electric street railway lines in the city of Cologne as well as in Bonn. The two end sections of this railway are fed by sub-station storage battery plants which are supplied with current through feeders connected in series with suitable boosters at the power house. The middle section is connected directly across the generators and secondary battery plants at the power station. At the power house a booster is used for controlling the buffer action of the battery installation, the main generator equipment consisting of two direct-current railway dynamos of 330 kw. each. On each motor car there are two four-pole 130 H.P. motors. These motors are designed for 990 volts and provided with reversing poles. Two sets of brushes are provided, the connections being such that the motors may be operated on the 550 volt Cologne trolley line, as well as the main line at 990 volts.

Accident on the Sunderland District Electric Tramways.—The report of Col. P. G. von Donop, one of the Board of Trade Inspectors of Railways, on the two accidents which occurred on July 29th last on the Sunderland District Electric Tramways has been issued, and the conclusions which he draws as to the causes of the accident are not without interest. It will be remembered that a car ran off the line about half-way down a steep hill and at a place where the route makes a sharp curve. According to the report the line was in good order, the outer rail had, however, no superelevation, and the inner rail was, if anything, the higher of the two; the rails were not much worn. The car was fitted with the Westinghouse magnetic track brake, and it appears that the Tramway Co. have special rules regarding their use. There is a compulsory stop at the top of the hill, but the evidence of the driver and passengers is conflicting as to whether this stop was duly observed before the accident. The driver appears to have applied the magnetic brake, but only to have placed the handle on the third notch, where the brake would not come into action until considerable speed was attained. As the brake did not act, however, the driver released the brake altogether and reversed the motors. The speed was now so great that nothing could stop the car, and derailment was inevitable. The inspector concludes that the cause of the accident was neglect of instructions, with which the driver admitted he was acquainted. To prevent a recurrence of this accident a compulsory stop some way down the hill has been imposed, and the line at the curve has been relaid to give the outer rail a superelevation. A second accident occurred at the same place on the same evening, when another car ran into the derailed car. In this case it is considered that the accident was due to an error of judgment on the part of the driver, who descended the hill too rapidly, and was not able to check the car without skidding.

ARRANGEMENTS FOR THE WEEK.

FRIDAY, October 4th (to-day).

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert in the King's Hall, Holborn Restaurant, W.C.

MONDAY, October 7th.

SOCIETY OF ENGINEERS.

7.30 p.m. Meeting at the Royal United Service Institution, Whitehall. Paper on "Liquid Fuels for Internal Combustion Engines," by Mr. R. W. A. Brewer.

THURSDAY, October 10th.

BIRMINGHAM AND DISTRICT ELECTRIC CLUB.

7.30 p.m. Meeting at the Colonnade Hotel, New-street, Birmingham. Paper on "The Possibilities of Electrical Development," by Mr. R. B. Matthews.

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ON THE ELEMENTARY THEORY OF ELECTRIC OSCILLATORS.

BY J. A. FLEMING, D.SC., F.R.S.

(*Continued from page 939.*)

Summary.—In this series of articles the author discusses the theory of the electric oscillator and the production of electric waves thereby. The first part dealt with the action of a Hertzian oscillator, and it was shown how to obtain expressions for the electric and magnetic forces at any point in space round it. The second part, in like manner, discusses the closed or magnetic oscillator, and expressions are obtained for the forces and radiative power. In the third part combinations of open and closed oscillators are discussed, and the elementary theory of the *bent* oscillator which radiates unsymmetrically is given.

In all hydrodynamic problems there are two methods, commonly called in Germany the Eulerian and the Lagrangean methods, of studying the processes which are involved. We may suppose ourselves to remain stationary at any point, and to watch and describe precisely what takes place at that point in the fluid. On the other hand, we may suppose ourselves to travel along with and record all the motions of a particular portion of the fluid. Suppose, for instance, we are concerned with wave motion on water. Then, if we remain fixed at a point, we find that the water surface is alternately raised and depressed periodically, but not simultaneously at each point. If we travel along so as to remain always in contact with a fixed state of elevation we find ourselves moving with a certain velocity in a certain direction, called wave velocity and direction. In the same manner, if we remain fixed at any point in the neighbourhood of the oscillator, but not too near it, we find an alternation of electric and magnetic force at that point, the first being directed along certain closed lines or loops in the plane of the oscillator, and the second in circles lying in planes perpendicular to it. If, however, we attach ourselves, as it were, to a particular line or loop of electric force we find it moving outwards from the oscillator and expanding as it moves.

The student has generally no difficulty in following an explanation given on the first or Eulerian basis, in which we record by mathematical expressions the magnetic and electric force at each point in space round the oscillator at any required time. The Hertzian expressions we have already given are in accordance with this method. If, however, we endeavour to follow in thought each closed loop of electric force as it moves outwards and represent the process of electric radiation as one of detachment of these loops from the oscillator, which mode follows the Lagrangean method of investigation in hydrodynamics, then the thoughtful student generally experiences a difficulty. He recalls to mind that he has been told that there is a tension along lines of force and a pressure at right angles, and he asks how it is there can be such a thing as a closed loop of force? Why does it not shrivel up at once to nothing in virtue of the tension along the lines? If lines of electric force extend from a positively charged body to a negatively charged one, then their mutual attraction from the Maxwellian point of view is only the effort of the lines of electric force extending between them to make themselves as short as possible. How, then, can this tension exist in a closed loop or endless lines of electric force?

In the first place, we may ask the student to notice that we cannot predicate of moving things the same qualities as when stationary. A rotating hoop or disc can stand upright, but not when at rest. On water at rest a hump or elevation on the water cannot be permanent. It sinks away at once, but a surface wave is an elevation of the water surface continually changing its position.

Thus, whilst it would be impossible to have a permanent *stationary* closed loop of electric force, it is quite possible to have a *moving* one. The fact is that the loop of force *does* shrink up and disappear, but re-creates itself in another place. For a line of electric force represents so much energy per unit of length, and this energy cannot vanish without leaving an equivalent behind it.

This equivalent is found in the closed lines of magnetic flux, to which the loop of electric strain gives rise on disappearing, and these, as they vanish, in turn give rise to fresh lines or loops of electric force in the space beyond. Hence, whilst the loop of electric force dies away at one place it comes to life again at a neighbouring place, and thus in effect moves along. The moving closed loop of electric force has therefore a permanence, just as the hump or ridge raised on water constituting a water-surface wave has a permanence, only whilst it is in motion.

We have next to consider the important matter of the energy sent out by an oscillator. Hertz solved this problem by making use of Poynting's important theorem. This last theorem is thus enunciated. If at any point in a field in which energy is travelling in any direction we resolve the electric (E) and magnetic (H) forces in directions at right angles to the direction of energy flow, and if the directions of these forces make an angle ϕ with each other, then the amount of energy which passes normally through an element of area dS in a time dt is given by the expression

$$dW = \frac{1}{4\pi} \text{E. H. } \sin\phi \, dt \, dS.$$

To apply this theorem to the Hertzian oscillator we imagine a sphere of radius large compared with the lengths of the oscillator described concentrically round it.

Let the axis of z be the axis of this sphere. Consider then the plane of yz. In this plane the components of the electric force are R and Q. If we draw any radius, r making an angle θ with the axis z, then the component of the electric force perpendicular to the radius is $R \sin\theta - Q \cos\theta$. The component of the magnetic force perpendicular to the radius is a. Everything is symmetrical round the axis of z. Hence, if we assume the radius r to revolve conically round z, and consider the zone swept out by a small increment of angle $d\theta$, then the area of this zone is $2\pi r^2 \sin\theta \, d\theta$.

The electric force and magnetic force, as resolved above, are at right angles to each other and to the radius vector r. Hence, by Poynting's theorem the element of energy which passes in a time dt out through the elementary zone is equal to

$$dW = \frac{1}{4\pi A}(R\sin\theta - Q\cos\theta) a \, 2\pi r^2 \sin\theta \, d\theta \, dt. \quad . \quad . \quad (15)$$

The symbol $A = 1/u$ is introduced because the electric force is reckoned in electrostatic units and the magnetic in electromagnetic units.

By equations (11) we have,

$$a = \frac{A\phi mn}{r} \sin\chi \sin\theta,$$

$$R = \frac{\phi m^2}{r} \sin\chi \sin^2\theta,$$

$$Q = -\frac{\phi m^2}{r} \sin\chi \sin\theta \cos\theta.$$

Hence, substituting, we have,

$$dW = \frac{\Phi^2}{2} m^3 n \sin^2\chi \sin^3\theta \, d\theta \, dt.$$

The above expression has then to be integrated from $\theta = 0$ to $\theta = \pi$ and from $t = 0$ to $t = T$ to obtain the whole energy sent out by the oscillator per period.

Now $$\sin^3\theta = \sin\theta - \cos^2\theta \sin\theta,$$

hence $$\int \sin^3\theta \, d\theta = \frac{1}{3}\cos^3\theta - \cos\theta,$$

and $$\int_0^\pi \sin^3\theta \, d\theta = \frac{4}{3},$$

also $$\int \sin^2(mr - nt)\, dt = \int \frac{dt}{2} - \frac{1}{2}\int \cos 2(mr - nt)\, dt$$

$$= \frac{t}{2} + \frac{1}{2}\frac{\sin 2(mr - nt)}{2n}.$$

But since $m\lambda = nT$, $mr - nT = mr - m\lambda = mr$, for by supposition r is large compared with λ. Accordingly, we have

$$\int_0^T \sin^2(mr - nt)\, dt = \frac{T}{2}.$$

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The whole energy in ergs sent out per period is therefore

$$W = \frac{\phi^2}{2} m^3 n \frac{T}{2} \cdot \frac{4}{3} = \frac{\phi^2}{3} m^4 \lambda = \frac{16\pi^4 \phi^2}{3\lambda^3} = 510 \frac{\phi^2}{\lambda^3}. \quad . \quad . \quad (16)$$

We may put this last expression into a form more useful for calculation. If C is the capacity in microfarads of each sphere or half of the oscillator with respect to the other, and V is the maximum P.D. in volts before discharge, then $\frac{C \times 9 \times 10^5 \times V}{300}$ is the maximum charge of the oscillator in electrostatic units. Hence, if l is the length of the rod in centimetres we have $3{,}000\ CVl = \phi$ as the maximum electric moment in electrostatic units. Accordingly the radiation per period is given by

$$W = \frac{17}{10^{23}} C^2 V^2 l^2 N^3 \text{ ergs},$$

C being the capacity in microfarads, V the P.D. in volts, l the length in centimetres and N the frequency.

The radiation per period for a given oscillator increases, therefore, as the cube of the frequency and as the square of the potential just before discharge.

For a given oscillator the initial energy imparted to it is $\frac{CV^2}{2 \times 10^6} \times 10^7 = 5CV^2$ ergs, and from this and the previous expression for the energy radiated per period we can tell how many oscillations take place in a train.

We may apply the above formula for the radiation per period to a particular case. Suppose a large Hertzian oscillator is constructed by taking two rods each 2 metres long and attaching to one end of each rod a spark ball and to the other a disc of metal 1 metre in diameter. These, when placed in line, give us an oscillator in which oscillations can be set up in the Hertzian manner. The capacity of a circular disc is d/π electrostatic (E.S.) units, where d in the diameter in centimetres. Hence the capacity of each disc of the above oscillator with respect to the other is $100/2\pi = 100/6{\cdot}28 = 15$ E.S. units, or $15/9 \times 10^5 = 1/60{,}000$ mfd.

Let the connecting rod be 0·5 cm. diameter. Now the inductance L of a straight rod of length l and diameter d_1 is $L = 2L\left(\log_\epsilon \frac{4l}{d_1} - 1\right)$ cm., and for the above rod is $800\ (8{\cdot}05 - 1)$ $= 5{,}640$ cm. Hence for the above oscillator the oscillation constant $\sqrt{CL} = 0{\cdot}3$ nearly, and the frequency N of the oscillation is $5{\cdot}033 \times 10^6 / \sqrt{CL} = 15 \times 10^6$ nearly. The wave-length λ of the fundamental wave is 2,000 cm. Suppose, then, that the spark-gap of the oscillator is 1 cm., then the spark potential V corresponding to this is 30,000 volts, or 100 E.S. units, and the radiation in ergs per period is given by

$$W = \frac{17}{10^{23}} C^2 V^2 l^2 N^3 = \frac{17}{10^{23}} \frac{9 \times 10^6 \times 16 \times 10^4 \times (15)^3 \times 10^{18}}{36 \times 10^{16}}$$

$$= \frac{17 \times 9 \times 16 \times (15)^3}{36 \times 10} = 22{,}950 \text{ ergs}.$$

Hence this oscillator radiates nearly 23,000 ergs per period. The original charge of energy is $\frac{1}{2} CV^2 = \frac{9 \times 10^6 \times 10^7}{2 \times 6 \times 10^{10}}$ ergs $= 75{,}000$ ergs. Accordingly the initial energy is all radiated in about three complete periods.

Suppose, however, we were to maintain this rate of radiation by creating on the oscillator persistent oscillations, the rate of radiation would be 34·5 kw., or nearly 40 H.P.

This example shows us the enormous radiative power of open or Hertzian oscillators.

One more point in connection with them is of considerable interest.

Let the maximum value of the current reckoned in amperes in the centre of the antenna be denoted by a and its electrostatic measure by I. Then $a/10 = I/u$ and $I = CV2\pi N$. Accordingly we may transform the expression for the energy W radiated in ergs per period as follows:—

$$W = \frac{16\pi^4 \cdot C^2 V^2 l^2}{3\lambda^3} = \frac{16\pi^4 a^2 u^2 l^2}{3\lambda^3 100 \cdot 4\pi^2 N^2} = \frac{4\pi^2}{800} \frac{l^2}{\lambda^2} \frac{u}{N} a^2. \quad . \quad (17)$$

If the oscillations are continuous and of frequency N the power in watts radiated is given by

$$P = 400 \frac{l^2 a^2}{\lambda^2}$$

since $\pi^2 = 9{\cdot}87$ or nearly 10.

For any given type of oscillator l^2/λ^2 is a constant independent of the actual length, and hence we have the interesting result that the power radiated by any transmitting antenna creating undamped oscillations is proportional to the square of the current at its central point. Since this in turn is proportional to the heat generated per second in a fine wire inserted in the oscillator circuit, we see that the power being sent off from a transmitting antenna is measured by, and proportional to, the total heat generated by the oscillations in a resistance wire inserted near the base of the antenna. Practically, therefore, we can compare the radiation from the same telegraphic antenna at different times by inserting near the earthed end of the antenna, or at the electrical centre, a hot-wire ammeter, and taking the square of the current so read as proportional to the power being radiated. The formula above given is, however, only for persistent oscillations. If they are intermittent then the decrement of each oscillation train and the number of trains per second have to be taken into account as well.

If we are dealing with undamped oscillations of maximum value I, then the current at any moment is simply a sine-function of the time. If we are considering damped intermittent oscillations, each train having a decrement per semi-period δ and initial maximum value I_1, there being N trains per second, then, provided that δ is small compared with π, it can be shown that the value i of the current at any instant, t, is given by the expression

$$i = I_1 \epsilon^{-\alpha(t - T/4)} \sin pt,$$

where $p = 2\pi T$, T being the periodic time and α stands for $2\delta/T$.

Let J stand for the square root of the mean of the squares or the R.M.S. value of the current, then

$$J^2 = N \int_0^\infty i^2 dt,$$

and if we substitute in the above the value of i from the previous equation and integrate we have

$$J^2 = N I_1^2 \epsilon^\delta \frac{p^2}{4\alpha(\alpha^2 + p^2)},$$

and since $\alpha/p = \delta/\pi$ is a small quantity, this gives us

$$J^2 = \frac{N\epsilon^\delta}{4\alpha} I_1^2 = \frac{N\epsilon^\delta}{8n\delta} I_1^2,$$

or

$$\frac{I_1^2}{J^2} = \frac{8n\delta}{N}.$$

Hence we see that the square of the amplitude of the first oscillation of a damped train of oscillations is to the mean square value as $8n\delta$ is to N, where n is the frequency of the oscillations, N the group frequency and δ the logarithmic decrement per semi-period.

In a damped train of oscillations the energy radiated per half period is not constant, but continually decays. Nevertheless it is proportional at each instant to the square of the current. Accordingly the mean radiation is to the maximum radiation in the initial half period as N is to $8n\delta$.

Hence, when comparing damped and undamped oscillations we may ask such a question as the following: What must be the amplitude of the undamped oscillations in a given radiator that they may radiate the same energy per second as damped intermittent trains of the same oscillation frequency, but group frequency N, decrement δ and initial amplitude I_1?

The answer is, the amplitude J of the undamped oscillations must be to I_1 as $\sqrt{N}$ is to $\sqrt{8n\delta}$. Thus, for instance, if the frequency $n = 10^6$ and there are 50 groups per second and the decrement is 0·1, then $\sqrt{N/8n\delta} = \sqrt{1/16{,}000} = 1/128$ nearly, or the undamped oscillations could have less than 1 per cent. of the initial oscillation of the damped trains and yet emit the same energy. Hence, persistent oscillations of very small amplitude can achieve the same results with a suitable receiver as damped oscillations of much larger amplitude.

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We may next consider the case of a so-called closed radiative circuit.

We have seen that a single Hertz dumb-bell oscillator of maximum electric moment ϕ placed with centre at the origin and axis along the axis of z creates a point whose polar co-ordinates are r, θ, a scalar potential ψ and a vector potential H, such that

$$\psi = -\phi\frac{d\Pi}{dz}$$

$$H = A\phi\frac{d\Pi}{dt}.$$

Suppose two such oscillators placed at the origin, but with electric poles reversed, and that then one is shifted parallel to itself by a distance $\frac{1}{2}\delta y$, and the other by a distance $-\frac{1}{2}\delta y$, then this double doublet creates at the same point (r, θ) scalar ψ and vector H potentials as follows :—

$$\psi = -\frac{d}{dy}\left(\phi\frac{d\Pi}{dz}\right)\delta y$$

$$H = +\frac{d}{dy}\left(A\phi\frac{d\Pi}{dt}\right)\delta y.$$

Again, let four such dumb-bell oscillators or doublets of equal moment be arranged square fashion symmetrically with respect to the origin and poles overlapping and pointing similarly all the way round, the parallel distances between them being δy and δz (*see* Fig. 4). Then it is easy to see that such a quadruple doublet or closed oscillator has no free poles, and therefore no scalar potential, but that the vector potential at any point $(r\theta)$ has two components, viz., G, parallel to the y-axis, and H, parallel to the z-axis, such that

$$\left.\begin{aligned} G &= A\phi\frac{d^2\Pi}{dz\,dt}\delta z \\ H &= A\phi\frac{d^2\Pi}{dy\,dt}\delta y \end{aligned}\right\} \quad \ldots\ldots \quad (18)$$

If Q is the maximum charge at the end of each oscillator, then $\phi = Q\delta y = Q\delta z$. Hence $\phi\delta z = Q\delta y\,\delta z = \phi\delta y$. If, then, I is the maximum current in the oscillator, we have $I = nQ$ or $I\delta y\,\delta z = n\phi\,\delta y = n\phi\,\delta z$. Let us call I $\delta y\,\delta z$ the magnetic moment of the closed oscillator. It is the product of its area $\delta y\,\delta z$ and the maximum currents in it. Then $\phi\delta y = \phi\delta z = I\,\delta y\,\delta z/n$.

If the current is measured in electromagnetic units and we denote by M the product of the area and current in such units, then we have $AI\,\delta y\,\delta z = M = An\phi\delta y = An\phi\delta z$. Therefore $M/n = A\phi\delta y = A\phi\delta z$ and hence

$$\left.\begin{aligned} G &= \frac{M}{n}\frac{d^2\Pi}{dz\,dt} \\ H &= \frac{M}{n}\frac{d^2\Pi}{dy\,dt} \end{aligned}\right\} \quad \ldots\ldots \quad (19)$$

are the components of the vector potential at the point $(r\theta)$ due to the closed oscillator of magnetic moment M in electromagnetic measure.

Hence by Maxwell's equations we have for the components of the electric and magnetic forces at $(r\,\theta)$ the values,

$$\left.\begin{aligned} P &= 0 \\ Q &= A\frac{M}{n}\frac{d^3\Pi}{dz\,dt^2} \\ R &= -A\frac{M}{n}\frac{d^3\Pi}{dy\,dt^2} \end{aligned}\right\} \quad (20) \qquad \left.\begin{aligned} a &= -\frac{M}{n}\left\{\frac{d^3\Pi}{dy^2dt} + \frac{d^3\Pi}{dz^2dt}\right\} \\ b &= \frac{M}{n}\frac{d^3\Pi}{dx\,dy\,dt} \\ c &= \frac{M}{n}\frac{d^3\Pi}{dx\,dz\,dt} \end{aligned}\right\} \quad (21)$$

The coefficient $A = 1/u$ appears before the expressions for Q and R, because M being in electromagnetic units we must divide by u to obtain the values of Q and R in electrostatic units.

We may leave to the reader the pleasant task of finding the various differential coefficients of $\Pi = \sin(mr - nt)/r$, or, as we shall write it, $\sin\chi/r$, and simply give the results.

Note that since $r^2 = x^2 + y^2 + z^2$, we have $dr/dx = x/r$, $dr/dy = y/r$, $dr/dz = z/r$, and that $y/r = \sin\theta = z\,r = \cos\theta$.

Then by differentiating Π and substituting in equations (20) and (21) we have for the components of the electric and magnetic force of the closed oscillator,

$$\left.\begin{aligned} P &= 0 \\ Q &= -\frac{AMn}{r^2}\left\{mr\cos\chi - \sin\chi\right\}\frac{z}{r} \\ R &= \frac{AMn}{r^2}\left\{mr\cos\chi - \sin\chi\right\}\frac{y}{r} \end{aligned}\right\} \quad \ldots\ldots \quad (22)$$

$$\left.\begin{aligned} a &= -\frac{M}{r^3}\left\{(m^2r^2\cos\chi - 3mr\sin\chi - 3\cos\chi)\frac{y^2+z^2}{r^2}\right. \\ &\qquad \left. + 2(mr\sin\chi + \cos\chi)\right\} \\ b &= \frac{M}{r^3}\left\{m^2r^2\cos\chi - 3mr\sin\chi - 3\cos\chi\right\}\frac{xy}{r^2} \\ c &= \frac{M}{r^3}\left\{m^2r^2\cos\chi - 3mr\sin\chi - 3\cos\chi\right\}\frac{x^2}{r^2} \end{aligned}\right\} \quad (23)$$

At distances such that mr is large compared with unity, the above expressions reduce to

$$\left.\begin{aligned} Q &= \frac{AMnm}{r}\cos\chi\cdot\frac{z}{r} \\ R &= \frac{AMnm}{r}\cos\chi\cdot\frac{y}{r} \end{aligned}\right\} \quad (24) \qquad \left.\begin{aligned} a &= -\frac{Mm^2}{r}\cos\chi\cdot\frac{y^2+z^2}{r^2} \\ b &= \frac{Mm^2}{r}\cos\chi\cdot\frac{xy}{r^2} \\ c &= \frac{Mm^2}{r^2}\cos\chi\cdot\frac{x^2}{r^2} \end{aligned}\right\} \quad (25)$$

These equations show that the lines of electric force are circles with centres on the oscillator axis and planes parallel to that of the oscillator, whilst the lines of magnetic force of the closed oscillator have the same form as the lines of electric force of the open or Hertzian oscillator.

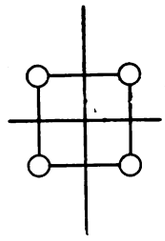

FIG. 4.

At large distances both the electric and magnetic forces vary inversely as the distance. Also we see that, since $A = 1/3\times10^{-10}$ is a very small quantity, the values of Q and R will be very small, unless $n = 2\pi$ times the frequency, is very large. In other words, the closed oscillator only radiates sensibly for very high frequencies. We can calculate this radiation by Poynting's theorem.

If we consider points on the (xy) plane for which $Z = 0$ we have the electric force reduced to a single component, R, perpendicular to that plane and the magnetic force to the resultant of the components a and b. If we call the vectorial angle θ, so that $y/r = \sin\theta$. $x/r = \cos\theta$ and H the resultant component of the magnetic force perpendicular to the radius vector r and in the plane xy, then

$$H = a\sin\theta - b\cos\theta = -\frac{Mm^2}{r}\cos\chi\,(\sin^3\theta + \sin\theta\cos^2\theta)$$

$$= -\frac{Mm^2}{r}\cos\chi\sin\theta.$$

If we call E the component of the electric force perpendicular to the radius vector, and also to the xy plane, then

$$E = \frac{AMnm}{r}\cos\chi\sin\theta.$$

Hence by Poynting's theorem the energy sent out in a time dt through an area dS is $dW = \frac{1}{4\pi A}E\,.\,H\,dS\,dt$, for E and H are at right angles to each other.

Consider a zone of the sphere swept out by this radius vector of length r and small angular increment $d\theta$. It is $2\pi r^2\sin\theta\,d\theta = dS$.

Hence we have by substitution

$$dW = \frac{r^2\sin\theta d\theta}{2}\frac{M^2n^2m^2}{r^2}\cos^2\chi\sin^2\theta dt$$

$$= \frac{M^2nm^2}{2}\cos^2\chi\sin^3\theta\,d\theta\,dt.$$

To obtain the whole energy sent out in ergs per period we have to integrate the above expression between the limits $\theta = 0$, $\theta = \pi$ and $t = 0$, $t = T$.

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Now $$\int_0^{\pi} \sin^3\theta d\theta = \frac{4}{3},$$

and $$\int_0^{T} \cos^2 \chi dt = \frac{T}{2}.$$

Hence $$W = \frac{16\pi^4 M^2}{3\lambda^3} = \frac{16\pi^4 S^2 a^2}{300\lambda^3}, \quad \ldots \quad (26)$$

where a is the maximum value of the oscillator current in amperes and S is its area in square centimetres.

But $16\pi^4 = 1{,}558$ nearly, hence

$$W = \frac{5S^2a^2}{\lambda^3} \text{ ergs per period.}$$

If the oscillations are continuous and of frequency N the power radiated in watts is given by

$$P = \frac{1}{6 \times 10^{36}} S^2 N^4 a^2.$$

We see, therefore, that the radiation from a closed oscillator varies as the fourth power of the frequency and increases with immense rapidity with rise in the frequency.

If we compare the above formula for the radiation of the closed oscillator with that already given for the open oscillator we arrive at the following simple expressions for the energy radiated in ergs per period :—

$$\left.\begin{aligned} &\text{For the open oscillator } W = \frac{2}{15}\frac{l^2 a^2}{\lambda} \\ &\text{For the closed oscillator } W = 5\,\frac{S^2 a^2}{\lambda^3}, \end{aligned}\right\} \quad \ldots \quad (27)$$

where l is the length of the open oscillator, and S is the area of the closed oscillator and λ is the wave-length, and a is the ampere value of the maximum current in it during the period.

These formulæ show that the closed oscillator is an exceedingly poor radiator compared with the open oscillator.

An example will make this clear. A square circuit was formed 8 ft., or 250 cm. in the side. It had five turns and was traversed by a continuous high-frequency current with a frequency of 150,000. The R.M.S. value of the current in it was 4·2 amperes.

If we assume that the current was sinoidal in form this corresponds to a maximum value of nearly 6 amperes or 30 in all for the five turns. Hence we have $S = 250 \times 250 = 10^6/16$ sq. cm., and $S^2a^2 = \frac{10^{12}}{250} \times 900$.

also $$\lambda = 8 \times 10^{10}/150{,}000.$$

and $$W = \frac{5 \times 9 \times 10^{26} \times 15 \times 225}{27 \times 10^{30} \times 256} = 0{\cdot}0022,$$

or nearly $\frac{1}{500}$ erg per period. For continuous oscillations having a frequency of 150,000 the radiation is, then, 300 ergs per second, or $3/10^5$ of a watt.

If we compare this with the radiation already calculated for the open radiator of 4 metres in length, which we found to be nearly 23,000 ergs per period, or 75,000 ergs per discharge, we see that such an open radiator even if discharged intermittently at the rate of only 50 discharges per second would radiate rather more than $3/10^2$ of a watt. Accordingly even with persistent oscillations in a closed circuit it is practically impossible to attain anything like the radiation which can be achieved with intermittent groups of oscillations in an open circuit. In other words, the open radiator is the very life and soul of wireless telegraphy by electric waves. Nevertheless, it is interesting to know that a closed circuit can radiate electromagnetic waves, and that it acts in effect like a short Hertzian oscillator. It is well to recall to mind that prior to the date of Hertz's memorable work the late Prof. G. F. Fitzgerald had shown that an alternating current in a closed circuit could radiate some of its energy into space in the form of electromagnetic waves (see "The Scientific Writings of the late Prof. G. F. Fitzgerald," edited by Prof. J. Larmor, Sec. R.S., p. 128), but did not submit the matter to arithmetical calculation. Soon afterwards Hertz discovered experimentally the enormous radiative powers of the open oscillator and thus disclosed a new field of work.

(To be continued.)

MUNICIPAL TRAMWAYS ASSOCIATION: SIXTH ANNUAL CONFERENCE.

(*Concluded from page 962.*)

Mr. Acland added some notes to his Paper, as a result of a recent visit to the Continent. These notes were not included in the printed copies of the Paper, but should be inserted before the paragraph beginning "No industry in modern times . . ." at the bottom of the first column of p. 960 in out last issue.

The author finds that his opinion regarding the ultimate form of the long wheel-base truck, with wheel centres spaced from 8 ft. 6 in. to 10 ft., is confirmed by the opinion of all continental tramway engineers and builders of trucks. The experience of the latter is as follows:—A long-bodied car with large platforms, on both of which 8 or 10 passengers are carried, is necessary. Double-bogie cars are unsatisfactory, owing to great weight, first cost and expensive maintenance. Experience with cars with two single-axle swivel trucks shows they are suitable for curves but not for straight track, owing to the tendency of the axles to remain out of square, with consequent excessive flange wear. The general practice is now to use a single four-wheel truck with a practically rigid wheel-base of from 9 ft. to 12 ft., and a clearance between the axle-box and horn cheek, varying from 2 mm. to 12 mm., the axle being maintained in a central position on the straight track by link suspension, two designs of which were given in the first two figures, p. 959 of our last issue, in conjunction with the Warner flexible suspension.

Friday, September 27th.

The proceedings on Friday, the last day of the Conference, were opened by a brief meeting of the Executive Committee at 9:45. At ten o'clock the discussion of Mr. Dalrymple's Paper on Staff Organisation was proceeded with. An abstract of the Paper was given in our last issue, and the discussion mostly turned on the question of the respective positions of the tramway manager and city surveyor in regard to the tramways undertaking. Managers from smaller towns appeared to favour the placing of the track and paving work in the hands of the surveyor. In the larger towns and great cities it was considered preferable for the tramways to be under the entire jurisdiction of a general manager who had control over all departments. Mr. Dalrymple, in summing up, was very emphatic on the matter of staff interference by committee-men and others. He caused much amusement by remarking that if any member of his committee wished to ride beside a driver he must wear a uniform.

After the expression of the thanks of the members to Mr. Dalrymple for his Paper, Mr. A. L. C. Fell was called upon for his Paper on

RAIL CORRUGATION.*

In May, 1905, the author visited America, and on his return presented a report to the London County Council, in which he made a few remarks on the subject of rail corrugation. In this report he stated that he had formed the theory that the trouble was originally caused by unevenness on the rail surface setting up a slight jumping or bounding action in the car wheels, this unevenness being due to three causes:—(1) Chattering or vibration of the rollers when commencing to roll the ingot into a rail, causing a rough rail surface; (2) Uneven or wide joints between rail ends, rigidly supported on a concrete bed; (3) Jumping action set up in car wheels by variations of the wheel or track gauge.

After further study and investigation on various tramway systems, the author has come to the conclusion that corrugations are not due entirely to one cause. The following are, in his opinion, some of the chief producers of the trouble:—(1) Original roughness of rail after rolling; (2) Cold rolling of rails by the car wheels; (3) Soft rails and

* Abstract.

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heavy cars; (4) Sand and grit on head of rail; (5) Defective and open joints; (6) Tight or wide gauge of track or wheels; (7) Loose or springy rails and points; (8) Defective trucks being out of square and buckling; (9) Slip of wheels at curves; (10) Wheels not being same diameter; (11) Flats on wheels; (12) Rapid acceleration and retardation, causing wheels to slip; (13) Defective brake mechanism, or by a too rapid application of the brakes causing chattering and a series of short skids.

It is quite possible that the use of sand on street tramways may cause corrugation. As a rule, sand is applied to the rail intermittently and lies in small heaps at short intervals. The natural tendency would be for the wheels, when revolving rapidly, to grind the head of the rail when passing on to each fresh heap of sharp sand; this would account for corrugations appearing at irregular intervals. It may be argued that under this theory there would be corrugation at all stopping places, but this is not a fact, and is probably due to the reduction in the speed of the cars before they arrive at the stopping places where sand would be applied. It has been found that at most of the stopping places the rails present a bright, regular surface.

With reference to the question of corrugation being caused by rapid acceleration, the author has made experiments and found that if a car is too rapidly accelerated distinct signs of corrugation appear. The markings are not very deep, but would most probably develop. Similar experiments have also been made with a traverser in one of the London car-sheds. This traverser, which is 14 ft. 8 in. long and 23 ft. 10 in. wide, is driven by one Westinghouse No. 200 motor, run from the 500 volt tramway circuit, connected through countershafts to gear wheels keyed to the independent axles carrying two of the four wheels on which the traverser is mounted. The approximate weight of the traverser is 15 tons unloaded. In the first experiments the rails in the traverser pit were clean and wet. When the traverser was standing still the controller was rapidly worked round on to the fifth notch, and the wheels slipped badly before the traverser gained much speed; corrugations appeared with each experiment at about 2 in. centres, the patch of corrugation being about 9 in. long. In the next experiments the rails were painted with grease, but the corrugations were not visible. This may be an optical illusion, but in the author's opinion it tends to show that corrugations are more liable to occur under the heading of rapid acceleration with the wheel in good metallic contact with the rail, and not when the latter is covered with a film of grease or soft, ungritty matter.

Any of the above matters may be responsible for the trouble, but the author still considers that the "original sin" is produced when the rails are rolled and will quickly develop into corrugation unless the surface of the rails is ground immediately after they are laid. On the Vauxhall to Victoria route of the L.C.C. tramways the rails were rubbed with carborundum blocks before electric cars began to run. Distinct signs of corrugation then appeared, and were ground out. A heavy service of cars has been in operation over these lines during the past 14 months, and there are only very slight signs of corrugation, except on the Vauxhall Bridge crossing the Thames, where the corrugation is more serious. This is, no doubt, due to the spring of the rails on the bridge. In another case where fully developed corrugations along the Clapham-road were rubbed out in a similar manner at the same time, the rails are now badly marked again, the service of cars and the speed in each case being practically the same.

Generally speaking, the outer rails of the curves are most deeply marked, and the pitch of the corrugations is fairly regular, the average being 2 in. The inner rails of curves are usually marked in irregular patches. On straight tracks, however, the corrugations are not so irregular. On inclines the corrugations are deeper and more regular on the up than on the down grade. As a rule, corrugations do not appear on down grades where track brakes are regularly used as service brakes. In places where the rails are not anchored the corrugation is much worse than on lines where the rails are anchored or laid on extended yokes.

In a recent Paper read by Mr. J. A. Panton before the Institution of Electrical Engineers,* he states that "enough evidence has now accumulated to contradict any rail theory that may be promulgated." He then gives various reasons why the rail theory fails to account for the presence of corrugation. Amongst others he states: "Because rails manufactured by every firm in the world have corrugated since the advent of electric traction." This is not quite correct, as there are several tramways where no corrugation has yet appeared. The author gives a list of these tramways in another part of this Paper. Again, "that the rails did not corrugate in the days of horse and steam cars." Very few cases are known of corrugated rails on horse and steam tramways, but the author saw an interesting case a few weeks ago in one of the London docks, where the rails carrying a large steam-driven jib crane were badly corrugated, the corrugations being about 2 in. long and extending nearly the whole length of the rail. Also, "that check rails are corrugated to an equal degree and parallel to that on the crown of the rail." With very few exceptions the check rails are not corrugated on the London tramways. And, "that it takes on the average three years to develop corrugations on a new system, and only three weeks on relaying with new rails thereafter." Corrugations have appeared on some of the rails in London after they have been in use for a few days, but on most of the rails they have appeared in about six months.

The author does not agree with Mr. Panton's view that corrugations generally are caused by defective trucks, although this may, under certain conditions, be responsible for corrugations. The reason for this statement is based on the following fact: When ordering additional rolling stock about two years ago, the author came to the conclusion that the ordinary stock trucks on the market were unsuitable for heavy service. He, therefore, in conjunction with eminent truck manufacturers, set to work to design a truck that would meet the requirements and be a thoroughly sound mechanical job. This was done, and the results have been very satisfactory. Some of these trucks were put into service on the Aldwych Subway line, and similar trucks were put into service on the Poplar line. On the Subway line, where the rails are laid on longitudinal sleepers, corrugations were noticed a few days after the line was opened. These were ground out, but appeared again after a few months' working, and it was anticipated that the trouble would become serious, but for the past three months there has been practically no change—if anything, the corrugations are somewhat less marked. On this line the steel cars are fitted with magnetic track-brakes and sand-boxes of the intermittent-flow type. On the Poplar route, which has been running with a heavy service of cars for upwards of 12 months, no corrugations have yet appeared. In this case the rails are mounted on extended yokes and are anchored. The author thinks the chief cause of corrugation on the Subway lines is the fact that the rails are on a springy bed and the cars run at speeds up to 20 miles per hour. On the Poplar route the cars cannot be run at a very high speed owing to the heavy vehicular traffic. The cars on this route are fitted with magnetic track-brakes and sand-boxes of the continuous-flow type.

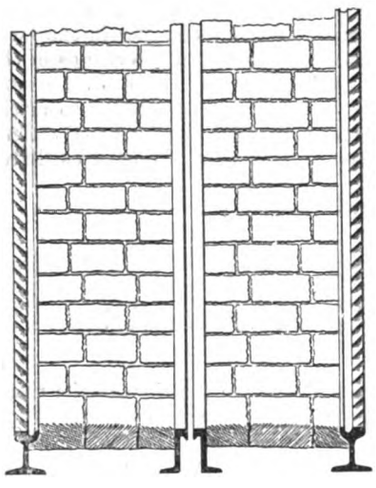

FIG. 1.—STRAIGHT TRACK.

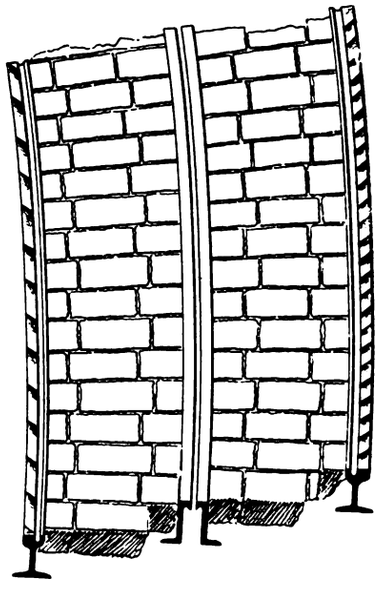

FIG. 2.—APPROXIMATE RADIUS, 500 FT.

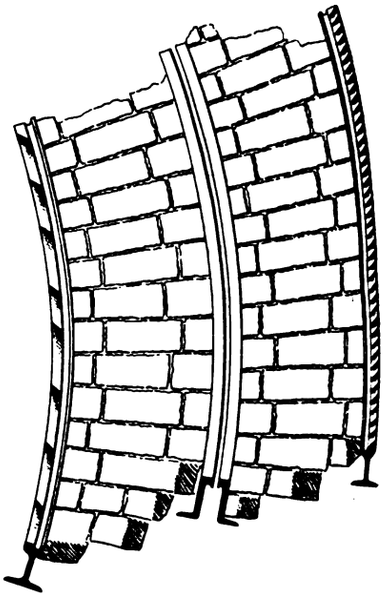

FIG. 3.—APPROXIMATE RADIUS, 40 FT.

Wave Form of Corrugations.—The wave form of corrugations is generally the same and the marking is usually not at right angles to the head of the rail. In most cases the corrugation appears as shown in Fig. 1, which gives a typical example of corrugations on a

* See *The Electrician*, March 22, 1907, p. 885.

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straight track. Occasionally the corrugation is at right angles to the rail and sometimes the reverse direction to that shown. Fig. 2 shows corrugations on the rails of a slightly curved track. Fig. 3 shows corrugations on the rails of a curve with a 40 ft. radius. The author has noticed that the corrugations on the inner rail become longer as the curve becomes sharper. This is, no doubt, accounted for by the additional slip on the inner wheels.

Some years ago, when inspecting the Hamburg tramways, it was noticed that the groove of the outer rail of each curve was partly filled up, so that the outer wheels would run on their flanges, thus increasing their running diameter and reducing the "marking-time action" on the inner wheels to a minimum. The writer believes that this method of construction would reduce corrugations at curves.

It has also been noted that apparently with very high speeds the corrugation wave is longer, but, in the author's opinion, it is not altogether the high speed which causes the long corrugation. Most probably the heavier cars used when running (as in America) at speeds up to 50 miles per hour are responsible for the longer waves.

On tramways where magnetic track-brakes are used constantly as service brakes, corrugation has not appeared to any appreciable extent. Several routes in London have been running for nearly 12 months under these conditions. If this state of affairs continues, it will support the theory that corrugations may sometimes be caused by the application of the wheel brake, but experience generally shows that corrugations may appear at any time, and in the majority of cases the trouble does not become serious until after about two years' service; this, of course, depends on the service of cars run on each particular tramway.

An important question which has to be answered before the root of the evil can be discovered is: "Why are corrugation waves the same length with varying speeds within certain limits, say, from four to 16 miles per hour?" One possible explanation is that corrugation may be in some instances caused by the cold rolling of the rail by the car wheels. With a light car, such as a horse car, the rolling is almost imperceptible. With a heavier electric car the weight is sufficient to start cold rolling, and a wave starts at the softest part of the rail and travels forward until the weight of the car is not sufficient to carry the wave further; the wheels then ride over the top of the wave and violent oscillation is set up and the corrugation gradually extends. This theory will possibly partly account for the non-appearance of corrugations on heavy railways. In this case the weight of the train would be sufficient to roll the rail throughout its whole length, especially as the whole of the wheels under the carriages are simply acting as rollers.

Numerous instances can be given of corrugations appearing on manganese and cast-steel special work. In most of these instances the corrugation has appeared on the rail butting up to the special work or on a movable point tongue, the corrugation gradually extending to the fixed casting. A peculiar instance of corrugation was observed by the author in St. George's-road, in London, where there are patches of corrugation 18 in. long and 9 in. apart extending throughout the length of one 45 ft. rail. The centres of the corrugations are 3 in. apart. It has been suggested by many engineers that corrugations most frequently appear at stopping places. This has not been the experience in London.

Corrugation on Cable Tramways.—The fact that corrugation has appeared on cable tramways with light cars rather opposes the theory of cold rail rolling, but this is a subject which should be dealt with separately. One fact, however, might be mentioned—viz., that on the Birmingham tramways some years ago corrugation appeared on one of the two systems then in operation. On one system the cars were, I believe, run at a speed of eight miles per hour, and on the other at six miles per hour. On the higher speed the corrugation was serious, but on the slow-speed line no corrugations appeared. Corrugation also appeared on the Streatham-hill line in London, where the cars were run at a speed of eight miles per hour. This supports the theory that speed in some degree is responsible for corrugation. No doubt in this instance it was caused by the vibration transmitted by the cable at the particular speed of eight miles per hour.

Suggested Remedies.—The following suggestions will, in the author's opinion, be found beneficial in reducing the trouble to a minimum :—

Track.—(1) The rail should be anchored down at intervals of not less than 7 ft. 6 in. (2) A hard wood packing block ¾ in. thick should be placed between the anchor and the rail flange. (3) All joints should be close butted and carefully filed. Possibly it would be an additional safeguard if the rail joints were welded. (4) A water car fitted with carborundum grinding blocks should be run over the line to remove all irregularities before the cars commence running. This will be found a simple, quick and inexpensive process if carried out immediately after the track is constructed, and the development of corrugations will be deferred for a considerable time. (5) Immediately the slightest sign of corrugation appears, to grind the rails, as suggested above. (6) By partly filling up groove of outer rail so that outer wheels run on flanges at sharp curves.

Rolling Stock.—(1) Secure first-class trucks of good mechanical design, which will not buckle or get out of square at sharp curves. (2) See that the trucks are absolutely square (3) The diameter of the wheels should be kept equal as nearly as possible. (4) By separately driving each wheel or by introducing differential gear, as in the case of a motor-car. (5) By using continuous-flow sand-boxes. (6) By using magnetic track-brakes as service brakes.

The author concludes by giving a list of towns and cities where rail corrugation *has* and *has not* been observed, taken from a return published in the early part of the present year in the *Tramway and Railway World*.

DISCUSSION.

Ald. F. A. DUNSFORD (Southampton) said that at Southampton their experience of corrugation on the tramways went to confirm his belief that the real cause of the trouble lay in the rail and was to be looked for there. Mr. Fell had referred to springing of the rail due to badly anchored track as a possible cause of corrugations. At Southampton some 5 or 6 miles of track had been relaid with heavy rails on a concrete bed and corrugations had appeared in three weeks. In certain cases corrugations had been discernible in a single day. Grinding had been resorted to, and up to the present the corrugations had not reappeared. He thought that there could be little doubt that the corrugations existed in the rail when it left the mill.

Mr. A. A. BLACKBURN (Belfast) caused considerable amusement by announcing that he had "a theory." This was based on his experience on the Liverpool Overhead Railway, where corrugations had not been noticed until gearless motors were given up. During the time that the equipments included these motors, rail corrugations were unknown on the line. When single-reduction geared motors were used corrugations put in an appearance. His "theory," therefore, was that the geared motor was the cause of the trouble. He considered that the use of a single pinion placed at the side of the car tended to take what he termed the "push" from the centre of the truck, consequently the forward motion of the car was only kept in straight line by the rails. As a remedy he suggested a pinion at each end of the motor axle and two spur wheels on the wheel axle. At Belfast he had always endeavoured to keep the horn plates on the trucks as tight as possible, to avoid all chance of whipping and swaying which might also contribute to the formation of corrugations.

Mr. J. ALDWORTH said that in Nottingham they had no trouble with corrugations, though why this should be so in the face of the theories and causes advanced he could not tell. On a portion of the track where a one-minute service was run, with mixed types of cars, they had no trouble with corrugations.

Mr. H. E. YERBURY (Sheffield) wished to correct Mr. Fell's statement that corrugations did not occur on steam railways. He knew of a stretch of line on the Midland, near Gloucester, where corrugations were not only perceptible to the eye but also to the feelings of passengers. His experience placed him in agreement with Mr. Fell that the cause of corrugations was to be sought in the rolling mill, and also in the cold rolling action of the car wheels on the rail head. The latter he considered to be confirmed by the fact that corrugations were also met with on trolley wire. He had brought an example of this with him, and handed round for inspection a piece of the Sheffield trolley wire (round section), in which were corrugations at about 1 in. pitch. He could not attribute corrugations in any degree to the use of sand, as Mr. Fell did in his Paper, as he found instances of corrugations on rails over which sand was seldom if ever used. The practice adopted in Hamburg of filling the groove in the outer rail on curves was not likely to be followed in this country, as the idea of running on the flanges of the wheels was one, he thought, which would not commend itself to tramway engineers. He had found corrugations appear on a well-anchored track with longitudinal sleepers. Mitred or splayed joints in the rail also commended themselves to him. The use of a separate drive for the wheels by the adoption of a differential gear might be a possible means of keeping down corrugation troubles, but he held that the "original sin," as Mr. Fell termed it, lay in the rail. He asked if the magnetic brake was regarded by Mr. Fell as having a grinding or smooth-file action on the rail; also he thought it would be interesting to have details of any physical tests of rails which Mr. Fell might have made, to ascertain if the higher portions of the waves were harder than the lower. A higher percentage of carbon in the rail composition might prove instrumental in removing corrugation troubles.

Mr. H. MOZLEY (Burnley) did not agree that corrugations were not met with on down-grades. At Burnley, on a slope of 1 in 18, down which they ran 15 ton cars fitted with cast-iron slipper brakes, and without current on the motors, corrugations were very pronounced and had to be rubbed out. He had found that the cost of grinding out corrugations worked out at 1·8d. per yard.

Mr. J. LANCASTER (Blackpool) stated that during the light traffic of the winter months corrugations were noticeable at certain parts of the track, but when the summer traffic, which was much heavier, was in operation the corrugations disappeared. For this reason they did not prove a source of trouble.

Mr. C. J. SPENCER (Bradford) proceeded to explode the theory propounded by Mr. Blackburn of Belfast at the opening of the discussion. The two pinion drive was no novelty at all. For many months past a car, designed to run on two different gauges between Bradford and Leeds, had been equipped with motors having two pinions, one at each end of the motor shaft. As to single-reduction geared motors causing corrugations because the drive was "on one side," he reminded Mr. Blackburn that the wheel axles were in one piece and took up the drive from the pinion without any skewing of the truck. Again, at Bradford, where these same motors were used on a tramway system which ranked among the largest in the country, there had been no trouble due to corrugations, with one slight exception where the track was laid over a short stretch of "made ground."

Mr. J. S. D. MOFFETT (Rochdale) regarded the speed and weights of the cars as largely instrumental in causing corrugations, also the skidding of the wheels.

Mr. S. SELLON, who was present at the meeting, was called upon by the President to express his views. He referred to the many contradictory theories which existed on the subject of rail corrugations, and of them all he inclined to that which placed the cause of the

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trouble to the rail. He quoted an experience which he had had when acting for the British Electric Traction Co. at a time, some years back, at which they required large quantities of steel rails for the tramway schemes they had in hand. A specification was drawn up, but the British rail makers would not comply with it, consequently the order was placed in Belgium. When it was being executed the makers were rigidly held to the specification. The result was that none of the rails delivered had developed corrugations. Subsequent extensions of the system with British rails had, however, given trouble in this respect. He laid emphasis on the point made by Mr. Fell that the chattering of the rolls had much to do with corrugations, so that, in fact, before ever cars started to run over the rails, the corrugations were actually existent. If the rail head was ground previous to the starting of the cars he thought that corrugations would be avoided. He recommended tramway managers to ask for a certain rail and to see that they got it. A high carbon rail was the thing, but, as a member of the Engineering Standards Committee, he had remained in the minority with Dr. A. B. W. Kennedy in advocating the addition of 0·5 to 0 6 per cent. of carbon in the standard tramway rail.

Mr. R. H. WILKINSON (Huddersfield) regarded the wear and tear of trucks as a cause of corrugations, a fact which he considered to be confirmed by the appearance of corrugations on lines which had been in use for some years. The skidding of wheels was also responsible for a good deal of trouble.

Mr. R. W. SMITH-SAVILLE (Darwen) said that in Darwen, with Belgian steel rails under seven years of steam operation of the tramways, there had been no corrugations, but these had appeared shortly after the conversion to electric traction.

Mr. J. B. HAMILTON (Leeds) said that in Leeds greater attention was being paid to the physical structure of the rails, and the Sandberg process referred to by Mr. Sellon was regarded with considerable favour.

Mr. H. E. BLAIN (West Ham) said that his system of tramways should now be transferred from the list of undertakings where corrugations had not been observed to the list of towns where the opposite was the case. On a section of route over which a 3 to 10 minute service was run corrugations in the rail had been recently observed.

Mr. A. L. C. FELL reserved the greater part of his reply to the discussion for a written communication to the *Proceedings* of the Association. He briefly remarked, however, that the opinions expressed appeared to confirm the idea that rail-makers could render much greater assistance, than they did, to tramway managers in removing one of the chief causes of corrugations. His experiments with the electric traverser referred to in the Paper clearly showed that corrugations could be produced by careless use of a controller. It was also interesting to note, in view of Mr. Blackburn's "theory," that the drive in this traverser was of the double-pinion pattern. He had not made any physical tests of rails, but data published by eminent authorities showed that the tops of the waves in corrugated rails were harder than the lower parts. He felt that, although most of the causes of corrugation were to be found in the rail itself, there were other sources to which it might be traced, and in his Paper a number of these had been set out.

A hearty vote of thanks was then accorded to Mr. Fell for his Paper. Communications were also read by Messrs. F. Spencer (Halifax) and H. E. Blain (West Ham) on the subject of maintenance of track between the rails and on the outer side of the rails.

The Conference proceedings closed with an expression of thanks to the Manchester and Salford Corporations for entertaining the members during their stay in the city.

On Friday afternoon a large party proceeded to Knutsford, whence they were conveyed in brakes to Tatton Park, the seat of the Earl of Egerton. A welcome was extended to the members by the Earl, and subsequently a pleasant afternoon was spent in the grounds under delightful weather conditions. Tea, which was provided by the Manchester Tramways committee, was partaken of at the Royal George Hotel, Knutsford, and Manchester was reached about 7:30 p.m.

THE ELECTRICAL EQUIPMENT OF THE SS. "MAURETANIA."

(*Concluded from page 943.*)

Summary.—**The equipment of the ss. "Mauretania," the latest addition to the fleet of the Cunard Co., is an excellent example of the varied uses to which electrical power can be put on a modern liner. In our last issue the system of power distribution, electrical generating plant, fans, motors for dismantling the turbines, cranes, lifts, &c., were described, whilst in our present issue we describe the lighting, refrigerating plant, the telephone installation and the means adopted for measuring the power of the turbines.**

Lighting.—The lighting is perhaps the most ordinary feature of the electrical equipment, in spite of its extensive character, some 5,000 incandescent lamps being fitted, which, it may be noted, only require just over a quarter the power demanded by the forced draught fans. Many of the state rooms seem to have been designed to show to greatest advantage with the electric light. They are fitted, for instance, with glass domes, and between these and the ordinary skylights are placed several incandescent lamps, which at night will give to the rooms a really magnificent appearance. Nowhere on the ship has light been stinted, the engine room being particularly well supplied, as is indeed essential and in reality economical.

Refrigerating Plant.—Two complete installations of refrigerating machinery have been fitted by the Liverpool Refrigeration Co. (Ltd.), Liverpool, on board the ss. "Mauretania," one for the preservation of ship's provisions and the other for the carriage of perishable cargo. The machinery for the ship's provisions is situated near the forward end of the turbine engine room on the main-deck level, and the cold chambers connected therewith on the lower deck, some distance forward from the machine. The ship's provision machinery is of the usual steam-driven type.

The greater interest will centre in the cargo machinery, which is situate on the orlop deck just abaft the forward funnel hatch, and refrigerates an extensive range of cold chambers on the orlop decks forward. This machinery is immediately under and adjacent to the first-class passenger quarters, and is entirely electrically driven. The plant is in duplicate throughout, and includes two double-acting carbonic anhydride gas compressors, with direct-coupled motors (as seen in Fig. 7), two condensers, two evaporators, two high-lift centrifugal "Gwynne" pumps for circulating brine with direct-coupled motors. The plant as a whole is specially designed and fitted for the requirements of the North Atlantic trade, for the maintenance of varied and accurately controlled temperatures to suit a variety of perishable goods carried.

The main electromotors, which, as already mentioned, are direct-coupled to the gas compressors, have been specially designed and constructed for the purpose by Messrs. Boothroyd,

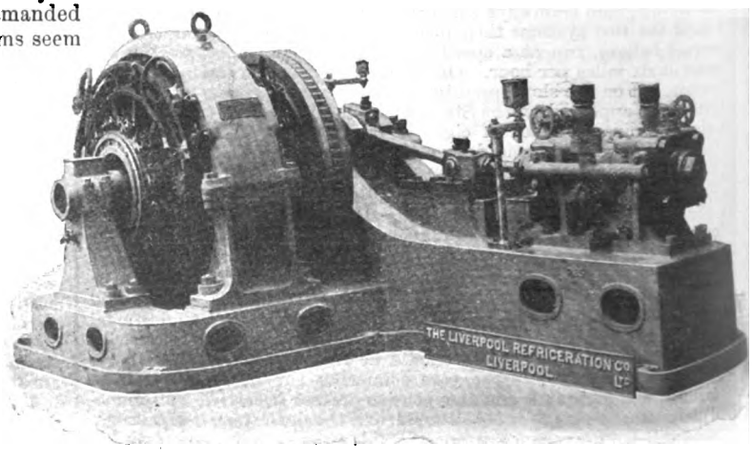

Fig. 7.—Refrigerating Plant.

Hyslop & Co., electrical engineers, Bootle, Lancashire, to fulfil the following conditions: Absolute silent running, light weight and limited floor space; to develop 35 B.H.P. with a constant torque for a variable speed of from 35 to 110 revs. per min. The motors are designed with 12 poles and are shunt wound. The armature has a two-circuit series winding, the conductors consisting of solid bars. This type of winding allows of the short-circuiting of any coil in case of fault. The two separate windings are placed side by side in

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the slots, thus ensuring a perfectly equal field for both. The brush gear is bolted in position to the frame, no rocking arrangement being provided for, as the motors are designed for sparkless running at all loads and speeds. The armature has a comparatively large diameter, the object being to obtaina fly-wheel action, a high peripheral speed and good circulation of air.

The operation of starting and varying the speed is carried out by means of one hand wheel as follows: When starting the two armature windings are in series, and by moving the hand wheel a certain distance the starting resistance is cut out. By moving the wheel still further the shunt resistance is inserted to vary the speed from 85 to 75 revolutions. A further

Telephone Installation.—In such a miniature town as the "Mauretania" may be considered, a comparatively large installation of telephones is necessary, not only for private but also for navigating purposes. For the latter extremely large and loud-speaking instruments are used, and the system is, of course, quite independent of the passengers' equipment. In the navigating room are three separate telephones, complete intercommunication not being considered necessary or even advisable. The first is connected to the engine room, which contains three telephones—one for the starting platform, controlling the low-pressure and astern turbines, and one each for the high-pressure turbine rooms, port and starboard; the

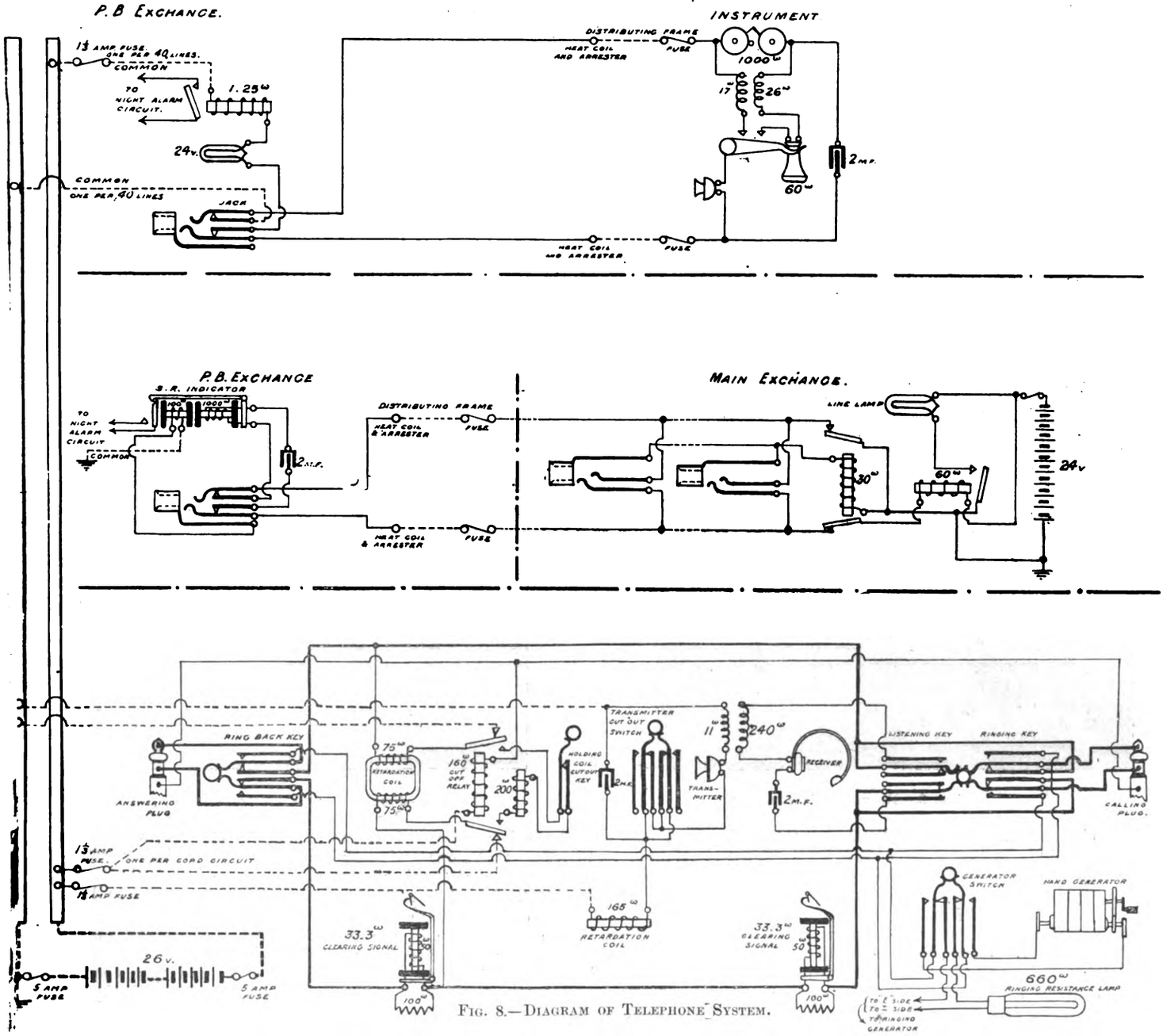

FIG. 8.—DIAGRAM OF TELEPHONE SYSTEM.

movement of the hand wheel actuates a change-over switch by means of a clutch coupling, changing the armature windings from series to parallel and cutting out shunt resistance. By further moving the hand wheel the shunt resistance is again inserted giving further speed regulation from 75 to 110 revolutions.

The motors for the brine pumps are of their standard "E" protected type of 3½ H.P. coupled direct to Gwynne's centrifugal high-lift pumps. They are shunt wound for a variable speed from 900 to 1,600 revs. per min. by means of shunt regulation only, and are particularly silent in their running.

navigating officer, by means of three switches, can speak to either of these at will, independently of the others. The second telephone is to the steering gear which, it should be mentioned, is steam-driven and can be controlled either from the navigating room or from the after end of the boat, the actual gear acting directly on the rudder just below the water line. The third telephone is connected to the forecastle, the crow's nest and the after bridge by means of three switches.

The passengers, or at least those occupying the best cabins, will have all the telephone facilities of a modern hotel. A complete exchange has been set up in a room set apart for the

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purpose, and not only will the passengers have communication among themselves and to the purser, steward, doctor and the bureau, but when the ship is in port connection will be made to the exchange at Liverpool or at New York, allowing business, &c., to be transacted up to the moment of sailing and also at the moment of arrival. The equipment consists of a switchboard (Fig. 9) capable of operating 200 stations and 20 exchange lines, the number at present fitted being 83 stations and 10 ex-

FIG. 9.—EXCHANGE SWITCHBOARD.

change lines, the central battery system having been adopted. There are two batteries, each of 13 accumulators, with a total voltage of 26. They are conveniently charged from the ship's supply (110 volts) through four 32 c.p. lamps, the charging being regulated from a power board mounted on top of the switchboard. For ringing, two machines are supplied for use alternately, also run from the ship's supply and operated from the power board. The distributing frame is vertical, and contains 120 pairs of fuses in the upper part and 120 pairs of arresters and heat coils below. It will be noticed from the diagrams in Fig. 8 that no relays are used; the lines being of low resistance allow the 24 volt battery to light the calling lamp direct. Otherwise there is no special feature.

For connection to the shore 10 pairs of wires are connected from the switchboard on to a box on each side of the ship, the boxes containing 10 pairs of platinum-tipped bronze springs on an ebonite slab, to which the lines are respectively joined. Several similar boxes are placed on the landing stages, and to couple them together a long cable with 10 pairs of wires is used, the wires being soldered on to 10 pairs of platinum-tipped studs carried on an ebonite slab, which is mounted on a gunmetal head at each end of the cable. The cable head, on being pushed into the box, engages with the springs and is held in position by an automatic spring catch which allows good contact to be made between studs and springs.

The telephones themselves are of handsome design and in no way detract from the appearance of the cabins—the bell, condenser and induction coil being in a casing, placed in a position in which it will be unnoticed. The whole installation was carried out by the National Telephone Co., who also installed a similar equipment on the "Lusitania." These two installations would appear to be the first of the kind, and certainly the most complete ever fitted on liners.

Electric Torsionmeter.—The measurement of the power developed in the propeller shafts is carried out by means of Denny & Johnson's electric torsionmeters, and, though these instruments are now fairly well known, a brief outline of their principle may be of interest. The arrangement consists of two light gunmetal wheels fixed on the shaft about 70 ft. apart in this case, each wheel carrying a small magnet sharpened off at the end to ensure a strong field at the tip, the magnet being clamped in a groove by small steel bands, as shown in the bottom position in the illustrations (Figs. 10 and 11). Underneath the wheel and bored out parallel to its circumference is an inductor of soft iron on which are a number of very small but insulated windings, 6 on one inductor and 14 on

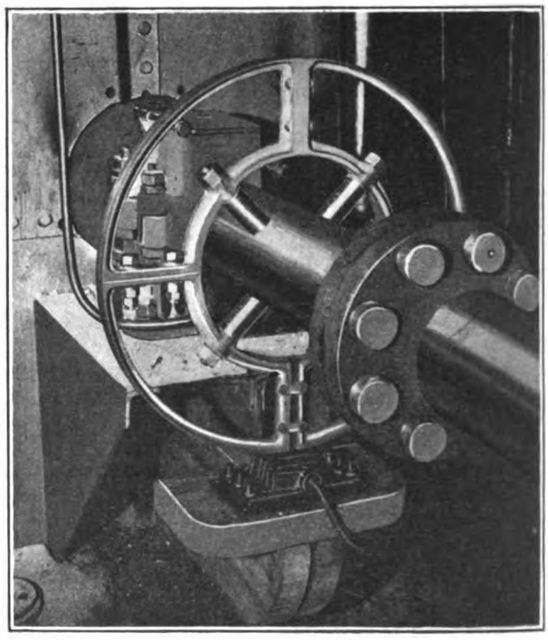

FIG. 10.—DENNY & JOHNSON'S TORSIONMETER.

the other, arranged circumferentially at such a distance apart that one winding on the one inductor represents a peripheral length of 0·2 in. and on the other of 0·02 in. The six windings on the front inductor have one end common, which is connected through a telephone to a contact arm in the instrument box, the loose ends being coupled to six contact studs arranged in a circle so that the arm may be moved on to either of them and thus connect any one of the windings to the telephone. Similarly by another set of contacts any one of the 14 windings on the second inductor may send its current through the telephone, but in an opposite direction since the instrument is differentially wound. If, then, the shaft is subjected to a strain of, say, 1 in. between the two wheels, due to the power it is transmitting, currents will be induced, not in those windings on the two inductors which are correspondingly placed, but in those which are 1 in. apart, and this position can readily be found by noting when silence is obtained in the telephone receiver on moving the contact arm on the studs. The displacement of the shaft in a given length is thus obtained whence the power transmitted can be calculated.

For minor purposes the applications of electricity are in-

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numerable, more interesting perhaps from a domestic than an engineering point of view. Knife cleaning and sharpening machines are to be found in abundance, as are boot-cleaning machines, ham slicers, bread-cutting machines; in fact, every conceivable operation that can be mechanically carried out is placed beyond the intervention of the human hand by the convenient aid of the electric motor. It may be stated that there are motors on board to a total power of about 2,000 H.P.,

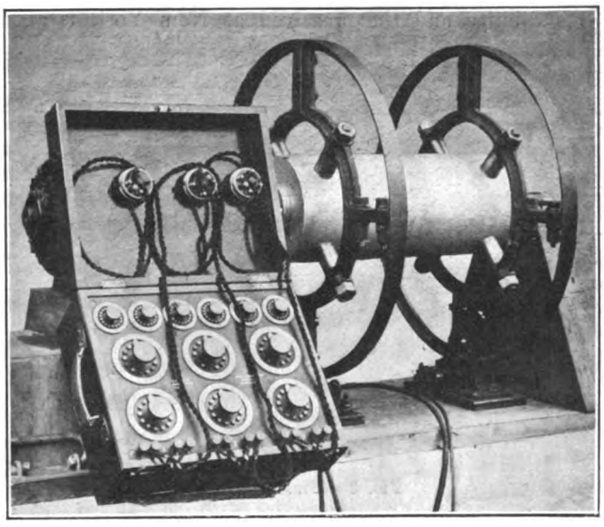

FIG. 11.—RECORDING BOX FOR TORSIONMETER WITH MAGNET WHEELS AND INDUCTORS.

though, of course, it will never be possible for more than about one-half to be working at the same time; nevertheless, they will constitute a load which for its high load factor would delight the hearts of many central station engineers and materially reduce the cost of production.

In our description of the ventilation arrangements on the "Mauretania" in our last issue, p. 941, we omitted to mention that the fan coupled to the Laurence Scott motor was a "Sirocco" fan, supplied by Messrs. Davidson & Co., of Belfast, who, we learn, supplied 20 large fans for ventilating this ship, as well as a large number of smaller fans.

LONG DISTANCE WIRELESS TELEPHONY.

BY R. A. FESSENDEN.

Summary.—The Author gives an account of the wireless telephone system of the National Electric Signalling Co. in operation between Brant Rock and New York, a distance of nearly 200 miles. The apparatus, which includes a high-frequency alternator, worked at 81,700 periods, and telephonic relays, is described, and the commercial possibilities of wireless telephony are discussed.

Wireless telephony has now been carried on for several months between Brant Rock, near Boston in Massachusetts, and New York City. As the distance between these stations is nearly 200 miles and 75 per cent. of the distance is overland, and as the stations have been operated almost entirely and regularly during daytime, some particulars of the installation may be of interest.

STATIONS.

The mast at Brant Rock is the trans-Atlantic tower of the National Electric Signalling Co. The station at New York City is a wooden mast of the ordinary type, 200 ft. high.

Generator.—The generator used is a high-frequency alternator, which has been run at a frequency of 100,000 cycles per second, but is normally used at a frequency of 81,700. No photograph has been taken of the present alternator, but it is similar to that shown in Fig. 1, except that there is no countershaft, and the alternator is driven direct by a De Laval gear. The construction of the armature and field coil is shown in Fig. 2.

The open circuit voltage of the armature shown is 150 volts at a frequency of 81,700 and a field current of 5 amperes. The resistance of the armature shown is 6 ohms and the inductance drop is approximately equal to the resistance drop, but this drop is, of course, neutralised by a capacity, so that it produces no effect on the output. Other armatures have been constructed having a resistance of 4 ohms, obtained by slightly shortening the wire, giving the same open circuit voltage. For some work double armatures are used giving an open circuit voltage of 270 volts and having a resistance of 9 ohms, but so far it has not been found advisable to use these for telephony, as the present transmitters will not handle the output.

The construction of the field discs is shown in Fig. 3.

The available output of the single-armature machines at 81,700 cycles is approximately 1 kw. The output of the double-armature machine is approximately 2 kw.

The difficulty of the narrow air-gap has been overcome by a simple device, so that very considerable outputs may now be obtained, machines of 10 kw. output being under construction and plans have been prepared for a machine having an output of 50 kw. On the other hand, experiments have shown that it is possible to obtain outputs as high as 1 kw. with frequencies as high as 250,000 cycles per second, with a field disc only 6 in. in diameter, using a double armature, the field disc being driven direct by a steam turbine. Apparatus of this type is also under construction, and it is anticipated that this type will be found very useful on board ship.

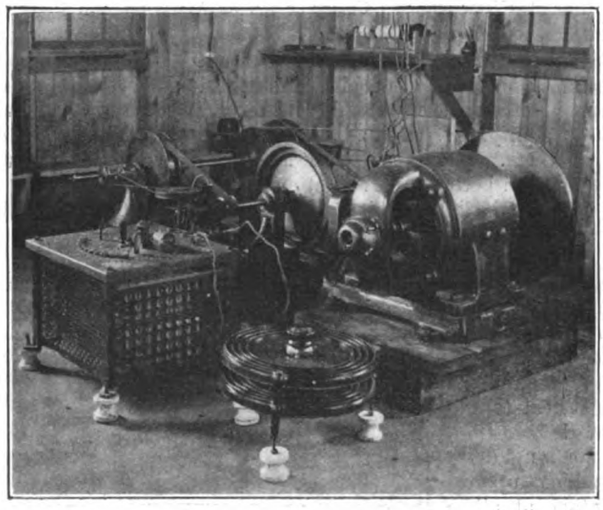

FIG. 1.—HIGH-FREQUENCY ALTERNATOR.

Method of Operation.—This is shown in Fig. 4. Of course, only a portion of the apparatus shown is necessary to the actual telephonic operation, the majority of the apparatus here seen being used for making quantitative measurements.

In operation the transmitter is generally placed directly in series with the antennæ and the armature of the high-frequency alternator, as shown in the lower diagram of Fig. 5 taken from U.S. patent 706,747. The antennæ current is generally about 6 amperes with the transmitter short-circuited, and about 5 amperes with the transmitter in circuit. The radiation resistance of the antennæ is generally arranged so as to be about 6 to 8 ohms.*

When talking from a local point near Brant Rock to a local point near New York, speech is transmitted over a wire line to the wireless station and there relayed wirelessly to New York and there relayed again over a wire line to the receiving station. An early type of transmitting relay is shown in Fig. 6. This

* The power radiated from any given antenna at any given frequency can be obtained by multiplying the square of the current by a constant quantity which I have called the "radiation resistance" (*American Telephone Journal*, February 2, 1907, p. 69). I there point out that the effective resistance of the carbon transmitter should be equal to the radiation resistance of the antennæ. This concept will be found to be very useful for wireless work, both in considering the transmitting antennæ and the receiving antennæ, as it leads to a set of equations similar to those of ordinary wire lines and simplifies matters very much.

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consists of a double differential magnetic circuit. This type of relay has, however, since been superseded by what is called the "trough" relay, shown in Fig. 7. This as above consists of a double differential magnetic circuit with a pivoted armature, to which is attached a spade of thin platinum iridium, which

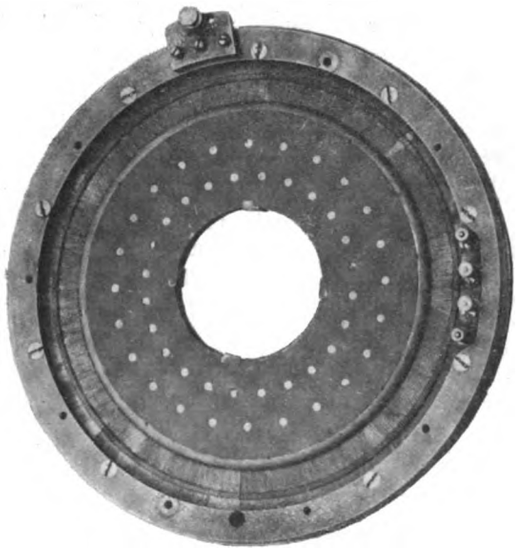

FIG. 2.—VIEW SHOWING CONSTRUCTION OF ARMATURE AND FIELD.

dips into a trough containing carbon powder, the sides of the troughs being formed of platinum iridium sheet. This relay is used both for transmitting and receiving, and is very sensitive, amplifying speech about fifteen times without loss of distinctness. It will amplify it as much as fifty times, but the speech then becomes indistinct and drummy.

The standard transmitter is shown in Fig. 8, and carries 5 amperes without undue heating.

The elements of the apparatus for tuning are shown in Fig. 9.

To the right is shown one of the National Electric Signalling Co.'s variable transformers. While this resembles a Wheatstone rheostat, its action is not dependent upon contact at all, as it was found that when wire is rolled on a metallic cylinder it makes contact at irregular intervals. The metallic cylinder is therefore formed of an undivided tube of pure electrolytic copper, which acts as the short-circuited secondary of a transformer. Where it is desired not to change the resistance, a sheet of mica or of paper is slipped between the wire and the cylinder, without, of course, affecting the action of the transformer.

Any desired ratio of primary and secondary, and any desired inductance in the primary or secondary circuit, and any desired degree of coupling, can be obtained in a few seconds.

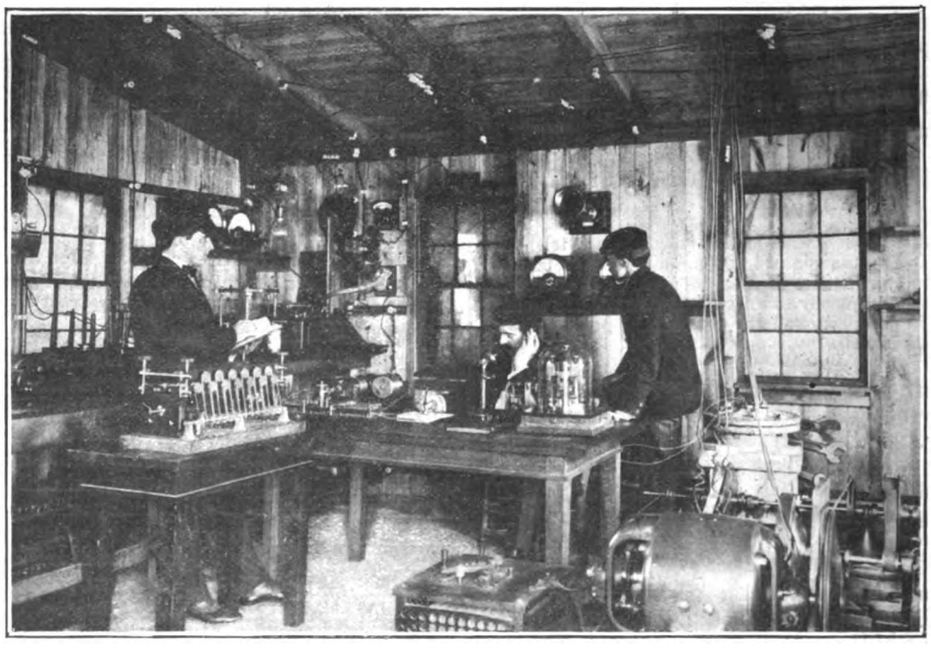

FIG. 4.—VIEW OF PLANT IN OPERATION.

To the left is shown one of the National Electric Signalling Co.'s composite variable condensers. These elements are combined to form an interference preventer which is so connected that it not only cuts out interference but also atmospheric electricity.

Strength of Signals and Speech.—The strength of the speech is approximately equal to the theoretical amount. The intensity of speech received at Plymouth (one of the National Electric Signalling Co.'s stations) is approximately 1,200 times audibility and that received at New York is about

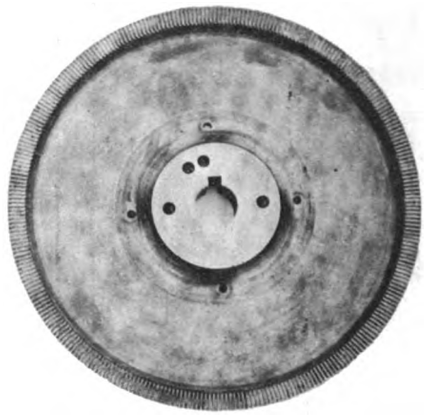

FIG. 3.—FIELD DISC

three times audibility. This is in daytime and without the use of a relay. With the use of the static and other types of transmitters better results can be obtained, but up to date these have not been completed for this installation, and practically all the work has been done with the standard transmitters a d relays shown above.

HISTORICAL.

Elsewhere (*Electrical Review*, London, February 15, 22 and March 1, 1907; *The Electrician*, February 15 and 22, 1907; and the *American Telephone Journal*, January 26th and February 2nd) I have given the history of the development of the wireless telephone. Briefly, I first transmitted speech over a distance of one mile in 1900, using a high-frequency spark. This was abandoned in favour of the Elihu Thomson singing arc (sometimes called by those unfamiliar with its history the Duddell-Poulsen arc). This was superseded in 1902 by my improved arc, for the reasons set forth in U. S. patent 730,753 (April 9, 1903)—*i.e.*, the difficulty of adjustment—and the variability in frequency and intensity of the original Elihu Thomson form. A comparison of the old method of the National Electric Signalling Co., using the Elihu Thomson singing arcs, with the new method, using my improved arc, has recently been

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made by Dr. Austin, of the Bureau of Standards, and his results were reproduced in *The Electrician* of August 2, 1907.

It will be noted that Dr. Austin's results entirely confirm those given in my 1903 patent above referred to—*i.e.*, he finds that the Elihu Thomson singing arc, both in air and hydrogen, is difficult to maintain in adjustment and is dis continuous (as was first pointed out by me in *The Electrician*, February 22, 1907, p. 710, and later confirmed by Fleming), and varies greatly in intensity and frequency, while, on the other hand, my improved arc gives but little hissing noise and is absolutely constant in frequency and intensity. Two corrections must be made to Dr. Austin's Paper—first, the figures given by him for the damping are not correct, as Drude's method of determining damping gives incorrect results when used under such conditions, owing to the overlapping of the trains of waves. The second correction is that,

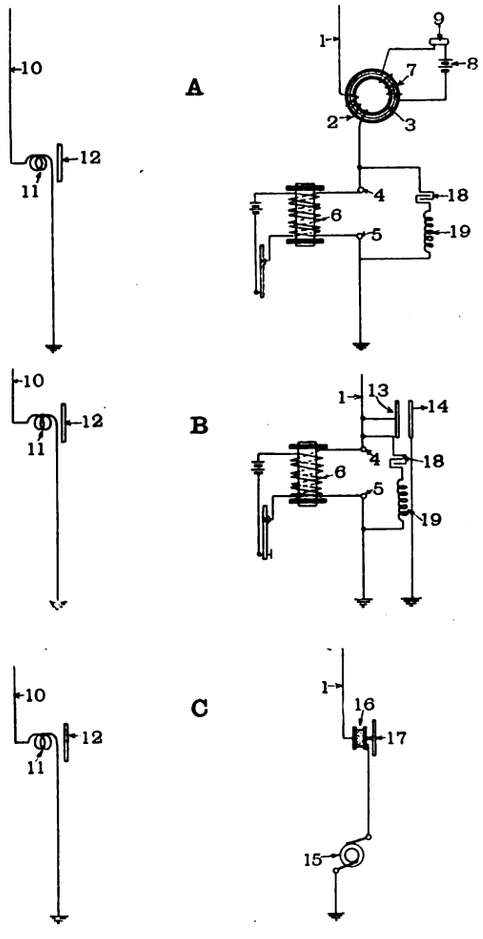

Fig. 5.—Diagram of Connections.

to properly use my arc, the inductance and capacity must be either so proportioned to the voltage that the discharges succeed each other at the same period as the natural frequency, or else a governing tuned circuit must be used, as mentioned in my previous article in *The Electrician*, February 15 and 22, 1907. It is, of course, not absolutely necessary to use the arc in this method, for, as pointed out in U.S. patents 727,330 (March 21, 1903) and 727,753 (April 6, 1903), it is not always advisable to use the arc under such circumstances that "the discharge frequency becomes identical with that of the wave frequency," and, indeed, in some cases it is preferable that this should not be the case.

In 1903, 1904 and 1905 the distance of transmission had been increased to 25 miles, and apparatus was so far developed that sets were tendered to the United States Government (see *The Electrician*, February 22, 1907, p. 711). The transmission was, however, still not perfect. By the fall of 1906, however, perfect transmission had been achieved—*i.e.*, transmission absolutely free from all extraneous noises, and stations were established at Plymouth and Brant Rock. In November, 1906, these stations were operated from and to local stations by means of the relays above described. This transmission has now been increased to a distance of nearly 200 miles—*i.e.*, between the present stations at Brant Rock and New York.

Commercial Uses.

The small sets above referred to will undoubtedly come into extensive use on shipboard, as they do not necessitate the employment of a skilled operator and run continuously without adjustment, and they can be used, where an operator is available, either for telegraphy or telephony by the mere throwing of a switch.

For telephoning across large bodies of water wireless telephony will, it is believed, have an entire monopoly, as, aside from the question whether a Heaviside-Pupin cable can be commercially constructed, laid and maintained, the cost of such a cable is so enormous as compared with that of a wireless telephone station that there would be no object in doing it. The fact that speech has already been successfully transmitted over a distance of 200 miles during daylight, and mostly overland, with an expenditure of only some 200 watts, proves conclusively that there is a commercial future for wireless telephony in this line.

Making all allowances for atmospheric absorption, it should be possible to telephone in daylight between England and America with an expenditure of less than 10 kw., for it must be remembered that the New York mast is only 200 ft. high, and a 600 ft. tower would be used for transatlantic telephone transmission.

As regards land work, I believe there is no doubt but that

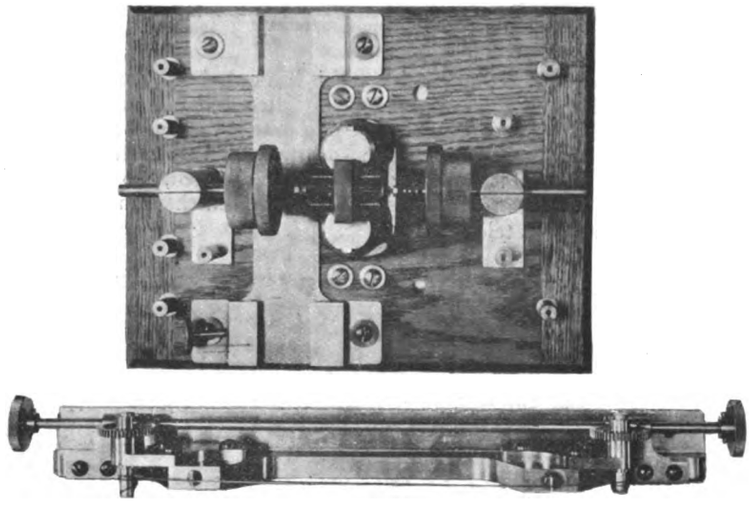

Fig. 6.—Early Form of Transmitting Relay.

in the future the wire trunk lines of the present telephone systems will be superseded by wireless trunk lines. Wire trunk lines are very expensive to construct and maintain as compared with wireless stations, and, moreover, one wireless station can transmit and receive simultaneously a great number of messages at the same time.

An incidental field is the establishment of telephonic newspapers, such as the one at present in Buda-Pesth. There may not seem to be much field for this at present, but when it is considered that a single wireless telephone station could transmit news all over England, and that all the installation necessary for each subscriber would be a light steel pole, costing perhaps $75 (£15), a thermo-electric receiver, a few tuning coils and a loud-speaking telephone receiver, and possibly a Poulsen phonograph, it will be seen that even this somewhat novel proposition is not without possibilities.

All this, of course, assumes that sooner or later the various Governments will appreciate the injustice and inadvisability of

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suppressing wireless communication. The question is sometimes asked why wireless telegraphy does not come into commercial use, but those asking this question will be able to supply their own answer on my asking the question as to where they would suggest establishing the stations. It is true that within the last few days the National Electric Signalling Co. has had the good fortune to secure a permit from the

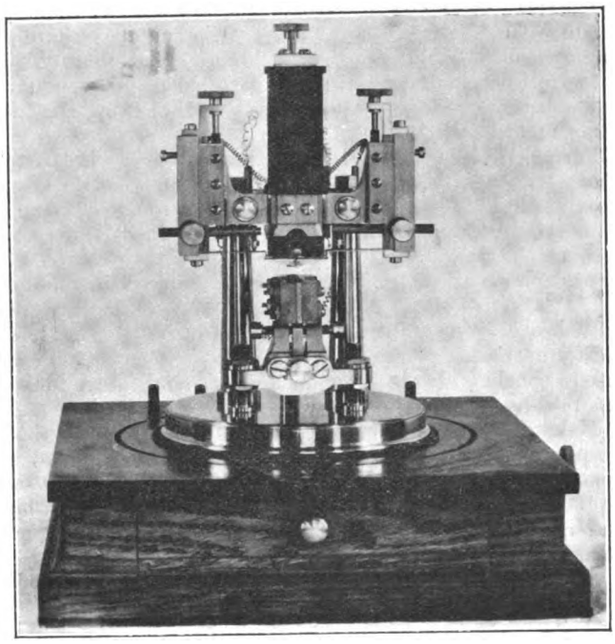

FIG. 7.—"TROUGH" RELAY.

English Government, but, as I say, this has only been obtained within the last few days, and is only for direct communication between England and America. Up to date it has been found impossible to obtain any other permits, and it will readily be seen that, unless this state of affairs can be changed, the development of wireless telephony will be stopped in the same way as that of wireless telegraphy.

that when the above-mentioned apparatus is used for telegraphing, by breaking the continuously generated waves into groups, as described in United States patent 727,330 (March 21, 1903), the signals received at New York are 60 times audibility with an expenditure of 200 watts, the measurements

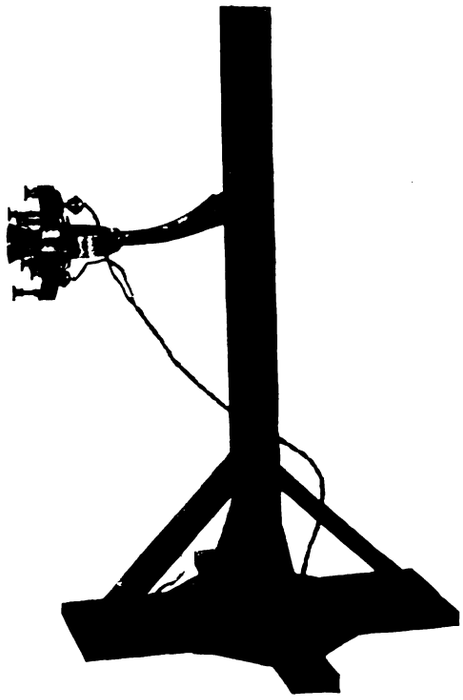

FIG. 8.—STANDARD TRANSMITTER.

being made in daylight between the hours of 10 a.m. and 3 p.m. and during the months of July and August.

The reason for this will be seen at once if the subject be examined quantitatively. The equations for the rise of current in a resonant circuit contain a well-known exponential term, and, if values of the inductance and capacity are taken such as are used in practice, it will be found that the presence of this

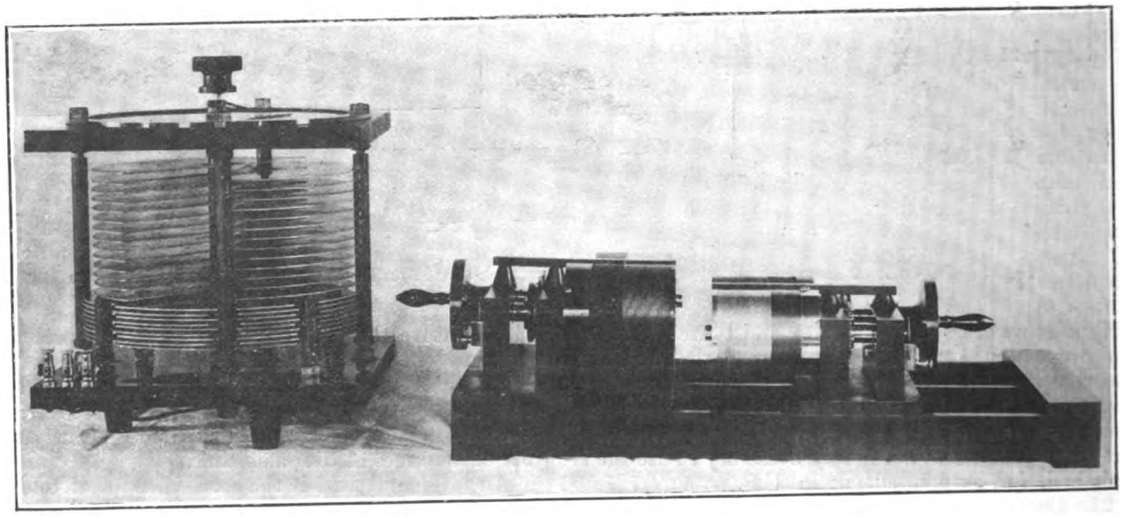

FIG. 9.—APPARATUS FOR TUNING.

EFFICIENCY OF HIGH-FREQUENCY ALTERNATOR WHEN USED FOR TELEGRAPHING.

There has been some discussion as to whether the statements contained in my early patents—for example, those of 1899 and 1901—in regard to the superior efficiency of continuously generated waves were correct. That the statements made were correct will, I think, be admitted when it is pointed out

exponential term has a great effect. As a specific case: with the inductances and capacities used in telegraphing between Massachusetts and Scotland, the value of the exponential term is such that the resonant rise at the end of 20 complete periods is less than 4 per cent. of the rise with continuous oscillations and the same amount of energy transmitted. It is obvious from this that my system of continuously-generated

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oscillations possesses marked advantages, both as regards efficiency and closeness of tuning, over spark methods.

Still another advantage will be realised later by those engaged on the problem of cutting out atmospheric interference, and that is that with the high-frequency alternator, or my arc with governing circuit, it is possible to maintain the phase constant for a sufficiently long time to make practicable some very interesting and important methods of receiving.

RESISTANCE COILS AND COMPARISONS.*

BY C. V. DRYSDALE, D.SC.

(*Continued from page 957.*)

Summary.—The author gives a survey of resistance coils, showing their evolution up to the present time and the methods used in accurate measurements of resistance. Results of tests on a number of resistance-alloys are given. The desirable features and temperature compensation of resistance coils are then discussed, and the author describes attempts which he has made at compensation by electro-depositing films of suitable thickness of certain metals on the resistance wires. In conclusion, the methods of standardising coils and bridges are considered, and a modified form of Carey Foster bridge, due to the author, is described.

Standards of Low Resistance.—For resistances of values less than 0·1 ohm, such as are required in the measurement of current by potentiometer methods, the use of separate current and potential

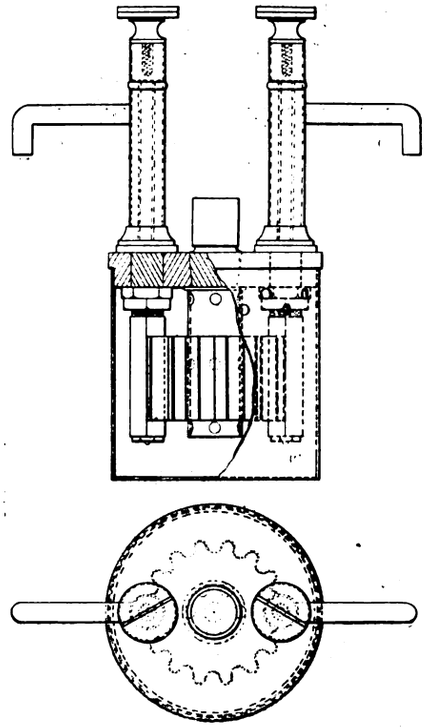

FIG. 13.—REICHSANSTALT, 0·01 OHM. One-third full size.

terminals is imperative. Such resistances have been made in the form of strips or sheets of manganin or other resistance alloy soldered to heavy copper lugs at the ends. The potential terminals are in some cases connected to the lugs and in others to intermediate points on the strips. Owing to the mode of use of such coils the dissipation of heat is most important, and liquid cooling is almost essential. Messrs. Crompton have made such resistances in the form of a tube enamelled on the inside, through which a continuous stream of water may be passed. Fig. 13 shows one of the lighter patterns of low resistance of the Reichsanstalt, and in the heavier patterns (Fig. 14),† the resistance is made up of a number of manganin plates hard-soldered to copper strips, which are in turn soft-soldered and screwed to massive copper blocks upon which the current terminals are mounted. Potential contacts are made to the blocks by copper straps leading to terminals on the case. The whole of the resistance is contained in a tank which may be filled with petroleum, and is provided with a small turbine for circulating

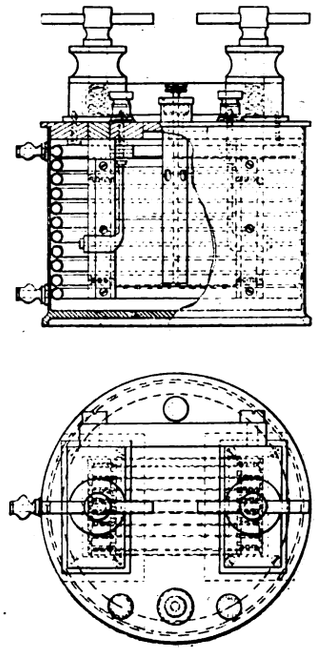

FIG. 14.—REICHSANSTALT, 0·0001 OHM. One-sixth full size.

the oil and a water-cooling worm. Similar forms have been made by Messrs. Nalder, Bros. & Co. and Messrs. Elliotts (Fig. 15).

Resistance Alloys.—Before dealing with the general question of resistance standards, the properties of resistance alloys require a little consideration. During the work of the Electrical Standards

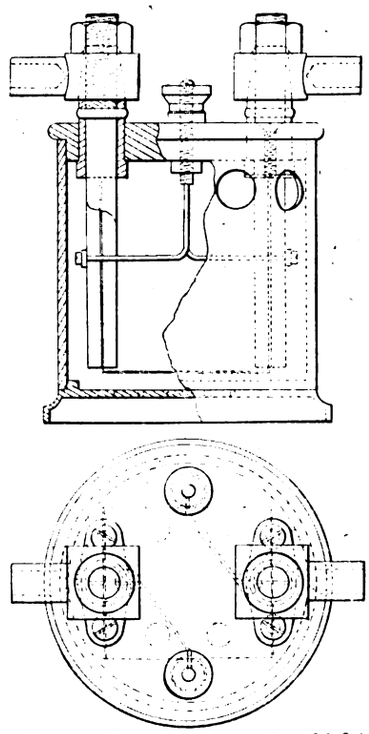

FIG. 15.—ELLIOTT BROS. 0·01 OHM. One-third full size.

committee of the British Association from 1861 to 1865 a very large amount of work on the electrical properties of pure metals and alloys was done by Dr. A. Mathiessen* who came to the conclusion that

* Paper read before the British Association at Leicester, August, 1907.

† "Einzelwiderstande für Kleineré Betrage." K. Feussner, *Zeit. fur Inst.*, Vol. X., p. 425, 1890. "Ueber die Haltbarkeit von Kleinen Widerstände aus Manganenblech in praktischen Gebrauch St. Lindsek." *Zeit. fur Inst.*, Vol. XXIII., 1903. "Ueber eine Neurung an Normalwiderstände von niedrigen Betrage." O. Wolff, *Zeit. fur Inst.*, Vol. XVIII., p. 19, 1898.

* A. Mathiessen, appendices A and B, B.A. *Report*, 1863. *Proc.* R.S. XII., p. 472, 1863. See also "The Measurement of Electrical Resistance," by W. A. Price. M.A.

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Table of the Electrical Properties of Resistance Materials.

Material.	Maker.	Serial No.	Specific gravity.	Specific resistance. Micro-ohm per cm. cube at 0°C.	Temperature coefficient. % at 17°C.	Thermo-E.M.F. Micro-olts per °C. to copper.	Annealing tests. % Alterat'n coiling on mandrel 1 cm. diam.	% Alterat'n after 10 hrs. annealing at 100°C.	% Alterat'n after 10 hrs. further annealing at 160°C.	% Alterat'n of annealed coil after two years.
Nickelin.....	Suddeutsch Kabel Fabrik Mannheim	13	$8{\cdot}82_4$	39·73	+0·021	20·75	+0·15	+0·265	+0·668	0
Nickelin.....	Basse & Lange	1	8·77	$40{\cdot}62_3$	+0·021	20·0	+0 04	+0·41	+1·04	−0·038
Nickelin.....	F. A. Lange	5	$8{\cdot}78_9$	$39{\cdot}29_3$	$+0{\cdot}0187_2$	19·06	−0·54	+0·271	+0·667	+0·035
Nickelin I.....	Fleitmann, Witte & Co.	6	$9{\cdot}08_2$	$43{\cdot}13_3$	$+0{\cdot}0024_5$	37·5	−0·13	−0·113	−0·152	−0·015
Nickelin 0....	C. Schniewindt	17	8·61	$26{\cdot}92_6$	+0·034	19·7	0	+0·238	+0·422	+0·16
Constantan ..	Vogel	11	$8{\cdot}99_3$	47 05$_6$	−0·0012	37·5	+0·517	−0·047	+0·004	−0·05
Constantan ..	Suddeutsch Kabel Fabrik Mannheim	12	$8{\cdot}97_2$	48 3	$+0{\cdot}00143_7$	35·75	+1·13	−0·06	+0·025	−0 0325
Soft constantan	Basse & Selve	2	$8{\cdot}90_8$	48·4	−0·00112	39·12	−0·003	−0·078	0	+0·044
Constantan ..	C. Schniewindt	19	8·92	48·21	−0·000732	57·6	+0·364	−0·119	+0·400	−0·04
Manganin	Suddeutsch Kabel Fabrik Mannheim	14	$8{\cdot}61_2$	36·62	+0·00175	1·4	+0·37	−0·17	−0·58	0*
Manganin	Isabellenhutte	10	$8{\cdot}60_2$	$39{\cdot}14_4$	$+0{\cdot}00176_3$	1·44	+0 34	−0·24	−0·52	0*
Rheostan	F. A. Lange	3	$8{\cdot}61_3$	47·55	+0·024	13·8	−0·42	+0·34	+0·127	+0·0167
Extra prima ..	F. A. Lange	4	$8{\cdot}80_1$	29·35	+0·028	16·55	−0·403	+0·298	+0·569	−0 08
Rheostatin I...	C. Schniewindt	18	8·60	$47{\cdot}57_8$	+0·0256	20·75	+0·1955	+0·385	+0·91	+0·03
Rheostatin II.	C. Schniewindt	21	8·65	$48{\cdot}43_2$	+0·0274	20 9	0	+0·45	+1·05	+0·027
Ger. silver II. A	Fleitmann, Witte & Co.	8	$9{\cdot}05_8$	$42{\cdot}88_7$	+0·00385	35·75	−0·12	−0·13	−0·17	−0·0374
Eureka	London Electric Wire Co.	15	8·96	$47{\cdot}40_4$	+0·0048	40·6	+0·6	−0·069	−0·95	−0·019
Platinoid	London Electric Wire Co.	16	8·83	33·62	+0 0224	23·5	+0·237	+0·463	+1·6	−0·037
Platinum silver	Standard Coil.....	1,168	..	..	+0·0263	..	..	..	..	..
Platinum silver	Standard Coil.....	5,657	..	..	+0·02714	..	..	..	..	..
New metal....	..	26	8 96	51·10	+0·0038	35·8	..	..	..	..
Superior	Fleitmann, Witte & Co.	7	$8{\cdot}24_1$	81·024	+0·1148	7·44	+0·2	−0·165	+0·025	+0·55
Excelsior No. I.	C. Schniewindt	20	8 04	80·292	+0·0947	4·6	+0·238	+0·262	−0·18	..
ExcelsiorNo.II.	C. Schniewindt	22	8·75	5 792	+0·1417	1·56	..	..	..	..
Ia-Ia	Fleitmann, Witte & Co.	9	$8{\cdot}97_6$	50·7	−0 0029	39·12	+1·4	−0·15	−0·42	−0·021

* The manganin coils were the only ones hard soldered and protected with varnish.

the variation of resistance of all pure metals except iron and thallium was the same, and also put forward the remarkable law that the ratio of the temperature coefficient of an alloy to the mean temperature coefficient of its constituents is equal to the ratio of the conductivity of the alloy to their mean conductivity for an alloy of two metals. It follows from these two statemen's that a low temperature coefficient is associated with a great increase in the specific resistance of the alloy over that of its constituents. Mathiessen came to the conclusion that an alloy of one part by weight of platinum to two parts silver had the lowest temperature coefficient, and that there would be great difficulty in obtaining an alloy with lower temperature variation. German silver was found to be nearly as good, while the addition of a little tungsten has since enabled the temperature coefficient to be reduced to that of platinum-silver. As to permanency, Mathiessen concluded that lead was the best of the pure metals, while an alloy of gold and silver was found the most permanent of the alloys. He also investigated the statement of Schroder van der Kolk that the conductivity of copper is changed by the passage of even a weak current through it, but found no such effect.

With the exception of Prof. Bottomley's measurements on platinoid,* invented by Martino in 1885, and some tests on platinum silver, platinum iridium and nickel, by Klemencic,† nothing of importance seems to have been done on the subject until 1889, when Weston‡ found that alloys of manganese and copper, or of manganese, nickel and copper, had a very small temperature variation. In an article in *The Electrician* in 1892, Dr. St. Lindeck‡ describes these alloys and the researches on them made at the Reichsanstalt, coming to the conclusion that an alloy of 84 per cent. copper, 12 per cent. manganese and 4 per cent. nickel was most suitable, to which the name manganin was given. The specific resistance was high, 42 microhms per cube centimetre, thermo force against copper only 1 to 2 microvolts per 1°C., and the temperature coefficient was only 0 0025 per cent. between 0°C. and 10°C., and practically nil between 30°C. and 40°C., after which it became negative. At the same time they had found that alloys of copper and nickel also had a very low coefficient, an alloy of equal parts of each, which was termed constantan, having a temperature variation of only 0 003 to 0·004 per degree Centigrade, but this was regarded as unsuitable for standards of high precision owing to its high thermo force (about 40 microvolts) against copper. Manganin was therefore adopted for standard resistances, subject to the precautions of protecting it from the atmosphere, owing to its tendency to oxidation, and of artificial aging by prolonged heating to 140°C. in an air bath.

In 1898 a further communication on the subject of resistance alloys was made by the Reichsanstalt,* giving the results, firstly, of tests on copper-nickel-zinc alloys, and, secondly, of manganin. The effects of composition, of winding and annealing, are given, with the conclusion that zinc is prejudicial to permanency. An extremely interesting set of observations on the properties of copper-nickel and copper-manganese alloys of various proportions were made, showing that with nickel alloys the temperature variation was negative between 38 and 48 per cent. of nickel, and zero with these proportions. This, of course, upsets Dr. Mathiessen's conclusions, but it is remarkable how closely the increase and diminution of the conductivity of the alloy is connected with the temperature coefficient. The addition of the small quantity of nickel in maganin is for the purpose of eliminating the small thermo force remaining in copper-manganese alloys (although copper-nickel alloys have a very high thermo force). The composition for manganin was fixed at 86 per cent. Cu, 12 per cent. Mn and 2 per cent. Ni.

Although the use of manganin has been adopted and adhered to in Germany, it has not found universal favour in this country, and even up to the present time many are sceptical as to its permanence. This is doubtless due in large measure to the fact that the early experiences with manganin in England were unfavourable. Many will remember that the first consignments of manganin which were obtainable here had by no means a low-temperature coefficient, and the alloy was frequently crystalline and brittle. In consequence of this opinion Mr. J. H. Agar Baugh in 1903 went to the trouble of procuring samples of all the resistance alloys at that time procurable, and gave the writer a set of these samples for the purpose of tests.

Recent Tests on Resistance Alloys.—Measurements have been made on these wires by Mr. Jolley, the senior demonstrator in the electrical department of the Northampton Institute, with the object of determining their specific resistance, temperature variation, thermo E.M.F. against copper, and in some cases the effect of bending, annealing, &c. A few of the more important alloys have also been chemically analysed by Mr. S. Field, the head of the chemical department.

For the resistance measurements the form of Carey Foster bridge devised by Mr. Hughson and the writer was employed, and the observations may be relied on to 1 part in 100,000. In obtaining the specific resistance the specific gravity of each specimen was very carefully determined by weighing in air and water, and the diameter calculated from the length and weight. Thermo forces were determined by the deflection on a moving coil galvanometer, which was calibrated in microvolts by connecting to the terminals of a 0·001 ohm standard resistance through which a known current

* *Proc.* Royal Soc., May 7, 1885. *The Electrician*, XV., p. 125.

† "Untersuchungen über die Verwendung des Platin Iridiumdrahtes und einiger anderer Legirungen zur Anfertigung von Normalwiderstande." J. Klemencic. *Anz. d. Wiener Akad. d. Wiss.*, 1888, p. 166.

‡ "Alloys for Resistance Coils." St. Lindeck. *The Electrician*, XXX., . 119, 1892.

* Rollo Appleyard. *Electrical Review*, XLII., p. 536, 1898.

† "Metallegirungen fur Elektrische Widerstande," K. Feussner and St. Lindeck. *Zeit. fur Inst.*, IX., p. 233, 1889.

‡ It should be mentioned, however, that nearly all of these alloys contained a trace of iron or other impurity.

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was passed. The effects of bending and annealing were determined by coiling the wire, which was in each case of 1 mm. diameter, round a mandrel 1 cm. diameter, and afterwards heating for 10 hours at 100°C. and 10 hours at 160°C.

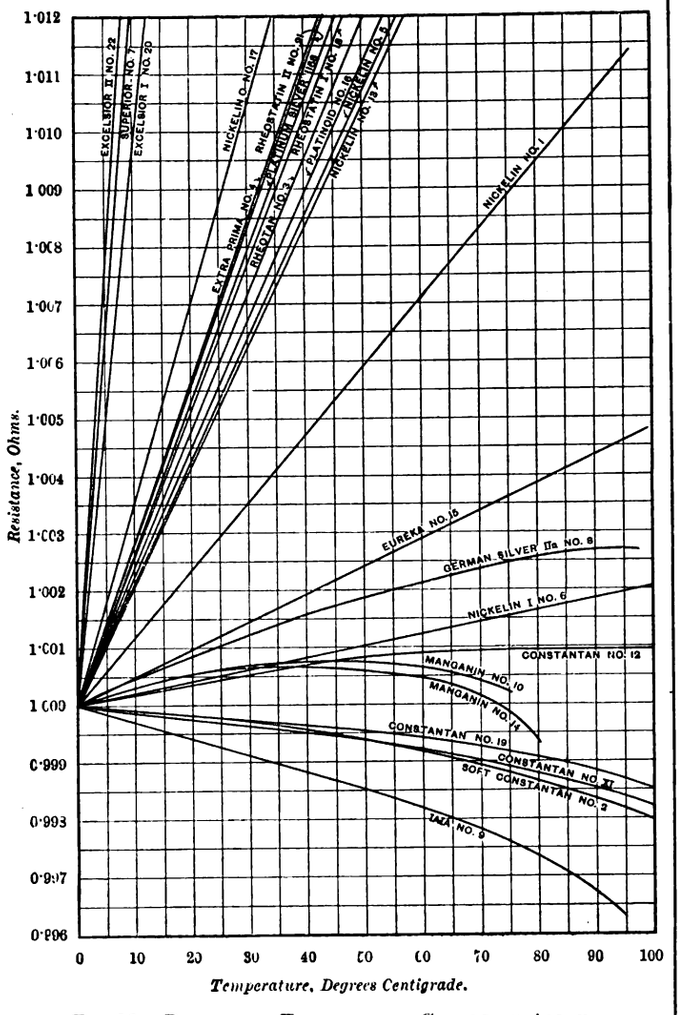
The curves in Fig. 16 and the accompanying table are self-explanatory and little comment is needed, except to call attention to the much greater curvature of the manganin curves over that of any other alloy, and to the fact that four alloys have negative co-efficients of from 7 to 29 millionths per 1°C.

An inspection of the manganin curves shows that they are sufficiently nearly parabolic in form for the resistance to be represented by formula $R_t = R_{max.}\{1+\beta(T-t)^2\}$, where $R_{max.}$ is the maximum value of the resistance and T the corresponding temperature. For the two specimens of manganin tested we have

Manganin No. 10 $\rho_t = 39{\cdot}17\{1 - 3{\cdot}9\times10^{-7}(42{\cdot}6 - t)^2\}$ microhms.

No. 14 $\rho_t = 36{\cdot}65\{1 - 4{\cdot}15\times10^{-7}(39 - t)^2\}$,,

The resistance of manganin coils might conveniently be stated as shown in the adjoining table.



Temperature, Degrees Centigrade.

FIG. 16.—RESISTANCE TEMPERATURE CURVES OF ALLOYS.

In connection with the last column in the table, which gives the alteration which has taken place in two years, it should be mentioned that the coils were soldered to copper lugs with ordinary solder and were not protected, except in the case of manganin, which was both hard-soldered and varnished. Little reliance can therefore be placed on these figures, but they have been included for what they are worth. They at any rate confirm within the accuracy worked to, the constancy of manganin when properly protected.

Mr. Baugh has recently obtained another resistance material from the Messingwerk Achenrain, which is made in various grades and is stated to have a temperature variation of only −0·001 per cent. per degree, combined with a thermo-E.M.F. of only 1·4 micro-volts per 1°C. Tests have not yet been made on these alloys, but will be undertaken shortly.

(To be continued.)

THE CALCULATION OF CENTRIFUGAL FORCE.*

BY EGON SIEDEK.

The circumferential velocity is usually given in the case of high speed machinery, such as dynamos coupled to turbines. But this is no measure of the centrifugal force, which depends on the speed of rotation, and might be great or small according to the circumstances. Thus, if a weight of 1 lb. rotates with a velocity of 80 ft. per second over a radius of 3 in., the centrifugal force will be about 800 lb.; if it rotates at the same speed over a circular path, having a radius of 6 ft. the centrifugal force will be only 33 lb.

The author, therefore, proposes that the centrifugal force acting on a weight of 1 lb. and moving with the velocity of the circumference of the given body shall be called the "centrifugal factor," and be denoted by the letter F. The centrifugal force, acting on any part of the body, moving under the same conditions—*i.e.*, at the same radius and with the same circumferential speed—will, therefore, be found by multiplying its weight by the centrifugal factor.

The following is an elementary exposition of the relation between the centrifugal factor, the velocity and the number of revolutions per minute. Let F be the centrifugal factor, G be the weight of the body in pounds, P the centrifugal force, which is equal to GF; g is the acceleration due to gravity, and is equal to 32; v is the circumferential velocity in feet per second; r is the radius of the path of rotation in feet, and n is the number of revolutions per minute, m being the mass of the body.

Then $P = \frac{mv^2}{r} = \frac{Gv^2}{rg}$, and $v = \frac{2\pi rn}{60}$. It is then easy to show that $P = \frac{Gnv}{300}$ nearly. The centrifugal factor is obtained by putting G equal to unity, and therefore $F = \frac{nv}{300}$.

This formula is very simple and convenient, and the centrifugal force acting on any mass is at once obtained by multiplying its weight by the centrifugal factor. The radius ought to be calculated for the centre of gravity of the rotating part, and as a rough approximation the formula gives very good results. It seems, therefore, desirable in describing the construction of machinery driven by turbines that the centrifugal factor should be given instead of the circumferential velocity, and it is then easy to calculate at once the forces acting on the different parts of the machine.

THE EFFECT OF FREQUENCY UPON THE CAPACITY OF ABSOLUTE CONDENSERS.†

BY J. G. COFFIN.

It has been proposed to construct an absolute condenser of two plates of optically plane glass. In order to render the faces conducting and at the same time employ the well-known method of Perot and Fabry for determining their parallelism and their distance apart it is necessary to half-silver the opposing faces of these plates. If such a condenser is to be charged and discharged many times a second, as is usually the case in their comparison with others, a doubt arises as to the completeness with which they acquire their charges, in view of the inevitable fact that this conducting film has a very high resistance. A theoretical calculation was made of this effect with rather surprising results—for example, if the condenser be two plates of rectangular shape 10 cm. long, resistance of 5,000 ohms per linear centimetre and capacity of 100 cm. per linear centimetre, it was found that at a frequency of 1,000 alternations per second the ordinarily assumed capacity was 1 per cent. too large, while if the frequency rose to 10,000 per second it was 65 per cent. too large.

The mathematical method employed is one involving the imaginary variable, and is somewhat similar to the method used in calculations of the influence of frequency upon the self-inductance of coils, with which the writer has had a great deal to do lately.

The two additional cases of a circular plate condenser, involving Bessel's functions, and that of a circular ring condenser involving ordinary functions, have also been solved. The results are in agreement with those for the rectangular condenser mentioned above.

In conclusion, it is found that condensers with plates of high resistance when used with alternating currents cannot be assumed to have their maximum capacity as ordinarily calculated. Their effective capacity decreases with increasing frequency, and this diminution may attain large values even under moderate frequencies.

* Translated from the *Elektrotechnische Zeitschrift*, April 25, 1907.

† Abstract of a Paper presented at the New York meeting of the American Physical Society, March 2, 1907.

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TELEPHONE RATES.

During the last few weeks there has been considerable agitation in the provinces due to the new policy of the National Telephone Co. in refusing to make further contracts on a purely flat rate. This change of policy does not mean that existing contracts will be in any way interfered with, but new subscribers will not have the opportunity of paying, say, £10 for an unlimited service costing possibly double that amount. Users of the telephone have become so accustomed to the flat rate that to many of them it appears quite irrational to suggest that any other rate is desirable, except for the subscriber who wishes to use a telephone to a comparatively small extent. Yet the large user would never expect to have an unlimited supply of gas or electricity for a fixed sum per annum, or if such terms were arranged the sum would certainly be fixed so high that no consumer would consent to accept the terms. There are very few commodities or services in which an unlimited supply is given for a fixed sum. The railway season ticket is an exception, but in that case it is a simple matter to estimate approximately the extent to which the ticket will be used. Domestic water supply is another case, and electricity supply on the Continent and in a few of the less important towns in the

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Colonies is also, to some extent, an exception to the general rule; for in the case of systems generating electrical energy by means of water-power it is not unusual to accept certain small consumers at a fixed price per lamp per annum in order to avoid the cost of a meter.

A telephone service, however, is a somewhat different matter. Originally telephones were used simply as private lines in order to connect the different sections of a business together, or to put an office into communication with a warehouse or works, and in such cases as these the service was an unlimited service as a matter of course. When, however, these users of the telephone were gradually connected together by means of an exchange, additional costs of another kind arose. The capital costs increased rapidly, as large switchboards were put down and the necessary exchange premises and wayleaves were obtained. The result of this change from a private to a public system is that the subscription has now to cover a much larger number of items. At the present time the capital cost per subscriber amounts to something approaching £35. In any case, therefore, the capital charges on this amount must be met; but, apart from this, there are the running charges, consisting of maintenance of the lines, instruments and exchanges, and the item of labour for handling the calls. The extent to which subscribers vary in the use of their telephones is enormous, and the cost of labour and of a great deal of the plant is in direct proportion to the number of calls. Moreover, the extension of a telephone system is a serious business. If the number of subscribers is doubled, this does not mean that the capital expenditure is merely doubled, for the capital increases very much more rapidly. This fact is forgotten by those who compare the telephone system of London with that of Stockholm, and always to the disadvantage of the former.

The result of the flat rate has been that if a subscriber does not feel it is worth his while to pay a comparatively heavy annual sum he changes to the toll system, but where he reaches the opposite conclusion he retains the flat rate, and probably works his line very much more heavily than it should be worked with any regard to efficiency. Consequently, other subscribers are apt to ring up and find the number of this particular subscriber continually engaged, until they come to the conclusion that the telephone service is very bad, that it is hopeless to ring up this subscriber in future, and the subscriber in question may thus lose a good deal of business which he might otherwise secure.

To those who are accustomed to deal with problems of power supply and the rates which should be charged, it will appear only reasonable that the National Telephone Co. should abandon the flat rate, as has been done in many other countries already, and should adopt the message rate exclusively. By the proposed system of charge a subscriber can contract for any number of calls per annum, the rate for which decreases as the number of calls increases, until a limit of something less than ½d. per call is reached. Considering that a subscriber is generally called up as frequently as he calls other subscribers, this means that he will pay at the rate of about ¼d. per call if he is a very large user. A rational basis of this kind enables all classes of subscribers to be treated fairly, whereas, if a subscriber who uses his telephone to a large extent is given a rate which is unremunerative to the Company, the small user is simply penalised to make up the difference. Naturally the large user objects to any movement that may tend to increase his payments. This is only what must be expected, but it is certainly strange that Chambers of Commerce, which are supposed to have the welfare of the small as well as the large trader at heart, should engage in agitation against the introduction of sound business principles.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

A Handbook of Wireless Telegraphy. By James Erskine-Murray. (London: Crosby Lockwood & Son.) 10s. 6d. net.

This very lucidly written volume is attractive and readable to a degree that few works on technological subjects can ever claim or hope to be. It would seem to have been put together with the idea in mind of pleasing the greatest possible number of people. In the first place, the dilettante of wireless telegraphy will here be able to obtain at a single reading, with judicious omissions, a bright picture of the possibilities and the actual accomplishments of wireless telegraphy. In the second place, the "heavy" electrical engineer will appreciate the broadly descriptive style of the book as a whole. And lastly, those who may call themselves experts or engineers in wireless telegraphy will find much interesting information not to be met with in other text-books on wireless telegraphy. Of this seldom-seen information just referred to, there are two kinds. One kind is purely and solidly scientific; the other kind consists of a résumé of the somewhat sensational promises which have been at times poured forth by boastful inventors. The purely scientific kind of information is, for the most part, provided in the shape of long extracts from published memoirs. The quotations from memoirs are in the main appropriate and well chosen, and will give many very practical people, for the first time, a clear notion of the bearing of some of the major researches into details of wireless telegraphy; but the other kind of information, what we have called the sensational matter, is of doubtful utility. For instance, it is scarcely proper to devote a whole chapter of a technical work, a work proposing to deal with facts, to the scheme of "world-wave" wireless telegraphy excogitated by Nikola Tesla, even though the scheme's fantastic character does make it delightful reading.

One of the principal and commendable features of the book is that an attempt is made, for the first time we believe, to set forth fully and connectedly the problems of the laws governing transmission of signals to long distances and of the losses that occur through atmospheric absorption or other causes. The subject is an important one, one that is demanding more attention every year. Its discussion in the present work is, unfortunately, greatly hindered by the scarcity at the present time of available quantitative data; but the author carries matters as far as published results allow him. Another principal feature of the book is that the various sensitive devices for detecting the oscillations produced in the receiving circuits by electric waves are more carefully discussed than usual, both as regards their practical performance and their scientific basis. Here, we think, the author is at his best; and some of his remarks on the processes taking place in the receiving circuits are acute and noteworthy.

The sending apparatus is not treated with the same strength and sympathy as is the apparatus at the receiving end. For example, the very important distinctions between direct coupling and inductive coupling, between loose coupling and close coupling, are not explained adequately; nor are the consequences of alterations in degree of coupling on the emitted wave-length expounded. The measurement of the damping factor of the oscillations generated is treated badly; and even the important measurement of the wave-length is somewhat neglected, only one particular form of wave-meter being mentioned. Most noticeable of all is the scant attention given to really modern methods of generating waves—the common induction coil takes up nearly all the space granted to this

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subject, while the methods of producing oscillations by the electric arc are passed over with bare mention. While grumbling at these things, it may be observed that it is unfortunate that in a book of this calibre so much space as is actually given should be devoted in Chapters IX., X. and XI., especially X, to long reprints, virtually commercial in character.

Precision Grinding. By H. Darbyshire. (London: Archibald Constable & Co.) 162 pp. 6s. net.

The writer considers that "on practical and economic grounds increased knowledge of the craft will lead to general adoption of grinding processes in workshops." He has found from long experience that the use of a suitable grinding wheel, combined with other essential conditions, produces better results than the older method of finishing details with file and emery cloth. The scope of the book includes the manufacture and re-setting of grinding wheels, cylindrical, plane and conical grinding, lapping of various kinds, and the relation of the grinder to machine design. The general rule is given that the softer the material the harder the grinding wheel to be used, the seeming paradox being explained by the fact that in grinding a hard surface the bond should readily give up particles of grit, and so quickly expose new cutting grit edges as the old ones become rounded and useless. Then again, stress is laid on the necessity of the wheel "always cutting freely even with the lightest depth of cut, for any pressure in the last finishing cuts will either overheat and so distort the work or else disturb the method of holding." The residual particles scraped from the surface by the grinding wheel are seen under the microscope to consist of shavings very like those obtained in any machinery process. All these shavings are coloured, showing intense heat, and in the case of cast iron they are rounded as if due to fusion. A liberal supply of water at the grinding point is essential for plane and cylindrical grinding, except in certain cases, of which cast iron is given as an instance.

A considerable space is given to such details as the true and rigid packing of the work on the machine, and to consideration of temperature changes as producing final irregular work and "chatter" marks. Minute details are given as to the technicalities of lapping, the best bond substance for which is "soft close-grained and well-annealed cast iron." But for an extra fine finish thick glass is used; it is first lapped with cast iron, and then it will grind without further charging.

Much useful information is compressed into the volume. The descriptions are clear, but the material used might be more systematically arranged and grouped. The drawings are good but not very plentiful.

SOME FACTS AND PROBLEMS BEARING ON ELECTRIC TRUNK-LINE OPERATION.*

BY F. J. SPRAGUE.

(*Continued from page 949.*)

Summary.—In this Paper the author makes a vigorous and detailed attack upon single-phase traction for trunk railways. The various parts of the electrical equipment are considered in turn. Conductors, when used for alternate currents, suffer loss of current capacity through impedance. Single-phase motors, although effective, are much heavier than continuous-current motors of the same capacity when considered on a thermal basis, and the weight of the complete single-phase equipment for a locomotive comes out to be about double. The differences between single-phase and continuous-current motors are given in some detail. Polyphase motors also are considered by the author to be unsuitable. After considering the pros and cons of electric braking, the author discusses the various systems of working conductors at present available, and describes an improved form of under-contact third-rail, designed by Mr. Wilgus and himself. Recent suggestions to use 15 cycles instead of 25 cycles show some advantages, but the total weight of single-phase apparatus on a car will remain much the same. After describing recent examples of locomotives, and considering some minor points, the author concludes that the field of the single-phase system is on roads with sparse traffic, and that where the traffic is dense a comparatively high-pressure continuous-current system is to be preferred.

Motor and Locomotive Constructions.—Locomotive designs, influenced in part by the type of motor adopted, show a great variety of constructions, and may be very generally classed as rigid frame with all weight on the driving axles and without leading trucks, rigid frame with either single axle or bogie leading trucks at each end, and bogie-truck locomotives, the bogies being pivoted under the cab, and sometimes linked together.

On all multiple-unit trains, except such as are designed for very high speed, in which case there is a possibility of a gearless motor development, the standard method of motor mounting introduced on the Manhattan Elevated Railway in 1886, and which has been in vogue ever since, bids fair to continue. It provides for centring the motor and carrying a part of its weight upon the driven axle, to which it is connected by any required ratio of gearing, the other end being flexibly suspended from the truck above the side springs.

Up to capacities of 250 H.P., about the limit required and permissible for motor-car equipment, single driving on one end can be used, but when this type of motor is built for larger sizes, in connection with locomotives, it seems almost necessary to provide for gear driving at each end, which presents some difficulties in construction. To overcome these, the introduction of a spring has been proposed, but the use of an adjustable gear rim seems preferable. To reduce the dead weight on the axle, one of the French railways some years ago centred the motor on a quill which surrounded but was supported clear from the axle, connection being made from the quills to the drivers through springs.

An analysis of the action of a locomotive demonstrates beyond question that this general type of machine, that is, one having a rigid frame and no guiding trucks, is limited to moderate speeds, and would be unsafe if operated at high speed on a road with much curvature and special work. Notwithstanding the fact that it has been strenuously advocated, even recently, I think this particular type will not find favour among the railroad men, and it is already practically abandoned in the proposals of the manufacturers in favour of a bogie-truck type, or an articulated type composed of two rigid frames with single-axle leading trucks at each end of the complete unit. It is also proposed to carry the geared motors, centred on a spring-connected quill, directly over the main driving-axles, and to support the entire motor by springs from the locomotive frame.

Particular interest naturally centres upon the distinctive types of locomotives installed on four important railway systems, the Valtellina and the Simplon Tunnel in Switzerland, the New York Central, and the New York and New Haven, which well illustrate three of the principal methods of construction developed to meet the demands of different electrical systems. I will briefly describe each, as well as make some comment upon a few of the many other types recently proposed.

As illustrating a high order of electrical and mechanical engineering, the work of the Ganz Company merits special mention, for it is undoubtedly true that the present status of the polyphase system, which stands on a favoured plane with many Italian engineers, is owing almost entirely to the efforts of this company. The polyphase motor locomotives built for the Valtellina Railway and for the Simplon Tunnel are strikingly individual in their construction. The axle mounting of motors is abandoned, the motors being entirely separate units mounted on the locomotive frame and coupled to each other and the 62 in. driving wheels through an ingenious combination of connecting and side rods. Of the three pairs of main drivers, the middle only is journaled in the main frame, each end-pair being journaled at one end of a pivoted guiding truck, at the outer end of which are guiding wheels about one-half the diameter of the driving wheels. The end drivers have a limited end play, and one king bolt has a similar freedom of movement, while the other is fixed, resulting altogether in great freedom of adjustment to track curvature. The two motors, spring supported through the locomotive frame, are each quarter-cranked, and connected to side rods having downwardly projecting jaws which loosely engage the driving pins of the middle drivers, the centres of which are somewhat below the centres of the motors. On each side of the jaws of the side rod are coupled the connecting rods of the outer drivers, provision being made in all bearings for the necessary freedom of movement and adjustment. In an earlier type, the locomotives were equipped with two sets of twin motors for high and low tension, the low tension to be operated in cascade relation to get slow speed in starting and for running on grades, then to be cut out and the regular running to be with the high-tension motors alone. In the latest machines the twin motor construction has been abandoned, and the locomotives are equipped with two 15 cycle high-tension polyphase motors, one having 8 and the other 12 poles, and an arrangement of field circuits in the latter machine such that it can be temporarily made a low-tension motor operating in cascade relation with the other. This combination permits of three regular operating speeds of about 16, 26, and 40 miles per hour. At the lowest speed the motors are in cascade relation with high draw-bar pull, at middle speed the 12 pole motor is in operation alone on high tension, and at the highest speed the 8 pole motor is used alone, likewise on high tension. Of course, the physical connection of the two motors together and to all driven

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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makes this method of operation possible. The rated capacity of the motors, as given by Valatin, is extraordinarily high, that with the 12 poles being stated as 1,200 H.P. and that with 8 poles 1,500 H.P., based upon the one-hour rise of temperature of 75 deg. The motors average about 13 tons each. The use of connecting rods in this locomotive is not as objectionable as the use of the driving and connecting rods in a steam locomotive, because the strains are very different and the rotative weights can be far more perfectly balanced. It can be fairly said to have the advantage that with the minimum possible weight of locomotive there is no such thing as slipping an individual wheel, a trouble which will occur at times with all locomotives having independently driven axles if equipped with powerful enough motors, because of variation in motor characteristics, track and wheel conditions, and unequal wheel pressure caused by the draw-bar pull. Almost the entire weight of the locomotive is spring-borne, and the behaviour of the machine on curves even at high speeds ought to be very satisfactory. The same general construction would lend itself very effectively to the application of high-tension interpole direct-current motors, and may be very seriously considered in this connection.

The New York Central type of locomotive, the Batchelor machine as developed by the General Electric Co., consists essentially of a heavy steel frame in which are journaled four main axles, and which is terminated by pivoted single-axle ponies provided with spring resistance against deflection from the central position. The motors are the gearless type, the armatures being mounted directly on the axles, and the bipolar field-magnets forming an integral part of the

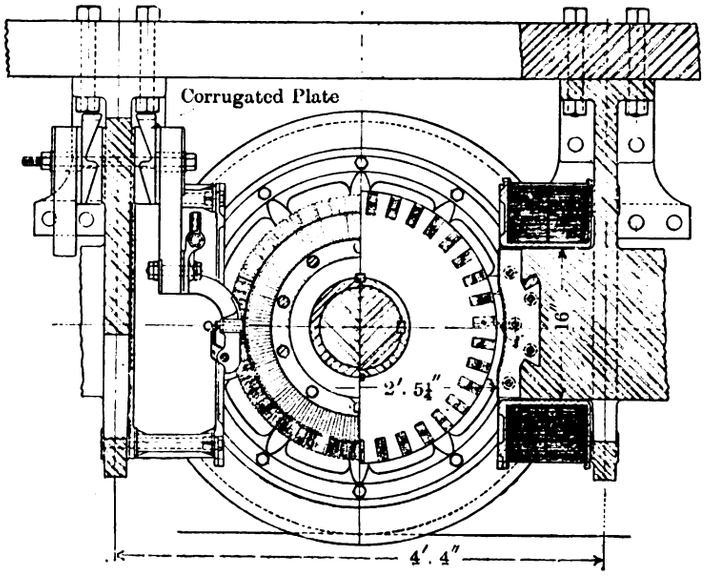

FIG. 9.—TRANSVERSE SECTION. BIPOLAR DIRECT-CURRENT MOTOR.

main frame; they are, therefore, carried with it by the equalising springs, and have free motion relative to the armatures. In addition to the regular truck frame, an additional path is provided for the magnetic flux, which passes through all the armatures and field poles in series, by a heavy bar extending the length of the frame and carried above the motors. Being of the two pole type (Fig. 9), and with a quadrant winding, the motors are extraordinarily free from sparking tendencies; in fact, they are, structurally, natural 1,200 volt machines, although only wound for present operation at 750. So marked is this characteristic that the brushes, which are 180 deg. apart, instead of being carried on yokes concentrically with the commutator, are carried on arms attached to the field-magnet frame (Fig. 10), and although moving with it operate perfectly. The electrical and mechanical construction is, therefore, reduced to an acme of simplicity never hitherto attained in electric locomotives, for not only are there no gears, but there are no armature or field bearings, quills, driving spiders or special spring connections, although all the weight of the motors except the armature is spring-supported. The air-gap is very large, and as the pole pieces are very nearly flat a complete axle unit with its armature can be readily dropped out, and replaced without disturbing the balance of the motor equipment. This type of machine, of course, cannot be used with any form of alternating current directly, no matter what the frequency. Experimental trials extending over two years, with 67,000 miles of operation, amply demonstrated its remarkable reliability and efficiency, qualities confirmed by the operation of 35 of these locomotives now delivered and in regular service. The total weight of the locomotive, without heating equipment, is about 95 tons, of which 70 tons is on the drivers. The nominal capacity, with 75 deg. rise and natural ventilation, is 2,200 H.P., at which output with 600 volts the machines run at 300 revolutions, corresponding to 40 miles an hour. The rigid wheel-base is 13 ft., the total wheel-base 27 ft. and the length over all 37 ft. The individual control is the series-parallel bridge method, with resistance variation, the grouping of motors varying from four in series to four in multiple, and current is taken from the under-contact rail by side-extending slipper-shoes. Although the electric service of the New York Central was inaugurated only as recently as December 22nd last, already 305 train movements, representing 86 per cent. of the present total of the New York Central and Harlem trains, both locomotive-drawn and multiple-unit, are operated electrically. The aggregate delay has been less than with the old steam service, a fact particularly noticeable in times of snowstorms.

The New Haven alternating-current direct-current locomotives* are built by the Westinghouse Electric & Mfg. Co. The first of these machines, pulling a short train, made entry into the Grand Central station on May 11, 1907, and in a short time the operation of the equipment should be under service test. Some question has been raised as to whether trucks with drivers of so large a diameter as 62 in., on which are concentrated 15 tons of motors in a limited wheel-base, will track properly under all conditions of rail. Experience, however, is the final criterion.

In order to combine the possibility of single-phase alternating-current transmission at high voltage by overhead trolley and the unquestioned advantages of the direct-current motor, it has several times been proposed to introduce between the line supply and the motors a motor-generator set, comprising an induction motor taking current directly from the line, and driving a continuous-current generator to supply the motors, this converting set being carried in the main cab, with provision made for the extra weight by bogie

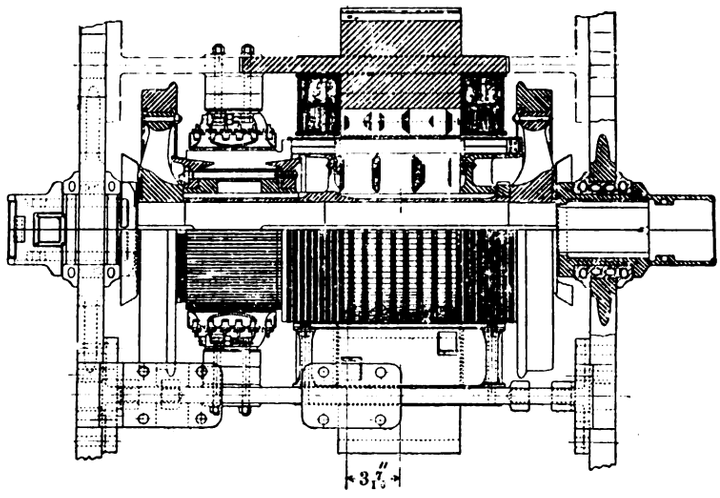

FIG. 10.—LONGITUDINAL SECTION. BIPOLAR DIRECT-CURRENT MOTOR.

trucks at each end, or in an independent tender taking the place of the steam tender in existing steam practice. Of course this is the introduction of a moving sub station individual to the locomotive which is operated by it, and makes the latter subject to all the idiosyncrasies of the intermediate apparatus, besides laying up an enormously expensive machine in case of any special trouble. Where the motor-generator set is carried in a separate tender this disablement only cuts out a part of the equipment, which can be replaced by another like part, but in any case it is debatable whether such a moving sub-station offers any advantage over the stationary one.

Sometime since I made a very careful investigation of the possibilities of direct-current gearless and geared motors, the former of the bipolar type, for identically the same service, a very severe one. Both machines were of the four-axle bogie-truck type, the trucks being linked together. The geared locomotive weighed 93 tons and the gearless 126 tons, but the weight per axle was well within the usual allowance. On each truck were four motors, connected two in series, to be operated at a maximum line potential of 1,500 volts. The geared motor construction was of the usual standard, but fitted with commutating poles, while the gearless machine had modified bipolar motors of the New York Central type. A comparison of the efficiency curves of the two machines showed for each from 87 to 88 per cent. on a five-hour load, and falling only to 83 per cent. with 50 per cent. increase, while at half this load the efficiency of the gearless machine was much higher than that of the geared. Some adequate idea of the capacity of the gearless machine may be gathered from a statement that it would maintain a drawbar pull of nearly 25,000 lb. at a good rate

* We hope to describe these locomotives in our next issue.—ED. *E.*

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of speed for several hours continuously, and with natural ventilation. These extraordinary characteristics would, for the class of service for which these machines were considered, amply warrant the additional weight because of the simplicity of the gearless machine.

A very promising type of machine, embodying many of the good features of those which had preceded it, is now under construction by the General Electric Co., for use either on direct current, or with a motor-generator set supplied from an alternating-current trolley. This machine is of the four-axle free bogie type, the drawbar pull being taken through the main frame. On each truck, and forming an integral part of it, are two bipolar gearless motors driving the middle pair of axles, and at either end of each truck is a pair of leading wheels of smaller diameter, which have a limited, spring-resisted side play. The normal wheel-base of each truck is 12 ft., the total wheel-base 32 ft. and the length over all 36 ft. This machine should be capable of an almost unmatched speed and freedom in following irregular curvatures, and with special ease of track approach.

The various locomotives thus briefly described are but a fraction of those proposed by various makers to fit particular conditions and types of apparatus. Their construction does not, in many particulars, meet the preconceived ideas of some steam locomotive builders, with whom a high centre of gravity and all the weight possible carried on springs is a cardinal principle, and a very correct one when we consider the necessities of the steam locomotive. The electric locomotive has a lower centre of gravity, that of the New York Central machine being about 44 in., the New Haven 51 in., and the Ganz probably somewhat higher, while that of the steam locomotive is sometimes as high as 73 in. The electric machine, therefore, will have less tendency to topple over, but a greater resultant side pressure in case of irregularity of track when entering a curve, or running on an irregular track, than its rival, a larger portion of whose weight heels over and increases the vertical pressure on the rail. Careful investigation, however, carried on through many sources, and inaugurated by reason of the recent derailment on the New York Central road, seems to indicate that with electric motors properly guided any increased tendency to side-thrust is more than compensated for by certain other advantages.

Train Control and Operation.—Ten years ago I inaugurated on the South Side Elevated of Chicago a new system of train control, now known the world over as the "multiple unit," and generally recognised and adopted as the best method of handling trains wherever service is crowded and high schedules are required. The essential result accomplished by this system is increase of capacity, by providing high power equipments proportional to the length of the train, increased schedules and density of train movement, the lowest maximum speeds for any given schedule, similarity of equipment, reduced switching and signal movements, increased safety, and generally the utmost independence and facility of operation. I believe that it is inevitable that all local and suburban passenger service on electrically equipped railways will be eventually conducted on the multiple-unit plan.

The use of steel car-bodies, heavier trucks and addition of motor equipment means increased weight, and increase of schedule means increased capacity of motors, and it is, therefore, of the utmost importance that capacity be got with a minimum of weight, and likewise with restricted armature speeds, especially where stops are frequent. According to all present developments, as I have already indicated, the direct-current equipment has in this service an enormous advantage over any single-phase alternating-current motor equipment with its car transformer.

Irrespective of the benefits to passengers, and the influence in building up suburban service by providing a high schedule train system which can be absolutely adjusted to the needs of traffic, the influence on the capacity of the terminal facilities of a railway is of the utmost importance. It has been declared by a competent English authority that the use of multiple-unit trains in the suburban service of a congested station at least doubles the capacity of that station in the matter of track movements and the dispatch of trains. Again, the use of electricity makes it possible to double-deck a terminal, bringing through trains in on one level and suburban trains on another, and using both for storage. As a net result, it may be safely stated that, so far as train movements are concerned, the capacity of a yard, over and above that required for the storage of cars alone, can be trebled as compared with steam-locomotive-drawn trains. In addition, the yards can be roofed over, and the space utilised for streets, parks or buildings.

The remarkable extension of the multiple-unit system and its recent application to locomotive practice, as, for example, on the New York Central Railroad, have led to the suggestion that freight trains shall be equipped with secondary controlling lines, and that a number of locomotives, not only at the head of the train but distributed throughout it, shall be handled by a single operator on the leading engine. I do not hesitate to pronounce this an impracticable scheme for general application. Quite aside from the cost of equipping the hundreds of thousands of rapidly deteriorating freight cars, it would be against public policy, and contrary to the most ordinary safety of train operation, to leave such an extended and high-powered train in charge of a single man. While double headers under a common control will undoubtedly be used when necessary on both freight and passenger trains, when one considers all the varying conditions of trunk-line operation, neither public policy, safe railroad operation, nor labour conditions would permit the handling of a train with two or more locomotives so coupled up with only one man in the cab.

(*To be concluded.*)

ENGINEERING EXHIBITION AT OLYMPIA.—III.

There are naturally many exhibits of machinery and apparatus accessory to engineering matters proper. Among these we may mention the constantly increasing devices—the products of the laboratory and the chemist rather than of the engineer—for the scientific control of combustion in raising steam and its subsequent utilisation in power plants of every description.

Central station engineers and steam users generally will be interested in the exhibit of "Sarco" specialities made by Sanders, Rehders & Co., who have an attractive stand in the body of the hall. The construction of the "Sarco" steam meter is based on the standard formulæ of Zeuner-Napier and others, relating to the flow of steam from one vessel to another and the drop in pressure which is thereby occasioned, and which has a certain relationship to the quantity of steam passing. In the application of this principle to the "Sarco" meter a disc with a bore slightly smaller than

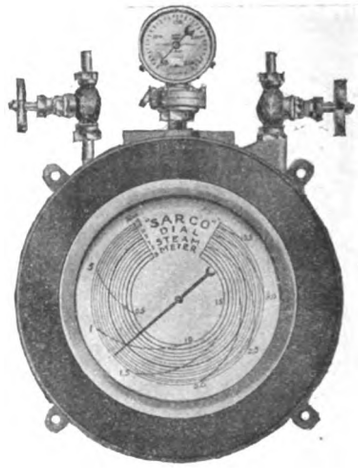

Fig. 5.—Circular Dial Pattern "Sarco" Steam Meter.

the diameter of the pipe is placed between two existing flanges at a point where it is desired to ascertain the volume of steam flowing. A slight drop in the pressure takes place behind the throttle, and the difference in pressure on the two sides is the medium through which the volume of steam is measured on the "Sarco" instrument.

The simplest form of indicator consists of a wrought-iron casing carrying a mercury gauge glass, and a circular drum upon which is a printed interchangeable diagram. The pressure on the boiler side of the throttle disc is transmitted to the base of the gauge glass through a tube on the right-hand side of the casing, whereas the smaller pressure behind the throttle is communicated to the top of the glass through the tube on the left. The glass is filled with mercury to the zero line on the diagram, and when the indicator is connected to the throttle disc by copper tubing the position of the mercury shows on the diagram, in pounds per second, the exact volume of steam flowing at that instant. For fine measurements, as, for instance, the checking of the working of steam engines, turbines, &c., a steam dial indicator is recommended. A hand on a large and clear dial takes the place of the gauge glass. The dial is interchangeable, and so arranged that pounds of steam per second are indicated directly, also at varying pressures (Fig. 5). The construction is similar to that of the recording instrument which will now be described.

The "Sarco" steam recorder, shown open in Fig. 6, is made for steady or varying pressures, fitted with charts or aggregating indexes for 24 hours. Its construction is as follows: A reservoir, A (Fig. 7), containing a quantity of mercury, is in communication, on the one hand, with the two tubes which connect to the throttle disc, and, on the other hand, through two tubes, B and C, with a vessel, D, of special shape and suspended on two finely balanced and carefully tempered springs, E. These connections are so arranged that the higher steam pressure tends to force the mercury out of re-

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ceptacle A, along tube B and into vessel D, whereas the lower pressure is communicated to the top of vessel D through tube C. Thus the difference in pressure again determines the height of the mercury and also the position taken up by vessel D. The motions of this vessel are communicated to the chart H by lever F and pen G; or they may be transmitted to an index of special construction. The drawing also shows at K-L a special arrangement by which the action of the pen is automatically controlled to conform to the fluctuation in the steam pressure.

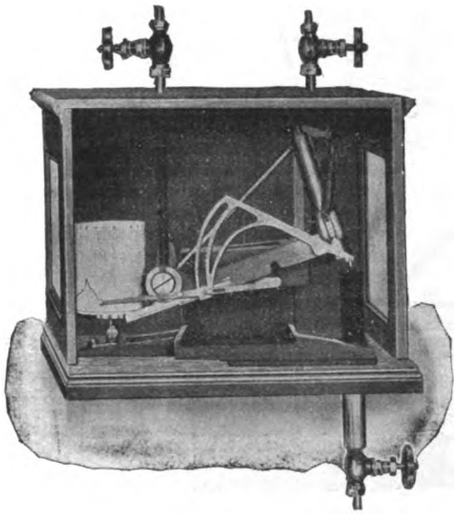

FIG. 6.—INTERIOR OF STEAM RECORDER.

The recording chart is arranged for 24 hours, and is calibrated in pounds of steam per second. The instruments are designed for all sizes of pipes and any pressure. Only the throttle discs and diagrams, dials or charts vary, and are supplied to suit each particular case. The instruments may be erected in any desired posi-

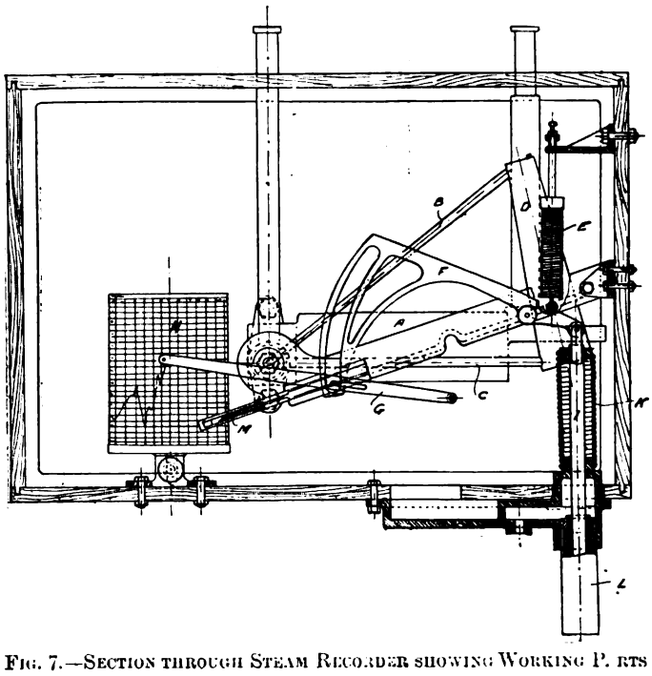

FIG. 7.—SECTION THROUGH STEAM RECORDER SHOWING WORKING PARTS

tion, and the connection between throttle and meter is made of ¼ in. copper tubing. This is kept full of water, so that the instruments are always cool, and they do not come in direct contact with the steam.

Another interesting instrument shown is the "Sarco" feed water meter, which consists of the strainer box A (Fig. 8), containing a cylindrical copper sieve, and the meter proper. The type having a capacity of 2,000 gallons per hour measures 18 in. in length without the strainer. The iron casing B has a phosphor bronze lining C, and the two covers are lined with the same material. The moving mechanism is an alloy of nickel steel, which is said not to be affected by sudden and wide fluctuations in temperature. It consists of the drum D (mounted on the spindle E), and the wings F, G, H, I, the latter having attached to them, both at the top and bottom, studs K. The water flows in at L, and falling on wing F causes the drum to rotate. This brings the studs K on this wing in contact with cam M (a similar cam is also attached to the top lid), and, on moving on further, the latter forces the outside rim of the wing tightly against the casing, making a water-tight joint, as shown in the position of wing G. Simultaneously, wing H has moved round towards the water outlet N, and, after having passed this, is gradually closed and pressed against the drum by the guide-block O. In the course of this movement all the water between that wing and the drum is forced out at N.

As a certain small amount of force is required to effect this injection of water, and as it must be removed before the wing can pass

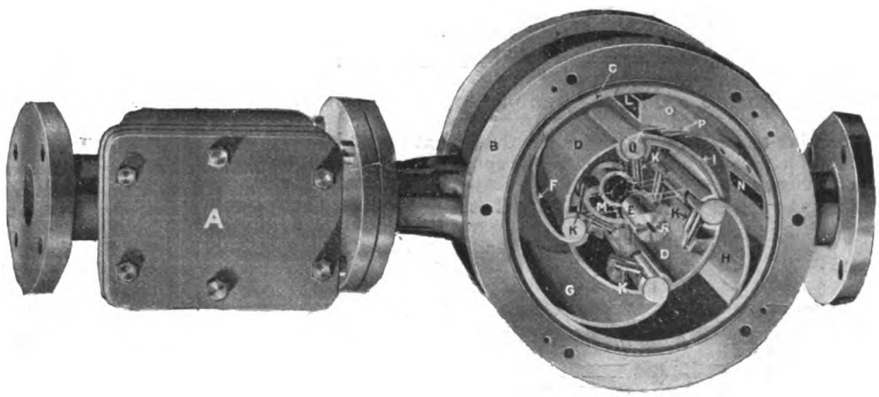

FIG. 8.—INTERIOR VIEW OF FEED-WATER METER.

the block O, the meter is not subject to inaccuracy on account of centrifugal force, which causes some rotary meters to revolve after the water supply has been interrupted. Before it can be released, the wing must pass the two blades P and Q, which are held open by the pressure of the water, and make a good joint between the inlet and outlet sides of the meter. These blades act at the same time as brushes, cleaning the wings of any scale that may have collected on them. The meter is designed to make about 30 revs. per min., and the motion of the mechanism is transmitted to the index, fixed on the upper lid (and isolated from the water) by a small spindle, the flat end of which engages in the small slot R at the top end of the main axle. The meter is suitable for the suction or delivery side of the pump, and is made for all pressures.

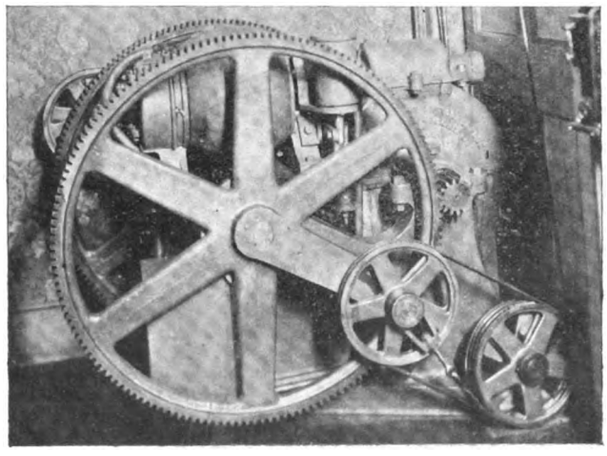

FIG. 9.—BARLOW ELECTRIC LIFT GEAR.

It works horizontally, vertically, or in an inclined position, and is placed direct in the feed pipe without special foundations or supports. These meters can be supplied fitted with thermometer pocket and thermometer.

BARLOW'S patent lift gear, which is exhibited in its application to service lifts, is shown in the annexe to the main hall at Olympia. This gear possesses many good points. As will be seen by the illustrations (Figs. 9, 10, 11), the novel idea of an extensible rope has been adopted, in conjunction with sets of fixed and revolving pulley wheels. The moving wheels are pivoted on a pin near the rim of a large spur-wheel, and in moving towards or away from the fixed pulleys cause the rope to lower or raise the cage which is

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attached to the free end of the rope. The other end of the rope is attached to the moving pin carrying the revolving pulleys. No reversing of the driving motor is needed as the spur wheel makes a half-turn for the up and down journeys of the lift respectively, remaining on the horizontal dead centre line at the end of each run. Suitable switch gear attached to the spur wheel causes the stoppage of the motor at these particular points. The arrangement is at present applied to two point lifts and starting is effected by push buttons at the upper and lower lift doors. A single-phase motor is shown in operation, the drive in this case being with double spur wheels as shown in line drawing (Fig. 11). We are informed that any desired speed may be arranged for with these lifts.

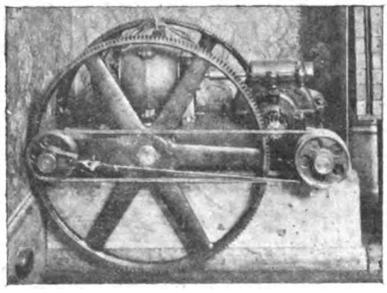

FIG. 10.—ANOTHER FORM OF BARLOW LIFT GEAR.

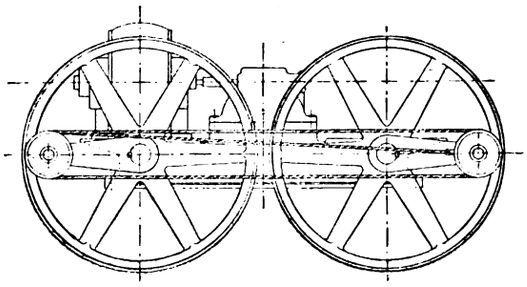

FIG. 11.—BARLOW LIFT GEAR FOR SINGLE-PHASE MOTORS.

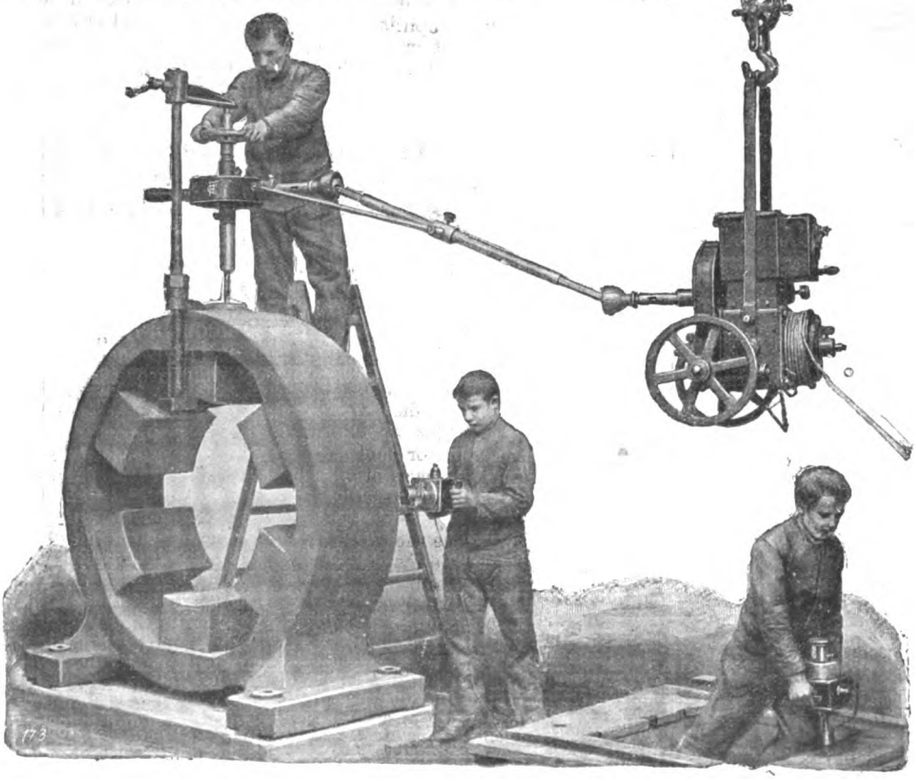

FIG. 12.—PORTABLE ELECTRIC TOOLS IN USE ON ELECTRICAL MACHINERY.

We have already referred briefly to the electric tool exhibit of Messrs. S. WOLF & CO. This appears to be one of the most complete of its kind in the Exhibition. The very light drills for work up to ¼ in. are well designed and constructed, though they weigh only 6 lb. These little tools are also made for alternate-current circuits, but as this is not available for power purposes at the stand only the parts of the drill are shown. A feature of the tools, both drills and grinders, is the neat manner in which the switch for starting and reversing is housed within the motor casing.

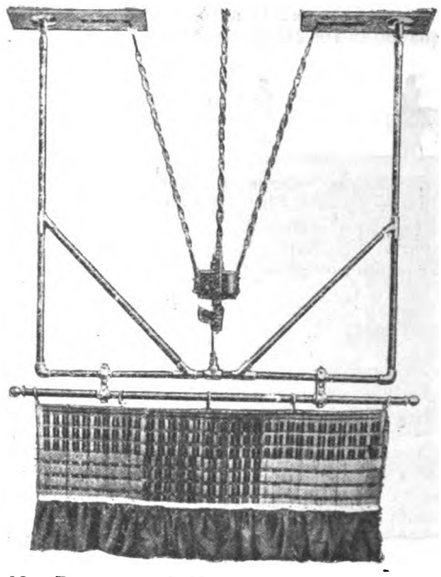

FIG. 13.—BERGTHEIL & YOUNG MOTOR PUNKAH FAN.

The switch is, in addition, within easy reach of the workman's finger. Among the exhibits is a number of small motors, on trolleys or in slings, fitted with flexible shafts for drilling or grinding at a distance. We give an illustration (Fig. 12) of various methods of applying these drills in the preparation of dynamo and motor parts in electrical manufacturing shops. On this stand is also shown a two-volt system of ignition for motor cars and cycles. This is made from trembler and non-trembler coils, and, judging by the experiments shown, gives a satisfactory spark. The current consumption is said to be reduced, and we were informed that a run of 5,000 miles had been made with a motor cycle on one charge of a 2 volt accumulator.

At the stand of Messrs. BERGTHEIL & YOUNG a novel form of electric punkah is shown in operation. This is stated to reproduce exactly the motion of the hand punkah common to Indian towns and cities. As will be seen by the illustration (Fig. 13), the arrangement consists of a rigidly suspended motor with conical pulley on the underside, and a swinging frame to which a short curtain of fabric is loosely hung. Attached to the upper side of the frame is a padded quadrant pivoted on a bearing pin and controlled by a spring. This quadrant is pressed either to one side or the other of the coned pulley of the motor with which it engages. When the motor is started, the pulley rolls against the quadrant and carries it away from the vertical position. In fact, there is a sufficiently strong pull given to the quadrant to take it and the punkah clear of the pulley to a point from which it tends to swing back again by gravity. On the return stroke, however, the motor is still running, and as the quadrant now strikes the opposite side of the pulley the punkah is swung in the opposite direction. This cycle of operations is repeated while the motor continues to run. The effect on the air is to produce a cooling and pleasant breeze.

In our reference to the exhibit of Messrs. Stirk & Sons last week we mentioned that the cut of the lathe was 15½ in. by ½ in. This should have read ½ in. to ¾ in. The last sentence of this description also obviously referred to the drilling machine and not to the lathe, in so far as tapping was concerned.

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CHOKE-COILS VERSUS EXTRA INSULATION ON THE END-WINDINGS OF TRANSFORMERS.*

BY S. M. KINTNER.

Summary.—In this Paper the author discusses the advantages and disadvantages of choke-coils used instead of extra insulation on parts of the transformer windings so as to withstand surges, and considers that for a given expenditure better results can be obtained by their use.

Surges along a transmission line are stopped and thrown back by choke-coils in a manner analogous to the reflection of water waves by a breakwater at the entrance to a harbour.

A choke-coil will be effective in reflecting and shielding all behind it according to its strength, which is measured by its inductance and its insulation. If the former is small, but little reflection will take place, the surge passing through the coil and continuing beyond it. If the insulation of the coil is weak and the inductance is of sufficient value to retard the oncoming wave and throw it back on to the line, the rise of voltage will cause a discharge over the coil face and the wave will continue past the coil.

There is no relation between the coil and the apparatus being protected that will make the coil more or less effective in its operation of throwing back surges that come in from the line. The choke-coil will produce the same percentage of reflection regardless of what it is protecting, and consequently can be said to be affording the same protection.

Tests indicate that the same percentage of protection will be afforded by the same coil for all parts of the same transformer—that is, measurements made over 200 turns of the winding of a transformer which was being subjected to static surges from a discharging condenser, first, when the transformer was unprotected, secondly, when it was protected by a choke-coil, showed practically the same percentage of protection afforded by the choke-coil when the measurements were repeated over only 20 turns of the transformer. A long series of tests, the results of a part of which have been recently made known to the Institute by Mr. R. P. Jackson,† have convinced the writer of the truth of the above statements.

In choosing a choke-coil for a particular installation the matter resolves itself into a consideration of: (1) the possible surge the apparatus can withstand safely; (2) the probable surge that can be transmitted over the proposed line, the line insulation indicating the maximum voltage that the surge can have during transmission; (3) the maximum allowable inductance that will not seriously affect the line regulation if an external choke-coil is used; (4) a consideration of the amount of money to be expended for choke-coils as insurance against interruption; (5) the selection of a choke coil which will most nearly meet the above conditions, the selection being guided by the above, combined with the results of tests and curves similar to those shown in Mr. Jackson's Paper.

The question of whether part of the transformer winding should be made strong enough to withstand the surges—and thus have within its own windings a choke-coil that protects the rest of the apparatus—or whether an extra coil should be used, will be discussed below.

The following is a list of the advantages and disadvantages of separate choke-coils.

Advantages: (1) On a choke-coil there is normally no voltage between turns, and consequently no tendency to hold a short-circuit in the event of a momentary surface discharge. (2) The choke-coil permits the construction of a transformer with uniform insulation throughout. This permits the safe working of such a transformer with several methods of connection to the line. (3) The choke-coil allows the safe use of a cheaper transformer. (4) The choke-coil can be insulated much more strongly than a transformer.

Disadvantages.—(5) Increase in the number of pieces of apparatus. (6) Increase in complication of station wiring when external choke coils are used.

1. One of the greatest advantages of choke-coils over extra insulation on the transformer windings lies in the fact that the choke-coil does not normally have a voltage between turns. In the event of a choke-coil insulation failing between turns, nothing in the nature of a short-circuit results, as there is no voltage difference to maintain an arc. On the other hand, a failure between turns in the insulation of a transformer is vital, and it is almost certain to result in a transformer burn-out. A part of the choke-coil will be cut out and will be inoperative, and consequently the coil less effective as a whole is the worst that can result from such a failure in the coil insulation.

2. The second point of superiority of the choke-coil—allowing the use of a transformer which is uniformly insulated—is of great advantage to the builder as well as to the operator. In the majority of specifications for power transmission transformers, it is required that the transformer be capable of operating at one-half voltage at full rated capacity. In general, it is expected also that occasion may arise when the transformer may be operated either in star or delta connection. It is evident that to meet all the above conditions with certain parts of the transformer specially insulated involves some very complicated insulation arrangements and requires extra insulation on a large part of the whole transformer.

3. In consideration of the third point, that of cost of transformer, it should be remembered that the better grade of power transmission transformers of 1,000 kw. and upward are wound with copper ribbon one turn per layer. These coils are insulated uniformly throughout, so as to stand momentary voltages of from 5,000 to 9,000 between turns. In order to get this result, only about 8 to 10 per cent. of the available winding space can be used for copper, the rest being given up to solid insulation and oil-ventilating ducts. An increase in insulation over the above is not desirable with the insulating materials in use at this time, for two reasons: first, the coils cannot be made strong enough mechanically to stay in place under the shocks to which they are subjected; secondly, the extra insulation retains the heat from the copper and thus either burns out or necessitates a much lower rating of the transformer. It is very difficult for workmen to handle large coils with extra heavy insulation without injury to the insulation. It is therefore evident that a cheaper transformer can be employed when a protecting choke-coil is used.

4. The fourth advantage of the choke-coil is that much better insulation can be obtained in it than in a transformer. This is due to the fact that more material can be used between turns, and it can be disposed to better advantage by allowing more extension beyond the copper than could be employed economically in a transformer coil; also the shape of the coil is much simpler than that of the average transformer coil and thus more readily lends itself to better insulation.

5-6. Both of these disadvantages are very materially reduced when it is permissible to mount the choke-coils inside of the transformer tank. It is thus possible to make the choke-coil a part of the transformer terminal, the coil being connected on the inner end of the terminal. For some installations it is possible to use choke-coils mounted out in the air and thus made a part of the station wiring, but in general the oil-insulated coil is to be preferred. Past practice has been to have each oil-insulated choke-coil mounted in its own tank, but there seems to be no good reason why they cannot be placed inside the transformer tank and thus save considerable floor space as well as outside wiring.

After a thorough consideration of what is involved in the above points, it is the writer's opinion that for a given expenditure to provide protection against surges, more can be obtained by the use of choke-coils than by extra insulation on the transformer.

* Abstract of a Paper read at the Convention of the American Institute of Electrical Engineers, at Niagara, June, 1907.

† *The Electrician*, March 15, 1907, p. 856.

MEASUREMENT OF INSULATION RESISTANCE AND CAPACITY OF INDIVIDUAL CONDUCTORS OF AN ALTERNATE-CURRENT NETWORK DURING WORKING.*

BY DR. J. SAHULKA.

In the case of continuous-current networks, the potentials to earth of the individual conductors are determined solely by the insulation resistances of the conductors, generators and consuming devices. In alternating-current networks two additional factors come into play: the capacities to earth of the conductors, generators and consuming devices, and the dielectric hysteresis losses in the insulating materials, in so far as these losses arise by reason of a P.D. between a conductor and earth. The capacities of the conductors relatively to each other, and the dielectric hysteresis losses arising therefrom, do not come into consideration in this connection, since a capacity between conductors is equivalent to a consuming device. Since the dielectric hysteresis loss varies as the square of the voltage, we may suppose it imitated by the loss in a certain equivalent constant resistance connected between the conductor and earth. This equivalent resistance may be conveniently termed the *hysteretic resistance* of the conductor, and the insulation resistance may be thought of as connected in parallel with the hysteretic resistance. The joint resistance of the two may be termed the *loss resistance to earth* of the conductor. The generators and consuming devices likewise possess a definite loss resistance. In what follows it will be assumed—as is usual when dealing with continuous-current networks—that all insulation and hysteretic resistances and capacities of the system are transferred to the main conductors. The methods described below for measuring the loss resistances and capacities to earth of the various members of an alternate-current system are based on the assumption that none of

* Abstracted from the *Elektrotechnische Zeitschrift*.

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the conductors are earthed, and, in the case of a three-phase system, that the neutral point is not earthed. A suitable measuring instrument is an electrostatic voltmeter. The only other pieces of apparatus required for the purposes of the test are resistances whose values are of the same order as the loss resistances.

Single-phase Systems.—Fig. 1 is the diagram of a single-phase system; L_1 and L_2 denote the two conductors, C_1 and C_2 their capacities to earth, f_1 and f_2 their loss resistances to earth (the earth connection being represented by 0). The working voltage is represented by e, the potentials relatively to earth of the two conductors by ϵ_1 and ϵ_2, R.M.S. values being understood in each case. The currents flowing through the loss resistances are denoted by i_1 and i_2, the capacity currents by i' and i''. Fig. 2 is a vector diagram of the voltages and currents.

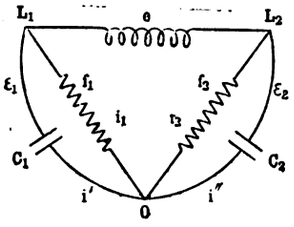

FIG. 1.

Although several methods of measurement are available in the case of a single-phase system, the author's experience has led him to the conclusion that the following method is the only satisfactory one.

The voltages ϵ_1, ϵ_2 having been measured under normal conditions of working, their new values ϵ_1', ϵ_2' are determined when a known resistance, r_1, is connected between L_1 and earth, their values ϵ_1'', ϵ_2'' when a different resistance, r_1', is substituted for r_1, and, lastly, their values ϵ_1''', ϵ_2''' when a resistance, r_2, is introduced between L_2 and earth. The ratio of the voltages to earth of the two conductors may always be put equal to the ratio of their impedances to earth (since the same current flows through both impedances). The above measurements thus yield four equations. It will be convenient to choose for our variables the following: $x_1=1/f_1$; $x_2=1/f_2$; $y_1=pC_1$

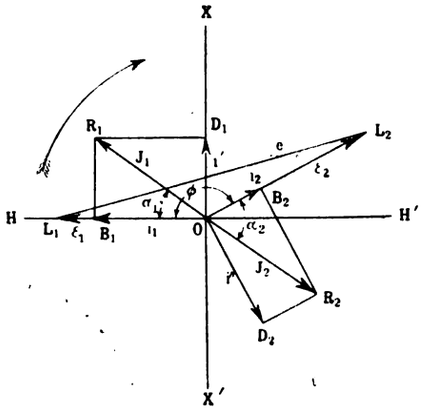

FIG. 2.

and $y_2=pC_2$, where p stands for $2\pi\times$ frequency. We thus have the following four equations:—

$$\epsilon_1^2[x_1^2+y_1^2]=\epsilon_2^2[x_2^2+y_2^2]. \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\epsilon_1'^2\left[\left(x_1+\frac{1}{r_1}\right)^2+y_1^2\right]=\epsilon_2'^2[x_2^2+y_2^2]. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$\epsilon_1'''^2\left[\left(x_1+\frac{1}{r_1'}\right)^2+y_1^2\right]=\epsilon_2'''^2[x_2^2+y_2^2]. \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\epsilon_1''^2[x_1^2+y_1^2]=\epsilon_2''^2\left[\left(x_2+\frac{1}{r_2}\right)^2+y_2^2\right]. \quad . \quad (4)$$

The most convenient method of dealing with these equations is as follows: On substituting numerical values for the known quantities the equations (1), (2) and (3) are divided respectively by ϵ_2^2, $\epsilon_2'^2$ and $\epsilon_2'''^2$; equation (2) is next subtracted from (1), and (3) from (1). Two equations are thus obtained not containing the variables x_2 and y_2. Between these the quantity $x_1^2+y_1^2$ is eliminated, and an equation obtained which is linear as regards x_1, so that the value of x_1 is easily determined. The value of y is next found by substituting the known value of x_1 into the equation previously obtained by subtracting the modified (2) from the modified (1). Equation (1) then yields the value of $x_2^2+y_2^2$, and on substituting this in (4) we obtain a linear equation in x_2, on solving which y_2 is finally obtained by means of the known value of $x_2^2+y_2^2$

Three-phase Systems.—Fig. 3 is the diagram of a three-phase system, Fig. 4 giving the relative magnitudes and phase relations of the various voltages and currents. The method of measurement is as follows: The three line voltages e_1, e_2, e_3, as well as the voltages to earth ϵ_1, ϵ_2, ϵ_3 of the conductors, are first measured under normal conditions (only two of the three voltages ϵ_1, ϵ_2, ϵ_3 need be measured). The values so obtained yield the voltage triangle of Fig. 4, and the angles ϕ_1, ϕ_2, ϕ_3. A resistance, r_1, is next connected between one of the conductors—say L_1—and earth, and the new values ϵ_1', ϵ_2', ϵ_3' of the voltages to earth are determined.

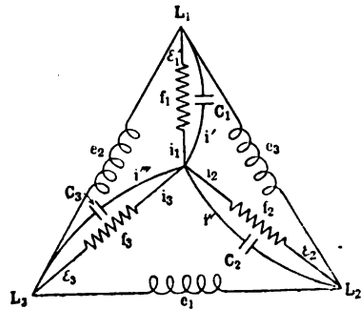

FIG. 3.

The corresponding vector diagram is constructed and the angles ϕ_1', ϕ_2', ϕ_3' are measured. The resistance r_1 must be so chosen that the neutral point 0 falls within the triangle, and should be of the same order as the loss resistance of the conductors. If the conductors of the system are not arranged symmetrically, an additional set of values, ϵ_1'', ϵ_2'', ϵ_3''', must be determined by connecting a resistance, r_2, between L_2 and earth; the corresponding vector diagram gives the values of ϕ_1'', ϕ_2'', ϕ_3''. In each case, the line voltages e_1, e_2, e_3 should be measured, as these may vary slightly from one measurement to another.

Each vector diagram yields two equations for the determination of the unknown quantities $x_1=1/f_1$, $x_2=1/f_2$, $x_3=1/f_3$, and $y_1=pC_1$, $y_2=pC_2$, $y_3=pC_3$. These equations are obtained from the considera-

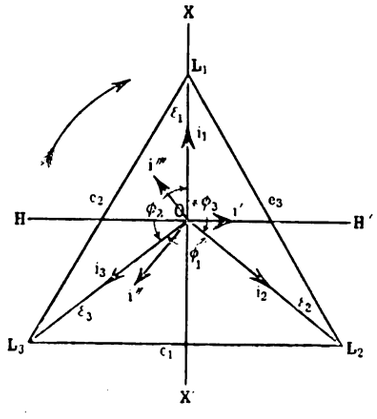

FIG. 4.

tion that the sum of the instantaneous values of the six currents flowing to earth (i_1, i_2, i_3, i', i'', i''' in Fig. 3) is zero, and hence that the sum of the components of the current vectors along any two mutually perpendicular directions must vanish. We may conveniently choose for one of these directions that of ϵ_1 (*see* Fig. 4). The six equations are:—

$$\epsilon_1x_1+0+\epsilon_2x_2\cos\phi_3+\epsilon_2y_2\cos(\phi_3+90^\circ)+\epsilon_3x_3\cos\phi_2+\epsilon_3y_3\cos(\phi_2-90^\circ)=0. \quad . \quad . \quad (5)$$

$$0+\epsilon_1y_1+\epsilon_2x_2\cos(\phi_3-90^\circ)+\epsilon_2y_2\cos\phi_3+\epsilon_3x_3\cos(\phi_2+90^\circ)+\epsilon_3y_3\cos\phi_2=0. \quad . \quad . \quad . \quad . \quad (6)$$

$$\epsilon_1'\left(x_1+\frac{1}{r_1}\right)+0+\epsilon_2'x_2\cos\phi_3'+\epsilon_2'y_2\cos(\phi_3'+90^\circ)+\epsilon_3'x_3\cos\phi_2'+\epsilon_3'y_3\cos(\phi_2'-90^\circ)=0. \quad . \quad . \quad (7)$$

$$0+\epsilon_1'y_1+\epsilon_2'x_2\cos(\phi_3'-90^\circ)+\epsilon_2'y_2\cos\phi_3'+\epsilon_3'x_3\cos(\phi_2'+90^\circ)+\epsilon_3'y_3\cos\phi_2'=0. \quad . \quad . \quad (8)$$

$$\epsilon_1''x_1+0+\epsilon_2''\left(x_2+\frac{1}{r_2}\right)\cos\phi_3''+\epsilon_2''y_2\cos(\phi_3''+90^\circ)+\epsilon_3''x_3\cos\phi_2''+\epsilon_3''y_3\cos(\phi_2''-90^\circ)=0. \quad . \quad . \quad (9)$$

$$0+\epsilon_1''y_1+\epsilon_2''\left(x_2+\frac{1}{r_2}\right)\cos(\phi_3''-90^\circ)+\epsilon_2''y_2\cos\phi_3''+\epsilon_3''x_3\cos(\phi_2''+90^\circ)+\epsilon_3''y_3\cos\phi_2''=0. \quad . \quad (10)$$

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On substituting in the above the numerical values of the known quantities, we obtain six linear equations, from which the variables are easily determined by successive elimination. In the commonly occurring case of a system having symmetrically arranged conductors, only two sets of measurements are necessary, and only the first four equations are required, since in this case $y_1 = y_2 = y_3$.

Insulation Tests during Working.—For the purpose of keeping a record of the state of the insulation of a system, an electrostatic voltmeter may be connected between one of the conductors and earth, and the voltage ϵ_1 measured. A resistance, r, is next connected in parallel with the voltmeter, the value of r being so chosen as to lower the potential of the conductor to the value ϵ_1', which is less by a definite amount, say 10 per cent. The worse the insulation of the conductor, the less must r be made in order to bring about this result. In the case of a bad earth, the distribution of potential will be altered considerably. The position of the point 0 of zero potential is, in the case of a single-phase system, determined by a single measurement, ϵ_1, and in the case of a three-phase system by two measurements, ϵ_1 and ϵ_2. The point of zero potential roughly coinciding with the position of the fault, it becomes possible to determine whether the fault has occurred in a conductor or in a consuming device. In the former case, ϵ_1 is equal to the working voltage between the faulty conductor and that to which the voltmeter is connected. If now a low-reading voltmeter be connected between the earth and the faulty conductor, the drop of potential to the fault may be measured, and by taking into account the current the position of the fault may be roughly determined. The fault resistance x may also (independently of the position of the fault) be found approximately, provided the effect of the fault greatly exceeds that of the normal insulation resistances and capacities. In that case we have

$$\frac{r}{x} = \frac{\epsilon_1'}{\epsilon_1 - \epsilon_1'},$$

so that

$$x = r\left(\frac{\epsilon}{\epsilon_1'} - 1\right).$$

CORRESPONDENCE.

MUNICIPAL AND COMPANY TRAMWAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. McElroy, in his presidential address to the Municipal Tramways Association, complains that most of the critics on municipal trading have failed to present their case free from bias, and so I assume that we have now presented to us by the mouth of the manager of one of the most important municipal undertakings the case for municipal trading closely reasoned and free from the taint which he rightly condemns.

We cannot blame him on account of his youth; on the contrary, we congratulate him that, like some of us, he has never had cause to learn what we should like to forget.

It is, therefore, unfortunate, that he goes back 40 years to find a tramway act which is put forward as "an act which was framed for the purpose of imposing proper conditions safeguarding the public interest in every possible way," because, beyond probably taking exception to the terms of purchase, no one has ever doubted its reasonableness applied to the methods of traction known when it was passed, as now defined by numerous legal decisions.

Many of us have, however, frequently protested against additional protective clauses beyond what the Legislature thought necessary, which have been inserted by amateur law-makers with the assistance of sec. 22 of the Standing Orders, which has been illegimately used so frequently for purposes akin to blackmail—a section which Mr. McElroy considers a most obstructive one, now that *he* wishes as a tramway promoter to invade other people's territory for the purposes of profit, as well as the establishment of a huge monopoly such as he condemns in others.

What particularly strikes me in the address is the complete absence of any generous spirit. There is no reference or any tribute given to the enterprise of those who laid the foundation stone of the splendid system of tramways now managed by Mr. McElroy—on the contrary, we have somewhat contemptuous remarks on selfish interests, speculators, and watered capital. Few, if any, municipal authorities entered into the field of gas, water or tramways until they had been induced by the results of private enterprise to covet Naboth's Vineyard, and they appear to grudge the inadequate prices "with no allowance for goodwill" at which they acquired the tramway companies' properties. The success of the Manchester undertaking does not appear to have been much affected by the existing law.

When local authorities acquired private tramway undertakings they knew what they were buying and the income that could be expected, a very different condition of things from that prevailing when the promoter and the capitalist took the risk of success or failure. If you took a North Eastern Railway director to Darlington he would not ridicule Stephenson's first engine; on the contrary, he would say that was the foundation of their enormous business. This is the difference between common broad-minded justice and generosity and the fanatic who thinks no good thing can come out of Nazareth.

Being dependent for my living on the professional assistance I render to both municipal bodies and private companies, I can have no bias. It is pleasant to be able to think that one's exertions, before Mr. McElroy was heard of, have assisted in the development of an industry which presents many examples of useful and prosperous undertakings in the hands of both private and municipal owners. Many of these municipal undertakings are well and ably managed by men whom I am glad to mention as friends—men brought up and trained in the field of private enterprise, whose services have been sought by the municipal trader. They know both sides; they know the senseless clauses devised by the fertile brain of Parliamentary agents for the protection of everything and the hampering of tramway companies on all hands, which are conspicuous by their absence in Municipal Acts. They are able to appreciate the difficulties met with in the past and the energy and industry of those they formerly served; they know how much they are indebted to the past, and my sympathy is extended to them for having to listen to much that would not appeal to their common sense, with the deference due to a presidential address.

If a town chooses to have a tramway all to itself, why not? Parliament says it may. I am not going to enter into the controversy of municipal trading. But if a town prefers to leave the problem of traction enterprise to private enterprise, rather than add to the number of those whose tramway undertakings are to-day a burden on the rates, then why should Mr. McElroy interfere by attributing selfish or corrupt motives to those who endeavour to remove what they feel to be unjust conditions obstructing the development of private enterprise in these cases? A tramway service is one for the public benefit, whoever owns it, and deserves justice, even if it belongs to shareholders. Let Mr. McElroy stick to the management of his tramway system, for which we give him full credit, and leave the question of public policy to men who are judicially minded and trained.—I am, &c.,

London, Sept. 30. STEPHEN SELLON.

ATLANTIC WIRELESS TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The statement made in your last issue that "the annual meeting of the Marconi Company will be held in a fortnight's time" is quite incorrect, and no notice has been sent out by the company for the next general meeting.

It is also incorrect to state that the Post Office takes no responsibility with regard to our wireless messages.

If a message is handed in, in accordance with the intimation supplied in the time table of ship-to-shore communications prepared by the Marconi Company and issued by the Post Office to their telegraph offices, the money paid for transmission will, in the event of non-delivery of the message, be refunded in full (the Post Office foregoing its portion of the charge). The only cases in which the money will not be refunded are:—

(*a*) If the sender hands in a message after the time specified in the time table of communications, or

(*b*) If the sender hands in the message before the time, but so close to it that the Post Office official accepting the message has considered it desirable to warn the sender, and has actually warned the sender, that there is a risk of non-delivery.

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If the Post Office official does not warn the sender the money is refunded.

The conditions regulating this service are fully stated in the Post Office Circular of 1904, No. 1,641.

The delivery of messages to ships is dependent both upon the efficiency of the wireless service and upon the ships being within range of the shore stations. Ships do not move with clockwork regularity, and they are sometimes within and sometimes out of range. When we guarantee communication refunds are made if the messages are not delivered. A guarantee of communication is always given unless a request is made for transmission of a message to a vessel at a time when the vessel by ordinary calculation is out of range. It should be remembered that vessels steaming from 20 to 25 knots may move out of range in a very short space of time. In accepting messages at the inland telegraph offices it is therefore necessary to limit the period during which a guarantee of communication can be given.—I am, &c.,

MARCONI WIRELESS TELEGRAPH CO. (LTD.)

London, Oct. 1. H. Cuthbert Hall, Managing Director.

[As to the meeting of the Marconi Company, we have the authority of an article, apparently inspired, in the *Daily Mail* for our statement. It was positively asserted that the meeting would take place in a few days, and as this announcement appeared in a journal which was devoting leading and other articles to the subject of the Marconi Company's business, we felt fully justified in accepting the statement as official. Moreover, as recently as Oct. 1 inst. the Marconi Company has informed the public that the shareholders' meeting should have been held in June, "but the directors decided not to hold the meeting until the intentions of the Government with regard to the Radio-telegraphic Convention became known." It is perfectly well known that the Government intends to ratify the Convention, and we have the authority of the Postmaster-General's report for this statement. This is confirmed by the Prime Minister's announcement early in August.

With regard to the Post Office and its relations with the Marconi Company, it is, we think, the assumed association between the company and the Post Office that is accountable for the fall in the price of telegraph securities and the consequent injury to an important branch of the electrical industry.

But our main point, after all, is that, in the event of the threatened competition between one branch of international telegraphy and another, the Post Office shall not associate its name and prestige with the wireless service until such time as this long-promised service has been demonstrated to be reliable, in the same manner as the service rendered by the cable companies is reliable.—ED. *E.*]

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.

"A Treatise on Hydraulics." By Wm. Cawthorne Unwin, F.R.S. (London: Adam & Charles Black.) 12s. 6d. net.

"Some Practical Notes on the Commercial Development of Electricity Supply Undertakings." By R. Borlase Matthews. (London: H. Alabaster, Gatehouse & Co.) Reprinted from the "Electrical Review."

"Proceeding of the Incorporated Municipal Electrical Association, 1907." (London: Wyman & Sons.) 5s.

"Proceedings of the Royal Society." Vol. LXXIX. Series A. No. A534. Mathematical and Physical Sciences. (London: Harrison & Sons.) 1s. 6d.

"Matriculation Directory." No. XLVII., Sept., 1907. (Cambridge and London: University Correspondence College.)

"Les Industries Électrochimiques." By Jean Escard. (Paris: Ch. Béranger.) 25fr.

"Müller-Pouillets Lehrbuch de Physik." By Leop. Pfaundler. Vol. III. (Brunswick: Friedrich Vieweg & Sohn.) 16m.

"Konstruktionen und Schaltungen aus dem Gebiete der Elektrischen Bahnen." Edited by O. S. Bragstad. (Berlin: Julius Springer.) 6m.

"Die Elektrischen Bahnen und Ihre Betriebsmittal." By Herbert Kyser. Part 9 of "Elektrotechnik in Einsel-Darstellungen." By Dr. G. Benischke. (Brunswick: Friedrich Vieweg und Sohn.) 5.50m.

MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

An assistant lecturer and demonstrator in the physics and electrical engineering department, and an assistant lecturer and demonstrator in the mechanical and civil engineering department of the Municipal Technical Institute, Portsmouth, are required. Salary £125 to £150 per annum in each case. Particulars and forms of application from the secretary. See also an advertisement.

The chief engineer of Ipswich electric supply and tramways departments has a vacancy for a premium pupil. See an advertisement.

An assistant is wanted in the calculating department of an engineering works, accustomed to the design of continuous and three-phase current machinery. See an advertisement.

A competent draughtsman is required for l.t. switchboards and another for d.c. machines. Knowledge of German essential. Applications to Elektrotechnische Abteilung, Norddeutsche Maschinen und Armaturen Fabrik, Bremen, Germany. See an advertisement.

Armature winders are wanted at once at the Westinghouse Works, Trafford Park, Manchester. See an advertisement.

A chief lecturer in mechanical engineering is required for the Auckland (New Zealand) Technical College. Candidates must have had good workshop experience, and, if possible, possess a diploma or degree in engineering. Salary £300 per annum. Particulars from the director of technical education and manual training (Mr. Geo. George, F.I.C., F.C.S.), c/o the High Commissioner for New Zealand, 13, Victoria-street, London, S.W. Applications by Oct. 8.

Mr. Claughton has been appointed by Brighton Corporation superintendent of the Southwick power station at £234, rising to £260 per annum.

Mr. J. H. Hodgson has been appointed chief assistant engineer to the Wycombe (Borough) Electric Light & Power Co.

Mr. S. G. Marston, senior charge engineer at Hanley, has been promoted to mains superintendent; and Mr. J. E. Bridgman, charge engineer at Stalybridge, has been appointed charge engineer at the Hanley electricity works.

Mr. J. R. Wilson, of the Heston and Isleworth electricity works, has been appointed second engineer-in-charge at Ilford electricity works at £120, rising to £150, per annum.

Mr. C. E. Vormeister has been appointed lecturer in electric wiring, &c., at the Royal Technical Institute, Salford.

Mr. E. Ford, accounts and correspondence clerk in Hanley electricity department, has been appointed to a similar position in the West Ham Corporation electricity offices.

Bacup.—The Council decided on Wednesday to offer £5,200 to the Rossendale Valley Steam Tramways Co. for the portion of their undertaking in the borough.

Barking.—The Council have asked the Board of Trade to intervene and settle the terms upon which inter-running with the Ilford tramcars may be arranged.

Bolton.—Powers are to be obtained for constructing a length of tramway from the centre of the town to the Darcy Lever Ward.

Bray (Ireland).—A sub-committee has been appointed to interview Mr. G. M. Harriss in regard to a proposal for the purchase of the electricity works. Mr. Harriss was formerly resident engineer at Bray and is now chief engineer at Alexander's Electric Works, Carlow.

Bristol.—The adjourned inquiry into the application of the Corporation to borrow £34,600 for the Avonmouth electric extension scheme was held on Tuesday.

The chairman of the Electrical committee (Ald. PEARSON) said an impression seemed to have got abroad that, owing to the fact that they could not give certain figures at the last sitting, the opinion they had formed as a committee had been jumped at, and was not the result of careful examination of figures. The matter had really been before the committee since March, 1905. As early as 1906 their engineer (Mr. H. Faraday Proctor) reported upon five separate schemes by which they might supply Avonmouth. After considering those five schemes the committee arrived at the conclusion that the first (generation by 3,000 kw. units at Avonbank) was the one they would recommend, and correspondence with the Docks committee then ensued. Mr. Proctor reported fully upon the prices at which they could give a supply. Mr. Proctor's figures were gone into. The Docks committee had asked them to make only a comparatively small supply (500,000 units). Their engineer had satisfied them that for any ordinary work at Avonmouth the supply as suggested was the best and only scheme they could recommend. That scheme had been before the Council and had been accepted by the Council with practical unanimity. They considered that the Council, having, as they had, spent nearly £3,000,000 in equipping the dock at Avonmouth, and having made up their mind that they would equip that dock electrically, the question as

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to whether they spent £20,000 or £30,000, and whether they lost £1 or £1,000 for the first year of their work, was a comparatively small matter against the convenience to the public of a cheap and efficient supply of electricity at Avonmouth. They regarded the electrical equipment at Avonmouth as an essential in the equipment of the docks, and, that being so, they considered the Electrical committee were the authority to do the work.

The Town Clerk (Mr. E. J. Taylor) gave details of the indebtedness of the city, &c.

Mr. H. FARADAY PROCTOR supplied detailed figures in respect of the several schemes for giving a supply to Avonmouth. The first scheme which it was proposed to adopt would cost in capital expenditure £31,900. The original figure was reduced from £38,000 to £31,900 because at the outset the estimate was a general one and the details had not been worked out. It was prepared on a very liberal basis. The annual charge for interest and redemption would be £1,914, and the total annual cost would be £5,167. The revenue was estimated at £4,316, so that the loss on the supply of 500,000 units would be £851. Although the capital cost of No. 1 scheme was slightly in excess of the others, it would be more economical in working. The work would be carried out by contract. The cost of a service to the dock would be 1·306d. per unit, and although there was no agreement between the Electrical and the Dock committees, there was an understanding that the charge should be 2d. per unit. The cost of generating electricity by the Docks committee was not quite 2d. at present. It would be cheaper to supply the Docks committee with alternating than direct current, and he believed quite as satisfactory, and the capital expenditure would be about £7,000 less and the working expenses 25 per cent. less, but the Docks committee were not willing to accept the latter. He should, therefore, like to consider the matter before he made a statement as to whether the cost and revenue would about balance if the alternating current were supplied. The Docks committee would like his committee to be in a position to augment their supply by 400 kw. by the end of this year, and another 200 to 400 kw. by the beginning of April.

Major P. CARDEW gave evidence in support of Mr. Proctor's views. He considered the decision of the Electrical committee a wise one. He thought the works would be carried out for the amounts mentioned in the estimates. He did not regard the scheme as unduly speculative, and he held the opinion that, though, basing their figures on 500,000 units, the Electrical committee would be losers, the scheme was the best for the mutual interests of the two committees and the ratepayers generally.

Mr. W. W. SQUIRE, docks engineer, gave particulars of the generating station at Avonmouth, which he said had been provided at a cost of £5,200. He estimated that the gas plant and dynamos would realise £1,000. He thought, from a Docks committee point of view, that it would be very desirable to have current from the Electrical committee. Electricity would be utilised at the docks for driving the cranes and grain conveying and elevating machinery, wagon and capstans, and for lighting and other purposes. He thought in the long run it would be cheaper to purchase current for 2d. than it would be to generate their own. There was a large estate at Avonmouth on which it was hoped factories would be erected needing a supply of current. It was difficult to attract manufacturers unless current was available. That fact had influenced the Docks committee very largely in their action.

Carlisle.—At the meeting of the Electricity committee last week it was reported that the resignations of the engineer (Mr. Charles D. Burnet) and of the assistant engineer (Mr. G. G. Scurfield) had been tendered. The committee resolved to accept the resignations, that of Mr. Burnet to take effect on March 31, 1908.

China.—At Swatow early in 1906 a native company was formed with a capital of $100,000 in $10 shares to supply electrical energy for lighting the city. The capital of this company has to be held exclusively by Chinese. A contract was signed a few months later for the necessary plant and apparatus, which was to be delivered, in the terms of the contract, within six months, but it is announced that, owing to disputes with the contractors, this electricity supply undertaking has not yet commenced working.

Edinburgh.—The Electric Lighting committee recommend that for one year a charge of 2d. per unit be made to consumers who undertake not to use their light between 4 p.m. and 7 p.m. during November, December, January and February.

Electricity Works Valuation.—At the Coatbridge Valuation Appeal Court last week, Bailie Lavell presiding, the Airdrie and Coatbridge Electric Supply Co. appealed against their works being valued at £633. Mr. J. H. Russell, for the company, intimated that his clients did not intend to press the appeal, but wished to argue that the known increased expenditure should be taken into account when fixing the valuation. Owing to the increase in the price of fuel the company's expenditure would be £2,000 higher this year. The Council refused to take this point into consideration, and agreed to abide by the system of imposing the assessment upon the closed accounts. The amount was, therefore, fixed at £633.

The Greenock Valuation Appeal Court considered the valuation of the burgh electricity works last week. Mr. Hamilton (assessor) stated that the figure last year was £5,440, and it was proposed to increase it to £5,770. As a result of negotiations it had been decided, subject to the approval of the Court, to fix the amount at £5,250. The Court agreed to the valuation being entered at that amount.

Factory and Workshop Regulations of the Home Office.—At a recent meeting of the Associated Municipal Electrical Engineers of Greater London the draft regulations which the Home Secretary proposes to make in pursuance of sec. 79 of the Factory and Workshops Act, 1901, for the generation, transformation, distribution and use of electrical energy in premises under that Act were considered. The regulations were printed in full in our issue for Aug. 23.

The following resolution was passed: "This Association is generally in accord with the proposed regulations, with the exception of the points referred to below, so far as regards new work, if reasonably enforced; but they consider that the regulations should not be made retrospective with regard to existing generating stations, on account of the large and unnecessary expense which would be incurred. They also consider that there should be a power of appeal, and suggest that a deputation of the Association be allowed an interview with the technical officers of the Home Office."

The regulations to which exception is taken are as follow, the specific objections being placed in parentheses:—

3. Every switch, circuit-breaker, and isolating link shall be: . . . (*c*) Provided with an efficient handle or other means of working, insulated from the system. (The Association consider that this should not apply to isolating links in generating stations.)

4. Every switch and circuit-breaker shall be so constructed as to be incapable of remaining in partial contact or of maintaining an arc on breaking circuit. (This should not apply to main switchboards, as in many cases these switches are only used to switch off feeders when not in use, and are only handled by competent persons.)

5. Every fuse and automatic circuit-breaker used instead thereof shall be so constructed and arranged as effectively to interrupt the current before it so exceeds the working rate as to involve danger. It shall be of such construction or be so guarded or placed as to prevent danger from overheating or from arcing or the scattering of hot metal or other substance when it comes into operation. Every fuse shall be of such construction or be so protected by a switch that the fusible metal may be readily renewed without danger. (This regulation should not apply to house service cut-outs.)

9. Where one point of a system is connected to earth no single pole-switch other than a link for testing purposes shall be placed in any cable connected thereto. (This should not apply to double-pole main switches on consumers' premises.)

11. Every motor, converter and transformer shall be protected by a switch or switches suitably placed, and so connected that all pressure may thereby be cut off therefrom and from any apparatus in connection therewith. (It should be made clear that "switch-fuses" will be allowed.)

12. Every electrical motor rated at more than ½ H.P. shall be further protected by a release that will automatically break the circuit if the current is interrupted, unless the motor is incapable of re-starting automatically on the current being restored. In every place in which machinery is being driven by any electric motor there shall be means at hand for quickly stopping the motor. (This should not apply to polyphase motors.)

13. . . . . Adequate precautions shall be taken against shock, due to leakage or other cause, in all cases where the person handling the portable apparatus is not insulated from earth. In such places, and in any place where the pressure exceeds low pressure, the switch shall be so constructed as to break the circuit on each pole. (Last sentence: In cases where the neutral is connected to earth a single-pole switch on the live side should be sufficient.)

14. The general arrangement of switchboards shall, so far as reasonably practicable, be such that: (*a*) All parts which may have to be adjusted or handled are readily accessible. (*b*) The course of every cable may be readily traced. (This could not apply to cables run in tubing or barrel.) (*c*) Conductors connected to different systems are kept apart and can be readily distinguished. (Same objection as to *b*.)

15. Every switchboard having conductors normally so exposed that they may be touched shall be located in an area or areas set apart for the purposes thereof and suitably fenced or enclosed. No person, except an authorised person or a person acting under his immediate supervision, shall have access to any part of such area. (This should not apply in small sub-stations. The terms "area" and "authorised person" should be defined.)

17. At the working platform of every switchboard and in every switchboard passage-way, if there be bare conductors exposed, or arranged to be exposed when live so that they may be touched, there shall be a clear and unobstructed passage of ample width and height with a firm and even floor. For low pressure and medium pressure the clear height shall not be less than 7 ft. and the clear width not less than 3 ft., and for high pressure and extra-high pressure 8 ft. and 4 ft. respectively. Bare conductors shall not be exposed on both sides of a switchboard passage-way unless the clear width of the passage is double that otherwise required, or the conductors on one side are so guarded that they cannot be accidentally touched. Adequate means of access, free from danger, shall be provided for every switchboard passage-way. (Existing switchboards in generating stations should be exempt.)

18. In every switchboard for high pressure or extra high-pressure . . . . (*b*) The metal cases of all instruments shall be either earthed or completely enclosed with insulating covers. (It would not be possible to effectually separate dead sections from live by removable screens in many existing boards.) (*d*) Every switchboard in continuous use shall be so arranged that the conductors thereof can be made dead in sections, and no work shall be done at any section unless that section be (*a*) made dead and (*b*) so separated by permanent or removable divisions or screens from all

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adjoining sections of which the conductors are live that the work may be carried out without danger. (Same objection as to *b*.)

24. Portable insulating stands and screens, boots and gloves shall be provided and used when necessary to prevent danger, and shall be periodically examined by an authorised person. (This should not apply to "low" or medium pressures, such "safeguards" having proved to be a source of danger in the past.)

31. Every sub-station shall be of ample dimensions and substantially constructed of fire-resisting material, and shall be so arranged that no person can obtain access thereto otherwise than by the proper entrance, or can interfere with the apparatus or conductors therein from outside; and shall be provided with efficient means of ventilation and be kept dry. (It has in several cases been found to be impossible to keep underground sub-stations dry, although every care has been taken, and the words "as far as practicable" should be inserted.)

It may be mentioned that all objections have to reach the Home Office by the end of October.

Fatality.—An accident occurred on Friday last at the Old Park Works of the Patent Shaft & Axletree Co., Wednesbury. John Brennan, blacksmith (assisted by Thomas Costello, labourer, and a youth named Watts), was cutting a piece of iron with an electrically-driven saw when the machinery became, by some means, "alive," and Brennan was killed.

Holland.—The "Nieuwe Rotterdamsche Courant" states that the construction of an electric tramway between Middleburg and Flushing is contemplated.

The "Vaderland" states that negotiations are in progress for the conversion to electric traction of the Goosche Stoomtram, a steam tramway 24 miles in length to the south of Amsterdam.

Hungarian Exhibition.—Steps are being taken to organise a Hungarian Exhibition at Earl's Court next year, and the Lord Mayor of London and the Lord Mayor Elect have both accepted positions on an influential honorary advisory committee which has been formed in London to carry to success an exhibition of the arts, products, industries and manufactures of Hungary.

Kent Collieries (Ltd.).—In the directors' report it is stated that an electrical plant has been installed with the requisite capstans and gear for lowering the electric pumps, and heavy expenditure has been incurred in the supply of fuel for steam power. Water heaters, economisers and patent stokers have also been fixed with a view to reducing coal consumption to a minimum.

Leeds.—On Wednesday the City Council decided to apply for sanction to borrow £42,313 for the construction of three tramway routes.

Leith.—In a preliminary report on the construction of four additional tramway routes (about 9⅓ miles) the cost of construction is put at £76,817.

Light Railways.—The Light Railway Commissioners have issued the Tottenham and Walthamstow Light Railways order. The lines will be constructed by the Middlesex Electric Tramways (Ltd).

Manchester and Salford Tramways.—A series of meetings of representatives of Manchester and Salford Tramways committees has been held to consider the question of mutual running powers on the tramway systems of the two corporations. Failing a general arrangement for through running, the experiment was tried of running the Salford cars from Swinton to Belle Vue. This has, however, been dropped, and for the present negotiations have been broken off.

Mansion Lighting.—The Earl of Mansfield has entered into a contract with Hampstead (London) Council for the supply of electricity for lighting his mansion at Ken Wood, adjoining Hampstead Heath. The work of wiring and fitting is being proceeded with. In this case electric light is to supersede wax candles, as the successive Earls of Mansfield have refused to use gas lighting, which accounts for the excellent preservation of the many art treasures in the mansion.

Middlesex Tramways.—Middlesex Council are negotiating with the L.C.C. with regard to obtaining running powers for constructing a tramway from Cricklewood to Harrow-road.

Monmouth.—On Tuesday the Council referred to the Electric Light committee a statement prepared by Mr. Sambrook, which shows that during the past six years the deficit on the working of the electricity department was £4,663, and in last year's account the deficit was £884.

Northfleet.—The Council have now considered the legal opinion obtained on the position created by the refusal of Gravesend Council to extend the electric lighting mains to this district.

On Tuesday it was stated as counsel's opinion that Northfleet would be justified in taking action for specific performance of the agreement to give a supply of electricity. The matter was discussed in camera.

Paddington (London).—On Tuesday the Works committee recommend that a portion of the Harrow-road be illuminated by arc lamps at an estimated cost of £264, which was stated to be equivalent to 1½d. per unit for current. The committee were, however, instructed to consider further the question of improving the lighting by incandescent gas.

Personal.—Mr. John Shaw, who has heretofore combined the duties of textile expert to the British Thomson-Houston Co. with those of manager of their Manchester office, has been appointed mill engineer of the power and mining department of the company, owing to the rapid and extensive development of their textile business, necessitating the organisation of a special staff for dealing with it. Mr. Shaw's headquarters will continue to be at the Manchester office of the company, although his duties will extend to the whole of the United Kingdom. Mr. W. J. Cusack, of the B.T.-H. head office staff, has been appointed manager of the Manchester office, vice Mr. Shaw. Both appointments date from Oct. 1.

Mr. Donald Robertson has been appointed secretary of the Department of Posts and Telegraphs of New Zealand, in place of Mr. Wm. Gray deceased.

Peterborough.—The Council have received sanction to a loan of £2,880 for extensions of the electricity undertaking.

Presentation.—The staff of the High Wycombe Electric Light Co. have presented a solid brass rolling parallel and an illuminated address to Mr. W. B. Turner, chief assistant engineer, who is leaving to join the staff of Mr. Fippard, consulting engineer, Westminster, London.

Ravensthorpe.—The Council have ordered their seal to be affixed to the agreement with the Yorkshire Electric Power Co. for supply of electricity in the district. The company undertake to supply current for lighting at 4½d. per unit and for power or heating at 2d. with reductions for consumption in excess of a certain quantity in a given period.

Reinstatement of Streets in London.—For some time past Camberwell Borough Council have carried out the work of reinstating streets for various public authorities and companies who have the right of breaking up the surface of roads for laying mains, &c. It appears that this work has to be done at net cost, as the Council cannot legally make a profit on it. The Council also undertake certain responsibilities in connection with this reinstatement work, and it has now been decided to give notice to all companies and authorities for whom the reinstatement work has hitherto been executed, that, after April 1 next, the Council will cease to perform such work, and will not undertake any responsibility in connection with any trench work or openings, unless they agree to such an addition upon the net cost of reinstatement as shall cover or indemnify the Council from the risk involved.

Rotherham.—On Wednesday the Electric Light and Tramways committee reported that they had considered the application of the borough electrical engineer and tramways manager (Mr. E. Cross) for an increase of salary, but they made no recommendation.

Ald. CLARK moved an amendment that an increase of £50 a year (from £350 to £400) be granted. In the discussion which ensued it was generally conceded that Mr. Cross had done his work well, and that he thoroughly deserved an increase of salary.

The amendment was carried.

Safety Devices for Petrol Tanks.—As the explosive nature of petrol is the cause of frequent accidents of a more or less violent nature, it is satisfactory to note that inventors are turning their attention to the reduction of its dangers. To overcome the drawbacks to its use by unskilled persons a device has recently been patented in Germany, the English rights of which are in the hands of the Safety Non-Explosive Reservoir Co.

The essential characteristics of the device are a "safety plug" and a "safety tube." The former consists of a metal plug fixed in one or more of the screwed stopper openings of the vessel by means of fusible solder, which is of such composition that it will melt when the temperature of the surrounding air would cause the pressure inside the tank to become dangerous. The tube is composed of wire gauze surrounded by a perforated metal cover, which is fitted to each opening of the reservoir, and which acts on the same principle as the gauze of a Davy lamp. Some demonstrations, carried out by the company at the British Fire Prevention committee's testing station at St. John's Wood, London, last week, proved that the claims made by the owners of this patent are not without foundation and that the device has a protective effect. The most striking test showed the effect of fire on (1) an iron cylinder with welded joints and screwed stopper, but not protected with safety devices; (2) a can protected with safety devices; and (3) a filling can not protected with safety devices. All three of these were about half filled with petrol and placed in a large bonfire. The explosion caused by the two unprotected cans and the damage done to them was very great, while the can protected with the safety device was uninjured.

Southampton.—The Corporation have decided to obtain powers to wire premises on the hire-purchase system and to let motors and fittings on hire.

Southwark (London).—The accountants called in by the Council (Messrs. Price, Waterhouse & Co.) have sent in another report on the electric lighting accounts.

The firm state that Mr. Carson Roberts approached the matter from a

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different point of view from that adopted by them, for whereas they concerned themselves with the question of the provision of a cash fund to be available for renewals as and when they might be estimated to fall due, Mr. Roberts was evidently concerned rather with the equalisation of the charge for renewals over a largely extended term of years. The two objects are incompatible with one another under the system by which the capital expenditure of the Council had been financed, and Mr. Carson Roberts' calculation of the result which would be achieved by an accumulation extending over 42 years, and which was, of course, perfectly correct, only tended to show that, under the system of finance which had had to be adopted, a heavier burden than a fair share must fall on the earlier years' revenue if a cash fund was to be provided to cover all renewals as the necessity for them arose. Revenue moneys applied in partial repayment of loans are not available for the execution of renewals, so that where moneys had been borrowed repayable over 42 years for the purchase of plant, a large portion of which was estimated to require renewal in less than half that period, it was clear that the earlier years' revenue must not only bear their full share of the first general renewal of the plant, but also their share of the repayment of the loans. They (the accountants) had not contemplated the continuance of the special contributions to a renewal fund after full provision for renewals had once been made either by means of such contributions or through borrowing powers becoming available to provide the necessary cash. Therefore, there would be no danger of such a fund being accumulated as that indicated by Mr. Carson Roberts if the principles outlined in their report were acted upon. What Mr. Carson Roberts described as a double discharge of capital—though they did not agree with his description—was inevitable under existing circumstances if they were to attain the desired object, namely, the provision of a cash fund for renewals as and when required. After carefully considering Mr. Carson Roberts' letter they adhere to the main principles upon which their report was based. They recognised, as was indicated in that report, that the figure suggested as the necessary contribution to the renewal fund for 1905-6 was susceptible of revision on the framing of the estimates of the life of the different units of plant of the undertaking, and they agreed that a deduction should be made as Mr. Carson Roberts suggested for the interest likely to be earned on the renewal fund pending its application. They were given to understand that the estimates since prepared by the borough electrical engineer indicated the expectancy of greater terms of years for the useful life of the plant of the undertaking than those upon which their calculations were based.

Stratton and Bude.—The Council have entered into an agreement with Christy Bros. & Co., Chelmsford, for public lighting.

The contract is for five years, commencing March 1, 1908; the company to provide and maintain 101 lamps (to be placed as the Council may require), and also to provide poles and brackets. The price and conditions of lighting to be the same as the present contracts with oil lamps; overhead cables to be erected in certain streets and underground cables across the links and under the canal.

"Technical Literature."—Messrs. Archibald Constable & Co. have accepted the sole representation in this country of a new American journal with the above title. The matter of the new paper is carefully selected and well arranged, and, if sufficient readers can be obtained for this specialist type of publication, the excellent get-up of "Technical Literature" should ensure its success.

Telephone Charges.—At the annual meeting of the Executive Council of the National Chamber of Trade, at Blackpool last week, the question of the recent changes in telephone rates was discussed and a letter was read from the Postmaster-General stating that the fact that at present the accounts of Hull Corporation showed a balance of profit after payment of working expenses was not in his view a conclusive proof as to the normal cost of a permanent telephone system. He pointed out that the Hull system was still comparatively new, and, therefore, the cost of its maintenance was low, but it would rise gradually year by year. A considerable part of the salary and wages was charged to capital account, and it had not been proved by experience at what date the plant would require renewal or reconstruction. The rates of wages were below those of the Post Office, and as the system was a young one, there was no liability for pensions and other charges incidental to an old-established system. Discussing the question of a flat rate as opposed to the measured service system, the Postmaster-General pointed out the anomalies arising from a flat rate system, which was unfair in its application to subscribers. The measured service system had been adopted by all the largest telephone concerns in the United States. With regard to charges, the Postmaster-General had no desire to secure more than a moderate return on the expenditure after providing for all capital charges and depreciation, but modification in the future must depend upon the results of experience.

Ald. J. Brown (chairman of Hull Telephone committee) subsequently read a Paper on "Future Telephone Rates and Administration." The speaker urged that the only safe course to adopt with regard to the telephone was for the municipalities to control the local telephone services, leaving to the Post Office the working of the trunk lines as at present. Referring to the threatened abolition of the flat rate for the telephone, Ald. Brown pointed out that if a subscriber under the measured service system had an average of only 13 calls per day, he would have to pay £14. 8s. per annum, whilst if he had an average of 25 calls a day for 300 days in the year, the charge would be £22. 5s. 6d. Hull Corporation could give him that service and more for £6. 6s. and make a profit. He moved: "That this Chamber is of opinion that the new rates for telephones are far too high, and calculated to restrict the use of the telephone, and place the commercial community at a disadvantage compared with other countries; and that such rates are unnecessary, in view of the experience gained in the working of municipal telephone exchanges."

Mr. T. G. Morrell (Smethwick) seconded, and the resolution was carried.

Ald. Brown also moved: "That this Chamber is in favour of municipal telephone administration after 1911, and, to prevent hurried legislation, strongly urges that the future telephone policy should be settled during the next session of Parliament."

This resolution was also adopted.

Tramcar Accident.—An accident occurred on the Lodge-road tramway route, Birmingham, on Tuesday morning, when a car, in rounding a curve, was overturned and about 20 persons were injured, two fatally.

At the time of the accident the car was in charge of an inspector. It is stated that Inspector Hall was informed by motorman Mountford that the magnetic brake on the car was defective. Hall thereupon boarded the car to test the brake, according to regulations. Going down a hill the inspector made the first test, and states that he found the magnetic brake did not act until he put the lever on the third notch. Then the car stopped suddenly. Hall made a further test when descending the next hill, believing that he could control the car by using the magnetic brake at the third notch. He found, however, that it would not hold the car, and, after a second attempt, used the hand brake. By this time the car had gathered such momentum that, in spite of the wheels being securely held by the brake, the car continued to slide down the hill. After a time the speed moderated, but before the car could be stopped it reached the bend and overturned.

Victoria Falls Power Scheme.—Mr. Ralph D. Mershon (of New York), one of the consulting engineers to the Victoria Falls Power Co., has arrived in England from South Africa.

To an interviewer Mr. Mershon is reported to have said that without doubt the project to transmit power from the Victoria Falls was one of the biggest things of the kind, so far as distance was concerned, that had yet taken practical shape. The length of the proposed transmission line was unique. He also stated that there was not the smallest doubt in his mind that such a transmission could be profitably effected. On his visit just completed to South Africa he had personally inspected the Victoria Falls, both above and below the Gorge, and he was satisfied that an excellent electrical development could be made up to, if need be, 300,000 H.P.; and if means were taken, which could probably be done very economically, to conserve the water some little distance back from the Falls, there would be a further large addition to the power that would be available. The immediate work which the company had to concern itself with was the early provision of a further steam-driven electrical generating station on the Rand. At the moment the company with its two existing stations was quite unable to cope with the demand for power, and they had been compelled in advance of the erection of the new station to arrange for an extension of the existing station at Brakpan. With regard to the erection of the new 24,000 H.P. station, they were taking every possible means to expedite its completion, and that was the work which was engaging his attention at the moment.

Wakefield.—The Wakefield & District Light Railways Co. have applied to the Board of Trade for permission to abandon the proposed tramway between Wakefield and East Ardsley. East and West Ardsley Council have decided to oppose the application.

Walthamstow.—The Council have decided, on the recommendation of the Electric Light committee, to allow a discount to companies and clubs, as distinct from private consumers of electricity, provided accounts are paid within a month.

The electrical engineer (Mr. G. R. Spurr) is to report on the lighting of the local hospital, and has been asked to provide means for testing the comparative cost of light in the various blocks and the administrative building.

West Bromwich.—Sanction has been received to a loan of £2,000 for mains and services and £3,586 for excess expenditure.

Wimbledon.—A sub-committee has been appointed to report as to additional plant required at the generating station to meet the probable demand for electrical energy during the winter of 1908-9.

Flame arc lamps are to be substituted for ordinary arcs in Hartfield-road, and tantalum lamps are to be erected in other thoroughfares in place of incandescent lamps.

The Electric committee have approved of plans for erecting a modern type remote control main switchboard containing eight generator panels and six feeder panels in substitution for the present switchboard. The estimated cost of the switchboard is £2,500 and of the structural alterations £1,100.

The total number of equivalent 8 c.p. lamps connected to the mains on Aug. 31 was 138,064.

"Wireless Alarms."—The "Daily News" announces that a wireless alarm system has recently been invented by a Chicago electrician. "This system will allow a policeman on his beat to be called up from his central office. The receiving apparatus may be carried in the pocket or helmet, and on the signal being given from the head office a bell in the pocket will ring. The inventor is now engaged in perfecting his apparatus, with which it is hoped some tests may shortly be carried out."

Worcester.—The electrical engineer (Mr. C. M. Shaw) has been authorised to proceed with the laying of a main to Messrs. McKenzie

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& Holland's works, at an estimated cost of £215. It has also been decided, provided the G.W. Railway Co. agree to take supply of current for their hoist motors at Shrub Hill, to extend the direct-current mains.

Wrexham.—Application has been made for sanction to a loan of £500 for a 60 kw. generating set.

ELECTRICITY SUPPLY ACCOUNTS.

Bournemouth.—The Chairman of the Tramways committee (Ald. Lawson) informed the Council on Tuesday that the total receipts of the tramways department from April to September, inclusive, were nearly £50,000, an increase of about £1,000 compared with last year. £850 had been saved in expenses during the half-year. An electric lift, giving access between the top of the cliffs and the sands is being erected on the East Cliff, and it is now proposed to erect a similar lift on the West Cliff.

Derby.—In moving the adoption of the minutes of the Tramways committee at the Council meeting on Wednesday, the chairman (Ald. Spriggs) stated that the net profit on the past year's working was £7,930. 8s. 10d., a record figure. The profit would have been greater but for a loss on the routes where horse traction still existed, and this showed the importance of substituting electric traction on those routes as soon as possible.

Hampstead (London).—During the midsummer quarter the receipts were £7,291, including £6,019 from private lighting, against £6,847 in the corresponding quarter of 1906.

During the quarter 115 new consumers, representing 4,147 8 c.p. lamps, were connected, against 106 consumers and 3,977 8 c.p. in 1906. At the end of June there were 5,966 consumers, against 5,513, and the connections were equivalent to 294,019 8 c.p., against 278,508 8 c.p.

Willesden.—The Electric Light committee report that there was a profit of £783 on the past year's working of the electricity undertaking.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The directors of the *Great Western Railway Co.* invite tenders for supply of stores for the 12 months ending Nov. 30, 1908, including telegraph instruments, telegraph apparatus (insulators, &c.), electrical wire and cables, telegraph ironwork and tools, electric light carbons, incandescent electric lamps, wire, indiarubber goods, &c., in group 1; and glass, acids, oils, varnishes, brasswork, zinc, antimony, brass, copper rivets, tools, &c., in group 2. Samples and patterns may be seen at the general stores, Swindon, from Oct. 14 to 19 for group 1 and from Oct. 30 to Nov. 9 for group 2. Specifications (with forms of tender) from the Stores Superintendent, Swindon, for group 1 after 7th inst. and for group 2 after 28th inst. Tenders to the secretary (Mr. G. K. Mills), Paddington Station, London, W., by Oct. 22 for group 1 and by Nov. 12 for group 2. Further particulars are given in an advertisement.

The directors of the *Metropolitan Railway Co.* invite tenders for supply of general stores during 12 months ending Oct. 31, 1908. Manufacturers and others desirous of tendering should apply to the secretary (Mr. R. H. Selbie), 32, Westbourne-terrace, London, W., for forms. The company's requirements include electric wires, cables, lamps, carbons, fuses, ebonite battery jars, zincs, &c. Patterns and samples will be on view from Sept. 30 to Oct. 5 inclusive. Tenders to the Secretary by 10 a.m. Oct. 7.

London County Council invite tenders for the manufacture, delivery and erection of three electrically-driven boiler feed pumps, each of 9,000 gallons per hour capacity, at the tramways electricity station, East Greenwich. Tenders to the clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 11 a.m. Oct. 8.

London County Council also want tenders by 11 a.m. Oct. 8 for erection of tramways sub-station at Lewisham. Forms of tender from the Architect's Department, 13, Charing cross, S.W.

Tunbridge Wells Corporation invite tenders for the supply, delivery and erection of the work in connection with the installation of a 500 kw. turbo-alternator, condenser and pipe work in sections: (*a*) 500 kw. turbine, (*b*) 500 kw. alternator and exciter, (*c*) surface condenser, with air and circulating pumps and (*d*) pipe work. Tenders to the town clerk (Mr. W. C. Cripps), Town Hall, Tunbridge Wells, by 10 a.m. Nov. 1.

Maidstone Corporation want tenders by Oct. 7 for supply and erection of seven electric motors and centrifugal pumps, motor-driven air ejectors, cranes, switchboard, starting switches, &c., and a complete electric-light installation, for the sewage disposal works. Plans from Mr. G. R. Strachan, 9, Victoria-street, London, S.W.

Manchester Electricity committee require tenders by noon Oct. 9 for supply and erection of high and low pressure steam pipes, valves, &c. Specifications from Mr. F. E. Hughes, Town Hall, Manchester.

Glasgow Corporation require tenders by Oct. 12 for supply of a 7 ton and (or) a 5 ton electric crane for the main drainage department. Specifications from the resident engineer, Partick pumping station.

Marylebone (London) Electricity Supply committee want tenders by 4 p.m., Oct. 16, for supply of flame arc lamp carbons. Specification from Mr. F. A. Wilkinson, 19 and 20, York-place, W.

Grimsby Corporation want tenders by first post Oct. 21 for supply and erection of additional switchboard panels. Specification from the borough electrical engineer.

The Deputy Postmaster-General, *Melbourne*, Victoria, wants tenders by 3 p.m. Dec. 10 for supply of 50 wall telephone sets. Forms of tender, &c., from the Australian Commonwealth Offices, 72, Victoria-street, London, S.W.

TENDERS RECEIVED AND ACCEPTED.

On Tuesday Dundee Electricity committee considered the tenders for the new electricity generating station. The electrical engineer (Mr. H. Richardson) recommended for acceptance the following tenders:—

Willans & Robinson, electric generating plant (including condensing plant), £19,200; Babcock & Wilcox, boilers, stokers, economisers and coal-handling plant, £14,735; and for brickwork settings for the boilers and economisers, £2,125.

The committee approved of these recommendations, but before coming to a decision it was resolved to inspect plant manufactured by other firms which had lodged schedules. With regard to the contract for cables, the committee were again of opinion that a combination existed amongst the leading British firms who had submitted tenders. Notwithstanding the fall in the price of copper, the amounts separating the firms on so large a contract as £12,000 was very trifling, and in the circumstances the engineer was instructed to advertise afresh.

Bermondsey (London) Council have accepted the tender of Johnson & Phillips for 220 yds. of 7/18 flat l.c. rubber cable, £21. 8s. 5d.; 110 yds. of 7/22 twin l.c. rubber cable, £8. 16s. 11d.; and 220 yds. 7/16 three core l.c. paper cable, £24. 7s. (to be delivered in 17 days, 2½ per cent. discount allowed), and for 500 ft. of flexible galvanised steel wire rope, £1. 7s. 6d. The British Insulated & Helsby Cables, Callender's Co., W. T. Glover & Co., W. T. Henley's Telegraph Works Co., and Siemens Bros. & Co. also tendered for rubber cable, and Adey & Co. and Bullivant & Co. for steel wire rope.

Wimbledon Council have accepted the tender of Stuart & Moore for supplying, erecting, and maintaining for seven years six "Pendulum" fire-alarm transmitters, type B, in their new pattern fire alarm posts, to be connected by separate single overhead wires to receiving apparatus at the central fire station, for £72 per annum, the alarms at the end of the term to become the property of the Council.

An order has been placed with Davidson & Co., Belfast, for a "Sirocco" induced-draught fan and engine to be installed in the Warrington electricity works. The fan will measure 60 in. in diameter and will be capable of dealing with the products of combustion of 11,500 lb. of coal per hour.

Messrs. Walters & Co., Birmingham, have secured an order from Malvern District Council for supply and erection of two Reavell water-jacketed air compressors, driven by two Rhodes electric motors. The plant, which is thoroughly up to date and highly efficient, is to be used for the purpose of sewage disposal.

In connection with the St. Kilda tramways the Victorian Railways Department have accepted the tender of the Australian General Electric Co. for two car equipments, £637, and hangers, turnbuckles, suspension yokes and core terminals, £250.

Derby Corporation have accepted the tender of Johnson & Phillips for trunk mains at £688. 10s.; that of the Gilbert Arc Lamp Co. for 20 arc lamps at £73; and that of Wm. Abell (Ltd.) for penstocks, screens, &c., at the electric lighting station at £552.

Walthamstow Council have accepted the tender of the British Westinghouse Co. for annual supply of 18 in. enamelled iron shades, and that of the General Electric Co. for annual supply of glass jars.

Newton's Limited, Taunton, have secured (through the Alliance Electric Co., Dublin) an order for two generators required at Clonmel (Ireland) district lunatic asylum.

Bolton Corporation have accepted the tender of the Corporation Electricity committee for the supply of electroliers for the Council Chamber; and that of Pollitt & Co. for the erection of a sub-station.

Morrison & Roebuck, Blackpool, have secured the contract for wiring and supplying the electric lighting fittings for the Alhambra Theatre, Brussels.

Tyrone Hospital Management committee have accepted the tender of A. Patterson & Son for an electric lighting installation at £720.

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Stoke-on-Trent Council have accepted the tender of their Electricity committee for the supply of Osram lamps for the market buildings.

The Medway Motor Engineering Co. have secured the contract for the electric lighting and power installation at the new paper mills of Wiggins, Teape & Co., Dover.

Southwark Electric Light committee have accepted the tender of Charrington, Sells, Dale & Co. for the supply of West Hallam nutty slack at 13s. 11d. per ton, delivered at the electricity works.

Poplar (London) Electricity committee have accepted the tender of the British Westinghouse Co. for the erection of switch panels and instruments at the southern sub-station.

Norfolk County Council have accepted the tender of the Tudor Accumulator Co. for a storage battery for the county asylum at £884. 12s. 6d. and £54 for maintenance.

Gloucester Council have accepted the tender of the Sloan Electric Co. for a year's supply of carbons at £132. 15s. 9d.

Ingleton Council have accepted the tender of the local electric lighting company for public lighting at £40 for the season.

Burnley Guardians have accepted the tender of Thornton & Co. for 12 months' electrical supplies.

The Postmaster-General's Department, Adelaide (S. Australia), have accepted the following tenders :—

G. R. Marks, for glazed earthenware conduits; S. A. Portland Cement Co., for cement; Forwood, Down & Co., for manholes, covers and frames; International Electric Co., for two switchboards and two lightning arrester boards for metallic circuit lines and for insulated copper wire; Lawrence & Hanson, for fuses for telephones; India Rubber, Gutta Percha & Telegraph Works Co., for Leclanché cells, galvanometers and electromagnetic transmitters; J. Bartram & Son, for mechanical registers; R. B. Hungerford, for resistance boxes; Oswald Haes, for copper tapes; J. A. Newton & Co., for copper binders; Gibbs, Bright & Co., for h.d. copper wire; Geo. Wills & Co., for copper tapes and binders; and Zwicker, Tod & Co., for porcelain insulators.

BUSINESS NOTICES.

The business of the late firm of McPhail & Simpson's Dry Steam Patents Co. (Ltd.) (together with the goodwill, patents, plant, &c.) has been acquired by McPhail & Simpson (Ltd.), Wakefield, and will be conducted under the personal management of Mr. McPhail.

Mr. R. Borlase Matthews, Wh. Ex., A.M.Inst.C.E., A.M.I.E.E., consulting engineer, has taken an office at 1, Victoria-street, Westminster, S.W., in addition to his Swansea office.

The Adams Mfg. Co. have appointed Mr. Charles H. Holgate, School Close Works, Leeds, their agent in the Yorkshire district.

BANKRUPTCIES, LIQUIDATIONS, &c.

In the bankruptcy of Albert Dickinson, electrical engineer, 19, Upper Mill-lane, and Dixon Lane-road, Wortley, Leeds, the trustee (Mr. J. Bowling, 22, Park-row, Leeds) has been released.

A first and final dividend of 6s. 8d. is payable at 47, Full-street, Derby, in the failure of David Roberts, electrical engineer, &c., lately trading at 3 and 5, Whiston-road, Derby.

First meeting of the creditors and contributories of Patent Exploitation (Ltd.), 8A, Lord-street, Liverpool, will be held on Oct. 10 at 35, Victoria-street, Liverpool.

Business for Sale.—Owing to illness of owner, a well-known engineering business in London is offered for sale as a going concern. The business has a well-established connection extending over half a century, and the business includes electrical, general and marine engineering. Freehold land and buildings may be purchased or leased, and the plant and stock taken at valuation. Particulars from the sole agents, Messrs. Wheatley Kirk, Price & Co., 46, Watling-street, London, E.C. See also an advertisement.

Cable and Apparatus for Sale.—Mr. Lake, 132, Upper Thames-street, London, E.C., advertises for sale large quantities of new and old electric light cable, also searchlight lamps, h.v. main switches, "New Radium" lamps, &c.

Plant for Sale.—Messrs. Workman, Yeames & Co., 6, Dublin-road, Belfast, advertise for sale two new 120 B.H.P. vertical enclosed two-crank compound steam engines; also a Babcock & Wilcox water-tube boiler.

An E.C.C. motor-generator or booster (primary 100, secondary 50 volts, 70 amperes) is offered for sale by Messrs. Mottershead & Co., 7, Exchange-street, Manchester. See an advertisement.

Timber for Sale.—Messrs. Remer & Co. (Ltd.), timber importers, Mersey Saw Mills, Liverpool, advertise for sale seasoned ash planks and ash in the round.

"Gas Works Directory and Statistics."—We have received from Hazell, Watson & Viney (52, Long-acre, London, W.C.) a copy of the 30th (1907-8) issue of the "Gas Works Directory and Statistics," price 10s. 6d. net. The technical and financial particulars regarding the gas undertakings of the United Kingdom are reliable and accurate. The information, which has been revised to July, 1907, includes a list of chairmen, managers, engineers and secretaries, and of associations of engineers and managers. Where electricity supply is available in the gas undertakers' area, the names of the supply authority are added. There is also a section devoted to foreign and colonial gas works with London offices. The book should prove invaluable to those having business relations of any kind with gas suppliers.

CATALOGUES, &c.

Sirocco Fans.—A handsome bulletin (No. 2,002A, superseding No. 2,002), dealing with the Sirocco centrifugal fan, is to hand from Davidson & Co., Belfast. The illustrations depict various types of this fan and different methods of driving it. Tables of outputs, standard types, overall dimensions and weights, and also standard arrangements of the fans, are included. The illustrations are tastefully produced and are well arranged in the text. Efficiency curves of the constant and variable speed fans are given.

Fuses and Switchgear.—A comprehensive list of standard fuses and switchgear manufactured by Dorman & Smith, Ordsal Electrical Works, Manchester, is a handsome publication of some 100 pages, divided into sections, which deal with fuses, small switches, distribution boards, "grip contact" circuit-breakers and ironclad switching apparatus and accessories generally. A line of ship fittings and watertight mill fittings is also described. The publication is a complete reference book on the subject of d.c. switches and switchgear.

Electric Radiators.—The season for electric radiators bids fair to be as erratic in its commencement as that for electric fans. In spite of the warm days now prevailing, interest will attach to the issues of radiator catalogues at present proceeding. A new list of luminous electric radiators has been issued by the Dowsing Radiant Heat Co., 24, Budge row, London, E.C. Prices, dimensions and other particulars are given of a great variety of designs in these radiators, which are all made under the original Dowsing patents. The same company is issuing a well-illustrated pamphlet on the advantages of electric heating, in which numerous designs of electric radiators are shown. It is evident, from the long list of the company's clients, that there is a considerable demand for electric stoves, radiators, &c., and engineers and managers of electricity works, electrical contractors, dealers in electrical supplies, &c., who wish to keep acquainted with the latest designs in electric heating apparatus should procure copies of this company's price list and pamphlets.

"Kalkos."—This is not the name of a new purgative, but the trade cognomen adopted by the Sun Electrical Co. for a tinned tube wiring system. An advance sheet of the catalogue gives preliminary particulars from which we gather that tinned brass tubes, tinned inside and out, are employed with the system. The continuity of the system is maintained by soldering, which is easily accomplished on account of the tinning. Among the advantages claimed are absence of sweating, oxidising and corrosion, sound mechanical and electrical jointing, and minimum number of accessories required.

Superheaters.—McPhail & Simpson (Ltd.), who are exhibiting at the Olympia Exhibition, have sent us a complete series of pamphlets dealing with their standard superheaters. The leaflets are printed on one side only, and may, therefore, be extracted for reference if required. The drawings, showing different positions for the superheater in a boiler, are well reproduced and clearly illustrate the arrangement of the apparatus.

Natural Ventilation.—The Boyle system of natural ventilation now possesses a powerful advocate in the form of an artistic booklet produced in a quaintly antique style. There are extracts from the opinions of eminent men on the subject of the Boyle system of ventilation and a quantity of useful information on ventilation in general. The booklet is closed by a neat copper clasp.

Paul's Instruments.—Correction.—In the description of the Duddell-Mather oil-insulated non-inductive resistance in our last issue (p. 968), owing to a clerical error, we stated that "the wire being immersed in oil is capable of carrying a current of $\frac{1}{60}$th ampere." This should have been *one-sixth* of an ampere.

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Sept. 25 to Oct. 1, with the ports of destination :—

Africa—Alexandria, £1,729; Beira, £262 (including £72 telegraph material); Benguella, £37; Cape Town, £256; Delagoa Bay, £70; Durban, £1,070 (including £400 telegraph material); Port Elizabeth, £63; Sekondi, £10. *Argentina*—Buenos Ayres, £4,497 (including £1,009 telegraph material). *Australasia*—Adelaide, £721; Fremantle, £385; Lyttelton, £46; Melbourne, £2,010 (including £311 telegraph material); Perth, £20; Sydney, £635; Wellington, £1,962 (including £1,252 telegraph wire). *Belgium*—Antwerp, £1,564. *Borneo*—Sarawak, £8. *British Guiana*—Demerara, £14. *Burma*—Rangoon, £37. *Canada*—Montreal,

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£60; Toronto, £65. *Canary Islands*, £25. *Ceylon*—Colombo, £173. *Channel Islands*, £20. *Chili*—Punta Arenas, £65. *China*—Shanghai, £1,156; Tientsin, £18. *Denmark*—Copenhagen, £675. *Germany*—Bremerhaven, £35. *Greece*—Pirœus, £18 (telegraph material). *Holland*—Amsterdam, £252; Rotterdam, £105 (including £10 telegraph material). *Hong Kong*, £107. *India*—Bombay, £1,995; Calcutta, £812; Karachi, £120; Madras, £2,084. *Italy*—Genoa, £186. *Japan*—Hiogo, £288; Kobe, £2,078; Nagasaki, £477 (including £319 telegraph material); Osaka, £747; Yokohama, £1,673. *Malta*, £164. *Mauritius*, £28. *Norway*—Christiania, £543. *Russia*—St. Petersburg, £350 (telegraph material). *St. Helena*, £19. *Straits Settlements*—Penang, £1,120; Singapore, £338 (including £30 telegraph material). *Sweden*—Gothenburg, £90; Stockholm, £92 (telegraph material). *U.S.A.*—New Plymouth, £25; New York, £1,640 (telegraph cable). *West Indies*—St. Lucia, £4 (telegraph material). *Zanzibar*, £105. Total, £33,118, against £20,212 in the corresponding week last year (Sept. 26 to Oct. 2).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

July 19, 1907.

16,536 MOORE & POWLES. Telephone or other message recorder.
16,553 GAMBRELL & GAMBRELL. Electrical testing apparatus.
16,571 LUCAS. Electrical measuring instruments.
16,574 LUNDBERG, LUNDBERG & LUNDBERG. Switches.*
16,577 BUCHHOLZ. Supporting electric conductors.*
16,582 SIEMENS-SCHUCKERT WERKE G.M.B.H. Controlling switches for electric trains. (Date applied for, 28/7/05.)*†
16,585 UPWARD. Electric clock systems.
16,586 BARTLETT. Washers and terminals for electrical work.
16,600 SCHREIBER. Electrically propelled vehicle.
16,615 B.T.-H. Co., WEDMORE & HAMLYN. Protective devices for electric distribution systems.
16,616 & 16,617 B.T.-H. Co. (G.E. Co., U.S.) Filaments for electric lamps.
16,618 ALLGEMEINE ELEKTRICITÄTS GES. Transformers and controlling apparatus therefor. (Date applied for, 19/7/05.)*†

July 20, 1907.

16,630 HUDSON & BOWRING & BOWRING. Lifeguards for tramcars and the like.
16,642 WEBBER. Electrical device for automatic control of time signals or electric light circuits.
16,644 HEWETT, SMITH & FOSTER. Electrical devices for exhibiting advertisements.
16,675 LUNDBERG & HOLMBERG. Magnetic ore separator.
16,696 BERRY. Electrically heated apparatus for cooking.

July 22, 1907.

16,705 ELECTRIC IGNITION CO. & HALL. High-tension distributors for electric ignition systems.
16,710 BRUCE PEEBLES & Co. and LA COUR. Dynamoelectric machines.
16,731 & 16,732 MANDERS. Conduits particularly for electric tramways.*
16,735 HARRISON. Electrolytic or chemical deposition of metals.
16,736 BASTIAN, CALVERT & SANDERS. Fusing glass or like vitreous material around conductors.*
16,745 LE MANQUAIS. Cabinets for electrical apparatus.*
16,763 B.T.-H. Co. (G.E. Co., U.S.) Electric heating apparatus.
16,766 KAESEN & SCHEIDEL. Arc lamps.*
16,778 WRIGHT. Printing telegraph receivers.*
16,780 METALLURGISKA PATENTAKTIEBOLAGET. Magnetic separation of ore. (Date applied for, 28/7/06.)*†
16,781 SCHALLER. Regulating the electrical potential of a network supplied by a generator driven at very variable speeds. (Date applied for, 11/8/06.)*†

July 23, 1907.

16,799 MONTGOMERY. Accumulator.
16,813 ECKSTEIN & HEAP. Switches.
16,837 DANNE. Electric automatic weigher.
16,847 MARCONI'S WIRELESS TELEGRAPH CO. & PRENTICE. Electrical therapeutic apparatus for giving high frequency currents.
16,854 TARDIEU. Telephonic apparatus. (Date applied for, 12/1/07.)*†
16,862 HARE. Automatically operating switches at predetermined times.*
16,865 BROOKES (Asbestos Wood Co., U.S.). Insulating materials.*

July 24, 1907.

16,910 MAYES. Non-arcing fuse devices
16,911 ELECTRIC IGNITION CO. & HALL. Electric ignition apparatus.
16,912 ELECTRIC IGNITION CO. & HALL. Magneto-electric ignition apparatus.
16,942 FROST. Electric current generating and motive power machine.
16,952 KJELLBERG. Electric welding.*
16,956 ANGOLD & MAXIM ELECTRICAL CO. Arc lamps.
16,968 MARTIN. Electrical resistance device.
16,974 SOCIÉTÉ ANONYME WESTINGHOUSE & BRUN. Direct current motors. (Date applied for, 26/7/06.)*†
16,984 LEITNER. Magnetic clutches.
16,996 PROCNER. Reversible steam turbines.

July 25, 1907.

17,012 BEVIS & KRAUSE. Wall plugs and sockets.
17,015 MARSHALL, CROOKES & ROBSON. Portable electrically-driven machine.
17,046 NEWMAN & LODGE. Application of electricity for stimulating vegetable growth.
17,058, 17,059 & 17,060 GROTE & ELY (trading as FOSTER & Co.). Arc lamps.
17,066 LOEBL & BRITISH EVER READY ELECTRICAL CO. Holders or fittings for incandescent lamps.*
17,067 LOEBL & BRITISH EVER-READY ELECTRICAL CO. Electric hand-lamps.*
17,078 BROWN. Electric signals.
17,079 GSCHWEND. Electric instruments for medical use.*

July 26, 1906.

17,097 ALLGEMEINE ELEKTRICITÄTS-GES. Switch mechanism for electric vehicles. (Date applied for, 26/7/06.)*†
17,100 MUDIE & GREGSON. Electrical "intermitters" for advertising.
17,102 TAYLOR & HANCOCK. Electrodes for secondary batteries.
17,127 POIFER. Electric air-suction apparatus.
17,145 GOOD & BELL. Electric time-meter hour-counter and electric clock.
17,147 SOUTHAM. Electrically operated fountains. (Date applied for, 4/8/06.)*†
17,178 MORDEY & FRICKER. Prepayment electricity meters.

July 27, 1907.

17,192 WILSON. Arc lamps.
17,193 HATFIELD. Improved electrolytic cell.
17,195 VAN HAGA. Magneto-electric machines.
17,199 BARTON. Globes for lamps.
17,226 WARWICK MACHINERY CO. (G.E. Co., U.S.) Turbines.
17,245 BROWN, ROWELL Jun., & ROWELL. Conduits for electric wires.
17,254 LE FEVRE. Portable electric massaging and like apparatus.
17,257 SIEMENS BROS. & Co. and GRIMSTON. Selective telegraphy or telephony.
17,258 MOLLE & DEBEDTS. Casing for electric conductors in buildings.

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

11,772 MOORE & HIRST. Safety cutout for electric motors and the like.
11,853A JOHNSON. (Felten & Guilleaume Lahmeyerwerke A.-G.). Compensating load variations in electrical installations. (Date applied for, 21/5/05.)
12,183 GARDNER. System of wireless telegraphy.
14,163 JOHNSON. Electric traction systems.
14,420 CORNELIUS & FEHN. Electrical resistance furnaces.
16,366 ASHWORTH. Indicator for trams, trains and the like.
16,582 BOULT. (Baron). Fittings for electric lamps.
16,627 WHEATLEY (Firm of C. Lorenz). Electrical harmonic signalling systems.
16,893 LAKE. (Electrelle Co.) Automatic pianoforte players.
17,272 WALKER. Apparatus applicable to electric signalling in fire-alarm installations.
18,600 PAULING. Electrodes for treatment of gases by arc discharges.
20,328 ZIEGENBERG. Charging lead-peroxide-zinc storage batteries.
20,435 BURCHELL. Adapting tramway rails for crossing railway rails.
21,071 LE TALL (Cooper Hewitt Electric Co.). Vapour electric devices.
22,807 LEITNER. Ligneous separating diaphragms for accumulators.
25,283 ACKROYD, BEST, BEST & BEST. Electrically igniting miners' safety lamps.
25,306 SIEMENS BROS. & Co. and DIESELHORST (Siemens & Halske, A.-G.). Cables.
26,454 TURNER. Spring fuses for electrical work.
26,537 SEFTON-JONES (Stebbins). Regulating electric motors.
26,981 REYNOLDS. Electric furnaces.
26,985 SIEMENS BROS. & Co. & FERREIRA. Locking frames for operating electrically controlled railway points and signals.
27,050 DREWELL. Operating type-setting machines by electric currents controlled by register strips.
27,938 DE FOREST. Signalling by electromagnetic waves. (Date applied for, 8/12/05.)
27,956 PEDERSEN. Transmitting apparatus for wireless telegraphy. (Date applied for, 8/12/05.)
28,015 SCHALOW. Vent valves for batteries.
28,125 DE FOREST. Wireless telephony. (Date applied for, 22/12/05.)
28,549 STAPLEDON. Submergible electric heaters.
28,669 PALOUS & NATHAN. Electric horns. (Date applied for, 19/6/06.)
28,795 ABEL & PERVESLER. Electric switches.
29,176 BOLTSHAUSER. Insulator for conductors.
29,193 MATTHIESEN. Unipolar dynamos.
29,271 FRICK. Transformer furnaces. (Date applied for, 27/12/05.)
29,276 FRIEDLÄNDER. Telephone apparatus. (Date applied for, 17/9/06.)
29,322 WESTINGHOUSE. Turbines. (Date applied for, 26/12/05.)†
29,394 JABURG. Arc lamps.
29,482 COOPER. Electrically propelled railway and tramway vehicles. (Date applied for, 3/1/06.)
29,620 DAVIS. Bayonet caps for glow lamps.

1907 SPECIFICATIONS.

210 METALLURGISKA PATENTAKTIEBOLAGET. Magnetic separation of ore. (Date applied for, 9/1/06.)
522 VON SONNENTHAL. Clip for fixing conductors to insulators.
538 KORNS. Slot switches for electric tramways.
615 MALLET. Electric safety lamps for use in mines.
1,082 FLUCKIGER. Electrical bell-ringing apparatus.

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1,162 DEAN. Electrical influence machines.
1,333 POTTERAT. Electric traction systems.
1,663 MAY. Electricity meters.
1,665 KOUNTZ. Telephones. (Date applied for, 22/1/06.)
1,671 TURES. Incandescent vapour lamps.
2,123 SIEMENS & HALSKE A.-G. Filaments of metallic thorium. (Date applied for, 29/3/06.)†
2,215 WOEHRLE. Circuit-breakers.
2,377 HADFIELD. Improving the magnetic qualities of a magnetic body. (Date applied for, 5/7/06.)
2,515 BAKER. Moulding insulating sheaths for electric conductors from sheet fibrous material. (Date applied for, 21/3/06.)
2,613 HATFIELD & REASON MFG. CO. Electrical maximum demand or rebate indicators.
2,983 ROSE & CROWLE. Automatic electrical targets for rifle practice.
3,008 LHOTTA, LHOTTA & LHOTTA. Fenders for electric tramcars.
3,082 SIEMENS BROS. & CO. & FERREIRA. Electrically detecting railway points.
3,245 CARBONE. Arc lamps. (Date applied for, 17/3/06.)
3,276 RANSFORD. (Soc. Anon. Electrometallurgique (procédés Paul Girod).) Covers of electric furnaces.
3,522 SCHULTZ. Indication of blowing of fuses in distribution systems. (Date applied for, 14/2/06.)
3,880 HEWITT. Systems of electrical distribution. (Date applied for, 14/3/06.)
3,933 EISENSTEIN. Electric wave meters.
4,000 JACKSON. Switches for circuits. (Date applied for, 3/3/06.)
4,045 FELTEN & GUILLEAUME LAHMEYERWERKE A.-G. Compensating or commutation poles of dynamo-electric machines. (Date applied for, 17/2/06.)
4,607 SIEGFRIED. Supporting electric motors on shafts. (Date applied for, 3/3/06.)
4,667 ALDIGIER. Electrode for sparking plugs.
4,927 CHAPLET, & SOC. LA NEO METALLURGIE. Electric furnaces. (Date applied for, 25/9/06.)
5,025 GRIFFITHS & BEDELL. Current collector for stud-contact system. (Date applied for, 3/3/06.)
5,116 MCALPINE. Switches.
5,164 MANDERS. Producing oscillatory currents from continuous currents of electricity.
5,654 BERRY. Ventilating alternating-current transformers.
5,865 NALDER BROS. & THOMPSON, HARRIS, WALLIS-JONES & COX. Automatically breaking circuit in the event of a leakage to earth.
5,887 DEKKER. Treating minerals by electrolysis.
5,890 FELTEN & GUILLEAUME-LAHMEYERWERKE A.-G. Electric coils having self-induction for shortening the time of energising and de-energising such coils. (Date applied for, 20/4/06).
5,937 LORD. Electric heating apparatus for dentist's instruments, &c.
6,193 GRÖNWALL, LINDBLAD & STALHANE. Transformer furnaces.
6,258 ARNOLD & BUMPSTEAD. Electric terminals.
6,408 EHRHART. Turbines. (Date applied for 19/3/06.)
6,502 THIBOT & MAGE (called NOUGUIER). Regeneration of the electrolyte employed in the extraction of copper from old bronze and bronze waste. (Date applied for, 26/3/06.)
6,552 NYA ACKUMULATOR AKTIEBOLAGET JUNGNER. Alloys for the metallic parts of accumulators with invariable electrolyte, and accumulators constructed with same. (Date applied for, 30/3/06.)
6,822 DAVEY. Turbines.
7,033 UNTERBERG & HELMLE. Locking device for magneto-electric machines for igniting purposes.
7,309 GLOSSEL & LITTMANN. Armatures of magnetoelectric and like machines.
7,552 CASLAKE. Pendant for electric lighting.
7,695 SIEMENS BROS. DYNAMO WORKS. (Siemens Schuckertwerk Ges.) Field windings.
7,696 SIEMENS BROS. DYNAMO WORKS & HOLMES. Reflectors.
8,555 SOC. DES GARAGES KRIÉGER ET BRASIER. Electric current interrupters. (Date applied for, 26/4/06.)
9,143 ISARIA ZÄHLER WERKE GES. Electricity meters. (Date applied for, 27/4/06.)

COMPANIES' MEETINGS AND REPORTS.

BRITISH THOMSON-HOUSTON CO. (LTD.)—The directors' report for the year ended March 31 states that the buildings and machinery at Rugby have been maintained in first-class condition, and the directors have followed their usual practice in providing for depreciation thereof. They have also provided for depreciation of patents and stock in hand, besides making reserves sufficient in their opinion to cover risks in connection with bad debts, depreciation of shares and for other contingencies. During the period under review the company has contracted to supply to the Metropolitan Railway Co. 10 electric locomotives, and the electrical equipment for several trains, most of which have since been delivered. The electrical equipments for heavy traction work heretofore supplied to various railway companies continue to give complete satisfaction, including the equipments used on the system of tube railways operated by the Underground Electric Railways Co., all trains of which are equipped with the company's apparatus. The company has sold a number of Curtis turbo-generators during the year, the largest single contract being with Liverpool Corporation for three of 2,000 kw. each, and it has also equipped a number of textile and other mills and installed a number of colliery plants, all of which are operating satisfactorily.

The directors believe the company has good value in the enterprises in which it has investments. During the period under review it has disposed of a large amount of securities, and reduced proportionately its liabilities. The net amount realised by the sale of securities (after taking into consideration some additional shares acquired during the year) was £136,727, and the entire proceeds were used to reduce the company's indebtedness. This leaves the debentures and shares owned at March 31 at £105,801. 12s. 3d., and also £54,600 in shares in a patent-owning company, or a net reduction during the year in all securities of a little over £111,000.

The trading profit for the year, after deducting general and technical expenses, discounts, debenture and other interest, amounts to £14,994. 11s. 2d. The amount carried forward from March 31, 1906, was £4,124. 17s. 10d., making a total available of £19,119. 9s. The whole of this profit, with the exception of £1,071. 15s. carried forward, has been applied to various depreciations. Last year the balance of the excess cost of manufacturing incident to the establishment of the manufacturing business of the company amounted to £31,707. 17s. 8d. (£36,000 having been previously written off). Nothing was added to this account during the year, and the directors have decided to write off a further sum of £15,000, leaving £16,707. 17s. 8d., from which further sums will be written off from time to time until finally disposed of. The directors have resolved to depreciate apparatus, meters, supplies and special tools, &c., necessary for their production, by a much larger sum than heretofore, appropriating for the purpose £29,642. 14s. To take care of these heavy depreciations it has been decided to make use of the premium reserve account of £40,000.

CLEVELAND & DURHAM ELECTRIC POWER (LTD.)—In the report to be presented to the first annual general meeting the directors state that during the year under review £28,769. 18s. 7d. has been expended on the construction and equipment of sub-stations, &c. The net revenue amounted to £10,977. 11s. 8d. After payment of the full 5 per cent. preference dividend for the year, £3,226. 14s. 6d. is carried forward.

DEVONPORT & DISTRICT TRAMWAYS CO.—At the meeting on Monday Mr. W. G. Bond moved the adoption of the report of the directors for the half-year ended June 30. The total revenue was £11,726, and after deducting expenses chargeable to revenue (including debenture interest) the profit was £443, added to £456 brought forward. This total of £900 was carried forward. The half-year receipts increased by £160, while the expenses decreased by £254, compared with the first half of 1906. On capital account £566. 4s. was expended, making the capital total outlay £162,271.

GLASGOW DISTRICT SUBWAY CO.—At the meeting last week a shareholder expressed the opinion that the subway would never develop as it ought to do until electricity was adopted as the motive power. The Chairman said they had had tenders to convert the line to electric traction varying from £60,000 to £250,000. He thought it would cost about £100,000, but if they took electric energy from the Corporation, which he thought would be the best way, it could be done for much less. He thought the Corporation were short-sighted in not taking over the whole enterprise.

SOCIEDAD CO-OPERATIVA TELEFONICA (BUENOS AYRES). — The directors' report shows that the net profit for the past year was $151,047 m/n, and a dividend of 8 per cent. was declared. Subscribers increased from 4,701 to 5,349. In accordance with the municipal regulations a start was made in July with the work of placing the cables underground. The preliminary works for the extensions to La Plata have also been begun.

WILLANS & ROBINSON (LTD.)—The report of the directors for the half-year ended June 30 states that, after the necessary adjustments involved in the recent reduction of capital and after writing off £6,466. 15s. 9d. as depreciation (at Rugby), a profit of £18,275. 4s. 9d. is shown for Rugby, reducible by a loss of £2,233. 14s. 8d. at Queen's Ferry. The net profit is, therefore, £16,041. 10s. 1d., out of which the directors propose that dividends be paid at the rate of 6 per cent. per annum on the preference shares (absorbing £9,999 18s.) and 10 per cent. per annum on the ordinary shares (equal to 2 per cent. upon the original value), absorbing £3,333. 6s., the balance of £2,708. 6s. 1d. being carried forward. The premises and plant at Queen's Ferry having been recently written down so heavily, further depreciation is for the present unnecessary. The remaining loss (£2,233 14s. 8d.) for the half-year is less than Queen's Ferry's contribution to the two items of debenture interest and directors' remuneration, and there can, therefore, be no question that it is more profitable to keep the works open and employed, even upon the present inadequate scale, than to close them.

YORKSHIRE ELECTRIC POWER CO.—At the meeting on Tuesday the chairman (Prof. A. G. Lupton, M.P.) stated that during the half-year £3,947 had been expended on capital account, principally for mains and service equipments. New consumers had been connected and the installations of old consumers increased to a total of 850 kw. which showed a satisfactory comparison with 445 kw. for the corresponding half-year in 1906. Since the close of the half-year the weekly sale of energy had steadily increased, and each week had shown a revenue more than sufficient to pay all costs of generation, distribution and management. The deficiency on the revenue account of £403 was largely due to the abnormal increase in the price of coal, and with regard to that they offered one important advantage to their consumers. They were prepared to make contracts for the supply of electrical energy for a period of years, taking the risk, and it was a serious one, of a possible increase in the cost of coal, thus entirely relieving consumers from any fear that the margin of profit might be absorbed by the extra price that might have to be paid for coal. The company had secured as customers a number of important textile manfacturers, and the special knowledge of the officials of the company was at the service

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of any manufacturer who was considering that form of drive. Amongst the agreements made during the half-year was one with the Electrical Distribution of Yorkshire (Ltd.). This company was now taking a supply at Gomersal, while mains were being laid at Horsforth for a supply during the coming winter, part of which would be used for public lighting. The Distribution Co. had also taken transfers of electric lighting orders for Calverley, Castleford, Farsley and Liversedge, whilst arragements had been made to transfer the orders now held by the Corporation of Ossett and the District Council of Hipperholme. The arrangement made was for the Power Co. to give the Distribution Co. a supply of lighting for small power users, while large power users (25 H.P. and upwards) would be supplied direct by the Power Co. Terms had also been arranged with Brighouse Corporation to give a supply for lighting, power and tramways at an early date. Since the close of the half-year the Power Co. had completed an agreement with the British Carbide Factories (Ltd.) to take a lease of part of the site at Thornhill. Buildings were being erected which would be ready for occupation by the end of the year. Calcium carbide would be made on a large commercial scale for the first time in England. The carbide company would require a night and day supply of about 1,600 kw. and had contracted to take a yearly supply from the company equal to three times the present rate of sale. With regard to the agreement with Brighouse Corporation, the mains would cost a large sum, but the directors anticipated that that would be fully justified by the revenue derived from the extension.

STATUTORY RETURNS, MORTGAGES AND CHARGES.

STATUTORY RETURNS.

ANGLO-IBERIAN ELECTRIC LIGHT & POWER CO. (LTD.)—Return to Jan. 14 (filed July 15) gives capital as £10,000 in £1 shares, of which 106 have been taken up. £1 per share has been called up and paid on 100. Nothing has been called up on 6. Mortgages and charges, nil.

ANGLO-PORTUGUESE TELEPHONE CO. (LTD.)—Return to July 17 gives capital as £100,000 in £1 shares, all of which have been taken up. £1,046 has been paid and £98,954 is considered as paid. Mortgages and charges £48,900.

CROMPTON & CO. (LTD.)—The capital in return to Aug. 7 is £300,000 in 100,000 shares of £3 each, of which 85,000 have been taken up. £249,000 has been paid on 83,000 shares and £6,000 is considered as paid on 2,000. Mortgages and charges, £100,000.

EDMUNDSON'S ELECTRICITY CORPN. (LTD.)—In the return to Aug. 9 capital is £800,000 in 80,000 ordinary and 80,000 preference shares of £5 each, all of which have been taken up. £734,000 has been paid on 146,800 shares and £66,000 is considered as paid on 13,200. Mortgages and charges, £435,000.

CHILIAN ELECTRIC TRAMWAY & LIGHT CO. (LTD.)—According to return to Aug. 15 capital is £1,150,000 in £1 shares (650,000 preference), all of which have been taken up. £650,000 has been paid on the preference and £500,000 is considered as paid on the ordinary. Mortgages and charges, £475,300.

ELECTRIC CONSTRUCTION CO. (LTD.)—According to the return to Aug. 1 capital is £400,000 in 50,000 preference and 150,000 ordinary shares of £2 each, of which 31,390 preference and 112,100 ordinary have been taken up. £40,690 has been paid on 18,245 preference and 2,100 ordinary, and £246,290 is considered as paid on 13,145 preference and 110,000 ordinary. Mortgages and charges, £250,000.

ELECTRICAL POWER STORAGE CO. (LTD.)—Return to July 11 gives capital as £100,500 in 20,000 ordinary and 100 founders' shares of £5 each, of which 18,592 ordinary and 66 founders' have been taken up. £5 per share has been called up on 66 founders' and £4 per share on 3,132 ordinary, and £13,332. 5s. 1d. has been received, including £474. 5s. 1d. paid on four founders' and 405 ordinary shares forfeited, £77,300 is considered as paid on 15,460 ordinary shares. Mortgages and charges £10,000.

ELECTRICITY SUPPLY CO. FOR SPAIN (LTD.)—The capital in return to July 19 is £205,000 in 40,000 preference shares of £5 each and 19,900 ordinary shares of 5s. each and 100 founders' shares of 5s. each, of which 34,660 preference, 19,900 ordinary and 100 founders' have been taken up. 5s. per share has been called up on 19,900 ordinary and £4,975 has been received. £173,325 is considered as paid on 34,660 preference and 100 founders'. Mortgages and charges, £189,500.

NEW GENERAL TRACTION CO. (LTD.)—Return to July 17 gives capital as £370,000 in £5 shares (50,000 preference and 24,000 ordinary), all of which have been taken up. £250,000 has been paid on the preference shares and £120,000 is considered as paid on the ordinary. Mortgages and charges, £280,000.

NEWARC LAMP SYND. (LTD.)—Statutory report dated Sept. 2 shows 5,107 shares taken up out of a nominal capital of £6,000 in £1 shares. £1 per share has been called up on 1,107 and £1,107 has been received. 4,000 shares are considered as fully paid. No mortgages or charges registered.

A. W. PENROSE & CO. (LTD.)—In return to Aug. 13 capital is £40,000 in £1 shares (10,000 preference), of which 30,000 ordinary have been taken up. £7 has been paid and £29,993 is considered as paid. Mortgages and charges, £10,000.

POTTERIES ELECTRIC TRACTION CO. (LTD.)—In return to May 7 capital is £600,000 in 300,000 ordinary and 300,000 preference shares of £1 each, of which 245,000 preference and 245,000 ordinary have been taken up. £1 per share has been called up on 178,340 ordinary and 245,000 preference and £423,340 has been received. £66,660 is considered as paid on 66,660 ordinary. Mortgages and charges £245,000.

F. W. SMITH & CO. (LTD.)—According to return to July 12 capital is £5,000 in £5 shares, of which 600 have been taken up. £5 per share has been called up and £3,000 has been received. No mortgages or charges.

SUFFOLK ELECTRICITY SUPPLY CO. (LTD.)—According to return to July 8 capital is £10,000 in 980 ordinary shares of £10 each and 200 founders' shares of £1 each, of which 877 ordinary and 200 founders' have been taken up. £10 per share has been called up on 628 ordinary and £1 per share on 17 founders', and £6,297 has been received. £2,673 is considered as paid on 249 ordinary and 183 founders. Mortgages and charges £3,875.

TOTNES ELECTRICITY SUPPLY CO. (LTD.)—The capital in return to Aug. 3 is £10,000 in £1 shares, all of which have been taken up, and £9,993 has been received. Mortgages and charges, nil.

VARIABLE ELECTRIC LAMP SYND. (LTD.)—Statutory report, dated July 30, shows 957 shares taken up, subject to payment in cash, out of a nominal capital of £7,500 in £1 shares. £367. 10s. had been paid up to the date of the report. No mortgages or charges registered.

MORTGAGES AND CHARGES.

CONSOLIDATED SUPPLY CO. (LTD.)—Issue on Sept. 11 of £970 5 per cent. debentures, part of series created July 18, 1906, to secure £15,000, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £12,725.

MAXIM ELECTRICAL CO. (LTD.)—Issue on Sept. 11 of £2,000 5 per cent. debentures, part of £15,000 charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series £12,200.

D. SANTONI & CO. (1906) (LTD.)—A second debenture, dated Sept. 3, 1907, to secure £330, charged on company's undertaking and property, present and future, including uncalled capital, has been registered. Holder, R. C. Power.

CITY NOTES.

MEMORANDA (Sept. 26).—**Bank rate 4½ per cent.** (since Aug. 15, 1907). Price of silver 30 11/16—30 7/8d. per oz. Consols 82 3/16—82 5/16 for money, 82 7/16—82 9/16 for account; 2½ per cent. annuities 80½—80¾. Consols Pay Day, Nov. 6; Stocks and Shares Continuation Days, Oct. 9 and 28; Ticket Days, Oct. 10 and 29; Pay Days, Oct. 11 and 30; Mining Share Carry-over Day, Oct. 8.

BRITISH ALUMINIUM CO. (LTD.)—The directors have declared an interim dividend at the rate of 7 per cent. per annum on the ordinary shares.

BRUCE PEEBLES & CO. (LTD.)—Intimation has been issued to the preference shareholders that "it is not intended to pay the interim dividend on the preference shares which is usually paid at this time. As the shareholders are aware, however, there is a special reserve fund invested out with the business for securing payment of the preference dividends. The fund is more than sufficient to pay the whole of the current year's dividend, and the matter will fall to be dealt with when the year's accounts are completed in March or April next."

CALCUTTA ELECTRIC SUPPLY CORPN. (LTD.)—The directors have declared an interim dividend on the paid-up share capital for the half-year ended June 30 at the rate of 6½ per cent., payable on Nov. 15. The number of units delivered to consumers during the five weeks ended Aug. 30 were 760,558, compared with 590,291 in the corresponding period of 1906.

CALCUTTA TRAMWAYS CO. (LTD.)—The directors have declared an interim dividend of 3s. 6d. each on the ordinary shares (at the rate of 7 per cent. per annum, tax free) for the half-year ended June 30.

EASTERN EXTENSION, AUSTRALASIA & CHINA TELEGRAPH CO. (LTD.)—An interim dividend of 2s. 6d. per share has been declared for the quarter ended June 30. The share register will be closed from 7th to 14th inst. inclusive.

EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)—The directors recommend payment of a dividend for the year ended June 30, at the rate of 4⅛ per cent. per annum, being 2s. 6d. per share on the A shares partly paid, and 4s. 2d. per share fully paid, each less tax.

FOLKESTONE ELECTRICITY SUPPLY CO. (LTD.)—An interim dividend of 2 per cent. on account of the year 1907 is announced.

HOVE ELECTRIC LIGHTING CO. (LTD.)—The directors have declared an interim dividend at the rate of 8 per cent. per annum for the half-year ended June 30, payable 15th inst.

METROPOLITAN RAILWAY CO.—Col. J. J. Mellor, one of the directors and formerly chairman of the board, has resigned, and Mr. Thomas Parker, consulting engineer to the company, has been elected to the vacant seat.

MEXICO ELECTRIC TRAMWAYS CO.—The directors announce payment of a dividend at the rate of 4 per cent. per annum for the quarter ended Sept. 30.

REUTER'S TELEGRAM CO. (LTD.)—The directors have declared an interim dividend of 4s. per share (at the rate of 5 per cent.), tax free, for the half-year ended June 30.

STOCK EXCHANGE NOTICE.—The Stock Exchange committee have been asked to appoint a special settling day in *Willans & Robinson (Ltd.)* unding certificates for £84,999, 19s

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Sept. 25	1,579	- 626	17	26,596	- 972
Airdrie	,, 20	236	+ 3	37	8,306	- 51
Anglo-Argentine	,, 30	17,319	+ 1,967	39	642,768	+ 62,975
Ashton-under-Lyne Corp	,, 28	434	+ 78	27	10,888	+ 1,082
Ayr Corporation	,, 28	311	- 51	20	8,146	- 293
Baker St. & Waterloo Ry.	,, 28	2,310	+ 730	13	29,445	+ 11,625
Barnsley	,, 20	170	+ 6	37	6,274	+ 69
Barrow	,, 20	290	+ 8	37	9,820	- 158
Bath Electric Trams, Ltd.	,, 25	930	- 28	39	31,642	- 1,314
Birkenhead Corporation	,, 29	1,133	- 23	...	...	...
Birmingham Corporation	,, 28	6,680	...	26	158,173	...
Birmingham & Mid.	,, 13	837	...	36	29,547	...
Blackburn Corporation	,, 25	1,213	+ 146	¶26	30,237	+ 1,760
Blackpool Corporation	,, 26	1,956	+ 153	25	40,827	- 1,809
Blackpool and Fleetwood	,, 28	1,126	+ 4	...	...	...
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 29	2,329	+ 182	26	60,797	+ 3,552
Bournemouth Corporation	,, 25	1,920	+ 78	¶25	49,121	+ 941
Bradford Corporation	,, 28	4,962	+ 317	26	124,067	+ 1,388
Brighton Corporation	,, 29	1,030	- 1	26	26,481	- 2,683
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 27	5,283	+ 151	12	60,920	- 774
Burnley Corporation	,, 28	1,253	+ 39	26	31,650	+ 749
Burton Corporation	,, 29	282	+ 4	26	7,788	- 372
Bury Corporation	,, 22	1,261	...	25	28,578	...
Calcutta Tramways Co.	,, 29	₹48,190	- ₹2,399	12	₹569,386	+ ₹28,924
Camborne-Redruth	,, 28	133	+ 10	39	4,787	+ 104
Cardiff Corporation	,, 28	2,119	+ 29	25	56,145	+ 1,824
Cavehill	,, 20	99	- 19	37	3,285	- 129
Central London Railway	,, 28	4,990	- 1,275	13	62,569	- 9,583
Charing C., Euston & H'stead	,, 28	2,550	...	13	32,555	...
Chatham & Dist. Lt. Rys.	,, 26	798	- 55	¶38	28,414	+ 1,661
City & South London Rly.	,, 29	3,069	+ 109	13	39,359	+ 6,716
City of Birmingham	,, 20	2,899	...	37	104,209	...
Colchester Corporation	,, 25	236	+ 10	...	...	...
Cork Electric Trams Co.	,, 26	549	- 6	39	18,380	- 749
Croydon Corporation	,, 27	1,525	+ 49	26	38,382	- 1,842
Devonport & Dist. Trams	,, 20	516	+ 14	37	17,364	- 166
Dover Corporation	,, 28	268	...	26	6,617	- 920
Dublin & Lucan Railway	,, 27	154	+ 20	13	2,046	+ 166
Dublin United	,, 27	7,070	+ 2,102	‡13	96,438	+ 22,651
Dudley Stourbridge	,, 20	909	+ 104	37	32,402	- 843
Dundee Corporation	,, 25	1,151	- 18	19	22,128	+ 471
East Ham Council	,, 30	966	+ 68	26	24,435	- 277
Exeter Corporation	,, 28	336	+ 1	26	8,860	+ 710
Falkirk and District	,, 25	282	...	...	...	...
Gateshead & Dist. Trams	,, 20	1,036	+ 23	37	37,590	+ 897
Glasgow Corporation	,, 28	18,309	- 484	17	301,308	+ 4,535
Glossop	,, 28	134	...	39	5,330	+ 14
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	,, 20	275	+ 11	37	9,297	- 73
Great Northern & City Rly.	,, 28	1,646	- 110	13	20,634	- 207
Gt. Northern, Piccadilly, &c.	,, 28	4,080	...	13	50,405	...
Greenock & Port Glasgow	,, 20	668	- 64	37	24,964	- 839
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 20	329	+ 18	37	11,044	- 639
Hastings Elec. Trams Co.	,, 26	1,365	+ 318	13	17,651	+ 593
Hong Kong	,, 28	$8,263	+ $1,219	24	$301,627	+ $39,805
Huddersfield	...	...	...	...	...	...
Hull Corporation	,, 28	2,422	+ 195	26	62,554	+ 3,256
Ilford District Council	...	...	...	...	...	...
Ilkeston District Council	,, 25	149	+ 18	26	3,835	+ 201
Ipswich Corporation	,, 28	451	+ 6	26	11,547	- 881
Isle of Thanet Co.	,, 28	774	+ 94	52	31,703	- 461
Jarrow	,, 20	123	...	37	4,618	...
Keighley Corporation	,, 26	187	+ 29	13	2,206	+ 151
Kidderminster & District	,, 20	146	+ 30	37	4,645	- 165
Kilmarnock Corporation	,, 28	158	- 9	19	3,213	- 86
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 26	1,320	+ 296	39	45,982	+ 11,577
Lancashire United	,, 25	1,344	+ 342	39	49,580	+ 12,653
Leamington	,, 20	241	+ 41	37	6,147	- 711
Leeds Corporation	,, 21	6,635	+ 432	25	166,463	+ 6,622
Leicester Corporation	,, 28	2,121	+ 98	13	28,539	- 415
Leith Corporation	,, 28	503	- 18	†20	10,754	- 76
Lincoln Corporation	,, 28	111	+ 4	26	3,202	+ 82
Liverpool Overhead Rly.	,, 29	1,538	+ 121	13	21,451	+ 1,302
Liverpool Corporation	,, 21	11,140	+ 272	38	418,448	+ 7,245
* London County Council	,, 21	32,365	+ 7 626	25	786,139	+ 127,686
London United	,, 27	7,452	+ 1,101	‡39	258,124	+ 10,957
Lowestoft	,, 28	261	+ 19	52	10,934	+ 1,033
Maidstone Corporation	,, 28	136	+ 13	26	3,022	- 213
Manchester Corporation	,, 28	16,290	+ 1,764	26	391,362	+ 29,777
Mersey Railway	,, 28	1,866	+ 104	13	23,552	+ 1,713
Merthyr	,, 30	219	+ 13	37	7,855	+ 397
Metropolitan Dist. Railway	,, 29	7,669	- 329	13	94,483	- 745
Metropolitan Elec. Trams	,, 20	5,574	+ 2,205	37	174,243	+ 43,313
Middleton	,, 20	381	+ 29	37	13,118	- 171
Nelson Corporation	,, 28	148	+ 11	27	4,047	+ 72
Newcastle-on-Tyne Corp.	,, 28	4,016	- 21	26	107,373	+ 338
Newport (Mon.)	,, 28	680	+ 30	26	18,791	+ 1,612
Northampton Corporation	,, 27	457	- 5	‡26	11,736	- 528
Oldham, Ashton & Hyde	,, 20	638	+ 57	37	22,726	+ 1,047
Oldham Corporation	,, 29	2,053	+ 131	27	53,227	+ 3,352
Perth (N.B.) Corporation	,, 25	167	- 6	19	3,338	- 1
Perth (W.A.) Elec. Trams	,, 27	1,244	- 118	39	54,643	- 1,978
Peterborough	,, 20	143	+ 13	37	4,803	- 256
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	,, 28	2,165	+ 160	26	56,370	- 2,047
Potteries	,, 20	1,999	+ 114	37	69,898	+ 2,073
Preston Corporation	,, 25	742	+ 17	...	...	...
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 26	615	+ 128	‡26	15,682	+ 2,501
Rothesay	,, 20	272	- 37	37	9,391	- 603
Salford Corporation	,, 30	4,868	+ 255	26	124,288	+ 3,365
Sheerness	,, 18	70	+ 3	37	2,258	- 72
Sheffield Corporation	,, 29	5,738	+ 402	27	150,849	+ 6,770
Singapore Trams	,, 28	$9,408	+ $1,119	26	$245,282	+ $13,593

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	Sept. 25	1,133	+ 135	...	...	...
Southend Corporation	,, 25	504	+ 80	26	12,336	- 214
South Metropolitan	,, 20	1,021	+ 614	37	30,937	+ 6,702
Southport Tramways	,, 20	342	- 5	37	11,728	- 633
South Staffs	,, 20	901	+ 93	37	33,616	+ 2,206
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	,, 29	1,267	- 69	26	37,984	- 493
Sunderland and District	,, 25	462	+ 30	39	17,736	+ 1,994
Swansea Trams	,, 20	1,043	+ 175	37	31,472	+ 2,290
Swindon Corporation	,, 25	185	+ 6	...	...	...
Taunton	,, 20	47	- 2	37	1,660	- 111
Tynemouth and District	,, 20	333	+ 59	37	9,752	- 758
Tyneside Trams Co.	,, 25	463	- 17	39	18,194	+ 729
Victoria, Elec. Supply Co., of	Aug. 25	717	+ 99	...	...	...
Wallasey District Council	Sept. 28	881	+ 42	26	23,239	+ 557
Walsall Corporation	,, 28	561	+ 45	39	20,083	- 69
Warrington Corporation	,, 26	378	+ 19	26	9,896	+ 390
West Ham Corporation	,, 26	2,362	+ 62	26	61,870	+ 1,403
Weston-super-Mare	,, 18	316	+ 85	37	6,222	- 484
Wolverhampton Co.	,, 20	534	+ 47	37	17,199	+ 1,047
Wolverhampton Corpn.	,, 25	824	- 16	10	8,789	+ 40
*Worcester	,, 20	358	+ 34	37	10,796	- 243
Wrexham	,, 20	113	- 5	37	3,880	- 68
Yorkshire W.R. Trams	,, 29	1,347	+ 530	39	45,477	...
Yorkshire Woollen District	,, 20	938	- 70	37	35,457	+ 978

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

Shre.	Last Dividend	Name.	Price Wed., Oct. 2.	Rate % Yielded. £ s. d.	Dividend Due.	Business Week to Oct. 2. Highest.	Business Week to Oct. 2. Lowest.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
5	4/0	†Anglo-Argentine Ord. Shares	7 13/16 — 8 1/16	4 19 6	Ap, Oct	8 1/4	7 3/4
5	..	Do. 5½ per Cent. Cum Pref.	5 15/16 — 6 1/16	4 8 3	Ja, Jul	6 1/8	5 15/16
St.	6%	Do. Permanent 6% Deb. Stock	131 — 134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 — 105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams. Invest. Ord.	3 5/16 — 3 7/16	2 16 0	May ..	3 7/16	3 3/8
5	2/6	Do. 5 per Cent. Cum. Pref.	4 7/8 — 5 1/8	4 18 6	My, Nv	4 29/32	..
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	93 — 100	4 10 0	Ja, Jul	95	..
St.	7%	British Columbia El. Ry. Df. Ord.	130 — 135	4 16 0	Mr, Spt	133½	132½
St.	6%	Do. Pref. Ord. Stock	113 — 117	4 5 3	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	104 — 107	4 13 6	Ja, Jul	106	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 — 103	4 7 3	Ap, Oct	..	..
100	4½%	Do. Vancouver Power Debs.	102 — 104	4 6 6	Ja, Jul	..	..
5	3/0	Buenos Ayres & Belgrano Ord.	4 7/16 — 4 1/2	3 9 3	Ap, Oct	4 13/32	..
5	3/0	† Do. 6 per Cent. "A" Cum. Pref	4 3/4 — 5 1/4	5 14 0	Ap, Oct	4 3/4	..
5	3/0	† Do. "B"	4 3/4 — 5 1/4	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 — 115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	102 — 105	4 15 3	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 — 97	5 3 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 — 103	5 7 0	Ja, Jul	..	..
100	6%	† Do. 6 per Cent. 1st Deb. Bonds.	97 — 102	5 18 0	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7 — 7 1/8	5 6 9	Mr, Spt	7 3/8	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5 — 5 1/8	4 11 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 — 106	4 5 0	Ja, Jul	103	..
St.	..	Cape Electric Tram Shares	1/4 — 3/8	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 — 98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 — 87	5 15 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	87 — 93	5 6 8	Ja, Jul	..	..
5	6%	Do. 6 per Cent. "B" Ditto	77 — 81	7 8 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 — 1 1/4	4 0 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 — 1 1/4	4 16 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb.	92 — 97	5 2 6	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 — 99	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 — 103	4 7 6	Fb, Aug	..	..
St.	1%	Perth E. Trams. 1st Mt. Db. Stock	101 — 105	4 15 0	Ja, Jul	..	..
..	8%	†Sao Paulo Tramway, Light & Power Co. $100 Stock	108 — 113	7 1 0	..	117½	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	13% — 15%	5 5 0	Ju, Dec	91 7/16	91½
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½ - 5	6 0 0	Mr, Spt	..	..
10	4/5 3/8	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7½ - 8	6 0 0	..	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 — 98	4 13 9	Ja, Jul	95½	94 7/8
£	5,3	Calcutta Elec. Supply Ord. (1 to 80,000)	6 3/4 7 3/4	5 3 3	Ap, Oct	7 3/16	6 7/8
5	2/3	Do. (80,001 to 160,000)	6 1/4 — 7 1/4	..	..	6 7/8	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 — 53	4 14 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2 1/2 — 2 3/4	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	8 1/2 — 9 1/2	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94 - 96	5 4 0	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	101 — 104	5 15 6	Ja, Jul	..	..
1	0/3 2	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	11/16 13/16	..	Ap, Oct	3/4	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 — 97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	3/8 — 3/4	3 6 9	April ..	11/16	..
1	1/2 3	Do. 6 per Cent. non-Cum. Pref.	7/8 — 1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 — 98	5 2 0	Ja, Jul	..	..
5	3/0	†Rosario Elec. Co. 6% Pref. (1-20,000)	4 7/8 — 5 3/8	5 11 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds.	99 — 101½	4 19 0	Ja, Jul	100 3/4	100½

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

Shrs.	Last Divi-dend	Name.	Price Wed., Oct. 2.	Rate % Yield-ed.	Dividend Due.	Business Week to Oct. 2. High-est.	Business Week to Oct. 2. Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord...	9⅜–10⅜	6 10 0	Mar, Sept,	..	..
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅝–10⅝	4 8 0	Feb, Aug	9⅞	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	9⅜–10⅜	5 17 0	Feb, Aug	10⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	99 –102	4 8 0	Jan, July	100⅝	100⅜
5	2/0	†Bromley (Kent) El. Lt. & Power Shares	4⅜–5⅜	5 7 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 –100	4 10 0	May, Nov	98½	..
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7⅞–8	6 5 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.....	7¼–⅜	4 5 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co 4% Guar. Db. Stock	99 –102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W. End & City) El. Sup. Co.	3⅜–4⅜	5 18 9	Feb, Aug	4⅛	..
5	2/3	Do. 4½ per Cent. Pref.	3⅛–3¾	5 16 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 – 99	4 1 0	Jan, July	97	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3⅜–4⅞	6 2 6	Jan, July	..	..
5	2/0	†Chelsea Electric Supply Ord.	3¼–4¼	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	102 –105	4 5 9	June, Dec	..	..
10	5/0	City of London Electric Lighting Ord...	9 – 9½	5 6 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	11 –12	5 0 0	Jan, July	..	..
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	122 –125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	Jan, July	..	..
5	5%	County of Durham Elec. P.D. Ord.....	3¾–4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅜–4⅞	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	6¾–7⅜	6 0 0	Feb, Aug	..	..
10	6 0	Do. 6 per Cent. Cum. Pref.....	10 –11	5 8 6	Mar, Sept	10½	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	106 –109	4 2 9	Jan, July	..	..
St.	4½%	Do. Second Deb. Stock Prov. Certs....	96 –99	4 11 0	May, Nov	..	..
5	2/0	†Folkestone Electricity Supply Co. Ord.	4⅜–4⅞	5 5 0	April, Oct	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	4¾–5⅜	4 13 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	96 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6⅞–7⅛	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¾–9⅛	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6⅛–7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 1 0	..	..	..
St.	4%	Kensingtn. & Knghtbg. Co. & Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 –102	3 18 0	April, Oct	..	..
3	2/4½	London Electric Supply Ord.	1¼–1⅝	6 8 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.....	4¼–4⅝	6 6 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	88 – 92	4 7 0	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	5⅛–5⅜	6 1 6	April, Oct	5⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜–4¾	4 5 6	Jan, July	5	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	1⁰4 –107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock (red.)	18 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –18%	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	9 –9½	4 17 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	9⁸ – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅞–6⅞	6 3 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	6 – 6¼	4 17 7	Feb, Aug	..	..
100	4%	Do. 4 per Cent. Mort. Deb. red. 1907.	97 –18	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 –99	4 11 10	Jan, July	..	..
10	6/0	Notting Hill Electric Ord.....	11 –12	7 10 0	March ..	..	..
5	2/6	†Oxford Electric Ord.	5⅛–6	5 17 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 –97	4 2 6	Jan, July	..	..
5	5.0	St. James' & Pall Mall Elec. Ord.....	7¼–7⅝	6 9 0	Feb, Aug	7⅛	..
5	3/6	Do. 7 per Cent. Pref.	6½–7½	4 17 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86–91	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	⅞–1⅛	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	8/0	South London Electric Supply Ord.....	1⅞–2⅜	6 6 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	⅝–¾	3 6 9	..	⅝	..
1	0/8½	Do. 7 per Cent. Cum. Pref.....	⅝–1⅛	5 18 0	Feb, Aug	..	..
St.	4½%	† Do. 4½ 1st Db. Stk. Red.....	98 –101	4 9 0	April, Oct	..	..
5	2/6	†Urban Electric Supply Ord.	1⅜–2⅛	9 8 0	April, Oct	1⅜	1⅛
5	2.6	† Do. 5 per Cent. Cum. Pref.	1⅞–2⅜	8 14 0	April, Oct	..	..
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb.....	92 – 95	4 14 9	April, Oct	..	..
5	5.0	Westminster Elec. Sup. Ord.	8⅛–8⅜	6 11 0	Mar, Sept	8⅜	8⅜
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜–4⅝	4 3 6	Jan, July	4½	5
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	88 –93	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	⅛–⅜	5 7 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅛–⅜	5 5 0	Jan, July	..	..
St.	4½%	† Do. 4½ 1st Mort. Deb. Stock (red.) ...	91 – 95	4 14 9	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 – 97	4 13 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14 –14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8⅜–9	4 8 11	..	..	..
St.	4%	Do. 4 per Cent. Debs.	98 – 1 0	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	1⅝–1¾	..	June, Dec	2	1⅝
10	6/0	Do. 6 per Cent. Cum. Pref.....	5⅝–6⅛	9 16 0	Feb, Aug	6⅛	5¹⁵⁄₁₆
St.	5%	Do. 5 per Cent. Perpetual Debs.	97 –100	5 0 0	April, Oct	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 –81	5 11 0	May, Nov	..	..
St.	8%	Central London Ordinary Stock.....	63 –65	5 8 0	Feb, Aug	6⅛	6
St.	4%	Do. 4 per Cent. Pref. Stock	83 –90	4 9 0	Feb, Aug	88	..
St.	..	Do. Deferred Stock	45 –48	8 7 0	Feb	45	..
100	4%	Do. 4 per Cent. Debs.	02 –105	3 16 0	Jan, July	..	..
St.	4%	Charing X. Euston & Hmpstd Per. Db. Stk.	81 –84	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼–4⅜	5 2 6	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 –101	3 19 0	April, Oct	..	..
St.	2½%	City & South London Rly. Con. Ord. ...	45 – 47	4 17 0	Feb, Aug	46⅜	46⅛
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	116 –119	4 4 0	Feb, Aug	..	..
St.	5%	Do. (1896)	113 –116	4 6 0	Feb, Aug	..	..
St.	5%	Do. (1901)	113 –116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Perpetual Debs.	1 2 –105	3 16 0	May, Nov	104½	..
10	6/0	Dublin United Trams. (1896) Ltd. Ord...	13 –14	4 5 9	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Pref.....	12½–13⅜	4 7 0	Feb, Aug	..	..
10	0/11½	Gt. Northern & City Rly. Pref. Ord. (4%)	1¼–1⅝	..	Feb, Aug	..	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 – 7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 83	4 16 6	Jan, July	..	..
St.	4½%	†Hastings & Dist. Elec. Trams. Co. 4½ Lb. St.	97 –100	4 11 0	April, Oct	98	..
10	9%	Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	Do. 6 per Cent. Pref.	10½–11	5 9 1	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb s.	96 – 98	4 11 10	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	⅞–1⅜	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	96 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	91 – 97	5 3 0	Jan, July	9⅛	..
10	..	Liverpool Overhead Railway Ord.	1⅝–2	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	7½–8	6 5 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	85 – 87	4 12 0	Jan, July	..	..
10	5.0	London United Trams. 5% Cum. Pref. ...	7⅞–8⅜	6 14 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	82 – 86	4 13 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	..	..
1	..	Metropolitan Elec. Tramways Def.	⅛–⅜	..	April ..	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½–⅝	5 3 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	..	..
..	..	New Gen. Trac. 6 per Cent. Cum. Pref.	¾–1⅛	..	May	..	..
1	0/6	Potteries Electric Traction Ord.	⅛–⅜	8 0 0	April Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	¾–⅞	6 13 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	95 –98	4 11 9	May, Nov	..	..
1	0/6	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	—1	6 0 0	Feb, Aug	..	..
St.	..	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	..	Sunderland Dist. Elec. Trams. 5% 1st Mt. Db.	84 – 88	5 13 6	Jan, July	..	..
..	..	Underground Elec. Rys. Co. of London ..	7⅜ – 7⅝	8 12 0	June, Dec	..	..
..	..	Yorkshire (W. R.) Elec. Trams. Ord. ...	1 – 1½	—	March ..	..	..
..	..	Do. 6 per Cent. Cum. Pref.	3½–3⅝	..	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – 90	5 0 0	Jan, July	..	..
		ELECTRIC MANUFACTURING, &c.		£ s. d.		High-est.	Low-est.
1	..	Aron Electricity Meter Ord.	⅛–⅜	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅜–⅝	8 12 0	April, Oct	..	..
1	1/1⅛	†Babcock & Wilcox Ord.....	3¾–4	5 0 0	April, Oct	3⅞	..
1	0/7½	† Do. Pref.....	1⅛–1⅜	3 16 9	..	..	..
5	4/0	British Insulat e & Helsby Cables Ord.	6¼–7	7 3 0	July, Feb	..	..
5	8/0	Do. 6 per Cent. Pref.	6⅝–6⅞	4 18 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.)	101 –104	4 6 6	Jan, July	..	..
St.	4½%	British Thomas'n-Houst'n 4½% 1st Mt. Db.	85 – 89	5 1 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 –1⅛	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	62 – 67	5 19 0	Jan, July	..	..
2	..	Brush Electrical Engineering	⅛–⅜	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜–1⅛	5 7 0	Mar, Sept	..	..
1	0/9½	Castner-Kellner Alkali Co.	1⅝–1⅝	5 12 6	May, Nov	1⅝	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. (red.).	97 –102	4 8 0	Feb, Aug	..	..
1	1/2½	Chadburn's (Ship) Telegraph Ord.	1⅝–1⅝	7 12 0	March ..	..	..
1	0/7⅛	† Do. 6 per Cent. Cum. Pref.	1⅛–1⅛	5 1 0	April, Oct	..	..
3	2/1	* Crompton & Co. (Nos. 1 to 86,000)	1¾–2	7 10 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	86 – 99	5 1 0	Jan, July	97	..
5	2/0	†Dick, Kerr & Co. Ord.	1⅛–1⅜	6 13 0	Sept	..	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	1 –1⅛	6 16 0	Sept	1⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
1	0/9½	Edison & Swan United ("A" Sh.) (£3 pd.)	1⅛–1⅜	9 12 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2⅛–2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	† Do. 5 per Cent. 2nd Deb. Stock	87 –90	5 11 0	Mar, Sept	..	..
5	..	Edmundson's Elec. Corp. Ord.	½–1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1½–2	..	May, Nov	1⅝	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜–⅝	..	Jan, July	..	..
2	..	Do. 7 per Cent. Cum. Pref.	½–1½	..	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 –8½	5 17 9	June, Dec	..	..
St.	4%	† Do. 4 per Cent. 1st Mort. Debs.....	10 – 93	4 6 0	Mar, Sept	..	..
5	5/0	Henley's Telegraph Works Ord.....	11 –12	6 5 0	Feb, Aug	..	..
5	2,3	Do. 4½ per Cent. Pref.	5 –5½	4 2 0	Feb, Aug	5	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½–107½	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14½–15½	6 9 0	Feb, Aug	..	..
100	4%	† Do. 4 per Cent. Debs. (red.).....	95 –97	4 2 6	April, Oct	..	..
1	1/2½	Richardsons, Westgarth & Co., Ltd. Ord.	1¼–1⅜	8 0 0	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	⅞–1	6 4 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 –96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5½	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	30½–31½	5 11 6	Mar, July	31½	..
100	4%	Do. 4 per Cent Deb. Bonds (1909) ...	99½–102½	3 18 0	Jan, July	..	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2½–2⅝	6 6 6	..	..	..
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅝–1⅝	4 5 6	..	..	119
St.	5%	Do. 5 per Cent. non-Cum. Preferred	1⅛–112	4 9 6	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Stk. (red)	102½–104½	3 16 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	106 –108	4 3 3	June, Dec	107	..
10	8.0	J. G. White & Co. 6 per Cent. Cum. Prf.	8½–9½	6 6 0	Jan, July	..	..
5	..	Willans & Robinson Ord.	1¼–1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅜–4½	..	Apr, Oct	4⅛	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	74 –78	5 2 6	May, Nov	..	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3½	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 –88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	55 –58	6 14 0	F,My,Ag,N	59	..
St.	20/0	Do. Preferred	97 – 99	5 19 0	F,My,Ag,N	101	..
St.	11¾	Do. Deferred	15⅜–16	8 15 0	F,My,Ag,N	16	..
St.	4%	‡Commercial Cable 4 per Cent. Deb. Stk.	90 – 92	4 6 6	Ju,Ap,Jy,O	94	..
10	5.0	Cuba Submarine Ord.....	6⅞–7¼	6 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15½–16⅜	5 19 6	Feb, Aug	..	..
5	2/0	†Direct Spanish Ord.....	3¼–3⅜	5 13 0	April, Oct	..	..
5	5,0	† Do. 10 per Cent. Cum. Pref.	9 – 9½	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100–103⅞	4 7 3	Jan, July	..	..
20	6/6	Direct United States Cable	12½–13½	7 0 0	Ja, Ap, Jy, O	14	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	130 –133	5 5 6	Ja, Ap, Jy, O	134	..
St.	17/6	Do. 2½ per Cent. Pref. Stock	86 –88	3 19 6	Ja, Ap, Jy, O	88	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	103 –105	3 16 3	May, Nov	103	..
10	2/6	Eastern Extension	11⅜–12¾	5 12 0	Ja, Ap, Jy, O	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	102½–104½	3 16 6	Feb, Aug	..	..
100	4%	Eastern & S. African 4% Mort. Deb. 1909	98 –100	4 0 0	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	100 –102⅝	3 18 0	May, Nov	35	..
10	5.0	G.N. (of Copenhagen), with Coupon 71...	84 –86	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 –102	4 8 0	June, Dec	..	..
25	£2,6	Indo-European.....	55 – 57	5 14 0	May, Nov	..	..
100	£1	Mackay Companies Common	64 – 67	5 19 0	Jan, July	67	..
100	£1	Do. Preference	64 – 67	5 13 0	Ja, Ap, Jy, O	..	..
1	..	Marconi's Wireless Teleg. Co.	1¾–1⅞	..	April	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 –100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 –10⅛	3 16 0	June, Dec	..	..
5	1/3	West Coast of America	1⅛–1⅜	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 –100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅛–⅜	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7 –7½	8 0 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.....	6¾–7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 –102	4 18 0	Jan, July	..	..
10	3.0	Western Telegraph	12⅛–13	5 8 0	Mr, Jn, O, D	13	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 –92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	19 –102	4 18 0	Mar, Sept	..	..
5	5.0	Chili Telephone	6⅝–7⅛	5 10 6	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	¾–1⅛	4 14 0	Nov	..	..
1	0/6	Do. 5 per Cent. Pref.	¾–1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	10 ⅜–107⅛	5 11 6	Feb, Aug	..	..
St.	6%	Do. Def. Stock.....	10 ⅜–107⅛	5 11 6	Feb, Aug	..	..
10	6.0	Do. 6 per Cent. Cum. 1st Pref.	10¾–12¾	4 16 0	Feb, Aug	..	..
10	6.0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	..	..
5	2,6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	4¼–5⅜	4 13 0	Feb, Aug	..	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	96 –98	3 11 6	June, Dec	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	101 – 103	3 17 6	Jan, July	..	..
1	0/9½	Oriental	1⅛–1⅜	5 6 6	April, Oct	..	..
1	0/7	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 10 0	April, Oct	..	..
St.	4%	Do. 4 per Cent. Red. Deb. Stock	91 – 94	4 5 0	Jan, July	..	..
St.	4%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98 –101	4 9 0	Jan, July	..	..
5	7.0	United River Plate.....	6¼–7⅛	6 18 0	July	..	..
5	2.6	Do. 5 per Cent. Cum. Pref.	5 –5½	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	2.0	Elec. & Gen. Investment 6% Cum. Pref.	3½–4⅛	6 13 3	Jan, July	..	..
10	2.0	Globe Telegraph & Trust.....	9⅝–10⅛	5 4 6	Ja, Ap, Jy, O	..	..
10	3.0	Do. 6 per Cent. Pref.....	13 –13⅜	4 8 9	Ja, Ap, Jy, O	..	..
10	6%	Submarine Cables Trust (Cert.).....	127 –130	4 12 0	April, Oct	..	..

* In calculating the yields, allowance has been made for accrued interest but not for redemption. † Ex dividend. ‡ The London Stock Exchange Committee have declined to quote these

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NOTES.

German Technical Education.

AT the present time, when our technical colleges are opening their autumn sessions, the account given by Mr. STANLEY P. SMITH in our columns this week of the work carried on at the Electrotechnic Institute in Carlsruhe will be read with interest. There are two main points in which such an institution differs from the colleges in this country; namely, in the students themselves, and in the course provided for them. As regards student life, Mr. SMITH lays stress upon the fact that a German school has no student organisations, there is no common room, and the sociableness which is so characteristic of an English college is almost entirely lacking. This appears to us to be a distinct disadvantage. On the other hand, students in Germany have a greater opportunity of following their own tastes, and it may come as a surprise to some of our readers to learn that the English student certainly has a greater inclination for work.

WHEN we come to the equipment and course provided for the students we find these are more elaborate, and it is, perhaps, for this reason that the German student generally takes a course of four years, whereas the English student is satisfied with three. One of the most interesting features is the fact that the course at Carlsruhe includes political economy and labour problems, subjects on which the English student is generally left in complete ignorance. It is also noticeable that at Carlsruhe the subjects are divided so as to be in the hands of several professors, and there is a greater tendency in Germany for the branches to be treated by professors who are also engaged in practical engineering work. Whether, however, it is desirable for a student to spend so long as four years in his technical studies, instead of our customary three years, is a matter for considerable doubt.

Municipal Co-operation.

GREAT inconvenience and expense to the public has often been caused by the lack of proper co-operation between two adjacent local authorities. One particular phase of this question was recently noticed by us in a leading article, in which we drew attention to the desirability of so designing tramway systems in adjacent towns that through-communication could be afforded between them when desired. This principle is not only applicable to intercommunication, but can also be adapted to many other matters of a similar nature. A joint consideration of matters of this kind by two or more adjacent local authorities would often decrease the total expenditure and give a more efficient service. A district in which this principle would be specially advantageous is that part of South Staffordshire known as the "Black Country." This district, whose interests are dominated by the city of Birmingham, by Wolverhampton and other large towns, consists of many smaller towns and villages in close proximity to each other, and making together practically one continuous town. It is, therefore, interesting to note that a scheme of mutual co-operation has been proposed by the Mayor of Dudley, and a conference of the local authorities concerned is to be held at Birmingham next Thursday for the purpose of discussing it. It is proposed to form a representative body, to be known as the "Association of Midland Local Authorities," which is to meet at least twice a year to discuss municipal questions affecting the Black Country as a whole. Sub-committees will be appointed to deal with special subjects, among them such matters as intercommunication and education, in which co-operation is specially

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advantageous. Control of water supply and the provision of gas and electricity will also come within the scope of the Association. A central authority of this kind should prevent a constant recurrence of friction on matters of mutual interest between adjacent municipal authorities, and should lead to a more co-ordinated and efficient system than is possible when each small community carries out its own ideas without reference to what is being done along the same lines by its immediate neighbours. This attempt at co-operation will, no doubt, be watched with great interest, and should, if successful, cause other similarly situated districts to adapt the idea to their own needs.

The Price of Copper.

THE remarkably rapid drop in the price of copper from the unprecedented figure of £110. 10s. down to about £62 per ton has, no doubt, come as a relief to the electrical industry, which is dependent upon this metal not only for cables but to a large extent in the general manufacture of electrical machinery. The effect of the high price, however, has probably been felt more as a restrictive effect on the extension of mains than upon manufacturing. This would be particularly the case where the policy of an Electricity Committee regarding extensions is largely dependent upon the prospective revenue amounting to a certain percentage, say 20 per cent., of the estimated cost of the extensions. There is probably only one branch of the industry which will look upon the reduction in the price of copper with disfavour, namely, those manufacturers who are attempting the substitution of aluminium for copper. Recently engineers, stimulated by the high prices, considered whether covered aluminium cables could be commercially used in place of copper, and such cables are now on the market; but, since the commercial possibility of such a substitution depends entirely upon the relative prices of the two metals, it is unlikely that the aluminium cable will now make much headway until the American copper combines see their way to again force the price of copper up to an abnormal figure.

"Flexible" in Electric Wiring.

SOME little time back we urged the claims of flexible and uncased wires for house wiring from the point of view of reducing the cost to the lowest possible figure. We are glad to note that this class of wiring has been permitted for some little time past at West Ham, though curiously enough the contractors, who might be expected to see the advantages of cheapness, have failed to modify their methods to any great extent. Mr. SEABROOK, with his usual energy, has, therefore, addressed a letter to the local contractors urging them to give their immediate attention to the benefits which are likely to arise from the use of such a system, by bringing electrical installations within the reach of those who might otherwise consider them too costly. West Ham is a district which is advancing rapidly, and is just of that character which should benefit largely by the adoption of this system.

Electric Theft.

THE scientific burglar is already well known, and electricity supply authorities have occasionally suffered from theft of current, but it has been reserved for Americans to carry on the business of tampering with supply meters on scientific lines, and to supply "regulators" for adjusting the readings to a nicety. The demand for such an instrument, consisting of a strong electromagnet, appears to have been quite brisk. By choosing a time when no official could enter the premises, and placing the electromagnet in a suitable position, the armature was reversed until the reading suited the consumer. Presumably no consumer was sufficiently rash to obtain a negative quarterly account, and, owing to the state of the law making it necessary that the offender should be caught in the act, some difficulty was experienced in checking the career of the ingenious inventor. Although the inventor is now passing some time in enforced seclusion, it is doubtless consoling to him that people should have been willing, so it is stated, to pay for regulators at the rate of £40 each. Whether this development will lead to a boom in electrolytic meters remains to be seen.

Rail Corrugation.—The *Light Railway and Tramway Journal* is informed by Mr. J. A. Panton that since altering the trucks of the cars on the Liverpool Overhead Railway the corrugations, which extended from end to end of the track, have entirely disappeared. The total disappearance took about nine months and no rail grinder was used to accelerate it.

Wireless Telegraphy.—The Liverpool "Daily Post" announces that the Marconi wireless telegraph service between "Great Britain" and Canada is to be inaugurated on Monday next, and that it is probable the service will begin with messages to the leading London newspapers. The same journal further states that "messages by this system can be transmitted at an average of 25 words per minute, but if an improved apparatus were adopted and an automatic recorder fixed on the receiving instrument, the speed could be increased to 100 words per minute." We await developments.

Telephonic Communication between Sydney and Melbourne.—It is announced that a telephone line between Melbourne and Sydney, a distance of over 600 miles, has just been completed. Exceptionally strong and heavy copper wires, interlaced and hung for the most part on new strong poles, are used. The cost to the Australian Commonwealth has been £46,686, of which £33,053 has been spent in New South Wales and £16,628 in Victoria. The work was done by contract in New South Wales territory, and by Post Office departmental gangs in Victoria. Construction progressed simultaneously in each State, and the whole undertaking was completed in less than four months.

Multiple Unit Control on Street Cars.—The *Street Railway Journal* gives particulars of some tests made on street cars in Columbus City. In order to reduce the congestion on one of its lines the company, instead of attaching a trailer to a motor car, two motor cars coupled together, and used a multiple unit control on the leading car. Tests made by the Ohio State University's Department of Electrical Engineering showed the two-car combination to be more economical, as regards energy, on the ton basis, but from the standard of energy per car mile and passenger, the single car showed a decided advantage. The conclusion arrived at was that the two-car combination should be operated only when traffic is dense enough to fill both cars.

Cable Interruptions and Repairs.

	Date of Interruption.	Date of Repair.
Garachico (Teneriffe)—Santa Cruz de la Palma	July 12, 1906 ..	—
Brest—Dakar	July 22, 1907 ..	—
Grand Canary—Lanzarote ..	Sept. 18, 1906 ..	—
Midway Islands—Guam	Sept. 22, 1907 ..	—
Fort de France—Paramaribo	Sept. 26, 1907 ..	Oct. 7, 1907
Pernambuco—Ceara	Oct. 9, 1907 ..	—
Pernambuco—Para	Oct. 9, 1907 ..	—

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Manufacture of Vases in Cast Silica.—*Le Journal d'Electrolyse* describes a furnace whose inner surface is of the same shape as the exterior surface of the article to be manufactured. A strip of carbon, which can be brought to a white heat by a strong electric current, is placed in the furnace and is pierced with holes through which air can be blown. The furnace is filled with sand, and by raising the carbon to red and then white heat, a layer of molten sand is formed over it. When the molten layer is sufficiently thick the excess sand is taken out and by continuing the heating the molten sand is completely vitrified. Air blown in through the carbon distends the vitrified layer and presses it against the side of the furnace, moulding it to the same shape. Objects prepared by this method have a shot colour caused by the innumerable air-bubbles enclosed in its mass. These objects, like those made of cast quartz, are capable of standing very great variations in temperature.

Electricity in Agriculture.—The successful application of electricity to agriculture and horticulture possesses a direct interest for the electrical industry, and, consequently, the experiments which are being made by Mr. B. H. Thwaite, in the gardens of the Royal Botanic Society, Regent's Park, London, should be regarded with more than usual interest by the electrical profession, as well as by those who are engaged in horticultural pursuits. Mr. Thwaite lectured last week on the general subject of electricity applied to plant life, but he appears to have carried matters no further than Siemens, Lemström, and, more recently, Newman's experiments in this country. More promising results may possibly await us in the near future. In the meantime, others are at work in this fascinating field, and amongst these may be mentioned Mr. A. E. Baines, who is engaged in a series of experiments by which, he informs us, he hopes to advance our knowledge of plant life from the electrical aspect. But the electrician and the horticulturist must benefit by any solid advance in our knowledge of these matters, and both branches of industry will, therefore, wish Mr. Baines success with his investigations.

Calorific Value of Blast-Furnace Gas.—The successful application of blast-furnace gas to the driving of gas engines makes it desirable to know the total quantity of gas that can be obtained from any given make. For this purpose a simple method has been devised by Prof. J. von Ehrenwerth, which was described by him before the Iron and Steel Institute at their recent meeting in Vienna. The data required are the weight of carbon contained in the gases, corresponding to unit weight of make and an analysis of the gas expressing the constituents usually determined in percentage volumes. The carbon in the gases corresponds to the total carbon charged into the furnace less the amounts used in carburising the metal, and carried away by the unconsumed fuel and intercepted in the dust-catcher. The total volume of the gas may be computed from the heat balance-sheet, but this only gives the weights of the gases, and a better method is to determine the weight of carbon per unit of make from a volumetric analysis of the gas, while from the results of this analysis the calorific value of the gas may be deduced. The author gives a fully worked out example showing the industrial adaptation of his method.

Electric Drive in Rolling Mills.—The *Elektrotechnik und Maschinenbau* gives some details of a rolling-mill equipment which has recently been erected by Messrs. Siemens-Schuckert at the Burbacher-Hütte. An existing power station, which contained three Deutz engines, worked by blast furnace gas and coupled to 420 kw. continuous-current generators, has been enlarged by the addition of another gas engine which drives a double-commutator generator supplying current at 2 × 240 volts and of a 1,250 H.P. steam turbine connected to two 420 kw. dynamos feeding the 2 × 240 three-wire network. A mill, which is designed to take 80-100 kg. iron blooms measuring up to 130 × 130 sq. mm. is driven by a 410-800 H.P. compound motor. This motor is coupled by a belt to a flywheel and its speed can be regulated between 230 and 300 revs. per min. by a shunt resistance. The rough rolls are connected to the flywheel shaft, while the finishing rolls are belt-driven direct from the motor. The mill can handle from 20 to 50 tons per day. For cutting the finished material a shears driven by a 20 H.P. compound motor and fitted with a flywheel is provided. Winches, &c., are installed which can be started and driven from a central position. For the transport of coke a 25 H.P. electric locomotive is used.

New Electric Locomotives for the Simplon Tunnel.—Up to the present time electric traction in the Simplon Tunnel has been carried out by two Brown, Boveri locomotives and three locomotives belonging to the Italian State railways. In order to release these latter Messrs. Brown, Boveri have constructed two new locomotives, which are described in the *Elektrotechnik und Maschinenbau*. The new locomotives have only four axles, instead of five as at present, two of which are trailing axles, and all four axles are coupled together, so that the whole weight of the locomotive can be used as adhesive weight. The axles are driven by two three-phase motors, which are fixed to the frame of the locomotive and drive through the wheel cranks and connecting rods. Each locomotive has a capacity of 650 H.P. and its weight is 67 tons, corresponding to a draw-bar pull of 1,675 tons. The new locomotives have four speeds which are obtained by changing the number of poles on the motors. The motors have short-circuited armatures and are started on low voltage. On each locomotive are two three-phase transformers whose secondary voltage can be varied. For collecting the current a special bow trolley, similar to that at present used on the locomotives, has been provided. The diameter of the driving wheels is 4 ft. 2 in., while the lowest speed is 17 and the highest 45 miles per hour.

Combined A.C. and D.C. Air Brake Apparatus.—The *Street Railway Journal*, in describing an air-brake apparatus suitable for use on electric railways using both direct and single-phase currents, gives an account of a motor suitable for this purpose. It is of the four-pole commutator type with two consequent poles, and is designed for operation on 500 to 600 volts direct-current circuits, and on 280 to 340 volts alternating-current 25 cycle single-phase circuits. The motor has two distinct field windings, one for alternating current and one for direct current. Laminated sheet-steel pole pieces are used. The pole faces have a compensating winding, consisting of four coils which are short-circuited upon themselves. The brush gear proper is fastened to a cast-iron yoke made in two halves, secured in a groove running entirely around a projection of the armature bearing at the commutator end of the motor. Two sets of brush-holders of two brushes are used. The inspection of the armature, commutator and brushes is rendered easy by the inspection doors at the sides of the motor casing. The compressor is started by throwing it directly on the full voltage, either alternating current or direct current. A relay is provided for automatically making the connections for running the motor either on alternating or direct-current circuits. When the direct-current circuit is closed, the necessary connections for direct-current operation are made by the solenoids of the relay attracting plungers to which the contact pieces are secured. When operating on the alternating-current circuit these solenoids are not in circuit, and the contact carrier drops by its own weight and makes the necessary connections for operating on alternating current.

ARRANGEMENTS FOR THE WEEK.

MONDAY, October 14th.

GRADUATES' ASSOCIATION OF THE INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's Gate. Paper on "Modern Locomotive Practice," by Mr. A. McKinnon.

THURSDAY, October 17th.

RUGBY ENGINEERING SOCIETY.

8 p.m. Meeting at Ketton Chambers, Regent-street, Rugby. Paper on "Steam Turbines, with special Reference to the Willans-Parsons Type," by Mr. E. R. Briggs.

FRIDAY, October 18th.

JUNIOR INSTITUTION OF ENGINEERS.

7 p.m. Annual General Meeting at the Westminster Palace Hotel, followed at 8 p.m. by a Paper on "The Economic Design of Hollow Shafts," by Prof. W. E. Lilly.

INSTITUTION OF MECHANICAL ENGINEERS.

8 p.m. Meeting at Storey's Gate. Paper "On the Indicated Power and Mechanical Efficiency of the Gas Engine," by Prof. B. Hopkinson.

CHEMICAL SOCIETY.

9 p.m. Meeting at the Royal Institution, Albemarle-street. "Faraday Lecture" on "Organic Synthesis and its Relation to Biology," by Prof. Emil Fischer, F.R.S.

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ON THE ELEMENTARY THEORY OF ELECTRIC OSCILLATORS.

BY J. A. FLEMING, D.SC., F.R.S.

(*Concluded from page 979.*)

Summary.—In this series of articles the author discusses the theory of the electric oscillator and the production of electric waves thereby. The first part dealt with the action of a Hertzian oscillator, and it was shown how to obtain expressions for the electric and magnetic forces at any point in space round it. The second part, in like manner, discussed the closed or magnetic oscillator, and expressions were obtained for the forces and radiative power. In the third part combinations of open and closed oscillators are discussed, and the elementary theory of the *bent* oscillator which radiates unsymmetrically is given.

Having obtained expressions for the electric and magnetic forces at any point in the field of an open or a closed oscillator, we can employ the same principles to enable us to predetermine the operation of certain combinations of these two fundamental forms. A completely closed circuit in which oscillations are taking place is called a magnetic oscillator because the effects in the external space are wholly due to the current in the circuit. There being no free ends, there are no free electric charges to create electric potential in the space. On the other hand, an open oscillator exhibits these free charges alternately at each end, and these, as we have seen, create a static or electric potential which contributes to creating the electric and magnetic forces. Hence, an open oscillator is usually called an electric oscillator. We shall now show that certain forms of oscillator may be regarded as combinations of a magnetic and an electric oscillator.

It is well known that a transmitting antenna as used in radio-telegraphy which is bent, inclined, or partly vertical and

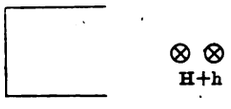

FIG. 5.

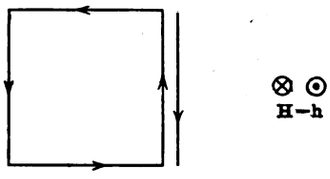

FIG. 6.

partly horizontal, sends out its radiation unequally in different directions. It radiates most strongly in a direction *opposite* to that towards which the free end points. This peculiar property was discovered experimentally, but it can be shown that it is a necesary consequence of the principles explained in this article. Let us first consider a simple case.

Suppose four equal dumb-bell Hertzian oscillators to be arranged in a square, the poles of opposite sign overlapping, then the free charges cancel each other, and we obtain as a resultant a closed circuit or magnetic oscillator. Imagine then that a fifth similar oscillator to be superimposed on one side of the square, so that its current is at any instant equal and opposite to that in the side of the square on which it is superposed. The result is to create an oscillator which is equivalent to one with a double bend in it. In other words, an oscillator such as that shown in Fig. 5 is the result of the superposition of a completely closed and an open oscillator, as in Fig. 6.

It is easy to see what the nature of the resultant magnetic field will be. Imagine yourself standing in front of the square closed oscillator of which the plane is vertical and the current at that instant flowing round it counter-clock wise. Then the magnetic field outside it and transversely to the plane of the oscillator will be away from you on both sides (see Fig. 6). Next consider the open or linear oscillator placed in contiguity to the right-hand side of the closed and that the current in the open one is downwards at the instant considered. Then the field due to this current will be towards you on the right hand and from you on the left hand transversely to the plane of the oscillator. Hence, the field of the open oscillator weakens that of the closed on the right-hand side and strengthens it on the left-hand side, and the same in all stages of the periodic current. Hence, the bent oscillator as in Fig. 5 gives rise to a magnetic field, and therefore to a radiation which is stronger on the side away from which the free end points.

Starting from this idea, we can easily obtain the equations for the electric and magnetic forces round a doubly-bent oscillator, as shown in Fig. 5.

We may also consider this doubly-bent oscillator as made up by the superposition of three dumb-bell oscillators (*see* Fig. 7). Taking the co-ordinate axes with z vertical and y drawn to the right, we have shown that if an open oscillator of moment ϕ is placed with centre at the origin and axis along z, then the scalar potential V at any point z, y or r, θ is expressed by

$$V = -\phi\frac{d\Pi}{dz},$$

where $\Pi = \sin(mr - nt)/r$.

Hence, if one oscillator of moment ϕ and length δz is placed with axis parallel to z, and with centre at a point $-\frac{1}{2}\delta y$, and if two other oscillators of moment ϕ^1 and length δy are placed with axes parallel to y and centres at distances $+\frac{1}{2}\delta z$ and $-\frac{1}{2}\delta z$ we have the bent oscillator in question.

Accordingly it is easy to see that the scalar potential V due to the three component oscillators is given by

$$V = -\phi\frac{d\Pi}{dz} + \frac{1}{2}\phi\frac{d^2\Pi}{dy\,dz}\delta y - \phi^1\frac{d^2\Pi}{dz\,dy}\delta z. \quad . \quad . \quad (28)$$

Also the components F, G, and H of the vector potential are given by

$$\left.\begin{aligned} F &= 0 \\ G &= \phi^1\frac{d^2\Pi}{dz\,dt}\delta z \\ H &= \phi\frac{d\Pi}{dt} - \frac{1}{2}\phi\frac{d^2\Pi}{dy\,dt}\delta y. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (29)$$

Let $\phi\delta y = \phi^1\delta z = M/n$, where M is the magnetic moment of the oscillator and $n = 2\pi/T$.

To obtain the components of the electric force P, Q, R and of the magnetic force a, b, c, we substitute the values of V, F, G, H, given in (28) and (29) in equations (7) and (8), and we obtain the following :—

$$\left.\begin{aligned} P &= \phi\frac{d^2\Pi}{dx\,dz} + \frac{M}{2n}\frac{d^3\Pi}{dx\,dy\,dz} \\ Q &= -\frac{M}{n}\frac{d^3\Pi}{dz\,dt^2} + \phi\frac{d^2\Pi}{dy\,dz} + \frac{M}{2n}\frac{d^3\Pi}{dy^2\,dz} \\ R &= -\phi\frac{d^2\Pi}{dt^2} + \frac{M}{2n}\frac{d^3\Pi}{dy\,dt^2} + \phi\frac{d^2\Pi}{dz^2} + \frac{M}{2n}\frac{d^3\Pi}{dy\,dz^2}. \end{aligned}\right\} \quad . \quad (30)$$

$$\left.\begin{aligned} a &= \phi\frac{d^2\Pi}{dy\,dt} - \frac{M}{2n}\frac{d^3\Pi}{dy^2\,dt} - \frac{M}{n}\frac{d^3\Pi}{dz^2\,dt} \\ b &= -\phi\frac{d^2\Pi}{dx\,dt} + \frac{M}{2n}\frac{d^3\Pi}{dx\,dy\,dt} \\ c &= \frac{M}{n}\frac{d^3\Pi}{dx\,dz\,dt}. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (31)$$

In these equations we have then to substitute for Π its value $\sin(mr - nt)/r$ and work out the differential coefficients.

For the present purposes we need only work out the values of R, a and b, and these are :—

$$\left.\begin{aligned} R = \Big\{ &\phi(m^2r^2 - 1) - \phi(m^2r^2 - 3)\left(\frac{z}{r}\right)^2 + \frac{M}{2u}\frac{3}{mr}\left(\frac{y}{r}\right) \\ &+ \frac{M}{2u}\frac{\delta m^2r^2 - 15}{mr}\left(\frac{y}{r}\right)\left(\frac{z}{r}\right)^2\Big\}\frac{\sin\chi}{r^3} \\ &+ \Big\{\phi mr - \phi 3mr\left(\frac{z}{r}\right)^2 - \frac{M}{2u}(m^2r^2 + 3)\left(\frac{y}{r}\right) \\ &+ \frac{M}{2u}(m^2r^2 + 18)\left(\frac{y}{r}\right)\left(\frac{z}{r}\right)^2\Big\}\frac{\cos\chi}{r^3} \end{aligned}\right\} \quad . \quad (32)$$

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$$a=\left\{\phi um^2r^2\left(\frac{y}{r}\right)+\frac{M}{2}3mr\left(\frac{y}{r}\right)^2-\frac{M}{2}3mr+3Mmr\left(\frac{z}{r}\right)^2\right\}\frac{\sin\chi}{r^3}$$
$$+\left\{\phi umr\left(\frac{y}{r}\right)-\frac{M}{2}(m^2r^2-3)\left(\frac{y}{r}\right)^2-\frac{3M}{2}\right.$$
$$\left.-M(m^2r^2-3)\left(\frac{z}{r}\right)^2\right\}\frac{\cos\chi}{r^3}. \quad . \quad . \quad (33)$$

$$b=-\left\{\phi um^2r^2\left(\frac{x}{r}\right)+\frac{M}{2}3mr\left(\frac{x}{r}\right)\left(\frac{y}{r}\right)\right\}\frac{\sin\chi}{r^3}$$
$$-\left\{\phi umr\left(\frac{x}{r}\right)-\frac{M}{2}(m^2r^2-3)\left(\frac{x}{r}\right)\left(\frac{y}{r}\right)\right\}\frac{\cos\chi}{r^3}. \quad (34)$$

In the above expression u is written for n/m.

Suppose we limit our attention to the values of the electric and magnetic force at right angles to a radius vector drawn in the plane xy bisecting the oscillator.

Let e be the value of the electric force parallel to the axis of z, and h that of the magnetic force at right angles both to e and to the radius vector r drawn in the plane of xy. Then $h=ay/r-bx/r$ subject to the condition that $z=0$.

Hence, if we multiply the value of a as given above by y/r and that of b by x/r, and subtract and put $z=0$ we have for the magnetic force h and electric force e,

$$h=\{\phi um^2r^2\}\frac{\sin\chi}{r^3}+\left\{\phi umr-\frac{M}{2}m^2r^2\cos\theta\right\}\frac{\cos\chi}{r^3}. \quad (35)$$

$$e=\left\{\phi(m^2r^2-1)+\frac{M}{2u}\frac{3}{mr}\cos\theta\right\}\frac{\sin\chi}{r^3}.$$
$$+\left\{\phi mr-\frac{M}{2u}(m^2r^2+3)\cos\theta\right\}\frac{\cos\chi}{r^3}. \quad . \quad . \quad (36)$$

In the above $\cos\theta=y/r$.

The amplitudes of e and h may be called E and H, and hence, remembering that the amplitude of a harmonic oscillation $A\sin\beta+B\cos\beta$ is $\sqrt{A^2+B^2}$, we have

$$H^2=\frac{1}{r^6}\left[(\phi um^2r^2)^2+\left(\phi umr-\frac{M}{2}m^2r^2\cos\theta\right)^2\right]. \quad . \quad (37)$$

$$E^2=\frac{1}{r^6}\left[\left\{\phi(m^2r^2-1)+\frac{3}{2}\frac{M}{u}\frac{\cos\theta}{mr}\right\}^2\right.$$
$$\left.+\left\{\phi mr-\frac{M}{2u}(m^2r^2+3)\cos\theta\right\}^2\right] \quad . \quad . \quad (38)$$

Now E is the amplitude or maximum value of the electric force parallel to the axis z and perpendicular to the radius vector r, drawn in the plane yx. H is the magnetic force perpendicular to the same radius vector and in the plane of yz.

Since when $\theta=0$, $\cos\theta=1$, and when $\theta=180$ deg. $\cos\theta=-1$, it is clear that the expressions for E and H are both numerically larger when $\theta=180$ deg. than when $\theta=0$.

In other words, the forces E and H are both greater at a given distance on that side away from which the open ends of the oscillator points.

If we put $M=0$ in the equations (30) and (31) they reduce to the equations given already for the Hertzian linear oscillator.

Again, the equations (37) and (38) for E and H have minimum values corresponding to a value of θ such that

$$\cos\theta=\frac{2\phi u}{M}\cdot\frac{1}{mr} \quad \text{or} \quad \cos\theta=\frac{2\phi u}{M}\cdot\frac{mr}{m^2r^2+3}.$$

The above expressions are numerically small when r is large compared with λ. For

$$\frac{2\phi u}{M}=\frac{2\phi n}{Mm}=\frac{2\phi}{\phi\delta ym}=\frac{z}{m\delta y}.$$

Hence the condition of a minimum is

$$\cos\theta=\frac{2}{\delta ym^2r}=\frac{\lambda^2}{2\pi^2\delta yr} \quad . \quad . \quad . \quad . \quad . \quad . \quad (39)$$

There will, therefore, be a minimum value of E or H corresponding to some azimuthal angle θ, rather less than 90 deg., reckoned from the direction in which the free end points.

The ratio of $\lambda/\delta y$ is fixed by the geometrical form of the bent oscillator, and therefore the inequality between the values of E and H for constant value of r but varying value of θ depends essentially upon the ratio of λ/r or of wave lengths to distance of point of observation, and in order that the inequality between the values of E and H corresponding to $\theta=0$, $\theta=180$ deg., may be as large as possible, it is necessary that the quantity ϕu shall be as nearly as possible equal to $\frac{1}{2}Mmr$, or λ^2 as nearly as possible equal to $2\pi^2\delta yr$.

Hence, when r is large, λ must be as large as possible; in other words, we can only secure considerable inequality at great distances fore and aft by using long wave lengths.

We may write the value of $\cos\theta$, which corresponds to the minimum value of the radiation, in the form

$$\cos\theta=\frac{1}{2\pi^2}\cdot\frac{\lambda}{r}\cdot\frac{\lambda}{\delta y}.$$

If the oscillator is one with three equal branches, then its total length $L=3\delta y$. Moreover, $\lambda=2{\cdot}5L$ nearly; hence

$$\cos\theta=\frac{1}{2\pi^2}\times\frac{2{\cdot}5L}{r}\times7{\cdot}5$$
$$=\frac{18{\cdot}75}{19{\cdot}75}\frac{L}{r}$$
$$=\frac{L}{r}\text{ nearly}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (40)$$

Accordingly, when the distance r of the point of observation is large compared with the total length of the oscillator, the azimuthal angle θ of the minimum radiation will be something less than 90 deg., reckoning from the direction in which the free end of the oscillator points.

The theoretical deductions have been fully confirmed by the experiments and observations of Mr. Marconi and of the author. Mr. Marconi employed an antenna which had a short

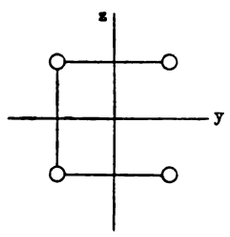

FIG. 7.

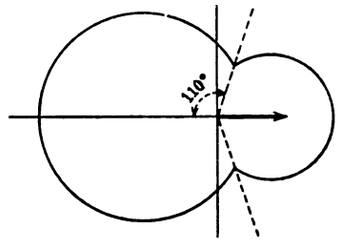

FIG. 8.

part of its length (earthed at the lower end) vertical and a much longer part horizontal. Such an antenna used as a transmitter creates a field which is similar to that of one half of the doubly-bent oscillator we have discussed. If measurements are made at equal but considerable distances round such an oscillator of the current induced in a vertical receiving antenna, and if these currents are plotted out in a polar diagram the radii of which represent in direction the azimuthal angle the extremities of the radii delineate a closed curve which resembles a figure 8 with one loop larger than the other. The longest radius is in the direction opposite to that on which the free end of the antenna points and the minimum is not at 90 deg., but at about 105 or 110 deg. reckoned from the maximum direction* (*see* Fig. 8). Referring to equation (37) we see that to obtain a large difference between the values of H when $\theta=0$ and when $\theta=180$ deg., it is necessary that $\frac{M}{2}mr$ should be as nearly as possible equal to ϕu, or, since $u=n/m$ and $M/n=\phi$, that $\delta z\,mr/2$ should be as nearly as possible equal to $1\,m$. This is equivalent to saying that δz should be as nearly as possible equal to $2/m^2r=\lambda^2/2\pi^2r$. If then r is large δz must be small. The condition of large fore and aft inequality is, therefore, that the antenna must have a short vertical part and a long horizontal part, and this was found to be the case experimentally by Mr. Marconi.

* *See* G. Marconi, "On Methods whereby the Radiation of Electric Waves may be mainly confined to certain directions, and whereby the Receptivity of a Receiver be restricted to Electric Waves emanating from certain directions," *Proc.* Roy. Soc., Lond., Vol. LXXVII., p. 413, 1906. Also J. A. Fleming, "A Note on the Theory of Directive Antennæ or Unsymmetrical Hertzian Oscillators," *Proc.* Roy. Soc., Lond., Vol. LXXVIII., p. 1, 1906. Also J. A. Fleming, "On the Electric Radiation from Bent Antennæ," *Phil. Mag.*, December, 1906.

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It is easy to see from equation (37) that the result of making the antenna with a very short length vertical is to diminish the absolute value of the radiation in all directions.

The writer tested this by special experiments, employing an antenna of given length, which was erected vertically and then bent over horizontally at successive greater and greater distances from the free end, the bent-over parts being held in a horizontal position. It was found that the current measured in a vertical receiving wires at a constant distance fore and aft of the direction determined by the horizontal part were more and more unequal but less in absolute value as the horizontal part of the transmitting antenna grew larger in proportion to the vertical parts.

The same theory can be employed to explain the action of a straight-wire antenna placed slantingly to the surface of the earth.

Since the surface of the earth is a zero potential surface, and all lines of electrostatic force terminate on it perpendicularly to the surface, we may regard the inclined wireless telegraph antenna as one-half of a complete oscillator bent in the middle as shown in Fig 9.

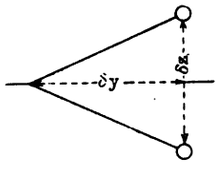

FIG. 9.

Let such a bent oscillator have the shortest distance between its ends denoted by δz and the straight line joining the apex with the centre of the straight line joining the ends denoted by δy. Let the origin be taken at the middle point of this last line. Then the co-ordinates of either end are $\frac{1}{2}\delta y$, $\frac{1}{2}\delta z$. If the maximum charge on either end is called Q, then it is easy to see that the electrostatic potential of the bent oscillator is the same as that of a straight oscillator whose axis is parallel to z and electric moment is $Q\delta y$, but is shifted to the right of the origin by a distance $\frac{1}{2}\delta y$.

Let I be the maximum value of the current in the oscillator, then $I = Qn$. Also let $M = \frac{1}{2}I\delta y\delta z$ be called the magnetic moment of the oscillator, then $M/n = \frac{1}{2}\phi\delta y$.

The static potential at any point in the field is then given by the expression

$$V = -\phi\frac{d\Pi}{dz} - \frac{1}{2}\phi\frac{d^2\Pi}{dy\,dz}\delta y$$
$$= -\phi\frac{d\Pi}{dz} - \frac{M}{n}\frac{d^2\Pi}{dy\,dz}. \quad . \quad . \quad . \quad . \quad (41)$$

The components of the vector potential at points not very near the oscillator are

$$\left.\begin{aligned} F &= 0, \\ G &= \frac{2M}{n}\frac{d^2\Pi}{dt\,dz} \\ H &= \phi\frac{d\Pi}{dt} - \frac{M}{n}\frac{d^2\Pi}{dt\,dy} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (42)$$

If we compare these last equations, (41) and (42), with equations (28) and (29) for the doubly-bent oscillator, we see that they are practically identical. Hence, when we employ the expressions for V, G and H given in (41) and (42) to obtain the forces as previously done for the doubly-bent oscillator, we shall be led to the same result—viz., that at a given distance the radiation is strongest in the direction opposite to that towards which the free ends point.

If, then, we set up a vertical Marconi antenna for wireless telegraphy, and gradually incline it over or place it in a slanting position, we see from the above investigations that, for equal distances round it, the radiation is enfeebled by such inclination, but is also made unsymmetrical, remaining strongest in the direction opposite to that towards which the antenna leans.

Many observers have experimentally noted this fact, and some of them have stated the direction of maximum radiation of the inclined antenna wrongly.

A point of some importance to notice is that electric wave antennæ, being radiators, fulfil the laws of all other radiators, and in particular the law of exchanges, in that they not only absorb the radiation of that wave length which they emit, but they absorb best on that side towards which they radiate best. Hence, a bent or inclined antenna is not only an unsymmetrical radiator; it is also an unsymmetrical absorber. If, then, a bent antenna, having a small part of its length vertical and a much longer part horizontal, is employed as a receiving antenna, it will receive best from the direction opposite to that towards which the free end points. If, then, the horizontal part points north, it will receive best waves coming from the south, and if the horizontal part can be swivelled round, such a receiving antenna can be employed to locate within certain narrow limits the direction of the sending station.

Mr. Marconi employs also combined bent sending and receiving antennæ placed back to back, the one radiating best in the direction opposite to that in which the free end points, and the other absorbing best in a similar direction. These results were discovered by a laborious process of experiment and practical trial, but they are capable of being fully explained on the theory given above, that such a bent radiator is equivalent to the combination of a magnetic or closed oscillator with an electric or open oscillator.

The limitation which has to be imposed on the discussion to render the mathematical analysis not intractable is that the current in the oscillator has the same value at all parts of its length at the same instant, and that the free charges are confined to the extreme ends. Neither of these assumptions is strictly true for the real wire antennæ used in radio-telegraphy, but they are approximated in the case of such a wire antenna with a capacity or metal plate at the top. Experiment, however, shows that the observed results obtained with bent or inclined antennæ in radio-telegraphy are in general accordance with the predictions of the elementary theory above given, but the problem of discussing mathematically the case of inclined or bent antennæ with distributed capacity and inductance, and, therefore, with currents varying from point to point in it, is one of such extreme difficulty that no one has yet grappled with it successfully.

BURTON-ON-TRENT CORPORATION ELECTRICITY DEPARTMENT.

The borough electrical engineer of Burton-on-Trent is able to present a satisfactory report of the working of his department for the last 12 months. The accounts and other matters outlined in his report are of considerable interest, and in what follows we give a summary of the results.

During the year the "restricted-hour" system has been adopted for power consumers, and the results show that while new lighting consumers representing 30 kw. and new motor consumers representing 220 H.P. have been connected, the maximum demand on the alternating-current side of the station has only increased from 492 kw. to 511 kw., while the output in units has increased 37½ per cent. The revenue from restricted-hour consumers has amounted during the year to £595. The present horse-power connected under this scheme is 261, and it is hoped that an extra 200 H.P. will shortly be added, making a total of 461 H.P. on this system out of the total horse-power of 675 connected.

The general working results may be considered as satisfactory, although the high standard reached in 1905-6 has not been maintained. On March 31, 1907, this undertaking completed its thirteenth year of working. The total units generated during the year were 1,164.355, as against 969,866 in 1905-6, an increase of 20 per cent. This is fully accounted for by the large addition to the motor load and by the units generated for the Burton & Ashby Light Railway. The lighting units used decreased from 311,772 to 310,382, while the power units increased from 103,100 to 260,601. It is hoped that by the end of this year the power units will be greater than the traction units, which during last year amounted to 591,555. The total equivalent in 8 c.p. lamps connected to the mains is 41,877, as against 36,662 in 1905-6. The total maximum load has increased from 742 kw. to 866 kw. The reduction in lighting units is put down to trade depression. The increase

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in assessment and taxes, together with increased capital charges represents a total of £913. This large extra sum has a good deal to do with the decreased surplus. The reduction in the current consumption by the trams has also adversely affected the electricity department. The works and management costs have decreased by a satisfactory amount and the gross profit has increased from £5,563 to £5,825, and represents 7·27 per cent. on the capital expenditure as against 7·13 per cent. during 1905-6.

We give below an analysis of the principal items of expenditure and income for the year. The total costs for the year ending March 31, 1907, are set out, together with the costs per unit for the years 1905-6 and 1906-7.

	1906-7	Cost per unit generated.	
Works Costs.	£ s. d.	1905-6.	1906-7.
Fuel	1,586 11 0	0·302d.	0·317d.
Water, oil, &c.	271 0 0	0·061d.	0·056d.
Wages	1,219 8 4	0·308d.	0·251d.
Maintenance and repairs	958 10 5	0·203d.	0·197d.
Total Works Costs	£3,985 9 9	0·874d.	0·821d.
Management Costs.			
Rents, rates and taxes	£676 17 2	0·155d.	0·140d.
Salaries	390 14 2	0·087d.	0·081d.
Printing and stationery	34 13 4	0·014d.	0·007d.
Loan and stock expenses	86 15 6	0·031d.	0·018d.
Fuel, light and water	23 5 8	0·005d.	0·005d.
Miscellaneous	54 15 2	0·019d.	0·011d.
Insurance	35 1 11	0·007d.	0·007d.
Total Management Costs	£1,302 2 11	0·318d.	0·269d.
TOTAL OPERATING COSTS.. (*excluding* Capital Charges)	£5,287 12 8	1·192d.	1·090d.
Capital Charges, &c.			
Public lighting	£3 5 1	—	—
Bank interest	47 8 3	0·004d.	0·009d.
Interest on 3 per cent. stock	1,096 11 0	0·277d.	0·226d.
Repayments ,,	1,762 10 7	0·433d.	0·363d.
Sinking fund on bills	303 5 7	0·075d.	0·063d.
Discount on bills	543 17 8	0·134d.	0·112d.
Sinking fund on loans	623 1 9	—	0·128d.
Interest on loans	654 5 9	0·112d.	0·135d.
Total	£5,034 5 8	1·035d.	1·036d.
TOTAL EXPENDITURE (*including* Capital Charges)	£10,321 18 4	2·227d.	2·126d.
TOTAL RECEIPTS	£11,115 10 3	2·51d.	2·286d.
Surplus	£793 11 11	0·283d.	0·160d.

This surplus was carried to the renewals fund.

THE ELECTROTECHNIC INSTITUTE OF THE TECHNICAL UNIVERSITY* IN CARLSRUHE (BADEN).

BY STANLEY P. SMITH, B.SC.

Summary.—A general idea is given of the curriculum followed at the typical "Technische Hochschule" in Carlsruhe and of the examinations which are there held. The general lay-out and equipment of the institute buildings themselves is also described.

In the present article the writer intends to confine himself more especially to a description of the Electrotechnic Institute at Carlsruhe rather than to attempt a complete description of the whole university. His reason for doing so is two-fold; firstly, an adequate description of all the departments would be much too long; and secondly, a general introduction to the whole university, followed by a more particular description of one of its chief and most modern branches, will enable the reader to form a very fair idea of the college as a whole.

The Technical University.

The general arrangement of the several buildings is given in Fig. 1. It will be noticed that nearly every department is separately housed. The oldest building, marked A, dates back to 1836, and was erected in the reign of Grand Duke Leopold of Baden, whilst the others have been built under the present Grand Duke Frederic.

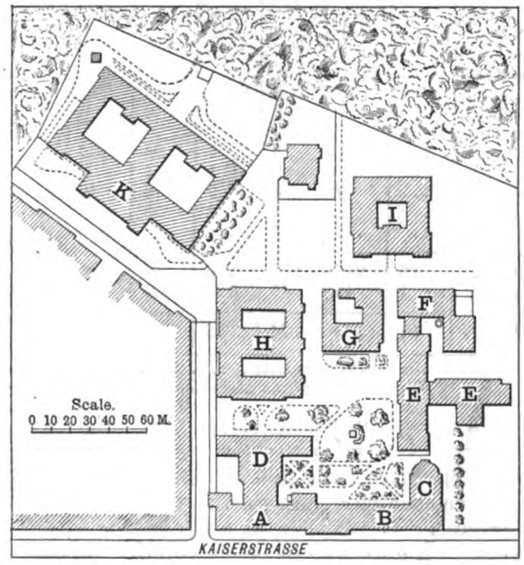
* The writer uses the term "technical university" advisedly as a translation of "technische Hochschule." The literal rendering "technical high school" conveys an entirely wrong impression to the English mind, whilst "technical college" in England implies a standard of training considerably lower than that given in the German "Hochschule."

Instruction is given in mathematics and nearly every branch of technology, but more especially in architecture, civil, mechanical and electrical engineering, industrial chemistry, and forestry. Surveying and other technical sciences are also included in the curriculum.

In all, there are seven departments:—

1. General (mathematics, literature, philosophy).
2. Architecture.
3. Civil engineering.
4. Mechanical engineering.
5. Electrical engineering.
6. Industrial chemistry.
7. Forestry.

Each department is controlled by its own staff, together with its president—a professor elected for two years. For the management of the entire university there is, first, the rector,



A, Main Building; B and C, Physical Institute; D, Library, &c.; E, Mechanical Engineering; F, Electric Generating Station; G and H, Chemical Institutes; I, Electrotechnic Institute; K, Architecture, Mathematics, &c.

Fig. 1.

who is chosen yearly from the professors; secondly, the senate, composed of the departmental presidents; and, thirdly, the board of professors, which serves as the council of the university and is entitled to send a representative to the senate.

The Students.

Probably the most interesting feature about the students is their variety. In the following table a list of the students for the winter session 1905-6 is given. The figures in some cases can only be taken as approximate, but the table will enable one to form a very fair conception of the cosmopolitan appearance of a German university.

Of course, it does not follow that every college has such a large percentage of foreigners; moreover of late the German policy has been modified somewhat in regard to students from outside by making the conditions of entrance more difficult and raising the fees, the principle being this: that foreigners should raise the standard of education and not lower it. The fees are extraordinarily low, rarely amounting to more than £10 per annum, and even what the foreigner pays is only about one-fifth of his cost to the State. As regards student life, it is altogether different from what one sees in England. There are no general organisations, there is no common room, all clubs are cliques, and in general the virility and sociableness so conspicuous in an English college are seriously lacking in a German Hochschule. It is certainly a pity to see how this aloofness, which is often determined by nationality, religious belief and income, effectually prevents any general friendly intercourse or union amongst the students, while numerous opportunities of international friendships are thus lost.

Generally speaking, the standard of technical training is higher at a German than at an English university. This, how-

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Table *of Students for the Winter Session 1905-6.*

Nationality.	General course	Architecture	Civil engineering.	Mechanical engineer'g	Electrical engineer'g	Industrial chemistry.	Forestry.	Total.
(*a*) *German subjects.*								
Baden	19	125	163	83	23	56	20	489
Other German States	7	121	66	187	66	107	2	556
						Total (*a*) ..		1,045
(*b*) *Foreigners.*								
America	..	..	..	1	2	2	..	5
Asia	..	..	3	..	1	..	..	4
Belgium	..	..	..	..	1	2	..	3
Bulgaria	..	1	8	4	..	1	..	14
Denmark ..	..	..	..	2	1	2	..	5
England	..	..	..	..	6	2	..	8
France	1	..	..	..	1	1	..	3
Holland	..	..	1	2	13	2	..	18
Italy	..	..	..	2	5	3	..	10
Luxemburg..	..	1	2	1	2	2	..	8
Norway	..	..	..	..	8	1	..	9
Austria-Hungary.....	..	3	1	14	15	16	..	49
Roumania ..	..	..	2	1	2	6	..	11
Russian subjects	..	27	16	83	56	108	..	290
Sweden	..	..	2	1	4	2	..	9
Switzerland .	..	9	8	9	6	10	2	44
Servia	..	2	1	2	3	..	..	8
Turkey	..	..	1	..	..	2	..	3
Total (*a*)..	26	246	229	270	89	163	22	1,045
Total (*b*)..	1	43	45	122	126	162	2	501
Total	27	289	274	392	215	325	24	1,546
Occasional students								68
Visitors (including 26 ladies).....								139
Sum total								1,753

ever, is largely due to the different circumstances existing in the respective countries. An English student will often leave school before he is 16 years of age, and will spend two or three years in the workshops before entering college. On the other hand, we usually find "middle-class" German students remaining at school until they are 18 or 19, and then entering college directly. Further, the German's college course extends over four years, whilst the former often graduates at the end of three years. In general, therefore, one finds considerably older students in Germany than in England, and the average time a German student stays at college is considerably longer than that of an English student. As to which of the two applies himself more assiduously to his work, it would be irrelevant here to discuss. It is certain, however, that students in Germany have greater opportunities of following their own tastes—whatever they may be—whereas in England students certainly have a greater inclination to work.

There is no matriculation examination on entrance, but certificates must be produced showing that a satisfactory course has been passed through in a German secondary school (gymnasium or realgymnasium or a German ober-realschule) or, if a foreigner, its equivalent.

The students are classed as follows :—

1. Students.
2. Occasional students.
3. Visitors.

Only those who can produce evidence of having passed a certain standard at school are allowed to enter the college as students. These generally take up a definite course of study in one of the seven departments. Occasional students generally come to college to take special courses, whilst visitors include those to whom the respective professors may grant the privilege of attending their lectures.

The student-year is divided into two sessions—the winter session, extending from October 1 to March 15, with a break at Christmas from December 24 to January 2, and the summer session, which runs from April 15 to July 31, with a break of a week at Whitsuntide. During this week excursions are generally arranged by the professors to enable the students to visit power installations, factories, public works, &c.

Examinations and Degrees.

Examinations may be taken for:—(1) Doctorate in engineering, (2) Diploma in engineering, (3) Departmental certificate.

The full college course extends over four years, making eight sessions in all, at the end of which time a student is eligible to sit for the diploma, provided that the school standard attained prior to entering the college is deemed satisfactory by the examiners. The examination for this degree is taken in two parts—the *preliminary* examination, taken in mathematics and science after two years, and the *final* examination, taken at the completion of the four years' course. This latter consists of an oral examination by the respective examiners and a "diplomarbeit," comprising examples on design, &c., set by the examiners, which must be completed within three months. If the previous training of the candidate has not been sufficient to satisfy the requirements above mentioned, he is, nevertheless, allowed to take the same examination as the candidate for the Diplom Ingenieur, and, if successful, is awarded the *departmental certificate*—the only difference between this and the diploma being in the previous school training.

There is also another examination, known as the "academical final examination," which can be taken by those who do not enter on the complete course.

The degree of Doctor of Engineering is awarded only to those who have already taken a diploma and have further carried out some definite research work.

Before taking the diploma examination students are required to spend at least one year in the workshops.

The Electrotechnic Institute.

The position of and space occupied by this building is seen from Fig. 1, and a photograph, taken from the south-west corner, is shown in Fig. 2. In 1896, building operations were commenced under the supervision of the present director of the Institute, Prof. E. Arnold. The design and construction were carried out under his directions, he, in 1894, being specially invited to come from Switzerland, where he was engaged as chief engineer at the Oerlikon works, for that purpose. The whole structure was designed exclusively for its present object, the teaching of electrical engineering, and such foresight, coupled with almost unlimited advantages, has yielded one of the most perfectly-equipped electrical engineering institutions in the world.

Figs. 4, 5 and 6 show the basement, ground floor and first floor respectively (the scales are in metres). The four wings enclose a quadrangle 16·5 × 13·5 metres, around which there is a corridor 3 metres wide on the inner side of the building. The external measurements of the Institute are 41 × 41·8 metres. The plan upon which the rooms on the several floors have been distributed is as follows.

Most of the laboratories in which a student, taking a normal course, works are situated on the ground floor (Fig. 5). The first floor contains the lecture theatres, drawing office, professors' rooms, &c., whilst in the basement are special laboratories, cell rooms and store rooms.

Ground Floor (Fig. 5).—The student, having successfully passed through the preliminary course (two years) enters the electrical laboratory in his fifth session. During this year the students are grouped in pairs.

They commence their work in the junior laboratories (Nos. 30, 31 and 32). In these laboratories experiments are performed illustrative of the fundamental laws of electricity, the measurements of electric current, pressure, resistance, &c., and also the calibration of instruments. The student then passes on to the second series of experiments performed in laboratories Nos. 21, 22 and 23, which he generally reaches by his sixth session. There he is introduced to the various phenomena of induction and capacity with the magnetic properties of iron, and at the same time obtains an insight into the measurement of alternating currents.

In the senior course (fourth year) the experiments are of a far less theoretical nature, whilst the groups are larger, consisting generally of four or five men. During this year most of the laboratory work is carried out in the machinery hall, the position of which is seen from Fig. 5, and a view

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looking west is shown in Fig. 3. The machinery hall is on a somewhat lower level than the ground floor and consequently obtains a height of 6·34 metres, which allows of a crane being conveniently used. The hall has a length of 24·36 metres and a breadth of 10 87 metres. In this spacious laboratory, dynamo-electric machinery of almost every description is represented, whilst most of the machines have been specially built for experimental purposes. On the same level as the machinery hall there is the switch room (No. 27) and a smaller laboratory (No. 26) in which such instruments are kept as are used in the machinery hall. It may be mentioned here that with the exception of a few special standard instruments all the apparatus in the Institute is made interchangeable. For example, voltmeters, ammeters, switches and field-regulating rheostats are all capable of being fitted to the same stand, and so on. Lastly, on the same level as the ground floor, there

Fig. 2.—The Electrotechnic Institute.

is the workshop (No. 24), where constant employment is found for three men and two boys.

The Basement (Fig. 4.).—Here we can start with room No. 9, which is fitted up as a standardising laboratory. In equipping this department great care was taken to exclude all materials of a magnetic nature, whilst in this room, as in all other laboratories on the same level, special stone slabs have been let in the floor, which serve as firm foundations for delicate galvanometers. For testing the insulation of and the phenomena connected with long cables, rooms Nos. 10 and 11 have been specially arranged. In the former a large trough has been built in which cables can be immersed, whilst other cables are provided by running mains round the Institute; also artificial cables are set up in room No. 11, where the measuring instruments are placed. Next to the cable laboratory comes the high-pressure laboratory (No. 12). Two transformers each of 20kw. capacity, have been installed here, and the testing of insulation can be carried out at any pressure up to 150,000 volts. Room No. 3 is set apart for special research work, whilst No. 2 serves as a photometric laboratory. In the smaller compartment glow lamps are tested, and in the larger arc lamps. In the boiler house (No. 4) there is the apparatus for heating the building on the low-pressure steam-heating system. The accumulator room is No. 8. In it there are three main batteries of 60 cells each, having a capacity of 500, 380 and 180 ampere-hours respectively, along with other smaller batteries.

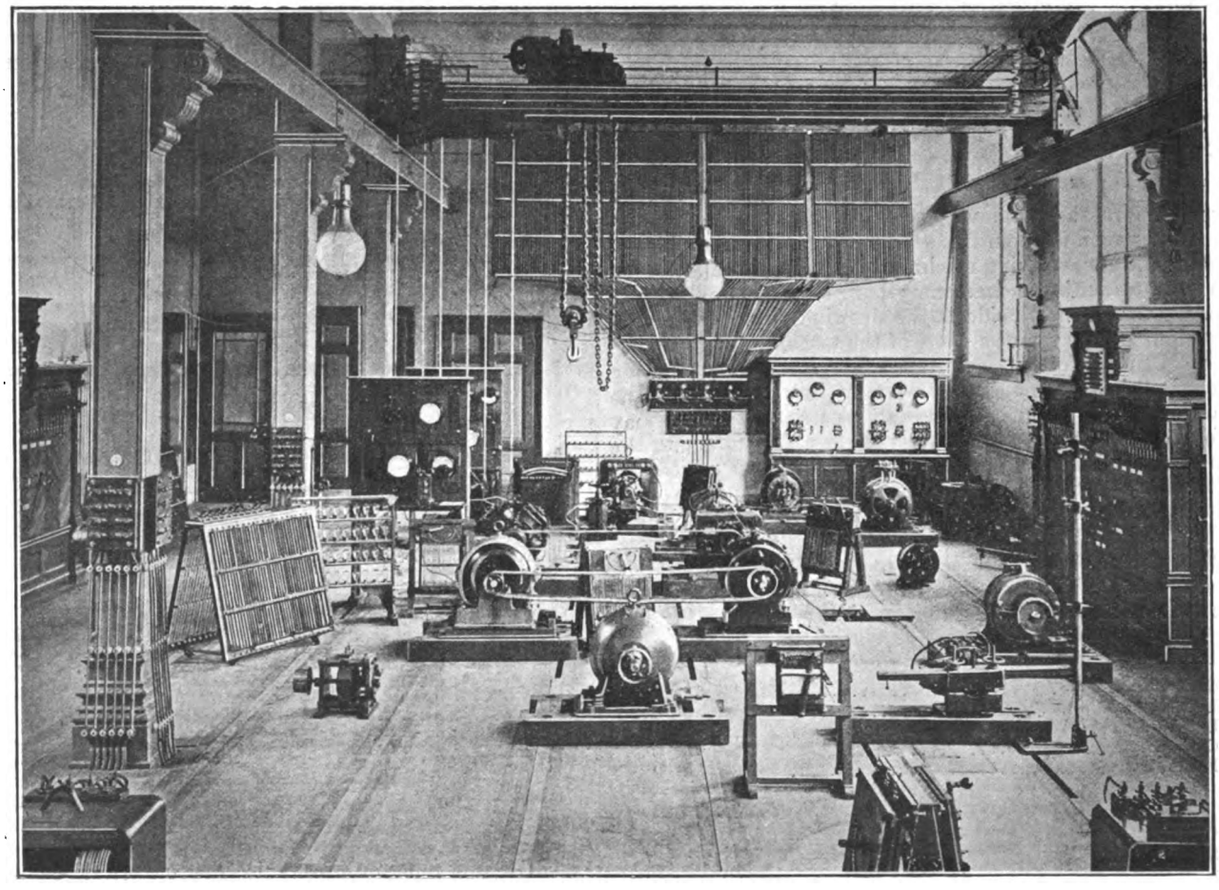

Fig. 3.—Machinery Hall (looking West).

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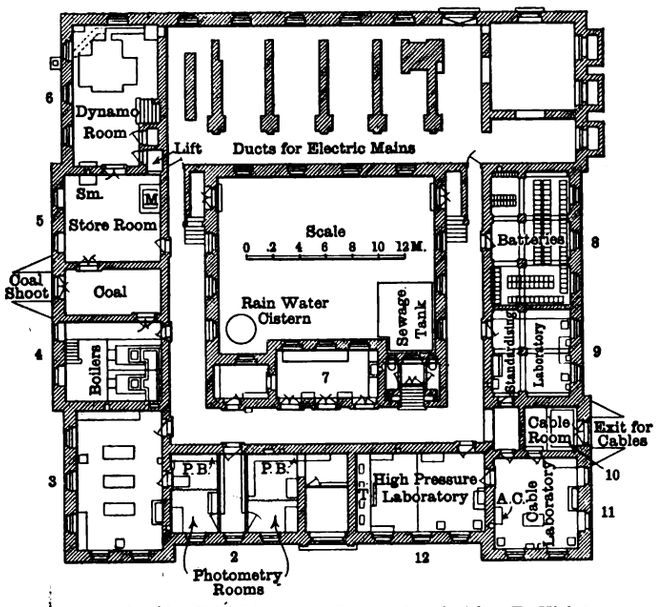
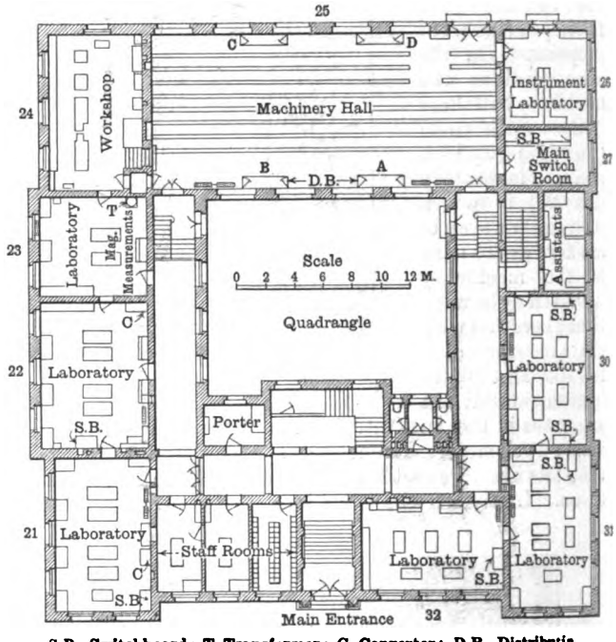
Amongst the other sources of current supply may be mentioned a 22 kw. dynamo and 22 kw. three-phase alternator direct coupled to a 35 H.P. gas engine; a motor-generator set of 20 kw., for both alternating and continuous-current; alternating-current from the town mains and continuous-current from the college lighting station.

First Floor (Fig. 6).—There are two lecture theatres (Nos. 44 and 42), capable of seating 192 and 72 persons respectively. The larger theatre is specially adapted for experimental and lantern demonstrations. For the latter purpose the room is darkened by lowering dark curtains (by means of electric motors) before the windows, whilst the lantern is situated behind the screen in room No. 45. The demonstration table is suitably built for receiving machines, &c., whilst an electric lift communicates with the machinery hall, workshop and lecture theatre. On the north side is the drawing office, whose floor dimensions are the same as those of the machinery hall underneath. Benches for 52 students are provided in the drawing office. Before leaving this floor we may draw attention to the library (No. 50). Here all up-to-date electrical literature may be found, and although it only serves as a sub-library to the main library of the university—where all modern periodicals may be seen—yet its usefulness and practicability are worthy of the highest praise. We shall conclude this section by appending a few of the chief items of cost. These, of course, must be understood to refer solely to the initial costs, and not to include any additions which have been made from time to time to keep in touch with recent practice :—



A.C., Artificial Cable; P.B., Photometer Bench; Sm., Smithy; T., High Pressure Transformers; M, Motor for Lift.

FIG. 4.—BASEMENT.



S.B., Switchboard; T, Transformer; C, Converter; D.B., Distribution Board (A to D).

FIG. 5.—GROUND FLOOR.

Chief Items of Cost.

BUILDING.			
Cost of building	£15,477	12	6
Lighting	555	0	0
Lift	225	0	0
Crane	280	0	0
Furnishing	1,250	0	0
	£17,787	12	6
EQUIPMENT.			
Apparatus for electric power supply	£2,464	10	0
Instruments and apparatus	3,743	0	0
Equipment of machinery hall	1,866	10	0
Switchboards and mains	1,686	10	0
Telephone installation	32	10	0
Electric clock	87	10	0
	£9,880	10	0

Total ..... £27,668. 2s. 6d.

The above calculations have been made on the assumption that 20 marks = £1.

THE COURSE IN ELECTRICAL ENGINEERING.

As an illustration of the all-round nature of the course through which the normal student has to pass we give on the next page a time-table, from which the varied nature of the course will be seen.

A special feature in the time-table is the inclusion of lectures on social questions.

The summer time-table differs somewhat from that for the winter, and commences one hour earlier (7 a.m.).

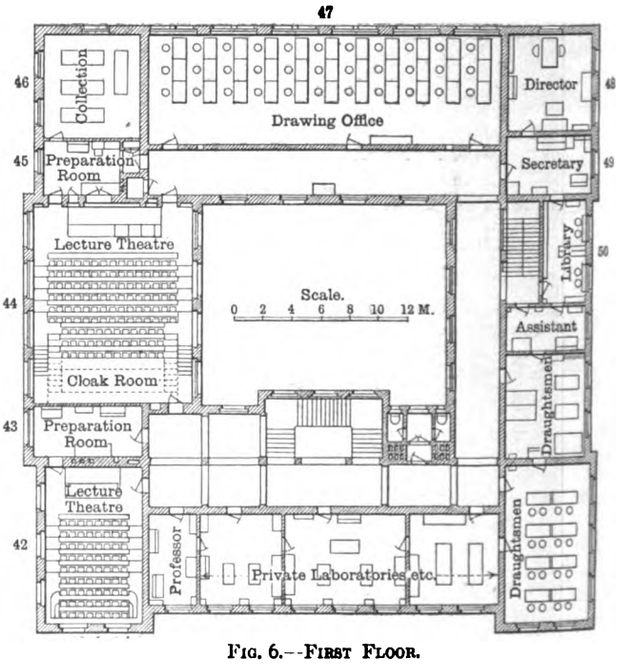


FIG. 6.—FIRST FLOOR.

There are four professors in the electrical engineering department—Prof. E. Arnold, Dr.Ing. (director of the Institute), Prof. O. S. Bragstad, Prof A. Schleiermacher, Ph.D., and Prof. J. Teichmüller. Their work is divided as follows:—

Prof. Arnold*: Continuous-current Machinery; Alter-

* Special mention should be made of Dr. Arnold's lectures, given under the headings "Dynamobau I. and II." respectively, and of the course through which he takes the students in the design of electric machinery. They are wonderfully complete.

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Third Year Time-table for Winter Session 1905-6.

Time.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
8— 9	Theory of machines (problems).	Theory of alt. current.	Theory of alt. current.	....	Water power installations.	Theory of machines.
9—10		Elec. measurements.	Theory of machines.	....	Metals.	
10—11		Theory of machines.	....	....	Dynamo electric machinery.	Steam engines and boilers.
11—12	Metals.	Steam engines & boilers.	Dynamo elec. machinery	Theory of machines.		
2— 3	Electrical laboratory.	....	Mechanical laboratory	....	Electrical laboratory.	Electrical laboratory.
3— 4		Machine drawing.		Machine drawing		
4— 5		Political economy.	Problems on alt. currents.	Political economy.	Political economy.	
5— 6	Electro-chemistry	Labour problems.	Electro-chemistry.	Labour problems.	Political economy (problems).	....
6— 7						

nating-current Machinery; Calculation and Design for Electric Machinery (Drawing Office).

Prof. Bragstad: Theory of Alternating Currents; Electric Railways and Tramways; Alternating-current Commutator Motors.

Prof. Schleiermacher: Theory of Electricity; Electrical Measurements; Fundamental Laws of Electrical Engineering.

Prof. Teichmüller: Electric Lighting; Electric Installations; Feeble Electric Currents.

In many of the above subjects there are both lectures and exercise classes. The subjects are fairly well distributed over the third and fourth years, whilst, in addition, the student is required to put in two afternoons per week in the laboratories.

We scarcely need apologise for adding a final word about the director of the Institute, Prof. E. Arnold, although nothing we can say can add to the great fame he has already gained for himself by his assiduity and his eminent services to the profession of electrical engineering. He has not only been honoured by the Court in having the title of "Geheimer Hofrat" conferred upon him, but has quite recently received an honorary doctorate in engineering from Hanover. Only a few months ago he completed his fiftieth year—an occasion which the students celebrated in a fitting manner. It was on this occasion also that the students learnt something of the many experiences of Prof. Arnold during his life in Russia, Switzerland and Germany. For many years, previous to studying electricity, he had been an instructor in mechanical engineering. It was certainly consoling for us to hear that, on turning his attention to electricity, he met with the same difficulties that are common to his students at the present day, whilst his account of his work on commutation, on the theory of windings and on numerous other matters showed us that he, no less than we, had to grope his way through many dark tunnels before attaining mastery.

THE NEW YORK, NEW HAVEN AND HARTFORD RAILWAY.

(*Continued from page 910.*)

Summary.—A description is here given of the overhead equipment, rolling stock and power station of the New York, New Haven and Hartford Railway. This railway is an interesting example of single-phase operation from an overhead line, in conjunction with a direct-current third rail over part of the route.

In the adaptation of electric traction to this railway a number of features were presented by the problem which required months of study, and which practically fixed the system which should be adopted, and to a large degree decided the design of both the locomotives and the line construction. Aside from the innumerable details which had to be considered, broadly speaking, the problem called for: (1) A system the first cost and maintenance of which would not be prohibitive; (2) a system which would permit of large extensions with a high degree of efficiency at a reasonable cost; and (3) locomotive equipments which would be capable of operating over the direct-current lines of the New York Central Railway.

After a most exhaustive study of the problem from all points, the single-phase alternating-current system was decided upon as being the only existing system which would successfully meet all of the conditions imposed. The alternating-current system was primarily selected on account of its facilities for transmission and transformation, and single-phase was decided upon because the characteristics of the single-phase motor make it eminently suitable for railway work, and also on account of the simplicity of the line construction.

The specifications under which the locomotives were sold require that each of them shall be able to handle a 200 ton train in the most severe schedule on the present time-table, corresponding to the local express, which stops about every 2·2 miles and operates on a schedule speed of over 26 miles per hour. This service requires a maximum speed of about 45 miles per hour. The locomotive is also to haul this weight of train at from 65 to 70 miles per hour and a 250 ton train at 60 miles per hour in the long runs; 300 ton, or even heavier, trains may be also handled on the long runs at reduced speeds. Heavy trains may be operated at high speeds by coupling two or more of the locomotives together and operating them on the multiple-unit system.

The design of the locomotives was largely dictated by certain requirements: (*a*) gearless motors having a flexible drive and with all the weight carried on springs were desired and finally adopted as the most desirable form, and (*b*) operation on 600 volts direct current necessitated the use of four motors in order that they might be operated in the usual series-parallel relation. Having these two requirements in view, the mechanical design of the locomotive follows as a natural consequence. The bogie truck type was adopted after very careful consideration as the one best adapted to meet the conditions imposed. It is well known that its riding qualities are of the best, and it offers the least resistance in taking the curves in the line.

The mechanical parts of the locomotives, which are entirely of steel, were built by the Baldwin Locomotive Works from designs developed with the co-operation of the Westinghouse Electric & Manufacturing Co. and the New York, New Haven & Hartford Railway Co. engineers. The locomotive measures 36 ft. 4 in. over bumpers, and weighs approximately 90 tons.

The propelling motors of the locomotives are of the compensated single-phase series type. For the direct purpose of improving the power factor, the magnetomotive force of the current in the armature is counterbalanced by an equal magnetomotive in stationary coils placed in the field core structure through which the armature current is required to pass.

It is noteworthy that by far the largest portion of the reactance of the motor circuits is found in the main field coils. As a rough approximation, it may be stated that at synchronous speed the tangent of the angle of lag (of which the cosine is the power factor) is equal to the ratio of the effective field turns to armature turns, and it decreases inversely with an increase in speed. Hence, with well-designed armature and compensating coils, the power factor can be rendered quite high by using a small ratio of field to armature turns and operating the machine at a speed which is high in comparison with synchronism.

The requirements for obtaining a high power factor are well met when the field is made magnetically very weak and the armature correspondingly strong, and a large number of poles is used. The improvement in the power factor by using a weak field will be appreciated when it is remembered that for a certain field current the field flux varies as the first power, and the field reactance as the square of the field turns. The advantage of using a large number of poles resides in the fact that the magnetomotive force for producing the field flux is distributed throughout a large number of coils of few turns (and hence having a small reactance) rather than concentrated in a few coils having a much larger total reactance.

Incidentally, when a large number of poles is used, "synchronous" speed occurs at a low rotative speed. If an increase in the number of poles did not, from mechanical considerations, entail a corresponding decrease in the rotative speed, it would be possible to improve the power factor of the motor by changing the ratio of the operating speed to the synchronous speed. It is to be noted, however, that, except in so far as an increase in the number of poles may allow a smaller pole-pitch or a higher peripheral speed to be used, no improvement in power factor is obtained from a change in the ratio of the operating speed to synchronism, because no such change takes place.

The motors on the New Haven locomotive are provided with 12 poles, so that the synchronous speed for 25 cycle current corresponds to 250 revs. per min. Since the locomotive drivers are 62 in. in diameter, 250 revs. per min. corresponds to a locomotive speed of 4,060 ft. per min., and at synchronous speed the locomotive runs at 46 miles per hour.

It is instructive to note that if the motor had 14 poles and the drivers were 72 in. in diameter, synchronous speed would again

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correspond to 46 miles per hour with 25-cycle current; if, however the frequency were lowered to 15 cycles, synchronous speed would occur at 27·7 miles per hour. Moreover, if the same motor were used for 15 cycles as for 25 cycles, at synchronous speed in each case, the tangent of the angle of lag would be the same; at the same locomotive speed in each case the tangent of the angle of lag would be reduced in the ratio of 25 to 15, or as 1 is to 0·6.

It should not be inferred from the statements made above either that there could be any very considerable improvement made in the operating characteristics of a motor by changing from 25 to 15 cycles, or that the performance at 25 cycles is unsatisfactory. The fact of the matter is that the power of a 25 cycle motor is so high that even a very great reduction in the tangent of the lag angle produces a relatively small effect on the operating characteristics. Assume, for example, that at a certain speed the power factor for 25 cycles is 90 per cent.; the angle of lag is 26 deg. and its tangent is 0·488. If the same motor is operated at the same speed with 15 cycle current, the tangent of the lag angle is 0·289, the lag angle is 16 deg., and the cosine (the power factor) is 0·96. Thus the power factor has been increased by only 6·7 per cent. In any event, whether the motor is operated at 25 cycles or 15 cycles, its power factor will be better than that of a corresponding induction motor.

It will be noted from the facts discussed above that the prime object in compensating the armature magnetomotive force is to improve the power factor, and not to prevent sparking during alternating-current operation (as is frequently stated). At a certain speed and field strength the sparking depends upon the amount of current to be commutated, so that an improvement in the power factor, which results in a reduction in the current required for a certain power at a certain E.M.F., does to a limited extent improve the commutation; but the minute reduction in sparking is of secondary consideration. During direct-current operation of the motors the current in the compensating coils prevents a distortion of the field by the armature magnetomotive force, and hence it removes

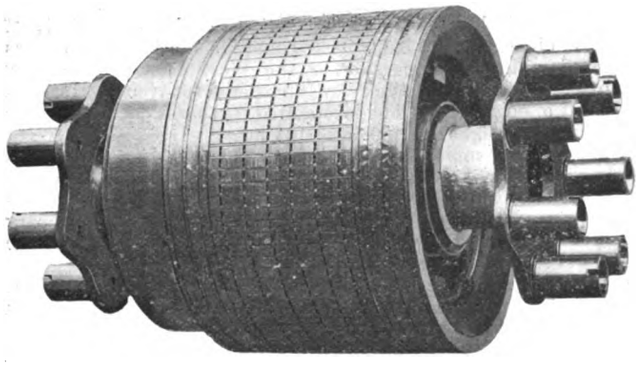

FIG. 10.—ARMATURE AND DRIVING SPIDER.

a portion of the cause for sparking at high speeds. To the extent that the alternating-current motor possesses the disadvantageous sparking characteristics of a direct-current motor, the compensation improves the commutation. Since the sparking in the alternating-current commutator motor is largely attributable to the transformer action of the field flux which is surrounded by the armature coil under the brush, it may be stated that in the prevention of sparking in such motors the compensation of the armature magnetomotive force plays an unimportant part. The means for the prevention of sparking, which are confined to the armature itself, will be discussed below.

The field core structure is divided through the middle of two field poles, and not between certain adjacent poles, as is done with the ordinary four-pole direct-current railway motor. The object in thus arranging the divisions is attributable to the existence of the compensating coils whose conductors are embedded in the pole faces and whose end connectors pass between the adjacent poles. There are 12 slots in each pole face; the conductors in six slots of each pole are joined directly to the conductors in the nearer six slots in the adjacent pole. To have divided the motor between adjacent poles would have necessitated the unsoldering and resoldering of 24 connectors in the compensating coil circuits. By dividing through the centre of two poles, only a single connector of the compensating winding need be disturbed. The splitting of the field core structure through the pole face has rendered desirable a slight change in the arrangement of the main field winding in order to minimise the disturbance to this winding when the two halves of the field structure are separated. Only one-half of the projecting pole cores are surrounded by main field coils, the magnetic poles at the other cores being of the "consequent" type. Thus only one connector in the main field circuit is disturbed when the field cores are separated.

Such an arrangement as the one here indicated might prove objectionable if the magnetic density over the pole area reached the saturation point of the core material. The field is magnetically very weak, however, and very little unbalancing of the poles takes place. Even when the field is strengthened for direct-current operation, the unbalancing is in itself of no great consequence. Moreover, the armature winding is connected at various equipotential points to "balancing rings," such as are commonly used in direct-current machinery, and no detrimental effect can be produced by a tendency to considerable unbalance in the magnetic fields.

Armature.—The most striking feature of the armature is its appearance of compactness and stability. Each is carried on quills, terminating in spiders at each end, which engage eccentrically-wound springs enclosed in pockets in the main drivers (Fig. 10). It differs from the ordinary direct-current armature in that the main winding is completely closed on itself, and connections to the commutator segments are made through resistance leads. The leads are tapped to the armature winding at the end of each turn, so that there is one armature turn per commutator segment. The object in inserting resistance between the armature coils and the commutator segments and in using only one turn per coil is to overcome the sparking.

Each armature coil in the position when its commutator segments are under the brush is electromagnetically in the relation of the secondary circuit of a stationary transformer of which the primary circuit is the main field coil; there is generated by transformer action in each secondary turn an E.M.F. proportional to the product of the main field flux and the frequency. The advantages of using a single turn per armature coil, a weak magnetic field and a low

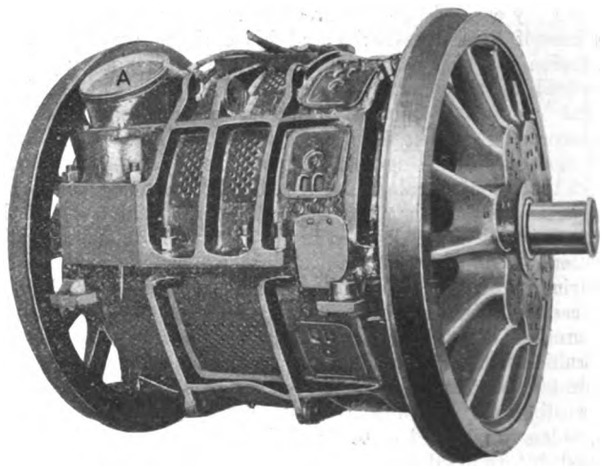

FIG. 11.—MOTOR SHOWING VENTILATING ARRANGEMENT.

frequency, will be noted at once. The E.M.F. generated in the single armature turn under the weak magnetic field at 25 cycles is low in value, but in an armature of the ordinary design it would produce a large value of current locally in the circuit including one armature coil, two commutator segments and the double-brush contact. The resistance of the leads, however, serves to limit the short-circuit current to an allowable safe value and to prevent detrimental sparking at the commutator.

As the preventive resistance leads are arranged so as to be non-inductive, the short-circuit current is approximately in time-phase with the transformer E.M.F. in the armature coil, or in time-quadrature with the main armature current; moreover, the current in the coil undergoing commutation can be reversed most readily when the circuit of the coil is non-inductive. It will be seen, therefore, that the preventive resistance leads are well adapted to minimise the causes for sparking.

Since the main line current passes through two resistance leads in parallel, it is evident that some loss is occasioned by the presence of the leads. An excess of resistance would cause an enormous loss due to the main current, but would reduce the short-circuit current to an insignificant value; a deficiency of resistance would render loss due to the main line current negligible, but the short-circuit current loss would be excessive. The resistance of the leads used on the motors of the New Haven locomotives is so selected that neither the loss due to the short-circuit current nor that occasioned by the main line current is large, while the sum of the two is reduced to a satisfactory minimum. The resistance leads are covered with insulating material similar to that used on the main armature winding and are placed in slots beneath the armature winding proper.

Although, as stated above, the armature structure is very compact, ample provision has been made for ventilation and cooling.

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Experience has shown that the most effective method of cooling dynamo-electric machinery is to embed the insulated coils snugly and compactly in the mass of iron and then to keep the iron cool. Iron is an excellent thermal conductor, and it serves to extract the heat from the coils through the insulating material more readily than is possible when air is depended upon to draw the heat from the coils. Advantage is taken of the knowledge of this fact in the arrangement of the coils and core of the motor armature. Numerous ducts are provided throughout the armature core structure through which air is forced for cooling the iron to which the heat is conducted from the armature coils and preventive leads. The air also passes through and around the commutator and serves to remove from it both the heat produced there by friction and C^2R losses and that thermally conducted to it from the resistance leads.

A view of the completed motor, indicating the means employed for cooling, is given in Fig. 11. The circular opening (A in Fig. 11) at the top is normally connected through a canvas hose to a source of supply of air under a pressure of several ounces per square inch. In entering the motor structure the air is required to pass through a filtering screen and to the opening in the armature spider, from which place it flows outward around the commutator and through the ventilating ducts of the armature and along the air-gap to the openings to the outer atmosphere, shown as perforations in sheet-metal plates of the field core in Fig. 11. The forced-draught method of cooling has proved extremely effective. To guard against the remote possibility of clogging of the air ducts or some enforced stoppage, an electrical pyrometer with its thermo-elements in the

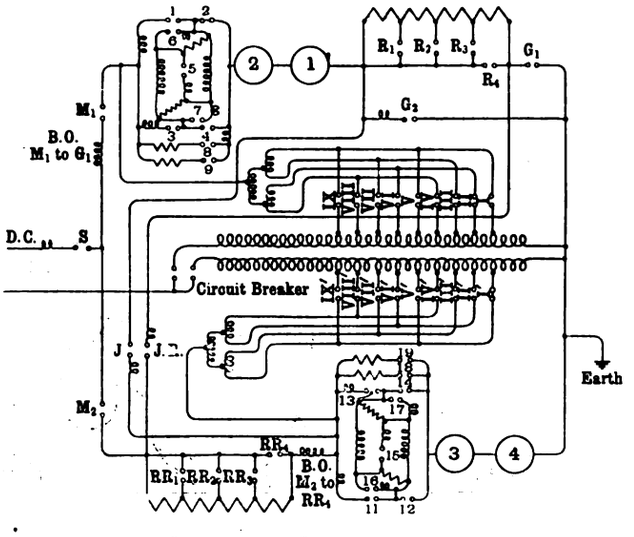

FIG. 12.—DIAGRAM OF LOCOMOTIVE CONNECTIONS.

motor structure and its indicating mechanism in the locomotive cab is used for showing continuously the temperature within the motor. By means of the pyrometer the motorman can ascertain when the service is too severe for the equipment or when the supply of air has been interrupted.

Controller Circuits.—A diagram of the motor-control circuits for both direct current and alternating-current operation is given in Fig. 12. It will be noted that the armatures of the four motors are arranged in two groups, the two armatures of each group being connected permanently in series and controlled as a unit. During direct-current acceleration the motor units are connected in series and then in parallel, while during alternating-current operation each motor unit receives power at variable voltage from a separate auto-transformer. Although not indicated on the diagram, the various switches are so interlocked that the circuits used exclusively for alternating current cannot become active during direct-current working, and those intended solely for use during direct-current operation are inactive when alternating current is used.

Direct-Current Control Circuits.—During direct-current operation switches 5 and 3, 2 or 1, 4, according to direction of travel, of one motor unit, and switches 15 and 12, 13 or 11, 14, according to direction of travel, of the other motor unit are kept closed, so that the main field circuits of each motor unit are connected at all times in series with the respective armatures. At the moment of starting, switches S, M and JR are closed, thus connecting the two complete motor units in series with each other and with eight sections of resistance. As the speed increases, switches R_1, R_2 R_3 and R_4 of one motor unit, and switches RR_1, RR_2, RR_3 and RR_4 of the other unit are closed in succession, thereby increasing the voltage impressed on each motor unit until the two units are in series across the line without resistance. Switch 8 of one unit and switch 18 of the other are then closed simultaneously, thus placing a resistance in shunt to the field windings and thereby increasing the speed by weakening the magnetic fields. The motors, being of the compensated type, permit of an enormous weakening of the fields at the commutators. The fields are further weakened by the simultaneous closing of switches 9 and 19, and the speed becomes accelerated to considerably more than one-half of the normal running value.

The next movement of the controller handle opens switches 8, 9, 18 and 19 (thereby increasing the strength of the fields), closes switch J, opens switch JR, and closes switches G_1 and M_2, thus subjecting each motor unit in series with four resistance sections to the full value of the supply potential. It will be noted that the transfer from full series to multiple connection is accomplished without opening any motor circuit and without short-circuiting either motor unit. Higher speed points are obtained by closing switches R_1, R_2, R_3 and R_4 and switches RR_1, RR_2, RR_3 and RR_4 in pairs successively until the full multiple position of the controller is reached.

Alternating-Current Control Circuits.—During alternating-current acceleration no resistance whatsoever is used, the speed changes being obtained by impressing variable voltages obtained from auto-transformers directly upon the terminals of the motor units. There are two electrically and mechanically distinct auto-transformers, one for each motor unit. Referring again to Fig. 12, it is to be noted that when alternating current is used the main line high-tension circuit-breaker and switches 6, 7 and 1, 4 or 3, 2, according to direction of travel, of one motor unit, and switches 16, 17 and 11, 14 or 12, 13, according to direction of travel, of the other motor unit are kept closed during operation. It will be seen, therefore, that the main field circuits of the two motors of each motor unit are placed in parallel; thus the field magnetism per armature ampere is less during alternating-current operation than during direct-current

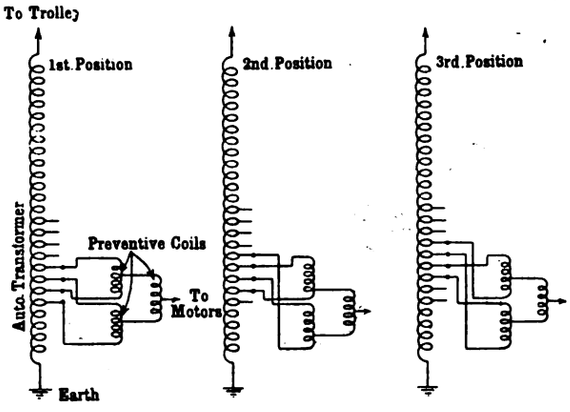

FIG. 13.—METHOD OF CHANGING CONNECTIONS OF AUTO-TRANSFORMER

operation (neglecting the fact that at times the field circuits are shunted for extra acceleration with direct current). There are six running points with alternating current, each corresponding to a certain voltage impressed upon the motor circuits. For changing from one voltage point to another on each auto-transformer use is made of three small so-called "preventive coils." These preventive coils are essentially auto-transformers, having a ratio of 2 to 1. It will be observed (Fig. 13) that the motor unit receives current from the middle connection of one preventive coil whose outer terminals are joined to the middle points of the two other preventive coils; the outer terminals of the latter preventive coils are connected to certain taps on the main auto transformer. In shifting from one running point to another, the tap (No. 1) would be opened and connection would be made at a tap four points higher (No. 5). There are a total of six running points with alternating current; at no time is the motor circuit opened or a transformer winding short-circuited. The current fluctuations are well limited and the acceleration is extremely smooth.

The various switches indicated in Fig. 12 and all of the switches in the circuits of the propelling motors and of the auxiliary equipment are operated by air under a pressure of 80 lb. per square inch, the supply of which to the switch valves is controlled by electro-magnets which receive current from a 20 volt storage battery. The switches are arranged in groups that are conveniently located along each side of the centre aisle of the locomotive. The groups on one side belong to one motor unit and those on the other side to the other unit. Moreover, the main auto-transformer, the three preventive coils, and the four resistance units for each motor unit are placed on the side of the locomotive devoted to that particular unit. There are two independent sets of storage batteries, each consisting of 10 cells, rated at 40 ampere hours. The batteries are charged by an induction motor-driven direct-current generator.

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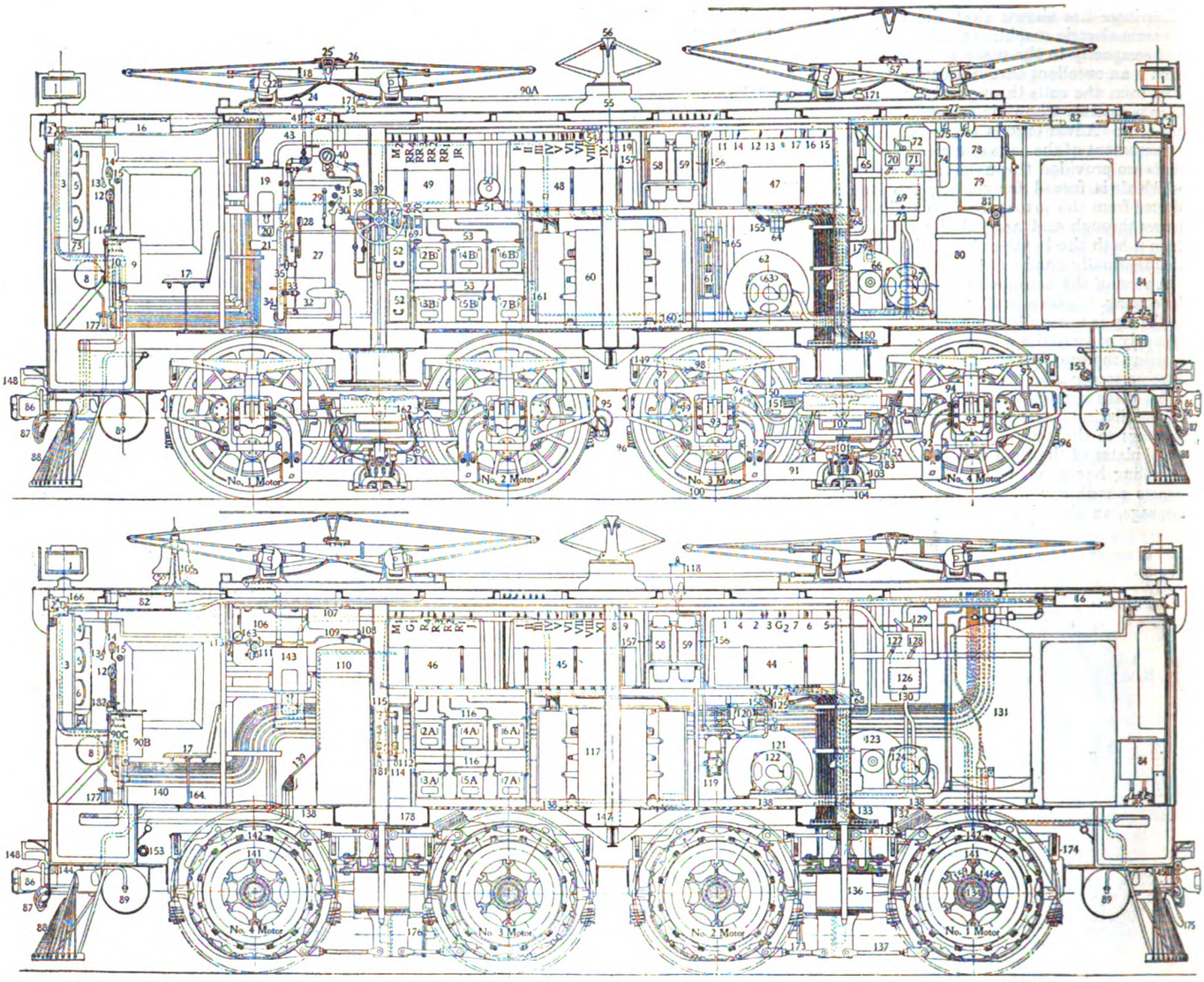

FIG. 14.—LONGITUDINAL SECTIONS SHOWING CONSTRUCTION AND ARRANGEMENT OF EQUIPMENT OF NEW HAVEN ELECTRIC LOCOMOTIVE.

KEY TO LIST OF PARTS.

1. Headlight.
2. Train line receptacles, type 444 D-E [and F.
3. Instrument board.
4. Speed indicator meter.
5. D.C. motor ammeter.
6. A.C. motor ammeter.
7. Temperature indicator meter.
8. Equalising reservoir air brake.
9. No. 1 master controller. [valve.
10. No. 1 automatic motorman's brake
11. No. 1 independent brake valve.
12. Duplex gauge main resistance and
13. Whistle handle. [train line.
14. Straight air-brake gauge.
15. Three-way snap switch in light circuit.
16. No. 1 junction box, type 427.
17. Motorman's seat.
18. No. 1 A.C. pantograph trolley.
19. No. 2 oil circuit-breaker.
20. Overload trip.
21. Oil tank on circuit-breaker.
22. Insulators for pantograph trolley.
23. Support for A.C. trolley.
24. High-tension cable from A.C. trolleys.
25. A.C. trolley shoe.
26. A.C. trolley lock cylinder.
27. Steam-heating boiler.
28. Gauge—air pressure on boiler.
29. Water gauge.
30. Drain cup.
31. Try cocks.
32. Fire door.
33. Burner.
34. Gold Car Co. regulating valve.
35. Mason regulating valve.
36. Steam line from boiler.
37. Air inlet to fire-box.
38. Water feed regulator.
39. Hand brake wheel.
40. Steam gauge.
41. Safety valve.
42. Stack for boiler. [former.
43. H T. conduit from oil switch to trans-
44. Switch group No. 1, type 259.
45. Switch group No. 2, type 251E.
46. Switch group No. 3, type 257A.
47. Switch group No. 4, type 259.
48. Switch group No. 5, type 251E.
49. Switch group No. 6, type 257B. [ing.
50. Motor generator set for battery charg-
51. Base for motor generator set.
52. Storage battery.
53. No. 2 set of resistance grids.
54. A.C. integrating wattmeter.
55. Base for D.C. trolley.
56. D.C. trolley.
57. No. a A.C. pantograph trolley.
58. Preventive coil, 100 volts, 250 amperes.
59. Preventive coil, 50 volts, 500 amperes.
60. No. 2 transformer.
61. Main D.C. switch.
62. No. 2 blower motor fan casing.
63. No. 2 blower motor. [No. 2.
64. Permanent D.C. field shunting grid
65. Hand air-pump for unlocking A.C.
66. No. 2 air compressor. [trolley.
67. No. 2 air compressor motor.
68. Magnet valves, type 386D.
69. No. 2 fuse box.
70. Canopy switch for No. 2 blower motor.
71. Canopy switch for No. 2 compressor
72. No. 2 motor control cut-out. [motor.
73. No. 2 A.C., D.C. change-over switch.
74. Relay box.
75. Snap switch for cab lights.
76. Snap switch for headlights.
77. S.P., D.T. switch light circuit.
78. Control reservoir.
79. Cover for resistance grid.
80. Oil tank.
81. Slide valve reducing valve.
82. No. 2 junction box, type 427.
83. Signal valve.
84. Sand box.
85. Electro-pneumatic sander.
86. Coupler.
87. Hose couplings.
88. Pilot.
89. Main air reservoir.
90. Hook for safety chains.
90A. Cable connecting A.C. trolleys.
90B. No. 2 master controller.
90C. No. 2 automatic brake valve.
91. Third-rail shoe beams.
92. Third-rail shoe bracket.
93. Journal box.
94. Truck frames.
95. Magneto for speed indicator.
96. Motor suspension springs.
97. Spring hanger.
98. Elliptical springs.
99. Wheel pocket cover.
100. Main driving wheel.
101. Third-rail shoe cylinder.
102. Third-rail shoe fuse box.
103. Main casting for third-rail shoe.
104. Third-rail shoe.
105. Bell. [circuit.
106. A.C., D.C. change-over switch heater
107. Fuse box, heater circuit. [reservoir.
108. Governor valve for emergency control
109. Three-way cock emergency control reservoir.
110. Emergency control reservoir.
111. Slide valve, reducing valve.
112. Balancing transformer (back of S.T. and D.T. switches).
113. Combined strainer and drain cup.
114. D.T. switch No. 1 heater circuit.
115. S.T. switch heater circuit.
116. No. 1 set resistance grids.
117. No. 1 transformer.
118. Whistle.
119. Governor—Air brake.
120. Distributing valve.
121. No. 1 blower motor fan casing.
122. No. 1 blower motor.
123. No. 1 air compressor.
124. No. 1 air compressor motor. [No. 1.
125. Permanent D.C. field shunting grid
126. No. 1 fuse box. [motor.
127. Canopy switch for No. 1 blower
128. Canopy switch for No. 1 compressor
129. No. 1 motor-control cut-out. [motor.
130. No. 1 A.C., D.C. change-over switch.
131. Water tank.
132. Air connection to motors.
133. Motor leads for No. 1 and No. 2 motors.
134. Axle of main driving wheels.
135. Upper torque rod.
136. Centre pin.
137. Lower torque rod (long).
138. Trap-doors over motors.
139. Heater circuit leads.
140. Air-brake piping.
141. Motor armature.
142. Motor field frame.
143. No. 1 oil circuit-breaker. [end.
144. 'Bus line socket heater circuit, No. 1
145. 'Bus line socket heater circuit, No. 2
146. Quill. [end.
147. Tool box.
148. Bumper block.
149. Motor suspension cradle.
150. Spring hanger.
151. Equaliser spring.
152. Brake-shoe.
153. Steam-heating line.
154. Equaliser bar.
155. Series transformer for A C. ammeter No. 3 and No. 4 motors.
156. Preventive coil, 100 volts, 250 amperes (back of No. 59). [No. 58.
157. Field shunting resistance (back of
158. Series transformer for A.C. ammeter, No. 1 and No. 2 motors.
159. Armature spider.
160. Air inlet to transformer.
161. Air inlet to resistance grids.
162. Third-rail shoe leads.
163. Gauge—Control line pressure.
164. Support for motorman's seat.
165. D.C. wattmeter.
166. Blind lights.
167. D.P., D.T. switch for battery.
168. D.P., D.T. switch for battery. [ect.
169. S.P., S.T. switch for motor generator
170. Snap switch for motor generator set.
171. Insulators supporting A.C. trolley cable. [1 and No. 2.
172. Shunt for D.C. ammeter motors, No.
173. Lower torque rod (short).
174. Motor suspension hanger.
175. Steam-hose coupling.
176. Brake cylinder.
177. Foot push-button switches.
178. Air conduit. [3 and No. 4.
179. Shunt for D.C. ammeter motors, No.
180. Motor leads for No. 3 and No. 4 motors.
181. D.T. switch, No. 2 heater circuit.
182. Independent brake valve No. 2.
183. Third-rail shoe unlock cylinder.

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Unit Switch Group.—Each unit switch is of the electro-pneumatic type. An interesting feature is found in the means employed for "interlocking." The switches are interlocked electrically in such a manner that when one switch is closed the circuits to the electro-magnets of the other switches which should not be operated are either held open or kept closed, as the case may require, by means of contacts controlled by the piston of the switch valve. All of the motor circuits and switch wires are run in metal conduit along the lower portion of the locomotive, while all of the low-potential battery control circuits are arranged in metal conduit along the roof of the locomotive.

As intimated above, only the wires of the battery and electro-magnet circuits pass into the controllers. These same wires are run overhead from each end of the locomotive, where they terminate in three contact plugs, taps being taken to each controller and to each unit switch along the route as desired. Thus the locomotive may be operated from either end, and two or more locomotives may be electrically interconnected through "jumpers" and controlled from a single point.

The master controller, of which there are two on each locomotive, is of the drum type, the drum shaft being revolvable by means of a handle closely resembling the throttle lever of a steam locomotive. The reverse lever, which is detachable, is mechanically interlocked with the operating lever of the controller, so that all control circuits must be dead before the reverse lever is thrown from one position to another, and the main lever cannot be moved when the reverse lever is in the neutral position. A row of knobs seen alongthe rear of the top of the controller (Fig. 15) serve as push buttons for performing certain duties not associated with the main controller lever or reverse handle, such as pulling the alternating-current trolleys down, pushing the direct-current trolley up, releasing the hooks which hold the alternating-current trolley down and the third-rail shoes up, pushing the third-rail shoes down, resetting the main-line circuit-breakers, operating the front and rear-track sanders and ringing the bell. All of the above-mentioned duties are actually performed by compressed air, the eight push buttons serving merely to complete the circuit from the storage battery to the proper air-valve magnets.

Arrangement of Apparatus on the Locomotive.—For the purpose of preventing the condensation of moisture on the underside of the steel roof of the locomotive the surface is covered with ground cork, which is then given a coat of white paint. Fig. 15 shows two views of the interior arrangement of the apparatus on each side of the locomotive, as seen from the centre aisle in each case, and indicates that, with the exception of such devices as are not in duplicate, the equipment on each locomotive is so placed that an interior view is the same from one end or side of the locomotive as from the other. Thus the weight is uniformly distributed over the drivers.

Current Collectors.—The small trolley seen over the centre of the locomotive in Fig. 14 is connected to the circuits of the third-rail shoes and is intended for used only in case the locomotive should come to rest at some point where the third rail had been omitted and an overhead conductor had been substituted therefor. The contact bows of the large trolley, which are made of galvanised steel, are 4 ft. in length. Each bow is given an upward curvature at the centre and is provided throughout its whole length with a single trough for containing the lubricating material, which consists of a mixture of graphite and grease.

The design of the third-rail shoe mechanism represents a solution of a number of difficult problems. The shoes must be held by spring pressure downward against an over-running rail, or by spring pressure upward against an under-running rail. They must be lifted so as to clear any ordinary obstruction along the track when a third rail is not used. The shoes are hinged from a framework, which, in turn, is hinged from the base plate of the device. The shoe framework may be thrown outward in a horizontal plane, or drawn upward to an angle of about 45 deg. from the horizontal by means of a toggle-joint mechanism, which is operated electro-pneumatically. When the framework is in the horizontal position, each shoe is held in place by means of a spring which resists motion in either the upward or the downward direction. The valve-control circuits of the magnets for the shoe mechanism are electrically "interlocked" with those of the alternating-current trolleys, so that when the trolleys are up, the shoes are up also, and when the shoes are let down, the trolleys come down also; the trolleys can, however, be pulled down while the shoes are up. It is noteworthy in this connection that the "interlocking" is not depended upon for safety to the motor equipment and control circuits. As a matter of fact, it is a physical impossibility for direct current to reach the motors from the third rail while alternating current exists in the auto-transformers, because the "throw-over switch" either connects the motor circuits directly to the third rail and disconnects them from the high-tension circuits, or it joins the motor circuits to the auto-transformers and thoroughly isolates them from the third-rail shoes.

Performance of Locomotives.—The locomotives were subjected to tests duplicating in many ways actual service conditions. The track upon which the tests were made was equipped both with a third rail for the supply of direct current at 600 volts and with an overhead catenary trolley wire for alternating current at 11,000 volts. The track was 2·2 miles in length and contained several curves and slight grades. In one test a locomotive was required to make a schedule speed of 26 miles per hour with 45-second stops at each end, the maximum speed reaching 45 miles per hour, the total weight of train and locomotive being 294 tons. Watt-hour meters placed in the supply leads showed that during direct-current operation the consumption was 44 watt-hours per ton-mile, and that the consumption for alternating-current working was 42·5 watt-hours per ton-mile. The values given represent the total energy received by the locomotive, including all losses in the control apparatus. Although the running efficiency was undoubtedly somewhat less for alternating than for direct current, the rheostatic losses during acceleration with direct current were much greater than the transformer losses during alternating-current acceleration, and hence the locomotive was operated more efficiently with alternating than with direct current. It is evident, however, that for longer hauls with less frequent stops, the advantage with respect to the efficiency of the locomotive as a unit would be with the direct-current working.

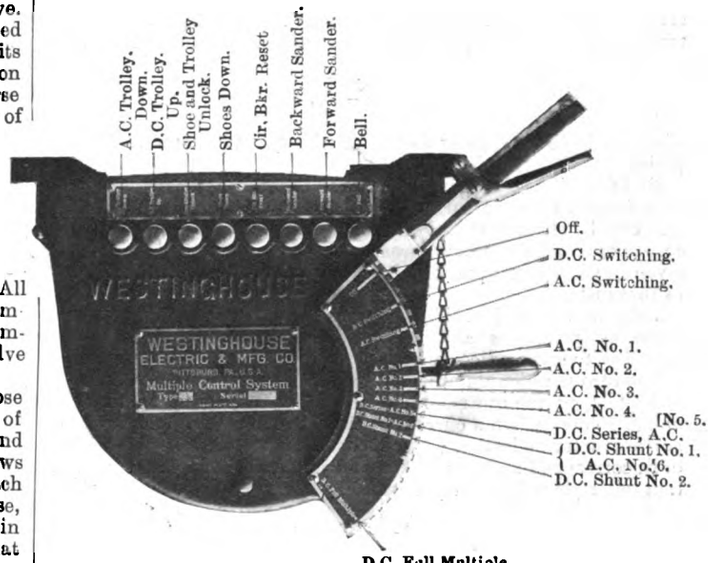

FIG. 15.—TOP OF MASTER CONTROLLER.

(*To be concluded.*)

ON TRANSFORMER INDICATOR DIAGRAMS.*

BY T. R. LYLE, M.A., D.SC.

1. The term "transformer indicator diagram" has been applied by Prof. Fleming to any series of periodic curves which gives the forms, relative phase-positions, and magnitudes of the waves of current and E.M.F. on both the primary and secondary sides of a transformer when working. Such diagrams have been obtained by many investigators in different ways, but by none of the methods hitherto used has it been possible to determine directly and independently either the wave of magnetic flux F in the core or the wave of magnetising-current turns usually represented by the vector sum $n_1C_1+n_2C_2$.

Both these quantities are of fundamental importance in the theory of the transformer. When they are known for any given load, all the other quantities (currents and E.M.F.s) can be determined for the same load when the primary and secondary turns, resistances and leakage coefficients are known.†

In addition, since, as will be shown later, the integral

$$\int(n_1C_1+n_2C_2)dF$$

for one cycle is equal to the total iron loss per cycle, the advantage of being able to determine both $n_1C_1+n_2C_2$ and F directly and accurately is apparent.

Theoretically, $n_1C_1+n_2C_2$ can be obtained by the vector addition of n_1C_1 and n_2C_2, but as the latter quantities are, when the transformer carries a load, approximately equal in magnitude and oppo-

* Paper read before the Physical Society. Abbreviated.

† See Lyle: "The Alternate-Current Transformer," *Proc.* Roy. Soc. Victoria, Vol. XVIII., part 1.

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site in phase, their vector sum is a small quantity compared with either of them. Hence small errors in the magnitudes of n_1C_1 and n_2C_2 may cause a large percentage error in the magnitude of $n_1C_1+n_2C_2$ while very small errors in magnitudes and phase difference of n_1C_1 and n_2C_2 may render the phase of $n_1C_1+n_2C_2$ calculated from them utterly unreliable.

By means of the wave tracer* designed by the author not only can the E.M.F. and current waves be accurately determined, but also the wave of magnetic flux pulsating in the core of the transformer, and, in addition, as will be shown in the sequel, we can obtain by its means the magnetising-current wave $n_1C_1+n_2C_2$ with the same accuracy as any of the other quantities.

Incidentally will be given new methods of comparing mutual inductances and of measuring both mutual and self inductances in terms of a resistance and a time.

2. In the Paper just quoted I have shown that if a periodic current C flows in the primary of a pair of coils whose mutual inductance is M, and if the secondary be joined through a suitably arranged commutator (running synchronously with the generator of the periodic current), which commutes twice per period, to a large resistance, r, and thence to a galvanometer, there will be a steady deflection, γ, in the latter which is connected with the instantaneous value C of the periodic current at the instant of commutation by the relation

$$MC=\frac{\lambda r T}{4}\gamma,$$

where λ is the reducing factor of the galvanometer and T the period.

By arranging so that the commutating brushes can be rotated on a divided circle round the drum of the commutator, commutation can be effected at any desired instant of the period, and the corresponding galvanometer reading when multiplied by the factor given in the above equation gives the ordinate of the current wave at that instant.

Take now a triad (*see* Fig. 1, T) of coils of which p_1 and p_2 are to serve as primaries and the remaining one s placed between p_1 and p_2 to serve as common secondary. Let s be connected as before through commutator and resistance r to the galvanometer, and let M_1 be the mutual inductance of p_1 and s, and M_2 that of p_2 and s. Then, when a current C_1 circulates in p_1 and none in p_2, the galvanometer deflection γ_1 produced is connected with the ordinate of C_1 corresponding to the instant in the period at which commutation takes place by the equation

$$M_1C_1=\frac{\lambda r T}{4}\gamma_1,$$

and when a current, C_2, equiperiodic with C_1, circulates in p_2 and none in p_1, a galvanometer deflection γ_2 is produced which is similarly connected with the corresponding ordinate of C_2 by the equation

$$M_2C_2=\frac{\lambda r T}{4}\gamma_2.$$

When both C_1 and C_2 are flowing in their respective primaries at the same time, the galvanometer deflection γ will be the sum of γ_1 and γ_2 produced by C_1 and C_2 separately, hence

$$M_1C_1+M_2C_2=\frac{\lambda r T}{4}\gamma.$$

If now n_1 and n_2 are numbers such that $M_1/n_1=M_2/n_2=M$, then

$$n_1C_1+n_2C_2=\frac{\lambda r T}{4M}\gamma;$$

so that if γ be the galvanometer deflection for a given position of the commutating brushes when C_1 is flowing in p_1 and C_2, correctly directed, in p_2, the ordinate of the wave which is the vector sum of n_1C_1 and n_2C_2 at the instant of commutation is the product of γ by $\lambda rT/4M$.

The same principle can obviously be extended to the determination of the vector sum of any number of equiperiodic currents each affected by an independent numerical multiplier.

In the Paper already quoted it is also shown that if a coil of v turns of wire is looped on a magnetic circuit in which a periodic magnetic flux of periodic T is pulsating, and if the ends of the coil are connected through the synchronous commutator that changes twice per period to a high resistance, r, and thence to a galvanometer as before, the ordinate F of the flux wave and the corresponding galvanometer deflection β for any position of the commutating brushes are connected by the relation

$$F=\frac{\lambda r T}{4v}\beta.$$

Hence any desired set of ordinates of a flux wave can be obtained.

3. From what precedes it is obvious that in order to obtain practically the vector sum of n_1C_1 and n_2C_2, where n_1 and n_2 are numbers and C_1 and C_2 currents of equal period, it is necessary to have a triad p_1, p_2, and s of coils such that the mutual inductance of p_1 and s is to that of p_2 and s as n_1 is to n_2. These can be wound in three grooves turned out of a circular disc of seasoned wood that has been well baked and then soaked in melted paraffin. A rough approximation to the required ratio of M_1 to M_2 can be obtained by attention to the relative numbers of turns, and a preliminary adjustment can most quickly be made by the wave tracer as follows: Send a periodic current of suitable value through the common secondary s. Join together one end from each of p_1 and p_2 and connect the junction to one fixed brush of the commutator. Bring the other ends of two terminals of a two-way key, from whose moving tongue a connection is made, to the other fixed brush. Join the two movable brushes of the commutator through a suitable resistance r to the galvanometer. Thus, when a current C is flowing in s, either p_1 or p_2 can be put in circuit with the galvanometer, and the deflections γ_1 and γ_2 due to p_1 and p_2 respectively for every position of the moving brushes are in the ratio of M_1 to M_2, since

$$C=\frac{\lambda r T}{4M_1}\gamma_1=\frac{\lambda r T}{4M_2}\gamma_2.$$

Obviously in making the comparison it is desirable to place the moving brushes so that the deflections obtained are near the maximum ordinate of the current wave.

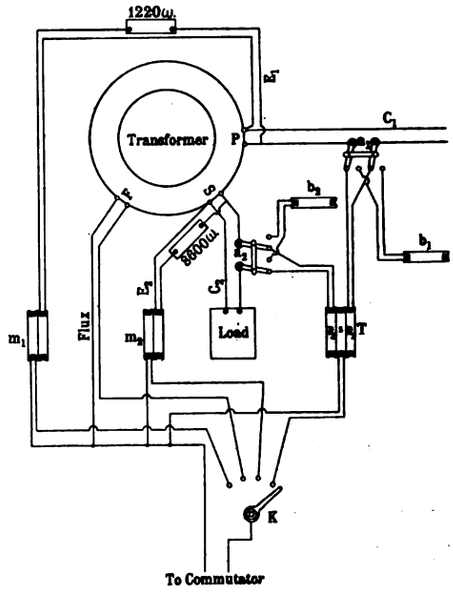

FIG. 1.

Otherwise we might put a resistance r_1 in the galvanometer circuit when p_1 is in, and r_2 when p_2 is in, so as to obtain equal deflections; then we would have that

$$M_1/M_2=r_1/r_2.$$

Hence the coils s and p_1 may be finished and their terminals permanently fixed, and, using the latter (equal deflection) method a resistance r_1 found to give a large deflection when p_1 is in circuit and the brushes placed so as to give approximately the maximum ordinate of the current wave. Now substitute r_2 obtained by the above relation, allowing for galvanometer or other appreciable resistance that may be in circuit, and switch p_2 on to the commutator and galvanometer. An assistant can increase or reduce the turns (or fractions) until the same deflection is obtained as was given by p_1 with r_1 in circuit. Spare wire should be left in case the further treatment of the coils causes any change in their M ratio.

As it is necessary, if high accuracy with the wave tracer be desired, that the M coils used should have high insulation, the triad should now be thoroughly dried in an oven to drive off moisture from the cotton or silk covering and placed in an iron dish that can be fitted with an air-tight lid that has an exhausting tube through it. A layer of solid paraffin is in the bottom of the dish, and on this the coil is placed and weighted with a piece of metal. The lid is luted on with melted paraffin, the air pumped out, and the dish then heated so as to melt the paraffin it contains. The coil now sinks in the melted paraffin, and as the air has been removed it becomes thoroughly impregnated. We can thus obtain coils of high insulation and permanent mutual inductance if, in addition, proper attention is paid to the insulation of the terminals.

A final and careful adjustment of the ratio of M_1 to M_2 should now be made with the wave tracer.

The absolute values of M_1 and M_2 must also be known, and they can easily be obtained by either of the methods just described in

* Lyle: "Wave Tracer and Analyser," *Phil. Mag.*, November, 1903.

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terms of a known standard of mutual inductance. An alternating current is sent through the primary of the standard, and either p_1 or p_2 of the triad (the one whose M is nearest in value to that of the standard) and the secondary of the standard and s of the triad arranged so that either can be switched on to the commutator and galvanometer. Then for any position of the commutating brushes the two deflections are proportional to the mutual inductances when the resistance in circuit is fixed, or if equal deflections be obtained the inductances will be proportional to the resistances. Obviously it will be desirable to make a number of independent comparisons by varying the position of the commutating brushes about the place at which the maximum ordinate of the current is obtained.

The absolute value of a mutual inductance can be determined by the wave tracer in terms of a resistance and a time, as follows: An alternating current is sent through a Kelvin balance, and at the same time a number (usually 30) of equispaced ordinates (γ) of it embracing one full wave is obtained by the wave tracer using the mutual inductance M to be measured; as

$$C_t=\frac{\lambda r T}{4M}\gamma,$$

the square root of the mean squares of C_t, which is the Kelvin balance reading (B say), is $\lambda r T/4M$ times the square root of mean squares ($\tilde{\gamma}$ say) of the galvanometer readings, hence

$$M=\frac{\lambda r T}{4}\frac{\gamma}{B};$$

T is given by the chronograph attached to the wave tracer, and the ratio of λ, the reducing factor of the galvanometer, to B can be obtained as follows: Send a continuous current = B through the balance and through a standard resistance ρ (usually 0·1 ohm). From the terminals of ρ lead a shunt circuit through a resistance, R, to the galvanometer and let the deflection of the latter be d.

Then $$\lambda d=\rho\frac{B}{R},$$

and hence $$M=\rho T\frac{r\gamma}{4Rd}.$$

4. The transformer, some of whose indicator diagrams will be given, was a small experimental one of the ring type of about ½ kw.

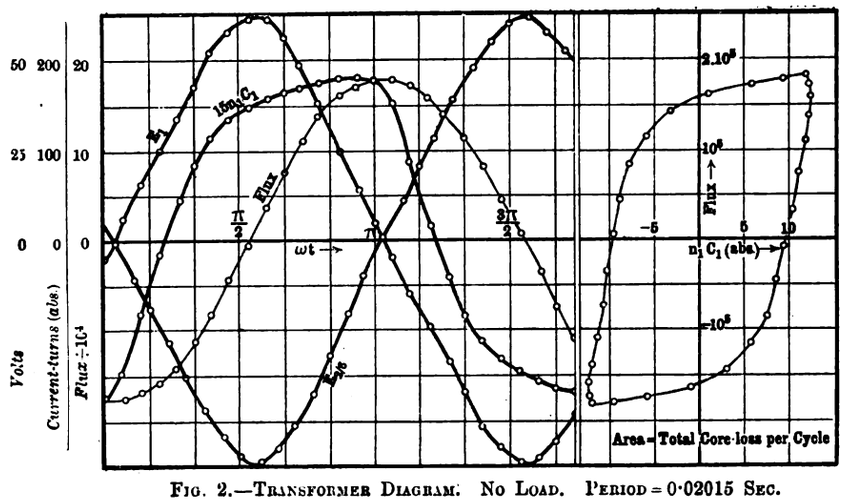

FIG. 2.—TRANSFORMER DIAGRAM. NO LOAD. PERIOD = 0·02015 SEC.

capacity. It was used as a step-up one of ratio 1 to 6 transforming from about 40 volts (virtual) to 240 at about 50 periods per second. Its details are as follows:—

Core: 144 annular laminæ annealed and paper-insulated.
Laminæ: Internal diameter ..... 15·25 cm.
External diameter ..... 27·75 cm.
Thickness ..... 0·047 cm.
Primary coil: number of turns (n_1) = 100.
Resistance (warm) = 0·0676 ohm.
Secondary coil: number of turns (n_2) = 600.
Resistance (warm) = 2·034 ohms.

Before either coil was wound a single turn of well-insulated wire was looped on the core to serve as a search coil for the determination, by means of the wave tracer, of the magnetic flux pulsating in the core. The secondary coil was wound next the core.

The primary current was drawn from the alternating side of a small rotary converter that was supplied with direct current from storage cells. The spindle of the commutator and that of the converter were in line and rigidly connected, so that perfectly synchronous commutation was obtained. A chronograph took a continuous record of the period, recording once every 200 alternations.

The arrangement of the transformer and the mutual inductances by means of which the different waves were determined is shown in

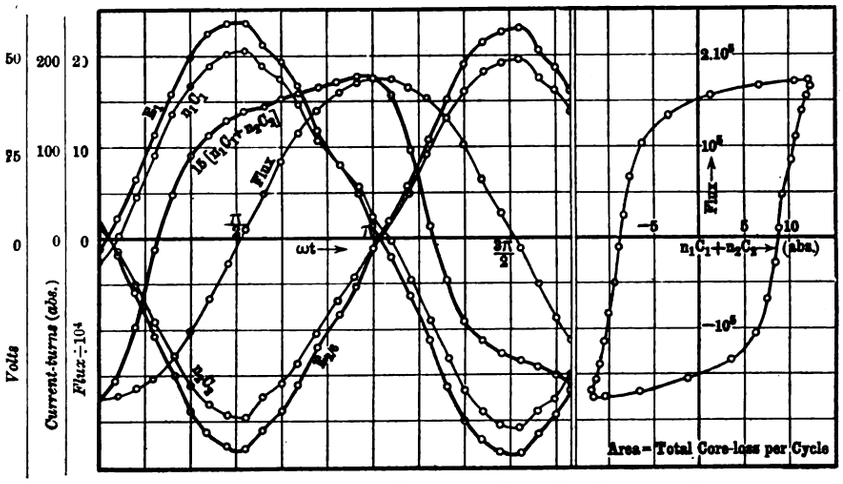

FIG. 3.—TRANSFORMER DIAGRAM. FULL NON-INDUCTIVE LOAD. PERIOD = 0·02053 SEC.

Fig. 1. The primary current C_1 from the converter enters by the two leads marked C_1. In one of these leads is placed a two-pole switch, a_1, by which C_1 can be sent through the primary p_1 of the triad T, or deflected through an equal compensating coil, b_1, leaving p_1 completely disconnected from the live circuit in case the triad is being used for the determination of C_2.

E_1 is determined by obtaining the trace of the current wave it sends through a non-inductive resistance of 1,220 ohms. The mutual inductance m_1 of 0·00061 henry is used for obtaining this trace. E_2 is similarly determined, the non-inductive resistance in circuit being 8,660 ohms and the mutual inductance m_2 0·003535 henry.

The secondary current C_2 may, by means of the switch a_2, be directed through the primary p_2 of the triad T or through the equal compensating coil b_2. When $n_1C_1+n_2C_2$ is being determined, both C_1 and C_2 flow through their respective primaries p_1, p_2 of the triad in the proper relative directions, the common secondary s being joined as shown to the commutator and thence through a resistance to the galvanometer. When C_1 alone is being determined, C_2 is deflected through its compensating coil b_2; similarly when C_2 alone is being determined, C_1 is deflected through b_1. The mutual inductance of p_1 and s was 0·0000485 henry, while that of p_2 and s was 0·000291 henry, which bear the same ratio to each other as n_1 to n_2, that is, as 1 to 6.

The points marked F in Fig. 1 represent the terminals of the single loop of insulated wire wound round and close to the transformer core. When the flux wave is being obtained these are connected direct to the commutator, and thence through a suitable resistance to the galvanometer.

By means of the key K either the flux leads or those of any of the secondaries of the different mutual inductances can be connected with the commutator so as to obtain the corresponding wave trace.

A glance at Fig. 1 will show that the true primary current is less than the measured C_1 by the small current by which E_1 is determined. To correct for this (if correction is necessary) we subtract from each galvanometer C_1 reading an easily determinable fraction of the equiphase E_1 galvanometer reading. A similar correction has to be applied to the C_2 readings; but in this case the corrections have to be added. The galvanometer readings for $n_1C_1+n_2C_2$ have also to be similarly corrected, and in this case the corrections are of great importance, as the C_1 correction is affected by the factor n_1 and the C_2 correction by the factor n_2, and both corrections are approximately in the same phase.

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5. For the present Paper three separate sets of connected transformer quantities were determined. These are shown graphically in Figs. 2, 3 and 4 for different loads, and in the original Paper the harmonic expressions are obtained by methods elsewhere explained.*

In addition to the sets of related waves, there is, in each of the three diagrams, an area very similar to the well-known hysteresis indicator diagram. In the present case these closed curves were obtained by plotting the flux as ordinate against the corresponding value of the magnetising current turns, *i.e.*, $n_1C_1+n_2C_2$, as abscissa for a complete period.

Thus the area enclosed (A say) is

$$\int_t^{t+T}(n_1C_1+n_2C_2)d\mathrm{F},$$

where T is the period, and this integral can be shown to be equal to the total core loss per cycle due to both hysteresis and eddy currents as follows:—

Neglecting rc^2 losses, the energy entering the transformer on the primary side in any element of time dt is eC_1dt, where e is the back E.M.F. due to variation of the flux; and as

$$e=n_1\frac{d\mathrm{F}}{dt},$$

this energy is equal to $\quad n_1C_1\frac{d\mathrm{F}}{dt}dt.$

Similarly, the energy leaving the transformer on the secondary side in the same element of time dt is equal to

$$-n_2C_2\frac{d\mathrm{F}}{dt}dt;$$

hence in the time dt the transformer absorbs energy to the amount

$$(n_1C_1+n_2C_2)\frac{d\mathrm{F}}{dt}dt,$$

so that in one cycle, of duration T, the energy absorbed is equal to

$$\int_t^{t+T}(n_1C_1 \quad n_2C_2)\frac{d\mathrm{F}}{dt}dt=\text{area A}.$$

6. It is easy to show that when $n_1C_1+n_2C_2$ and F are expressed in the forms

$$n_1C_1+n_2C_2=m_1\sin(\omega t-\mu_1)+m_3\sin 3(\omega t-\mu_3)+m_5\sin 5(\omega t-\mu_5)+\&c.,$$
$$\mathrm{F}=f_1\sin(\omega t-\phi_1)+f_3\sin 3(\omega t-\phi_3)+f_5\sin 5(\omega t-\phi_5)+\&c.,$$

the integral or area A, and therefore the total core loss, in ergs, per cycle is equal to

$$\pi\{m_1f_1\sin(\phi_1-\mu_1)+3m_3f_3\sin 3(\phi_3-\mu_3)+5m_5f_5\sin 5(\phi_5-\mu_5)+\&c.\},$$

which, when divided by 10^7T, where T is the period, gives the total power lost in the core in watts.

This form of expression has the advantage of giving separately the power absorbed by the iron by means of the harmonics of different orders, and from the analytic expressions for E.M.F.s and currents we can also obtain for the different orders of harmonics the input, output and copper losses.

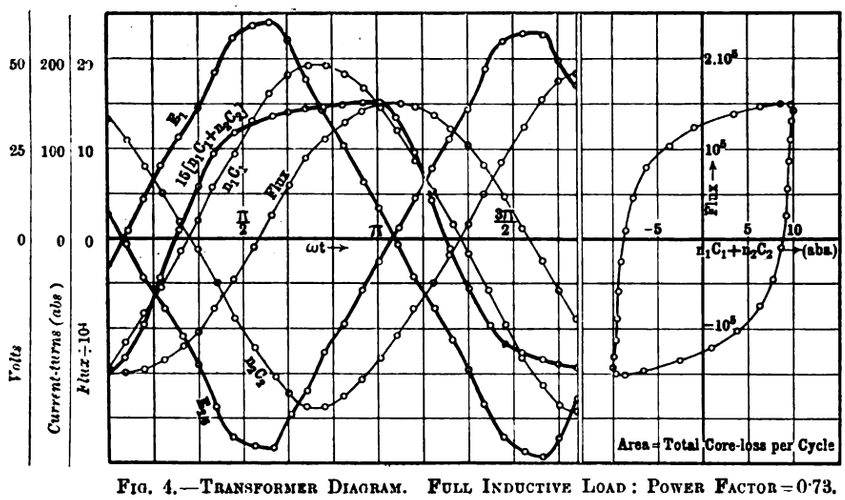

FIG. 4.—TRANSFORMER DIAGRAM. FULL INDUCTIVE LOAD: POWER FACTOR = 0·73. PERIOD = 0·01835 SEC.

* "Wave Tracer and Analyser," *Phil. Mag.*, Nov., 1903. "Variation of Magnetic Hysteresis wit Frequency," *Phil. Mag.*, Jan., 1905. "Expeditious Practical Method of Harmonic Analysis," *Phil. Mag.*, Jan., 1906.

A NEW AUTOMATIC METHOD OF STARTING MOTORS.*

BY DR. MARTIN KALLMANN.

The present Paper contains an account of the application of iron resistances, similar to those used in conjunction with Nernst lamps, to the starting of motors, and describes various forms of these resistances, as made by the Allgemeine Elektricitäts Gesellschaft. These resistances are called "variators," though the properties of iron seem unlikely to lend themselves to the starting of motors. When iron is heated to a dull red heat, its resistance is about eight times that which it has when cold. At first sight it would almost seem as if this property were the reverse of that required in a material for a starting resistance; but this is not the case if the design is suitably arranged, for the rate at which the iron heats can be made to be very great, and as soon as it is hot it cools again automatically, owing to the reduction of current which is caused by the gradual increase of the back E.M.F. of the motor. Two methods are, therefore, available, the first of which consists in giving the resistance a preliminary heating before switching on the motor, and the second involves such an arrangement of the design that the time required to heat the resistance is very short.

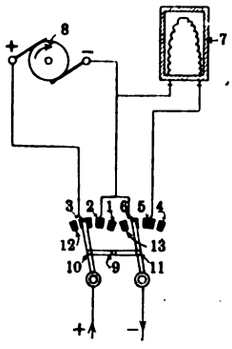

FIG. 1.

DIAGRAM SHOWING CONNECTIONS OF RESISTANCE TO MOTOR BY MEANS OF A STARTING SWITCH.

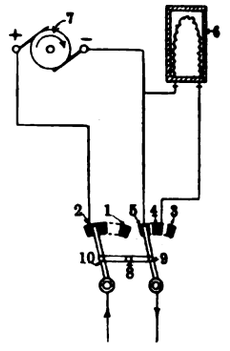

FIG. 2.

CONNECTIONS OF MOTOR AND RESISTANCE TO STARTING SWITCH.

A start was made on resistances such as are used in Nernst lamps, and they were made of a size to carry as much as 5 amperes. For heavier currents several were put in parallel, and this has the obvious advantage of allowing a resistance of any required amount to be built up out of standard units. It is possible to use a heavier form of construction by employing stouter wire or iron strip; but this leads to serious sluggishness, which is fatal to success.

Fig. 1 shows the simplest arrangement with an ordinary starting switch. The resistance 7 is placed in series with the armature of the motor and is controlled by a double-pole switch. In the first position, when the switch rests on the contacts 1, 4, the motor is out of circuit; in the second position, 5, 2, the resistance or variator is put in circuit, and, being able to withstand 220 volts, it instantly reaches a red heat. When the switch rests on the contacts 3, 5, the armature of the motor is switched into the circuit in series with the variator, the temperature of which gradually falls as the motor gets up speed. The switch is then placed on contacts 3, 6, and the motor receives the whole applied voltage, the resistance being cut out. Fig. 2 shows a very similar arrangement without any preliminary heating of the resistance, and in many cases this works perfectly. Obviously this scheme is capable of all sorts of variations and extensions; the resistances can be arranged in groups, either in series or in parallel.

The device adopted for the purpose of making these resistances work automatically may be described as follows. A constant resistance is placed in series with the variators, and this serves to keep the rush within proper limits. The variators themselves are divided into two groups, which are controlled by a relay which cuts them out in two steps. This is explained by Fig. 3, where at the

* Abstracted from the *Elektrotechnische Zeitschrift*.

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moment of starting all the variators from 2 to 9 are in series with the motor. The coils of the relay receive so much current that the core, 11, is raised until the contact-piece, 13, touches the contact-plate, 14. This cuts out the variators from *a* to *b*. As the voltage on the motor rises still further, the core, 11, pushes up the movable contact piece, 14, until the lower armature, 12, makes contact with 16 and 17. This has the effect of cutting out the variators entirely. The arrangement here shown can be varied in many ways, and the device has been placed upon the market in different forms, adapted to meet the circumstances of particular cases; but the general principle, shown in Fig. 3, is incorporated in all of them in some shape or another. The resistances are usually mounted in glass bulbs filled with hydrogen; a single resistance will carry as much as 6 amperes and 100 volts. A small one, very similar to those used with Nernst lamps, will carry about 1 ampere at 50 volts, and has the advantage of low heat capacity; but for a 2 kw. motor, 40 would be required, and this makes them too small for the general run of practical work. Larger wires have therefore been used up to a diameter of 0·5 mm., and resistances have also been made of iron strip. Other forms have been designed to carry heavier loads. In this case bundles of iron wires are wound on a very light triangular framework of incombustible material, as many as nine wires being in parallel with one another; they are fastened to the support by a kind of cement. In this way it has been possible to make a variator taking a load of 1 kw., but, of course, it was only possible to carry this for a few seconds. Still, with resistances of this type, a bright red heat is possible for several hundred hours, and no kind of disintegration is noticeable in an atmosphere of hydrogen. In fact, it seems that the effect of this temperature on an iron wire is less than that produced on a carbon filament run at its normal temperature. Curves have been made showing the current taken by a motor when started by one of these devices. The motor settles down to its normal state at full load within five seconds of the start, and the rush of current at the moment of switching on the pressure is easily kept within suitable limits. It is possible to determine the magnitude of the rushes of current during the initial

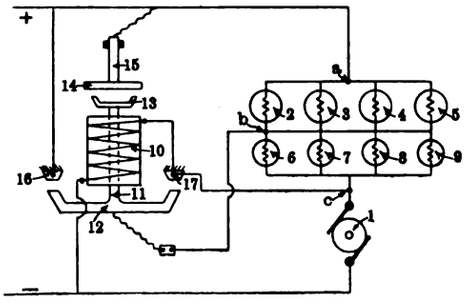


FIG. 3.—AUTOMATIC ACTION OF A RELAY CUTTING OUT THE RESISTANCE IN TWO STAGES.

stages by carefully watching the ammeter; but the best method would undoubtedly be to employ the oscillograph. Quite apart from these accurate methods, however, it may be said that such rushes have no effect on the apparatus and that the steadiness of the lights in the immediate neighbourhood is practically unaffected by the starting of the motor.

The present plan is to use a constant resistance in series with the motor and variators for the purpose of stopping the rush until the variator has had time to heat. The constant resistance need be only of comparatively small size, whereas the variators will do the main part of the work. An advantage of this method lies in the easy adaptability of the system to different cases; the separate elements composing a resistance would probably merely require to be rearranged in order to be able to deal with the requirements of a totally different case, and by grouping them either in series or in parallel, or partly in series and partly in parallel, it is evident that the adaptability of the method is very great and the whole cost very small.

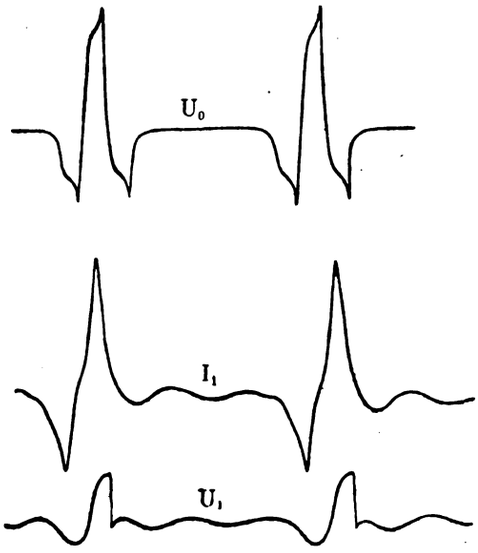
Iron has, moreover, a high specific resistance, even at low temperatures. It is twice that of constantan or manganin. But iron is used in these resistances at a red heat, and has in this state a resistance which is 8 or 10 times that which it has when cold. An iron wire having a cross-section of 1 sq. mm. and 1 metre long will have a resistance of more than an ohm when red hot; this is about the same as the resistance of mercury and more than twice that of rheotan. In so far as economy of material is concerned, iron would seem to be about the best that can be had. It might be thought that if iron were frequently heated to a red heat it would be gradually disintegrated; but this is not the case if the heating is done under a vacuum, or, better still, in an atmosphere of hydrogen. Under these conditions it will outlive the life of a feebly glowing carbon filament.

A GENERATOR FOR SPARK TELEGRAPHY.*

BY P. VILLARD.

The sparks used in wireless telegraphy are usually obtained either by an inductorium or by an alternating-current transformer. The former method is of very limited power output, and the second has the inconvenience of giving too many sparks and thus wasting energy. A method to reduce the sparks in number from, say, 80 or 100 per second to 10 or less per second, has recently been described by M. Blondel.† It consists in having the secondary circuit of the transformer slightly out of resonance with the alternating current, so that beats are produced; and thus the sparks may be reduced in number till there is, say, only one every 10 alternations. In this method the regulation must be very precise. The same problem may be solved in an easier way, however, which renders the discharges of a rarity mechanically determinable.

The method consists in the use of a special alternator. The armature is fixed and carries two bobbins, and the field-magnet rotates inside it. This field-magnet is shaped somewhat like the letter H, and presents four poles of alternate sign arranged in two close pairs, one pair diametrically opposite the other. During nearly a half-turn these poles do not pass in front of either bobbin and the losses reduce to those in the sheet iron of the stator. All the driving power is spent in a small fraction of a turn. First one pole passes before a bobbin and produces therein an E.M.F. of, say, +E, then a second pole replacing the first produces an E.M.F. of



−2E, and finally this latter pole in leaving the coil induces +E. Thus each period is composed of three alternations, of which one is double either of the others. In the figure, U_0 is the oscillograph of the tension in open circuit or of the current through ohmic resistance. By aid of a transformer it is easy to arrange that each period gives one spark, and each spark is always in the same sense. If a condenser is in the secondary of the transformer, discharging itself through a spark-gap, the current and potential curves are as shown at I_1 and U_1.

Measurements made by the oscillograph show that the maximum voltage is three times the effective voltage—double that which occurs with ordinary alternating current. The experiments in the laboratory, as well as those in the field, have shown that the machine described is much more efficient, especially in the indirect method of coupling to the antenna, than the induction coil.

Electric Power Tariffs.—In a recent issue of *Cassier's Magazine* there appears an article on this subject by Mr. C. S. Vesey-Brown. Tables are given showing the comparative rates charged for motor power, under varying load factors, by various electric power supply authorities in several countries. In the case of a 15 H.P. motor, and 30 per cent. load factor, the average of the prices given is for Switzerland 0·955d., Canada 1·22d., India 1·29d., Africa 2·4d., Great Britain 1·14d. An analysis is also made of the methods of charging for power in Great Britain.

* Abstracted from the *Comptes Rendus*.
† *The Electrician*, August 2, 1907, p. 642.

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SPECIFICATIONS FOR STREET LIGHTING.

IN this country little trouble has been taken in regard to specifications for street lighting, because, generally speaking, street lighting is carried out by local authorities themselves, and where a company has been responsible some general agreement has been reached that lighting by a certain class of arc lamp, with lamps spaced a certain distance apart, gives the required result. In America, however, matters have been chiefly in the hands of companies, and specifications have been more in evidence; and, since requirements have by no means been always clearly stated, there has been a certain amount of trouble. Not so very long ago there was a controversy in an American town because a contract for public lighting specified that arc lamps of standard 2,000 c.p. were to be used. Originally open-type arc lamps were installed in this town, but later on these were replaced by enclosed arc lamps giving a candle-power of something like 300. After a time the officials suddenly awakened to the fact that the illumination was not as good as it should be, with the result that, after consulting

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the contract, they claimed a candle-power of 2,000 from each lamp. When the case went to arbitration the fallacy of 2,000 c.p. from a 10-ampere lamp was soon demolished; but the case served to show that the subject of street lighting, as between electric lighting companies and consumers, was in a rather chaotic state.

It is a little difficult for any really satisfactory basis to be arrived at on which an electricity supply authority can supply light for street lamps. The old basis of supplying energy is insufficient. A simple course, no doubt, is for the consumer to select the type of lamp and to test a certain number of the lamps in a laboratory to see if the photometric result, judged by candle-power in certain directions, comes within the guarantee; but this method gives no check on the subsequent working of the lamps, or upon the efficiency with which they are trimmed and generally looked after. What is really required is a definite illumination in the streets, and that such illumination shall not fall below a certain minimum at a point midway between any two lamps, and, therefore, that the variation of illumination from maximum to minimum shall not be excessive. The last point is, of course, fixed once for all by the type of lamp and the distance at which the lamps are spaced. The actual minimum may be made subject to measurement. There is, however, some difficulty in making satisfactory measurements of low illuminations, such as are likely to occur as minima. If illumination measurements are to be adopted, it will probably be better to make such measurements comparatively near to the lamp under test, the minimum illumination being deduced if required. In any case, a good deal of care is necessary in such measurements, because an arc lamp is by no means a very steady source of illumination, and, therefore, measurements, if not fairly numerous, might give results considerably above or below the actual time average.

As Streets Committees are likely to be more stringent in their requirements as to street lighting in the future, the recommendations recently made by the National Electric Light Association (U.S.A.) are of some interest. The Association specifies that, with lamps spaced 200 ft. up to the somewhat unusual distance of 600 ft. apart, the mean illumination of an individual lamp should be measured at the height of the observer's eye and perpendicular to the rays at some point not less than 200 ft. nor more than 300 ft. from the lamp, this distance being correspondingly less with smaller units of light. The lamp under test is to give a mean normal illumination at the test point not less than the illumination given by a stationary standard incandescent lamp of 16 c.p. at one-tenth the distance, and the unobstructed mean normal illumination must not be less at shorter distances than at the point of test.

REVIEWS.

(Copies of the undermentioned works can be had from *The Electrician* Office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.)

Electricity in Mining. By SYDNEY F. WALKER. (London: Harper & Bros.) 9s. net.

This book has been written with the object, we understand, of giving the mining engineer and those connected with mines a practical view of the application of electricity, and with this object in view the author has collected together an amount of useful information in a very general way which may prove of service if properly applied.

The first chapter of the book is devoted to explaining what electricity is. The whole of this chapter, as regards its practical value, might as well have been left out, as it only tends to create confusion in the mind of the reader. The following chapters dealing with definitions, units, &c., are useful to some extent, but a certain amount of subject matter is introduced which again would have been better left out from a merely elementary book, which this evidently is. As an example, on page 15 the author, in describing the effective value of pressure or current, makes the following statement: "Stated accurately the effective or virtual pressure or current is the square root of the mean of all the values of pressure or current for a half-period," whereas the mean squares are, of course, what is intended.

On page 191 the author gives the square root of 3 as 1·71 instead of 1·732, and it would have been very much better if he had worked out examples of calculations embodying these formulæ, so that the engineer could have seen at a glance how to apply the information given.

A number of diagrams of connections of various types of continuous-current and alternating-current generators are given. These are very liable to confuse the ordinary reader, and it would have been better if the author had used proper outline drawings of the generators showing the positions of the windings and the method of coupling up. No doubt the author's idea throughout his book has been to explain various phenomena in a popular manner, which may account for the popular description, in dealing with the relative advantages of copper and carbon brushes, of the "current being poured through the coils of the armature." Similarly, the general notes re commutation, whilst of value to some extent, could be better understood by reference to a standard text-book on the subject. Taking the book generally, it would have been far better if a great deal of the introductory matter had been very greatly condensed, or omitted altogether, reference being given to standard text-books on the subject, and if the author had devoted himself to describing in a practical way the best methods of applying the different classes of machinery, both underground and on the surface.

With regard to switchboards, there is a great deal of information given, but after reading through the whole chapter one is left entirely in doubt as to which is really the best type of switchboard to adopt, and the same general remarks apply to starting gear. The mining engineer wishes to know whether he should use open switches, at what voltage open switches should not be used, and the relative advantages of oil-filled switches; also fuses against an overload, and also time relays. But whilst a scanty description is given of these different classes of apparatus no definite advice is given as to which should be adopted under varying circumstances.

Dealing with cables, there are several well-known methods of suspension of cable in shaft and underground, but there again the reader is left without advice as to the class of cable to be used. The author proposes that main shaft cables should be unarmoured. This advice could not possibly be adopted where heavy cables have to be used in the shaft, as the mere weight of the cable without the armouring would necessarily ruin it, and the proposal to use wood boxing from top to bottom of the shaft is a method of fixing which is strongly objected to by some colliery owners on account of the risk of fire, and all those acquainted with colliery work must know how very serious a fire in the shaft would be, particularly a shaft which is timbered.

A table giving the carrying capacities of cables, both in amperes and horse-power, for continuous and three-phase currents, would have been of great practical value, but this has been omitted, and the formulæ with regard to heating—whilst they might be applied by some people—are not of a sufficiently practical nature to be of service to the ordinary mining engineer.

Dealing with generating machinery, the reader is also left in hopeless confusion as to what class of machinery to put down, or the number of units to be adopted. Several illustrations are given of high-speed engines and a very casual reference is made to slow-speed engines. The author then deals with petroleum engines, the Diesel engine and other types which are very little known.

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The chapter devoted to pumping machinery has evidently been written without a recent knowledge of the subject. Three types of pumps are described—viz., the three-throw ram pump, which is stated to have a maximum efficiency of 66 per cent.; the centrifugal pump, stated to have an efficiency varying from 70 to 86 per cent.; and then the high speed differential type of pump is described, which is also supposed to have an efficiency of 90 per cent. Anyone conversant with the efficiencies would know that there is no type of pumping machinery so efficient as the slow-speed three-throw pump if properly constructed, and there are many working instances of well designed three-throw pumps and motors for high lift having a combined efficiency between the input into motor terminals and the water horse-power of over 80 per cent. and with a volumetric efficiency of 97 per cent. In dealing with centrifugal pumps, the author should have explained that the efficiency varies greatly with the head and quantity of water which the pumps have to deliver. Pumps for small capacities and high heads are necessarily uneconomical, whereas with large capacities and smaller heads the efficiency rises very greatly. It is a pity that the author did not put himself in communication with the leading firms manufacturing pumping machinery before compiling these chapters.

The information in connection with haulage is also equally vague, and the illustrations given of haulage gears, particularly of the friction clutches—of which only one example is shown, and that very badly—are misleading. The formula given for calculating the horse powers required for main and tail and endless rope haulages is approximately right under certain circumstances, but the author should have explained how this formula would be greatly varied by uneven roads, small tub wheels, and also crooked roads. Generally, this part of the book—which certainly deals with a subject of the greatest interest to the mining engineer—requires very careful revision and extension to be of real practical value.

The chapter dealing with coal-cutting is also very much condensed. The author should have given some actual results obtained from coal-cutting machinery in different classes of seams, and under different conditions, with the savings. Many examples of this could be obtained from the leading builders and users of coal-cutting machinery.

A chapter is devoted to winding, but the illustration which is given of the Zollern winding gear represents the gear with the accumulator switches, which have now been discarded in favour of the motor-generator, so that this illustration is out of date. Generally, this chapter requires considerable extension, and many more illustrations of modern winding gears included, to be of practical use, and, in addition, the author would be well advised if he regarded electric winding not only from a scientific standpoint, but also from the commercial possibilities.

Taken generally, the book has merits, as it is an honest attempt to collect together as much information as possible, but in a very condensed form, and the book will be found of use to a good many readers.

The Application of Graphic and other Methods to the Design of Structures. By William W. F. Pullen. 2nd edition. (Manchester: Technical Publishing Co.) 5s.

After a short introductory chapter on the graphic solution of equations and some useful hints on drawing, the author expounds at length the theory of bending, and shows its practical application in a great variety of well-chosen examples, many worked out numerically. Other chapters deal with the theory of counterbracing, maximum bending moment with moving loads, design of a plate girder, stability of masonry structures, masonry and metal arches, the theory of structures containing redundant members, effect of wind pressure, &c. The work is an admirable example of clear and concise writing, and as it is, moreover, thoroughly practical throughout, it can be confidently recommended.

High-Frequency Currents. By H. Evelyn Crook. (London: Baillière, Tindall & Cox.) 7s. 6d. net. Pp. xx., 206.

This book gives a useful résumé of the methods of production of the high-frequency currents used in medical practice, with an account of their physiological effects and therapeutic uses. Works on high-frequency currents in English have been few in number, and for the most part they have been vague and unsatisfying upon practical points. The effects of high-frequency currents upon the human body in health and in disease are difficult to understand, and although these currents have been extensively employed it is still not easy to form a clear estimate of their value. In general their application has been found useful in various conditions of general debility, and it appears that they have a selective influence upon the heart and the blood-vessels, tending to strengthen the circulation when carefully employed. The spark discharges of the high-frequency apparatus are also useful where a mild cauterising effect upon the surfaces of the body is required, and this cauterising effect can be very finely graduated to suit different classes of cases. The book may be read with advantage by those who are interested in the subject, for it gives a good account of the instruments and apparatus used in producing high-frequency currents. The latter part of the work, dealing with their therapeutic action, is largely a compilation from the writings of others.

HOW TO FIND THE DIAMETER OF A CABLE COMPOSED OF A NUMBER OF SMALL WIRES.

BY H. LUCKIN.

When reading through specifications for electrical contracts one often finds that the motor or switchboard terminals or sweating sockets are to be arranged to suit certain cables which are not quoted in the usual pocket-books and cable lists, and consequently it is a matter of some difficulty to find the diameter of the cable over the bare copper, and, as this has to be found before the terminals can be drilled, it is as well to have an easy method of determining this diameter.

The writer has found the following formula very useful in solving the difficulty:—

$$D = \sqrt{d^2 \times \frac{\pi}{4} \times n \times c \div \frac{\pi}{4}}.$$

Therefore $D = d\sqrt{nc}$,

where D = diameter of cable over bare copper, d = diameter of one wire, n = the number of wires, c = constant to allow for clearances between wires owing to wires being round = 1·33.

Take, for example, a 61/14 S.W.G. cable. This, as everyone knows, means a cable composed of 61 strands of No. 14 S.W.G. wire. Then, by making use of a wire-gauge table (to be found in almost any pocket-book), it is found that the diameter of a No. 14 S.W.G. wire is 0·080 in., therefore the formula will then read

$$D = 0{\cdot}080 \text{ in.} \sqrt{61 \times 1{\cdot}33}$$
$$\therefore D = 0{\cdot}080 \text{ in.} \sqrt{81}$$
$$\therefore D = 0{\cdot}080 \text{ in.} \times 9 = 0{\cdot}72 \text{ in.}$$

Therefore the diameter of a 61/14 S.W.G. cable over the bare copper is 0·72 in.

In this case it will be seen that the writer has taken a cable which can easily be checked up to any cable list.

As nearly all cables are composed of either 3, 7, 19, 37, 61 or 91 wires, the formula can easily be carried a step further, for $\sqrt{n \times 1{\cdot}33} = 2$ for 3, 3 for 7, 5 for 19, 7 for 37, 9 for 61 and 11 for 91 wires per cable. Then if we take a 37/14 S.W.G. cable all we have to do is to multiply the diameter of a No. 14 S.W.G. wire by 7 (as there are 37 wires) to get the diameter of cable over the bare copper—*i.e.*, 0·080 in. × 7 = 0·56 in.

This cable, again, is a size that can be easily checked to any cable list, such as Messrs. Glover's, as the writer is well aware that it does not do to take any and every formula on trust, and one likes to check the said formulæ before making use of them.

BOOKS RECEIVED.

(Copies of the undermentioned works can be had from *The Electrician* office, post free, on receipt of published price. Add 5 per cent. for abroad or for foreign books.

"Electrical Traction." By Ernest Wilson and Francis Lydall. Vol. I., Direct Current; Vol. II., Alternating Current. (London: Edward Arnold.) 15s. net each.

"Year Book of the Michigan College of Mines." 1906-1907. (Michigan: The College.)

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RESISTANCE COILS AND COMPARISONS.*

BY C. V. DRYSDALE, D.SC.

(*Continued from page 991.*)

Summary.—The author gives a survey of resistance coils, showing their evolution up to the present time and the methods used in accurate measurements of resistance. Results of tests on a number of resistance-alloys are given. The desirable features and temperature compensation of resistance coils are then discussed, and the author describes attempts which he has made at compensation by electro-depositing films of suitable thickness of certain metals on the resistance wires. In conclusion, the methods of standardising coils and bridges are considered, and a modified form of Carey Foster bridge, due to the author, is described.

Desirable Features of Standard Coils.—The ideal standard resistance coil should have, in as high degree as possible, the following characteristics, which are arranged roughly in order of decreasing importance :—

1. Permanence.
2. Freedom from, or protection from, corrosion.
3. Low and uniform temperature variation.
4. High and constant insulation.
5. Independence of atmospheric humidity, &c.
6. Large current-carrying capacity.
7. Easily maintained at constant temperature.
8. Admit of exact determination of temperature simultaneously with the resistance determination.
9. Freedom from external thermo forces.
10. Freedom from appreciable inductance or capacity.
11. Terminals of definite and convenient form and equally suited for bridge or potentiometer work.
12. Simple and robust in construction and easily adjusted.

If we examine each of the forms which have been above described with these criteria in view we find that most of them fulfil conditions 1, 2, 4 and 5 very well, but the remainder only partially or imperfectly. In no case is condition 3 well satisfied from the point of view of an accurate standard. With the exception of manganin standards, the temperature coefficient of most other coils is of the order of 0·025 per cent., or 250 parts in a million for 1°C. Hence, for measurements to an accuracy of one part in a million, which is fairly easily attained in the electrical measurement, the temperature must be known to one 250th of a degree, and ought to be kept constant over the whole coil for some minutes at least to within this amount. Manganin coils have, of course, a much lower temperature variation, but this is offset by the fact that the law is by no means linear, and the inconvenience of this, coupled with the fact that the standardisation is usually only carried out at two temperatures and thus does not define the curve, largely discounts the advantage. The temperature coefficient of manganin wire is as a rule about 0·0035 per cent. at zero, 0·002 per cent. at 15°C, and falls to zero about 35° to 40°C.

Few of the British patterns of standard coils are satisfactory from the point of view of carrying capacity and dissipation of heat. An exception to this is Prof. Burstall's coil, but this has employed platinum silver with its high temperature variation. The manganin coils of the Reichsanstalt are certainly the best from the point of view of carrying capacity combined with low temperature variation, but Dr. Rosa and Mr. Babcock† have just found them to be somewhat seriously affected by variations in the humidity of the air, owing to the expansion of the shellac coating when damp.

The determination of the temperature can rarely be made with sufficient accuracy, in fact, in all but manganin coils the determination of the temperature is the most troublesome and unsatisfactory part of the work,‡ and greatly increases the length of time necessary for standardisation. This is due both to the want of uniformity of temperature at various parts of the coil, and to the difficulty of getting sufficiently accurate thermometers. Where accurate temperature measurement is required, it is undoubtedly best to measure it electrically by the resistance of a platinum or other wire wound close to the working wire over its whole length, as has been done by the writer and by Prof. Burstall.

The design of the terminals has rarely recived sufficient attention. Not only should they be of sufficient section for their temperature variation to have negligible influence, but they should be such that the contact with the bridge blocks is always of the same definite character. Again, in order to provide for both bridge and potentiometer measurements of the highest accuracy, each terminal should have three contacts, one serving as an electrode for the passage of the current, and the other two (which should be symmetrically placed with respect to the first) being employed alternatively as potential contacts. Of these two one should have a terminal of definite form for the reception of a potential wire, while the other should be a mercury contact. Care should be taken in the shaping of the terminals and lugs so that the points of entrance and exit of the current, and between which the P.D. is derived, are always the same, and so that the stream lines or equipotential surfaces are unaffected by small variations in the connection of the leads. The resistance of the potential contact must also be less than one millionth of the bridge ratio coils, and a small current taken from them should not appreciably distort the equipotential surfaces. Lastly, no thermao forces should be introduced by them.

The only coils in which this question has been studied are those of the Reichsanstalt, but in none of them have all the conditions been fulfilled. In coils of 1 ohm and upwards three patterns are made by the Reichsanstalt, one with plain mercury contacts, the second with two screw terminals and one mercury contact on each side, and the third form which is considered the best, in which there are mercury and screw main contacts, and separate potential terminals. The two main contacts are in quite different positions and would give a different stream line distribution, while in bridge working the only convenient way is to use the potential terminals as current terminals and vice versa. Of course the variations due to these causes are extremely small in a 1 ohm coil, and there is the well-known reciprocal relation between the current and potential terminals in a network, but in the coils of lower resistance such as the 0·01 ohm standards we have the anomaly that the current terminals are the right gauge for the bridge, while the potential terminals cannot be connected to it without the use of wires clamped in terminals, while if the current and potential terminals are interchanged the latter are unsuitable for carrying a large current. The diagram Fig. 16A shows the connections used at the Reichsanstalt for such coils, and that this construction of coil is

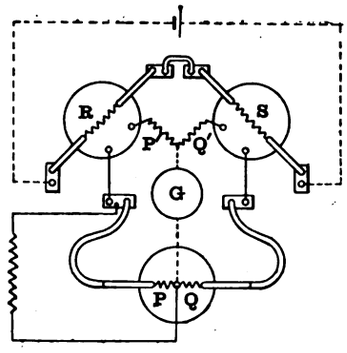

FIG. 16A.—CONNECTIONS OF REICHSANSTALT BRIDGE FOR COILS WITH SEPARATE CURRENT AND POTENTIAL TERMINALS.

both inconvenient for connection and productive of many possible errors. In all bridge measurements the ratios should be connected to the potential terminals, and these should therefore be made of the correct gauge for the bridge.

The question of thermo forces is also of some importance, principally on account of convenience rather than of accuracy in testing. From this point of view manganin is undoubtedly by far the most perfect material, as its thermo E.M.F. against copper is only about 1·4 microvolts per degree. Especially troublesome from this standpoint are the nickel alloys, such as constantan. Fortunately the thermo forces which come into play in testing are only differential ones and are due to temperature differences between the junctions. These may be set up by Peltier effects, but are principally due to conduction of heat across the bridge from the hot tank to the cold tank when testing temperature coefficients.

The greater number of the above requirements will probably be met by an open wound coil of incorrodible or suitably protected alloy, with as low a temperature variation as possible, which may be secured by suitable compensation; while thermo forces must be kept down, either by selecting an alloy of low thermal force against copper, or by making provision for keeping both junctions at the same temperature. This is in accordance with the opinion of Kirchoff in his letter to the B.A. Committee (1862) in which he says "In choosing the metal or alloy of which the normal standard and the copies are to be made, care must undoubtedly *first* be taken that the resistance is as unalterable as possible for *one* temperature. It is undoubtedly desirable that the resistance shall not vary rapidly with the temperature. This is, however, not very important provided that the temperature of the wire can be accurately observed at any moment. To satisfy this condition the wires must not be coiled upon cylinders, but fastened so that for the greater part of their extent they lie clear, and hence rapidly assume the temperature of the surrounding air, or of the non-conducting liquid in which they may have been immersed."

* Paper read before the British Association at Leicester, August, 1907.

† "The Variation of Manganin Resistances with Atmospheric Humidity," by E. B. Rosa and H. D. Babcock, Am. Phys. Soc., Washington, April, 1907; *The Electrician*, LIX., p. 339, 1907.

‡ *See* also Dr. R. T. Glazebrook, *Phil. Mag.*, pp. 410-416, Oct., 1900.

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The convenience, however, of very low temperature variation is so great that the writer has felt it worth while to give special attention to it, and has experimented with three methods of compensation, which may be described as series, shunt or compound compensation respectively. In the first of these, due originally to Prof. G. Forbes,* who made use of the negative coefficient of carbon, two wires of positive and negative coefficients are joined in series with suitable proportions. The shunting method has already been described, and has the advantage of having no joint in the centre of the coil. In both these methods, however, unless special precautions are taken to bring the two wires close together over their whole length, trouble may be experienced owing to stratification of the liquid, and hence the idea has been conceived of simply electroplating a wire of negative temperature coefficient with a pure insoluble metal, thus protecting the wire, compensating its coefficient, and eliminating stratification at one operation.

Theory of Compensation.—The temperature variation of a metal or alloy may be represented by the expression $r=r_0(1+at+bt^2)$; or, more conveniently, in the form $r=r_\theta\{1+a(t-\theta)+b(t-\theta)^2\}$, where θ is the mean working temperature at which it is desired to adjust. Hence, the rate of change of resistance at any temperature is

$$\frac{\delta r}{\delta t}=r_\theta^{\circ}\{a+2b(t-\theta)\} \quad \text{and} \quad \frac{\delta^2 r}{\delta t^2}=2br_\theta.$$

Consequently for two coils in series we have

$$r_\theta+r'_\theta=\mathrm{R}_\theta,$$

$$\{a+2b(t-\theta)\}r_\theta+\{a'+2b'(t-\theta)\}r'_\theta=\frac{\delta \mathrm{R}}{\delta t},$$

$$2br_\theta+2b'r'_\theta=\frac{\delta^2 \mathrm{R}}{\delta t^2}.$$

When t is very nearly equal to θ

$$r_\theta+r'_\theta=\mathrm{R}_\theta,$$

$$ar_\theta+a'r'_\theta=\frac{\delta \mathrm{R}}{\delta t},$$

$$br_\theta+b'r'_\theta=\frac{1}{2}\frac{\delta^2 \mathrm{R}}{\delta t^2}.$$

For $\frac{\delta \mathrm{R}}{\delta t}$ to be zero $\frac{r'_\theta}{r_\theta}=-\frac{a}{a'}$, from which

$$r_\theta=\frac{a'}{a'-a}\mathrm{R} \quad \text{and} \quad r'_\theta=-\frac{a}{a'-a}.$$

Under these conditions the coil will have no temperature coefficient at the point considered.

If in addition $\frac{b}{a}=\frac{b'}{a'}$, the third equation will be simultaneously satisfied and the compensation will be perfect for all temperatures.

The theory of compensation of a coil is very similar to that of achromatic lenses, except that the dispersion which is analogous to the temperature coefficient is here negative for one of the components. In lens combinations we may achromatise for two lines in the spectrum which is somewhat similar to satisfying our first conditions, and this gives us what is called an achromatic combination. If, however, we select our glasses so that the variation of refractive index is of similar form in both components we obtain an achromatism of a higher order, and the combination is termed apochromatic. Coils may be termed compensated or hyper-compensated according to whether the one or both equations are fulfilled.

For shunt compensation we have

$$\frac{1}{\mathrm{R}}=\frac{1}{r}+\frac{1}{r'},$$

and

$$\frac{1}{\mathrm{R}^2}\frac{\delta \mathrm{R}}{\delta t}=\frac{1}{r^2}\frac{\delta \mathrm{R}}{\delta t}+\frac{1}{r'^2}\frac{\delta \mathrm{R}}{\delta t},$$

from which we find that for compensation

$$\frac{r'}{r}=-\frac{a'}{a} \quad \text{and} \quad \frac{b}{a}=\frac{b'}{a'}$$

as before.

The compensation by deposition is of course equivalent to shunting, and the amount of metal required can be easily calculated from the formula

$$\frac{m'}{m}=-\frac{a}{a'}\frac{\rho'}{\rho}\frac{\Delta'}{\Delta},$$

where a, ρ and Δ are the temperature coefficient, specific resistance and specific gravity of the material respectively. This enables us to calculate the number of coulombs required to give the necessary deposit. The coil is adjusted high by the calculated amount and the metal deposited until the correct resistance is reached when the temperature variation is automatically corrected.

Experiments were first made with gold and platinum on a wire of $I_A I_A$ having a negative temperature coefficient of 0·0029 per cent. On calculating it was found that the weight of gold required was only 1/1,400th of that of the wire, which was insufficient to cover it.

* "Compensated Resistances." G. Forbes, *Jour.* Soc. Tel. Eng. and Elec., Vol. XIII., p. 185, 1884.

Of course, this was of no importance as far as compensation was concerned, but the protective effect was done away with. In the case of platinum the weight should be 1/240th, which is ample for covering, but although a platinum bath on one of the most approved formulæ was made up by Mr. Field it was found difficult to get a

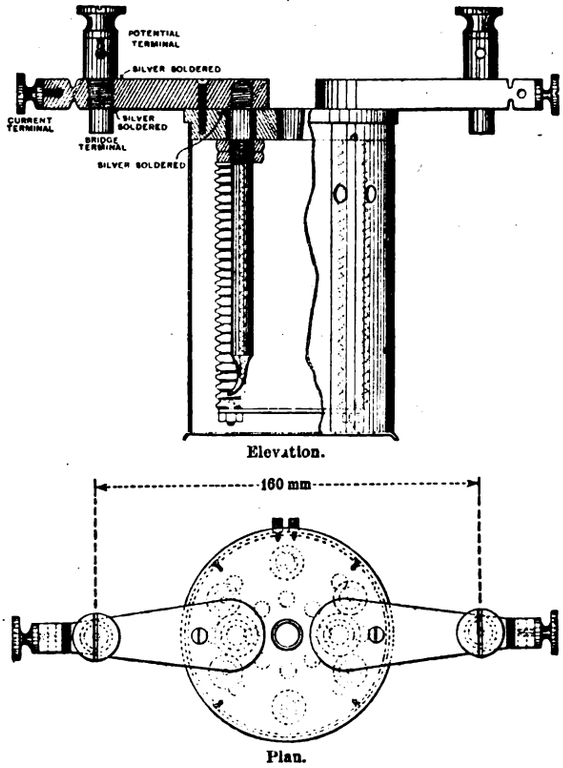

FIG. 17.—NEW STANDARD COIL. One-third full size.

sufficiently thick covering, and the platinum in the bath soon went into the colloidal form and refused to deposit. On looking at the results of Messrs. Dewar and Fleming, nickel appeared to be suitable on account of its high specific resistance, permanency, and the fact of its temperature variation has an upward bend tending to

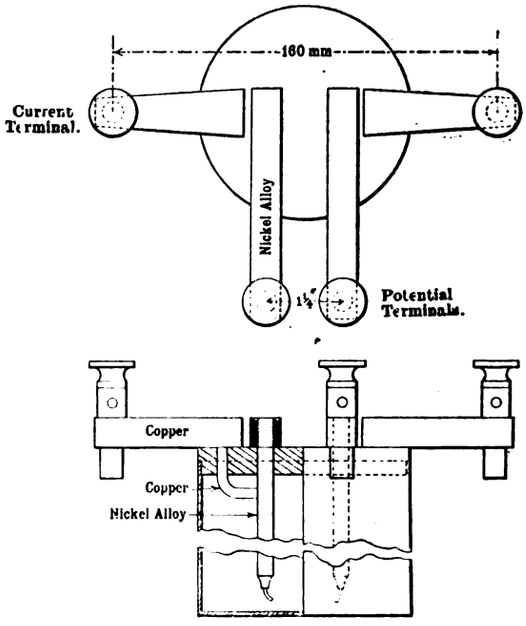

FIG. 17A.—ALTERNATIVE DESIGN OF COIL TERMINALS.

compensate for the downward bend in the curve $I_A I_A$. Experiments made with nickel-plated wire indicate that a very good compensation can be secured.

As the correction for temperature variation has, therefore, been carried out to such an extent, it has not been thought necessary in the later form of coil to provide for temperature measurement beyond the use of an ordinary thermometer. As seen in Fig. 17, the

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compensated wire is wound round corrugated porcelain pillars sufficiently tightly to avoid slipping out of the grooves, while at the same time permitting a small amount of expansion and contraction.

The terminals are of solid-drawn copper bars, into which long copper rods 10 mm. diameter are screwed and hard soldered, the lower ends of these rods being tapered and drilled up to receive the wire. No soft solder whatever is employed. On each of the bars there are three terminals, one projecting from the extreme end, which serves for the introduction of the current, and two others symmetrically above and below the bar as potentiometers and bridge terminals respectively. The current and potentiometer terminals each have holes in them, so that the point of contact is always the same, and the bar is grooved top and bottom, between the current and potential terminals, so as to produce a narrow isthmus and keep the equipotential surfaces to a definite form. Similar grooves may also be made at the base of the potential contacts. By making the hole in the upper potential terminal the same distance from the centre of the bar as the bottom of the mercury contact the almost perfect equivalence of these two terminals is ensured. As

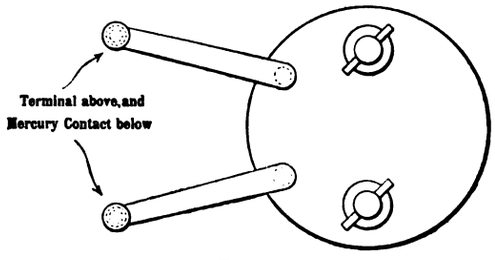

FIG. 18.—ARRANGEMENT OF TERMINALS FOR LOW RESISTANCES.

the copper terminals are brought down to the bottom of the case, and are thus for 3 in. or so under the liquid, their temperature is very closely that of the coil, and no trouble has been experienced with thermo effects with the nickel alloys.

As an alternative to the previous design, that shown in Fig. 17A may be employed. Here the whole of the potential terminals are of the same metal, and there is the additional advantage that the potential at all parts of the potential contacts will be more nearly equal than in Fig. 17. This form is, however, more complicated to construct, and has in addition the defects of thermo-junctions between the potential contacts and the bridge bars, and of somewhat high resistance in the potential leads. The former design is, therefore, considered preferable.

Low Resistance Standards.—The low resistance standards of the Reichsanstalt can hardly be improved upon, except in the design of the potential terminals. These most certainly ought to be in the form of bars projecting from the top and with mercury contacts of

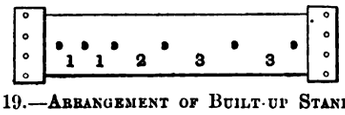

FIG. 19.—ARRANGEMENT OF BUILT-UP STANDARD.

such a gauge as to drop into the mercury cups. Potential terminals symmetrical with the mercury contacts should also be provided as is diagrammatically shown in Fig. 18. Fig. 19 also shows diagrammatically the arrangement of a build-up low resistance standard in which each section can be checked against a preceding one, and in which all values from 1 up to 10 units can be obtained without difficulties with contacts. Such an arrangement would often be useful.

(To be continued.)

Electrical Development in Munich.—The hydro-electric station at Moosberg, on the Iser, which feeds Munich, is, with the single exception of the station at Kykelsruth, in Norway, the only one in Europe with three-phase transmission at 50,000 volts. This station, which was recently opened, transmits power a distance of about 30 miles, 6 per cent. being lost in the line. Two feeders erected on poles, and each consisting of three copper wires 16 sq. mm. in section, transmit the required 4,200 kw. The usual lightning protectors are provided. At present the station is working at only about three-quarters of its output, as the current consumption is least in the summer. In spring and autumn the station will be fully loaded, while in winter it will require help from the existing steam station. Next year, when the hydro-electric station to the south of the town will also be opened, Munich will possess two cheap sources of power, and great savings in coal and oil will be effected.

SOME FACTS AND PROBLEMS BEARING ON ELECTRIC TRUNK-LINE OPERATION.*

BY F. J. SPRAGUE.

(Concluded from page 996.)

Summary.—In this Paper the author makes a vigorous and detailed attack upon single-phase traction for trunk railways. The various parts of the electrical equipment are considered in turn. Conductors, when used for alternate currents, suffer loss of current capacity through impedance. Single-phase motors, although effective, are much heavier than continuous-current motors of the same capacity when considered on a thermal basis, and the weight of the complete single-phase equipment for a locomotive comes out to be about double. The differences between single-phase and continuous-current motors are given in some detail. Polyphase motors also are considered by the author to be unsuitable. After considering the pros and cons of electric braking, the author discusses the various systems of working conductors at present available, and describes an improved form of under-contact third-rail, designed by Mr. Wilgus and himself. Recent suggestions to use 15 cycles instead of 25 cycles show some advantages, but the total weight of single-phase apparatus on a car will remain much the same. After describing recent examples of locomotives, and considering some minor points, the author concludes that the field of the single-phase system is on roads with sparse traffic, and that where the traffic is dense a comparatively high-pressure continuous-current system is to be preferred.

Storage Batteries.—The storage battery in connection with electric railway operation is being used successfully in connection with direct-current equipment of moderate potential, and it has been stated that it is equally available for alternating-current installations. The latter claim is misleading. On direct-current systems the principal function of a battery is that of an equaliser. With an alternating-current system the battery at a sub-station plays an entirely different rôle. It must be charged by a direct-current generator driven by an alternating-current motor, and in discharging drives the alternating-current motor as a dynamo through the direct-current generator acting as a motor. In addition to the introduction of moving machinery in an alternating current sub-station, its watt capacity must be equal to that of the full discharge of the battery, and the latter can have no function in supplying current to the working conductor except through the medium of two rotating machines of large capacity.

Use of Step-up and Step-down Transformers.—Where the distance is not great, as on the present proposed limited operation of the New Haven road, both step-up and step-down transformers have been omitted, and the 11,000 volt trolley line is supplied from the station switchboard. This means direct connection between an extended system of overhead working conductors and generators operated at high potential with one side earthed, with, of course, whatever protection lightning arresters can provide. Such are the vagaries of lightning and the uncertainty of the very best arresters that I cannot but feel that this practice, which subjects costly generating equipments to direct lightning attack and special earthing stress, will not obtain to any great extent; for the possibility of laying up a complete unit of great capacity, steam engine as well as generator, because of a lightning flash or accidental earth is too great a penalty to pay for eliminating transformers, and is a special handicap upon the possibilities of transmission.

It is certain that standardisation should be directed to the construction of generators. Any material increase of potential above that now common means reduced capacity and efficiency, increased danger of breakdown, and greatly increases individual cost, to say nothing of the capitalised risk of failure. Quite aside from the question of cost and efficiency, air-cooling, the only possible method for generators, manifestly cannot be safely carried above that which is tolerable for static transformers, which, when wound for the higher potentials, are invariably oil cooled. Therefore, I expect to see standardisation of generator potentials, the pressure being stepped up by transformers to whatever transmission potential is necessary, and then stepped down to the working pressure on the trolley wire if alternating current be used, or to a lower pressure and converted if direct current be used.

The tranformer, per se, is the simplest and most flexible device for changing alternating-current volume and pressure, and its moderate cost and high efficiency, taken in connection with the like elements of moderately high-potential generators, will leave the total cost and efficiency of generating equipment roughly the same. There will be the additional very great practical advantage that the generators not only work at lower potentials, but on closed metallic circuits are removed from direct contact with working conductors and earth, and have interposed between them and the line at least one set of static transformers, which practical experience has shown to be one of the best generator safeguards against

* Abstract of a Paper read before the American Institute of Electrical Engineers.

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lightning, and which, if broken down, do not involve large and costly units nor wholesale sacrifice of capacity.

General Cost Comparison of Direct-current and Single-phase Alternating-current Systems.—Summarising briefly, the alternating-current–direct-current and the single-phase alternating-current systems have certain features in common, and others differing, which may be briefly stated as follows: Each must have a central station, which in the former will generate three-phase currents delivered to step-up transformers to raise the voltage of the transmission lines to any required degree, while in the latter single-phase currents will be generated, and likewise stepped-up for transmission. Assuming equal kilowatt outputs, the generating part of the three-phase system will be cheaper than that of the single-phase, because of the higher weight efficiency of the polyphase apparatus; but the switching devices will be somewhat more costly, while the transformers will cost about the same, with the net result that the cost of installation per kilowatt, and with equal conditions in the matter of speed, reliability and efficiency, will be somewhat less for the polyphase than for the single-phase equipment. The transmission lines, especially where provision is made for duplicate or reserve circuits, may for the purpose of this general comparison be roughly considered as of equal cost. Sub-station transformers must be provided on each system to lower the transmission to the operating or transforming voltages. There will be approximately an equality in these features. There is a line of departure, the transformed current in the alternating-current–direct-current system being passed through synchronous converters, and delivered to either an overhead trolley or a third rail, assuming for this purpose the latter, while in the single-phase system it is delivered to an overhead trolley. The converters and the necessary housing and switching apparatus is an excess cost chargeable to the older system.

We come now to the working conductors of the two systems. The third rail, which is prohibitive to the alternating-current system, cannot be put in except on what may be fairly called a permanent basis, at a certain approximate cost per mile of track equipped. The overhead trolley for the alternating-current system can be put in on either of two plans, one more or less tentative and temporary, using wooden poles and wire suspensions; the other, which is practically the only way affording reasonable permanence, with steel poles or bridge supports. Under this latter condition of permanence, the cost of such an overhead system per mile of track will run fully as high as, and in many cases higher than, the cost of the third rail installation. The costs of section houses, circuit-breakers and automatic apparatus will be quite as much with an overhead system as with the third rail. Tracks in either case must be bonded more heavily, and hence at greater expense, for the direct current than for the alternating, but the difference will often be met by features connected with the overhead system, such as extra cost of piers, pull-off columns, changes necessary in telegraph and telephone circuits and clearing the right of way from trees.

The remaining element is the locomotive and motor-car equipment, the motors for the direct-current system being operated on the series-multiple plan, with resistance variation and possibly with field shunts, those for the single-phase alternating-current system, except where there is the intermediary of a motor generator set, through a secondary or auto-transformer carried on the car. According to present developments, there is here very great difference in the weight and cost of apparatus and in the number of motors necessary to perform any given service. Judged from every standard which I have been able to compare, the cost of this part of equipment with 25 cycle alternating-current motors is so much higher than that with direct-current motor equipments that, assuming a reasonable operating potential on the third rail, it is certainly a debatable question whether the increased cost and cost of operation of the motor-car equipments will not fully offset the cost of the synchronous converters and the losses in their operation.

I have made many comparative analyses, involving millions of dollars, and I have found that where equal permanence of installation is provided for, and equal ultimate as well as average duty, there is not on demonstrated facts a wide variation in the initial cost of plant.

Ordinarily, the signal systems used on railroads will have to be changed at considerable cost. Fortunately, methods have been developed which permit the use of all the rails for the main return-circuit by using a special alternating-current circuit for operating the signals. Where the tracks are used for direct-current return, reactance bonds are inserted which permit the flow of the direct current, but resist that of the alternating signal current. Where the tracks are used for alternating-current operation, and are likewise subject to the flow of direct currents, the signals must be operated by alternating currents of high frequency through apparatus which is inoperative to currents of low frequency or continuous currents.

Field of the Single-phase Alternating-current Motor.—No one can deny that if the single-phase motor be developed to a high state of weight-efficiency, unhandicapped by excessive weight of the collateral apparatus necessary on a car to utilise it, and if the capacity of conductors, especially steel conductors, for alternating currents can by any discovery be raised, the elimination of moving machinery in and the simplification of sub-stations would open up a very extended and important field for the use of this type of apparatus. But with developments as they are at present, what is the actual field? As there is no general agreement as to methods of construction, so, too, I find no fixed conclusions as to the field of commercial usefulness; rather, on the contrary, the sharpest differences of opinion. Some, with enthusiastic catholicity, make it all-embracing for steam roads, quite irrespective of well known limitations. Others, although at times seemingly contradictory, are even more elastic in their claims. It has even been stated that for such services as that on our elevated and underground rapid-transit roads, with their congested train movements, quick accelerations, high schedules and limited clearances, the single-phase alternating-current motor would find a fruitful field.

It seems to me that the present principal field of usefulness of the single-phase system is on roads of considerable extent which operate an irregular and sparse traffic, and where only a moderately expensive, or what may be called a second-class overhead construction, which will keep down the ratio of line investment to that of the balance of equipment, is tolerable. As one departs from this condition, adopts more permanent construction, and faces the problems of denser traffics and higher capacities, any advantages of the single-phase system will disappear, and a superiority of the direct-current equipment, with such improvements as are in sight, becomes manifest. But whatever may be the future of single-phase operation under the conditions stated, any present claim for it as the preferable equipment for congested service demanding high schedules and great capacity is not worth a moment's thought, for in this field, at least, it cannot touch the direct-current system.

In conclusion, I see no practical necessity to formulate conclusions by averaging conditions, and I cannot conceive the responsible officers of any trunk-line road being guided in their determination of what seems best for their own requirements by consideration of what some road thousands of miles removed in location and enormously removed in operating conditions may do. In any case, the most satisfactory system will be that one which will permit of continuous all-round operation under such conditions as will utilise to the utmost all the beneficial features of electric application. If any one system can be demonstrated to meet these conditions better than all others, then that system will become pre-eminent, no matter what standards may have been adopted or recommended, and no matter what our preconceived prejudices may be.

DISCUSSION.

Mr. W. J. WILGUS urged that electrical engineers should avoid a partisan spirit in discussing these matters, as heated claims and counterclaims only confused railroad men who should look to the electrical profession for guidance. Facts should be clearly stated. For example, the ordinances of the City of New York absolutely precluded the use of overhead construction for the New York Central terminal, and therefore it was absurd to state that a great mistake had been made in using continuous current in that case. A most important point was reliability, and so important was this felt to be in the case of the New York Central that storage batteries were in use and duplicate power stations had been put down. In a particular installation with which he was concerned he had found that the continuous-current system was the cheapest in both first cost and maintenance to the extent of 20 to 25 per cent. Concealment of bonds beneath fish-plates was desirable, so as to avoid theft. The cost of electric signalling was sometimes a deterrent factor in electrification.

Mr. L. B. STILLWELL thought that the author had failed to grasp the position taken up by himself (Mr. Stillwell) and Mr. Putnam in their Paper read before the Institute last January, as they had said nothing to exclude the three-phase or other alternating-current systems from consideration, nor had they opposed direct-current motors except for trunk-line service, for which the speaker still considered the 15 cycle alternating-current single-phase system possessed the greatest advantages. The only data given by the author was a comparison of the relative outputs, speeds and weights of 240 H.P. direct-current and 125 H.P. alternating-current 25 cycle motor. This comparison was misleading, for if two motors of equal outputs instead of weights were taken the figures would have been more favourable to the alternating current. Also the figures given were not at all representative of the two types, and 15 cycles would have given better results. Some figures which he had recently obtained from one of the large manufacturing companies were practically identical for 200 H.P. motors of 15 cycle single-phase and 600 volt direct-current types. The author implied the use of 1,200 volt direct current motors, although he only used the 550 volt motor for comparative data. As regards auxiliary car equipment and wiring the alternating-current system had considerable advantage.

Mr. W. B. POTTER said that financial advantages or local requirements were often sufficient to determine the choice of system. Commutation difficulties had been overcome in direct-current railway motors by the use of commutating poles, but inferior commutation had still to be overcome in the single-phase alternating current motor. He suggested 1,200 volts as the next higher standard above 600 volts.

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Mr. C. F. SCOTT thought that Mr. Sprague had made a number of his comparisons on a particular basis, instead of considering the different methods or conditions under which the two motors might operate.

Mr. N. W. STORER gave the following table showing that the efficiency of the single-phase motor was not as low as might be inferred from the Paper.

Per cent. of full-load torque.	Direct-current 90 H.P. motor.	Alternat'g-current 25 cycle 100 H.P. motor.	Direct-current 200 H.P. motor.	Alterna'g-current 15 cycle 200 H.P. motor.
125	86·25	82·0	88·8	87·3
100	86·8	85·0	89·0	88·0
80	87·0	86·0	89·2	88·3
60	86·5	86·8	88·8	87·7
40	85·0	86·0	87·0	85·0
25	82·0	82·5	84·0	82·0

Mr. W. McCLELLAN said that, for trunk-line operation, opinion favoured the single-phase motor. A high voltage seemed necessary, and therefore an overhead structure.

Mr. A. H. ARMSTRONG mentioned a 50 per cent. overload test which he had recently witnessed on a 125 H.P. 25 cycle series-compensated alternating-current motor, the commutation being excellent. Owing to the almost universal adoption of 25 cycles in and around large cities, the use of a lower frequency would be unwise and unnecessary, as shown by the above test.

Mr. C. P. STEINMETZ considered it was not yet time to standardise one type of railway motor or one particular system. Alternating-current motors were necessary for a long railway with infrequent and irregular service—*i.e.*, where synchronous converter sub-stations would show a poor load factor. On the other hand, with a four or six-track railway with heavy traffic, the distance between the trains being only limited by the safe headway, the high load factor, and necessarily high acceleration and motor capacity, made the direct-current system the most advantageous. What was to be guarded against was the adoption of one system which precluded the possibility of afterwards changing to any other system. For example, 15 cycles at the present time would be most unsuitable, considering that all the heavy power of the country was transmitted at 25 cycles, and, if this latter frequency was adhered to, it would not be such a serious matter to eventually change to the direct-current system or vice versa. He considered the commutation of the 1,200 volt direct-current motor was infinitely superior to all alternating-current motors, excepting the one mentioned by Mr. Armstrong, which might even be better than the standard direct-current motor.

Mr. L. B. STILLWELL (in a written communication) considered that the author's conclusions had been based upon a misconception of the facts regarding the comparative figures of weight and performance of direct-current and single-phase alternating-current motors. The author had also ignored the consideration that a third rail interfered with the rolling stock equipment; for example, on the New York Central the large steel coal-cars could not now be operated, and this constituted a strong argument in favour of the overhead construction.

Mr. F. J. SPRAGUE (in reply) stated that he had considered it necessary to utter a warning against the present excessive confidence regarding railway electrification. Mr. Stillwell laid too much stress upon the "conditions of average steam railway service in the United States," and he (the speaker) had endeavoured to show that these conditions, measured financially, did not permit of electrification. The motors for which the comparative figures were given in the Paper were of the General Electric Co.'s manufacture, for which Mr. Stillwell was largely responsible. Mr. Stillwell had also said that sufficient attention was not paid in the Paper to the cost of the intermediate link between the generating station and the locomotives. The following additional information bore on this point: The New Haven electrical equipment comprised 35 locomotives weighing 93·3 tons each, or a total of 3,266 tons, with an aggregate capacity of 35,000 H.P. on the one hour rating. Considering the individual capacity, the number of machines which would be under repairs, the time in the shop and other lay-overs, not more than 23 of the New York Central machines would be required to do the work of the 35 New York, New Haven and Hartford ones. The New York Central locomotive weighed 95 tons, which would make a total of 2,185 tons, with an aggregate capacity of 50,600 H.P. The difference in total weight was 1,081 tons and on an assumption of an average duty of even 200 miles per day there would be an excess of 216,200 daily locomotive ton-miles on the New Haven system. The difference in the cost of the above locomotives would ordinarily be about £80,000. The total distance from Stamford to the Grand Central Station was 33·48 miles, 21·45 miles comprising the single-phase section. As pointed out in the Paper, the direct supply to the overhead line from the main station was but a special provision; it did not mark any wide application, for step-up and step-down transformers would be absolutely necessary as a general rule. Therefore, for comparison, the presence of those transformers on the New York, New Haven and Hartford line might be assumed. The introduction of synchronous converters in addition, assuming the same number of sub-stations, would add about £3 per kilowatt of normal capacity, so that the £80,000 difference in locomotive costs would provide for a synchronous converter addition of 26,667 kw., which would have a temporary excess capacity of anywhere from 100 to 200 per cent., according to the specifications of the engineer and the zeal of the manufacturers. In a letter addressed to Mr. W. H. Newman, president of the New York Central, under date of October 27, 1905, and published in the technical press in December of that year, in which the abandonment of the system then being introduced and the adoption of the single-phase alternating-current system were urged, one of the principal reasons given was a great saving in cost of the working conductor system, which it was claimed would aggregate £1,800,000 between New York and Buffalo on the Central's line alone. The actual difference in the number and cost of equipments which would be required was ignored. The estimate per mile of road of a four-track line, with catenary construction from bridges over the tracks, and with operation at 6,000 volts, exclusive of transformers, was given as £2,487. Some time afterwards an estimate was published purporting to give the cost of the New Haven installation, which, with additional provision for an extension of the bridges to cover six tracks instead of four, but not including the additional overhead work, was stated to be £5,400 per mile of road, although with operation at 11,000 volts. A careful analysis of actual construction made this probably over £10,000 per mile, which probably was exclusive of any lowering of tracks, clearing of right-of-way from trees or work in connection with telegraph or telephone circuits. The cost of the working conductors of a third-rail system for four tracks, the protected under-contact rail being used, supplemented by a main conductor so that any of the tracks could be cut out, was much less than this. It would thus seem that in the first really comparative examples on a large scale, the cost of the working-conductor construction of the alternating-current system as actually erected was considerably higher than that of the third-rail construction, when installed on a trunk-line railroad in operation, and also that the cost of equipment to do equal work was much higher, this latter difference alone being enough to pay for a great abundance of synchronous converter apparatus. The lower efficiency quoted for the single-phase motor, as compared with the direct-current motor, was given by Mr. Mordey, a well-known advocate of single-phase apparatus.

EXPERIMENTS WITH CONCRETE TELEGRAPH POLES.*

BY G. A. CELLAR.

So far as the writer has ascertained, the preservation of steel imbedded in properly constructed concrete is perfect. Concrete not only does not disintegrate, but hardens and improves with age. Therefore, a structure of reinforced concrete has a life that is practically unlimited, and a telegraph pole made of reinforced concrete ought for many generations to endure and answer the purpose for which it is erected.

The use of concrete for the manufacture of telegraph poles is not new. As nearly as I have been able to ascertain, the first concrete poles were designed by Col. G. M. Totten, chief engineer of the Panama Railroad Co., at a date uncertain, but probably about 1856, the road having been put into operation in that year. These poles were cone-shaped, 12 ft. long, with a diameter of from 12 in. to 15 in. at the base and from 6 in. to 8 in. at the top. The wires were supported by iron brackets, which were fastened to the poles by wrought-iron bands passing around them and around the poles near the top. The proportions of the ingredients used in the manufacture of these poles are not obtainable, but the strength to resist strains was so inadequate that means were sought to overcome this fault, and the poles were a few years later replaced from time to time by the first reinforced concrete poles of which record is known, the reinforcement consisting of 3 in. by 3 in. pine cores, extending throughout the length of the poles. The concrete poles, it is understood, were used because the available wooden poles were very short-lived, by reason of the ravages of insects. The poles with wooden reinforcement evidently were not attacked by the ants soon enough to prevent the cores from swelling and cracking the concrete, so that the first pattern of reinforced poles was not an appreciable improvement over the solid pole. After being used for a few years, the disruption of both classes of poles was such that they were practically abandoned, they having been replaced as occasion required by other patterns until, in 1888, there were only about 20 of the original poles standing, one or two of which still remain erect on the line of that road.

A method of re-stumping wooden poles by means of cement bases has met with considerable success. In installing this concrete base, the rotten pole is sawed off, the lower end swung a little to one side, the cement base put in the place of the rotten stump, and the pole is then swung into the socket formed by the iron strips and securely bolted. The pole, when thus equipped, is alleged to be better than new. In re-stumping in the manner just outlined, no wiring need be touched nor telegraph communication interfered with in the least. Another feature of the use of these cement butts is that when a pole has deteriorated beyond the point of usefulness, and has to be replaced, a pole 5 ft. shorter can be furnished, thus materially reducing the cost.

* From an abstract in the *Electrical Review*, New York, of a Paper read before the Convention of the Association of Railway Telegraph Superintendents.

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The experience of late years on all lines of railroad is that the expansion of track and other improvements have made it necessary to move so many telegraph poles that, in planning for a pole of infinite life, it would be better, if possible, to procure a type which would be secure without the foundation which would render its location when once set up a permanent fixture, and this type would be preferable to the fixed type because (*a*) of its smaller cost to construct, (*b*) of its smaller cost to set up in the line, and (*c*) it will be easily removable to a new location. The procedure to be followed would then preferably be to manufacture the poles in a yard and have them thoroughly seasoned there before moving. We proceeded to make experiments, first in design and later in various and many patterns. In the working out of the plans for the requisite strength with the minimum of weight, the two hollow poles referred to in detail hereafter were made. The results of the tests are given in this Paper as an example of progress and are not to be taken as the best form for adoption, but quite the contrary. One of the patterns was square in section, with the corners chamfered off; the other octagonal in section and a hollow space extending from the base for about two-thirds of the length of the pole, the upper third being solid and the walls of the lower two-thirds being from 1¾ in. to 3 in. thick. These poles weighed approximately 3,500 lb. and were calculated to withstand any stress in any direction that could possibly be imposed upon them by a line of 50 wires, each wire coated with sufficient ice to make it 1 in. in diameter. The test was made in connection with two carefully selected cedar poles of the same length (30 ft.), and all were set in concrete, the bases being 3 ft. by 3 ft. by 5 ft. deep.

Just within the outer surface the walls of the concrete poles were reinforced with iron rods, which consisted of four ¾ in round bars, each 24 ft. long, and four ⅝ in. round bars of the same length. The poles were 8 in. in diameter at the top and 13 in. at the base, having a taper of 1 in. to each 5 ft. Galvanised iron steps were screwed into wooden blocks moulded into the concrete, and holes were left for through bolts for supporting the cross-arms. The cross-arm braces were attached to the arms by through bolts in the same manner and fastened to the poles with ordinary lag bolts driven into wooden plugs which were placed in the concrete at the proper places. The concrete poles were set to a depth of 5 ft. in concrete with the two white cedar poles of practically the same dimensions, and, after standing long enough to permit the cement to become solid, they were tested in turn in the following manner:—

An iron clevis was placed around the pole to be tested 10 in. from the top, to which a wire rope was attached, leading over a pulley placed at the same height and at an equal distance from the pole so as to form a right angle, and fastened to a differential pulley block which was attached to a laboratory weighing machine.

The results are fully shown in the accompanying tables.

After the cement poles had been broken the reinforcement so held them that it required almost the breaking pressure to further deflect them from their slightly inclined position. The wooden poles, under strain, presented the form of an arch before breaking, and when they gave way were fractured completely; but these features were lacking in the cement poles, which were very firm and did not give until they began to crush at the ground line.

The mixture used in these cement poles was 1 to 3. They were constructed in cold weather, and, through some mischance, at the last moment we were unable to get suitable gravel. Pole No. 1 was found to have a defect in the casting, which is believed to be the cause of its early rupture. Pole No. 2 gave a very much better result.

The consensus of opinion seems to be that a 1 2-4 mixture is the best for use in this class of construction, and, while the experiments related above were entirely satisfactory in the development of the problem, the hollow pattern is not considered to be the highest type desirable—that is, to combine sufficient strength with the least possible weight, in order to obtain ease in handling, and that the removal from place to place may be readily feasible.

The argument has been advanced that the reinforced cement pole would be very liable to damage or disruption by shock, but the fact that concrete piles, both of hollow and solid designs, are driven by pile drivers, and especially with the knowledge of the experiments made, which showed that the poles, even after they had been fractured at the surface of the foundations, required an extremely heavy pressure to produce further deflection from the positions at the time of the fractures—in other words, that they were almost as stiff as when they stood upright, and continued to be so throughout the entire test—I feel that any alarm at the prospect of damage by collision between the pole and anything less than a movable object that would destroy any pole of natural or manufactured composition is unfounded.

As to the insulating qualities of the concrete pole, it is hardly necessary to mention that they are superior to those demonstrated in any other pole manufactured in this country.

It is expected that within a few weeks some steel poles with just enough concrete to serve as a preservative, and other steel poles covered experimentally with a cement paint, will be set in the line along the Fort Wayne Road. Experiments have also been made with several sizes of reinforced concrete cross-arms with very satisfactory results.

Particulars of Poles.

—	Length.	Base diam.	Top diam.	Depth in concrete anchorage.	Distance from point of fulcrum to point of load.
Pole No. 1	30 ft.	14 in.	8 in.	5 ft.	24 ft. 2 in.
Do. 2	Do.	13 in.	7 in.	Do.	Do.
Do. 3	Do.	14 in.	8 in.	Do.	Do.
Do. 4	Do.	Do.	Do.	Do.	Do.

Pole 1, concrete (octagonal); Pole 2, concrete (square); Poles 3 and 4, white cedar.

Pole and Test No.	Deflection at top. Inches.	Load. Pounds.	Deflection 12 in. above ground line. Inches.	Remarks.
Pole 1 — Test No. 1	3¾	1,830	1/32	....
Pole 1 — Do.	5¾	2,230	1/16	....
Pole 1 — Test No. 2	½	50	1/32	....
Pole 1 — Do.	8	2,630	⅛	....
Pole 1 — Do.	11⅝	3,030	3/16	Cracks.
Pole 1 — Test No. 3	1¼	50	1/16	....
Pole 1 — Do.	14¼	3,430	¼	Cracks.
Pole 1 — Do.	18	3,210	5/16	Crack and crushed bolt.
Pole 1 — Do.	25½	3,150	⅜	Pole broke at gr'nd. level.
Pole 2 — Test No. 1	¾	50	..	....
Pole 2 — Do.	2½	1,830	..	....
Pole 2 — Do.	3½	2,230	..	....
Pole 2 — Test No. 2	¾	50	1	....
Pole 2 — Do.	4 9/16	2,630	..	....
Pole 2 — Do.	8½	3,030	1/16	....
Pole 2 — Test No. 3	3¼	50	..	....
Pole 2 — Do.	31	3,290	..	....
Pole 2 — Do.	34½	3,430	1/8	Crack.
Pole 2 — Test No. 4	21¼	50	22	.... [gnd. lev.
Pole 2 — Do.	39	3,690	..	Pole crushed, crack at
Pole 3	..	14	172	..	....
Pole 3	..	37	2,230	..	....
Pole 3	..	47	2,530	..	Pole broke.
Pole 4	..	20	1,930	..	....
Pole 4	..	22¼	2,230	..	....
Pole 4	..	29	2,630	..	....
Pole 4	..	35	2,870	..	First crack.
Pole 4	..	36½	2,950	..	....
Pole 4	..	38½	3,030	..	....
Pole 4	..	50	3,370	..	....
Pole 4	..	56	3,430	..	....
Pole 4	..	66	3,494	..	Pole broke.

TRAINING THE YOUNG IDEA—A SUGGESTION FOR MANUFACTURERS.

We have received the following from a member of the electrical industry who has had considerable "publication department" experience, and is entitled to claim success for his methods of working:—

There are very few manufacturers who recognise the fact that the student of to-day is the potential buyer of to-morrow, and a still smaller number appreciate the value of this. In these days, when it is necessary for business men to be constantly in search of new fields for prospective business, it is somewhat surprising that there does not appear to be much in the nature of a coherent and organised attempt to reach young fellows attending engineering classes at some technical college or school. It may be that many manufacturers look for quicker results than can be obtained from an outlay devoted to making the student conversant with the salient features of his goods, but if this is so it is a short-sighted policy, which says little for the manufacturer's enterprise. That the present-day engineering undergraduate will form the nucleus of the industry a few years hence may be taken for granted, and for the benefit of those manufacturers who are sufficiently far-seeing to devote a small proportion of their yearly advertising expenditure to this branch, I propose to roughly outline a scheme for reaching this field with best results.

I have now for the last two or three years conducted a plan of campaign in this direction, with results, as far as can be ascertained after so short a period, eminently satisfactory to the firm on whose behalf it was carried out. There are two ways in which one can go to work to reach the student—viz., direct, by means of circulars, display advertisements in the college magazine, and so on, or, indirectly, through his lecturer. The former method is the one which first presents itself to the business house about to take up this matter, but from

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experience I feel convinced that this procedure is both expensive and unsatisfactory. Some years ago a prominent firm of engineers sent out expensive publications relating to their manufactures, costing 2d. to 3d. each for postage, addressed to all the students at the leading technical schools: 18 months later this firm failed. So much for results obtained from the "direct attack."

As to the second method, dealings are almost exclusively with the college professor and lecturer, and, as these are invariably gentlemen in the true sense of the word, relations between them and the manufacturer are of the pleasantest, especially as they keenly appreciate any effort to assist them in their work. Some professors, however, regard trading concerns with a certain amount of suspicion, and it is therefore advisable for the manufacturer to approach them without conveying any idea of commercial advantage being derived.

The basis of the proposed scheme is to bring prominently before the notice of students samples of the manufacturer's goods. I am aware that there is nothing absolutely original or new in this idea, but in the way of carrying it out, simple as it may seem, from experience I can say that manufacturers have something to learn. Ninety-nine times out of a hundred makers wait until they receive a specific request from principals of colleges before supplying samples to engineering classes. On receipt of a request, a meagre selection is usually sent which are relegated to a glass-fronted case in a lecture room and labelled "iron-clad switch," "trolley wire insulator," as the case may be. The maker does not usually attempt to provide that his name is brought before the student, and so the samples are left for all time to gather rust and dust until scrapped to make room for somebody else's goods. They are rarely seen or handled by the student, and never explained by the lecturer.

This surely proves that the task of reaching the student must be the subject of a well-planned scheme, and that to proceed haphazard is a waste of time and money.

Supposing it is desired to push some make of electrical goods, the first step is to compile a list of electrical engineering lecturers throughout the kingdom. This can best be obtained from "The Electrician" Electrical Trades' Directory, where an exhaustive list appears, although it is well to keep an eye on the "Personal" columns of the technical papers, as changes are constantly taking place, and it is of importance that the gentlemen interested should be addressed personally on the matter. From this list an idea can be obtained as to what will be required as regards quantity of samples. The list is most conveniently kept on the card file system, each lecturer having a card on which his name is written and every communication entered thereon. It will also be found advantageous to cross-index the file with the names of the institutions.

As to sending out samples, I wish to point out at the commencement that the ordinary form of "show-board" is useless. The samples, since they are permanently fixed in position, cannot be properly explained by the lecturer or critically examined by the student, and the whole arrangement is cumbersome. It will be found that some form of box or cabinet in which the samples can be laid loose is the most satisfactory. These boxes can take various forms which the maker must design for himself according to his class of manufactures, but for his guidance I will briefly describe those I have found most satisfactory for electric lighting accessories such as switches, ceiling roses and so on.

The first type adopted was a box about 2 ft. 6 in. by 2 ft. by 1 ft. 6 in. This contained four loose trays resting one on the other, divided up into a number of partitions so that samples could be laid in with little packing necessary for transit. It will be seen that a box of this description can be carried into any lecture room when required, and the trays lifted out and placed on the lecture table so that all the samples can be seen and examined by the students.

A second cabinet of a more portable description was of a design similar to the ordinary portmanteau, size 2 ft. 6 in. by 1 ft. 6 in. by 8 in., opening flat and with two leather handles. The space available for samples was again partitioned, but in this case each division was provided with a cover to keep the samples in place when travelling, so that the cabinet really consisted of a number of small boxes. This was designed for those lecturers who did not require so large a selection of samples as contained in the box described above.

Another form which proved popular was also of box form, but of smaller dimensions, and so arranged that the sides, front and lid swing back until they are in the same plane as the bottom, and thus can be laid flat on the table or any other place convenient. The samples are, of course, fastened in position on the insides; but, to facilitate removal, a spring clip is adopted similar to those used for holding tools on a carpenter's bench. The cost of these cabinets varies, of course, with the quantity ordered at one time—for instance, those first described, in quantities of half-a-dozen, in deal, planed inside and out, stained on the outside only, can be obtained from 18s. to £1 each. The smaller cases, size 2 ft. by 1 ft. 6 in. by 1 ft. 6 in., cost 8s. each. They will be made up to any design by the ordinary packing case maker.

So much for the actual arrangement of the samples; the method of disposing of the cabinets when completed is that each institution retains one for two or three weeks, during which time it is exhibited and dealt with by the lecturer whenever he is discussing the branch of engineering in which goods of the description as the samples form a part. The cabinet is then sent on to another college for a similar period: if desired, of course, it can be despatched direct from one to the other, but since it can be overhauled if returned to the issuing firm this is not advisable.

When the cabinets are completed ready for distribution, the next step is to ascertain which technical schools desire to receive and make use of them. A suitably worded letter should be sent to all on the file previously mentioned, and it will be found that practically all who can make use of a cabinet will reply, and a further letter can be sent to those who have not replied after a short interval. Some idea of the warm response obtained will be gathered from the fact that on the occasion of my last circular sent to 60 institutions I received 20 favourable replies in two or three days. To deal efficiently with all requests during the session, so that no delay occurs, at a rough estimate a dozen cabinets are sufficient.

It will be found advantageous to enclose with the letter a printed leaflet descriptive of the cabinet, so that the recipient can tell without entering into correspondence whether the set is likely to be of use to him. On later occasions such a leaflet is useful for recalling them to his memory.

The above outline gives what, in my experience, is the most successful manner of reaching the technical student, who by this method has brought under his notice each session samples made by a certain firm on which he is lectured and which he has full opportunities to examine. His interest in that maker's goods is much more lively and keen than it is in those of a manufacturer whose samples are locked up in a glass case, or exposed high on the wall of the class room out of reach and often invisible. Each of the samples in the cabinet should bear the maker's name and description which becomes impressed on the student's mind so that in after years when in a position to place orders he remembers that such and such a firm make such and such goods—and this is the firm which gets the business.

The scheme outlined above can, of course, be amplified in many ways, to fit any particular business. When despatching the boxes it is advisable to enclose the manufacturer's latest catalogue and descriptive booklet addressed personally to the lecturer for his special use, together with catalogue literature (an obsolete edition of a catalogue will serve admirably if it is not too ancient) for distribution to the class. From students I have met and also from what I remember of my own college days such literature is eagerly perused and frequently kept for reference, while the cost to the manufacturer is trivial.

Incidentally, I may mention that I have gone so far as to draft a few notes for the lecturer to use when dealing with my firm's samples, and it has acted as an incentive in many instances for him to dwell longer on and deal more fully with the subject than would otherwise have been the case.

See that cabinets are carefully advised on their outward journey, with a schedule of their contents for reference; send an addressed label with instructions for despatching, route, &c., when it is due to be returned, and pay carriage both ways.

A few small sets of lantern slides showing details of machines, photos of the manufacturer's goods in actual use will also be useful to instructors, at the same time acting as a good advertisement for the manufacturer. Carefully carried out and supervised the cost of keeping a dozen of these cabinets in constant circulation, together with samples, need not much exceed £50 per annum. September is the month to commence negotiations with lecturers, as most schools and colleges open for the winter session at the end of that month or early in October, and the greatest demand will be experienced from November to the end of March.

CORRESPONDENCE.

BULK SUPPLY AT WEDNESBURY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of October 4th has been handed to me by the town clerk, to whom you sent it, presumably because it contained a reference to the Wednesbury Corporation in your Editorial Notes.

I would point out that you have made several mistakes in the data on which you base your somewhat hasty conclusions, and that this question cannot be settled in such an off hand manner as that adopted by you.

In the first place, Wednesbury can hardly be called a small town; if so, it is rather difficult to see why it was, as recently as 1886, granted a charter of incorporation. Its rateable value is £100,000 approximately, and it contains within its boundary some very large works indeed.

In the second place, I would point out that the development of large power companies is not the most important point to consider. The power companies are, or should be, well able to take care of themselves, and it is the duty, I should think, of municipalities to see that the companies do not take care of themselves to such an extent as to damage the municipality and to deprive the ratepayers of cheap electricity. At any rate, in Wednesbury the Council has done its best to work with the power company, and for that reason it deserves the credit for having tried bulk supply. I should say that the result shows the futility of pushing the bulk-supply idea too far. We have had 3½ years' experience of it on a fairly large scale, and we are in a position to judge of its defects and advantages (if any).

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The Wednesbury Corporation allowed the Midland Corporation (which is not really a "power company," but a company owning several orders and dealing retail in every case, except in Wednesbury) to obtain an order for the district; but the company did not carry out that order, and the Corporation itself then obtained an order and made arrangements with the company for a bulk supply, the Corporation bearing the expense of laying the mains and of providing a sub-station in which the alternating current is transformed to continuous current for distribution.

The supply started about 3½ years ago, since when the charges have been reduced by the power company to all its consumers in the neighbouring districts, and, as you are quite aware, charges have fallen for electricity supply throughout the whole country. The power company has not reduced the charges to the Wednesbury Corporation, and as a result the retail charges in Wednesbury for electricity remain practically what they were 3½ years ago, and the development of the undertaking is seriously hindered. Further, even at these higher prices, the Corporation cannot make the concern pay (although its plant is loaded up), and there is no prospect of its ever doing so on the present lines; as, even continuing the bulk supply, further heavy capital expenditure would be necessary. The Corporation now pays to the company practically 1·9d. for every unit sold to the consumer, and in an industrial district like Wednesbury we have been compelled to see the power load which we might have had being absorbed by suction gas, private plants and other forms of motive power, simply because we could not supply electricity for power purposes at a reasonable rate. Further, in evidence given at the Local Government Board inquiry, the power company's supply to the Corporation was shown to have failed since April, 1906, some 14 times, the fluctuations of voltage and periodicity have been so great on 43 occasions as to cause serious variations of pressure on the Corporation mains, and on 12 occasions this has caused the Corporation to shut down its motor-generators, and fall back on the battery. You say that the power company *naturally* opposed the Corporation's application. I have no doubt that the power company would be very pleased indeed if the Local Government Board refused the loan, and compelled the Corporation to continue indefinitely to pay the exorbitant price for its bulk supply. You say also that the Mond Gas Company has power to supply electricity in the borough, but this is not a fact, and your statement seems to me to show an ignorance of the conditions existing in the Black Country. Although Wednesbury may offer a poor field for lighting in shops, there is a large field for works lighting, and a large field for motive power. One works alone in the district has a private plant of some 3,000 to 4,000 kw. equal to the total output of many large town supply where you would no doubt approve of a municipal power station. Whatever the result of the Local Government Board inquiry which was held here recently, there is no doubt that the Corporation of Wednesbury cannot be expected to put its hands into its pockets for ever to make up the deficit on the bulk supply, in order to develop an outside company, and further than that, it is extremely doubtful if the said power company can deliver electricity in Wednesbury at as low figure per unit as we can generate it on the spot, taking into account the losses in transmission and in conversion, and also taking into account the interest on capital for mains, sub-stations and transforming plant in connection with the bulk supply, and the item of profit expected by the company. It is my opinion that we can generate in Wednesbury with the plant we propose at a lower price per unit than this company can deliver and sell to us at a profit in Wednesbury. At any rate one is forced to that conclusion when considering the fact that the company has continually refused to reduce the charge for the bulk supply to a price which will enable the Corporation to supply power consumers at the same rates as those charged by the company in adjoining districts.—I am, &c.,

W. FENNELL,
Engineer and Manager.

Wednesbury, Oct. 9.

[We have no wish to be unfair to municipalities or to suggest that Wednesbury is a smaller town than it really is. In fact, we said nothing about the size of Wednesbury at all, though certainly we should not term it a large town from the point of view of electrical enterprise. Towns of similar size have found it worth while to take a bulk supply; for example, Swinton and Pendlebury and Brighouse, and the latter is even going so far as to discard its own generating station. We are still inclined to the view, more or less supported by Mr. Fennell, that Wednesbury is not a good field for lighting, and evidently the Midland Electric Corporation were not favourably impressed with the prospects of the district as one for a general supply. If the charge by the Midland Corporation is too high, that is a good argument for a municipal supply, but it is noticeable that the output is small and of low load factor. Moreover we are not acquainted with the terms of the agreement under which power is supplied. Finally, we hope that Mr. Fennell will be fortunate enough to secure the large power load to which he refers if a municipal station is put down, but private works are apt to require as an inducement to discard their plant a much lower price than can be offered by a small station—ED. *E.*]

LEGAL INTELLIGENCE.

Tramcars and the Right to the Road.

At Manchester County Court on Wednesday, Messrs. Walker & Homfray sued Manchester Corporation for £47. 6s. damages sustained by a pony and float and a horse and dray in a collision with one of the Corporation electric tramcars.

After hearing the evidence, which was of a contradictory character, Mr. RHODES (for Manchester Corporation) contended that, even assuming there was negligence on the part of the driver of the tramcar, there was contributory negligence on the part of the drivers for plaintiffs. He contended also that before crossing the road in front of other vehicles it was necessary for drivers to take precautions.

Judge PARRY: Why? Because the tramcars never will stop for anybody? Hasn't a man a right to cross the road?

Mr. RHODES: Yes, but in crossing over the track of any vehicle a driver should give a warning, so that he should not be run into.

His HONOUR: Do you contend that carters must stop on one side of the road until your cars pass?

Mr. RHODES: I submit it is a rule of the road for slow-moving vehicles to give way to the faster.

His HONOUR: I don't agree with you at all. There is no law in England that I am aware of in support of your contention.

His HONOUR decided that the evidence was conclusive as to the negligence of the servant of the Corporation. As to the speed, his own experience of the cars was that, if driven at a reasonable speed under proper control, a car ought not to run 20 or 30 yards beyond the point of a collision. He had often seen drivers of cars, on finding other drivers about to cross the road, whistle and attempt to pass in front of them. He did not agree with Mr. Rhodes that other traffic ought to wait until the cars passed. Both had a right to the road, and there must be a certain amount of give-and-take. The public were entitled to expect that the tramcars were kept under such control that they could be slowed down and pulled up in time to prevent accidents. Plaintiffs were entitled to succeed, but as they had not made every item clear he would give judgment for £40, with costs on the C scale, as the case had been one of importance and length, and also a certificate for plan.

The Influence of Steam and Smoke on Overhead Wires of Electric Railways.—*Le Genie Civil* gives an account of some tests which have been made for the purpose of determining whether when steam locomotives work on high-tension electric railways the exhaust steam and smoke is likely to cause a "flashover." Researches were carried out on two metal balls, between which a very high P.D. was set up. Different length spark-gaps were used, first in clean atmospheric air, and secondly in a stream of wet steam. It was found that up to a voltage of 55,000 the spark-gap in steam was wider than that in air, but less with higher voltages. No difference could be found between wet and dry steam. A slightly wider spark-gap was obtained with black coal smoke containing no steam. Sufficient safety against sparking to earth is obtained if the distance to the nearest part of the locomotive is made five or six times as great as the spark-gap. The corroding effect of exhaust steam on overhead networks is shown in the following case: A 500 volt direct-current network which crossed the lines of a steam railway showed, after five years' working, that the copper wires on the end insulators had been so corroded by electrolysis that the insulators had become conducting and arcing was caused. Sufficient insulation could only be obtained by the use of several insulators, although on the parts which were not touched by the smoke from the locomotive this phenomenon was not noticed.

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MUNICIPAL, FOREIGN & GENERAL NOTES.

APPOINTMENTS VACANT AND FILLED.

The chief engineer of Ipswich electric supply and tramways departments has a vacancy for a premium pupil. See an advertisement.

An assistant is wanted in the calculating department of an engineering works, accustomed to the design of continuous and three-phase current machinery. See an advertisement.

A competent lecturer is required to give 10 popular lectures on "Practical Electricity as Applied to Collieries," each lecture to be delivered three times—namely, on Monday, Tuesday and Wednesday evenings—and to be illustrated by practical experiments. Applications to Messrs. Barber, Walker & Co., Eastwood Collieries, near Nottingham. See an advertisement.

A junior assistant is wanted for electrical laboratory in steel works. Experience with magnetic and electrical testing instruments and pyrometers necessary. Applications to Hadfield's Steel Foundry Co. (Ltd.), Sheffield. See an advertisement.

An engineer is required for a central station of an electric supply company to take charge of generation and distribution, must be experienced in a c. and c.c. systems, and also in dealing with power consumers from a commercial and technical point of view. See an advertisement,

An assistant lecturer and demonstrator in the physics and electrical engineering department, and an assistant lecturer and demonstrator in the mechanical and civil engineering department of the Municipal Technical Institute, Portsmouth, are required. Salary £125 to £150 per annum in each case. Particulars and forms of application from the secretary.

Limerick Electric Lighting committee require a borough electrical engineer. Salary £160 per annum. Applications to Town Clerk by 2 p.m. Oct. 15.

Mr. W. G. Griffiths, B.Sc., has been appointed lecturer in electrical engineering at Bradford Municipal Technical College at £200 per annum.

Accrington Council have appointed Messrs. F. C. Whitehead, John Scott and E. G. Hodgkinson as shift engineers at the electricity works.

Mr. R. M. Prescott, town clerk of Fulham (London), has been appointed town clerk of Sheffield at £1,250 per annum.

Mr. J. P. Gallinagh, having obtained an appointment at Singapore, has resigned the position of city electrical engineer at Limerick.

Mr. G. H. Broom, B.Sc , A.R.C.S., of the Technical College, Huddersfield, has been appointed lecturer and demonstrator in physics at the Derby Technical College.

Mr. Whittington, Norwich, has been appointed assistant electrical engineer at Kilmarnock.

Mr. C. H. Klyne having resigned his position as chief assistant engineer at Lynn, Mr. C. Jackson has been promoted to the vacancy, at a commencing salary of 40s., increasing to 45s. per week. Mr. Adam Brown, of Lincoln, has been appointed to succeed Mr. Jackson.

Civil Service Appointments.—Notice is given of a forthcoming examination for assistant examiners in the Patent Office (20-25). Nov. 6 is the latest date at which applications can be received. Forms from the Secretary, Civil Service Commission, Burlington House, London, W. See an advertisement.

Aberdeen.—After Dec 1 the manager of the tramways (Mr R. S. Pilcher) is to have charge of the whole of the Corporation tramway undertaking, with the exception of the permanent way, the overhead electrical equipment and the feeder cables.

The special committee of the County Council appointed to consider whether the option conferred by the Aberdeen Electricity Act of 1907 to acquire the Cults electricity works should be exercised, unanimously recommend, after consideration of a report by the consulting engineer (Sir Alexander Kennedy), against the purchase by the County Council of the undertaking.

Abertillery.—An inquiry was held here last week into the application of the Council for sanction to a loan of £10,000 for the electric lighting of the south ward. The inquiry was adjourned for further evidence.

Accrington.—The formal inauguration of the recent extensions of the plant at the electricity works took place on Monday.

On Friday last the new electric tramway route from Accrington to Clayton le-Moors was opened for traffic.

Argentina.—The "Review of the River Plate" says the machinery for the electric lighting of Posadas, Misiones Territory, is to be exempt from import duty.

Buenos Ayres Public Works Department recommend the Municipal Council to grant exemption from fines for non-fulfilment of time conditions in connection with the concession held by Mr. V. Rissotto for the construction of tramways, as the Department recognises that the delay has not been caused by the concessionnaire.

Ascot.—Current from the new electricity works of the Ascot Gas & Electricity Co. was switched on to the mains on Saturday, but the formal opening, which will be performed by Sir Walter Palmer, will not take place until about the 24th inst.

Australasia.—A deputation of electrical manufacturer waited upon the Minister of Customs last month to ask that, under the new tariff of import duties, electrical machinery and apparatus should be grouped together and not scattered over the metal items in the tariff as they are at present. It was requested that on dynamos "which can be, or soon will be, made in Australia," an adequate protectionist duty should be put.

It was stated in the House of Representatives of the Commonwealth Parliament on Sept. 5 that the Government had been unsuccessful in their efforts to obtain telephone insulators in the Commonwealth. They had, however, given instructions for tenders to be invited for 50,000 insulators made in Australia.

Award.—The Electric & Ordnance Accessories Co. inform us that they have been awarded a gold medal for their exhibit ("Stellite" telephones and telephone accessories, electrical apparatus, &c.), at the 1907 New Zealand International Exhibition. The exhibit was in the hands of the company's sole agents for New Zealand, Messrs. C. A. Hamlin & Co., Auckland.

Belfast.—From April 1 next the following scale of pay for motormen and conductors of the electric tramways department will apply: First year, 4½d. per hour; second year, 5d.; third year, 5½d.; after three years, 6¼d. It is estimated that the change will entail an additional cost of about £1,300 a year.

Blackburn.—The Corporation propose to promote an omnibus bill for additional electricity supply and tramway powers.

Bradford.—The Electricity committee reported on Tuesday that they had entered into an agreement for the supply of electricity in bulk to the Bradford Dyers' Association.

The new tramway from Little Horton to Wibsey, via Brownroyd Hill, was inspected on behalf of the Board of Trade and opened for traffic on Wednesday.

Canada.—It is reported that a representative of a British syndicate is at Edmonton, the capital of Alberta, is investigating the tramway situation. If successful in the negotiations for the purchase of the local franchises, the syndicate will develop the tramways in other parts of Western Canada.

Colchester.—The Corporation have rejected a proposal to unite the electricity and tramways undertakings under one committee.

Dewsbury District Tramways.—Soothill Nether Council have sealed the agreement with the National Electric Construction Co. for constructing the portion of the Dewsbury to Ossett tramway system in Soothill Nether. The work is to be commenced within a month and will be finished by Whitsuntide next year.

Doncaster.—On Wednesday the Council authorised the Tramways and Electricity committee to construct three new passing places on the tramways at a cost of £1,020.

Dover.—The Council have applied for sanction to a further loan of £1,000 for "free" wiring work.

Edinburgh.—On Tuesday the Council adopted the recommendation of the Electric Light committee to reduce the charge for current for lighting to 2d. per unit to consumers who do not use the light between 4 and 7 p.m. during November, December, January and February.

A communication from Mr. Norman A. Thomson, consulting engineer, submitting terms for converting the tramways to electric traction was remitted to a committee. Mr. Thomson asked if the Council would consider selling the present tramways to a new company and grant a concession for working the same for 60 years, and, if so, what sum in cash down would the Council require? The new company would convert the present lines to electric traction and construct extensions (aggregating some 9 miles of double track) on the overhead system. All capital required would be found by the company. The existing tramway company were approached on the matter several months ago, and stated that they did not wish to stand in the way of the scheme provided the terms were satisfactory to themselves.

Electrical Legislation.—The Associated Municipal Electrical Engineers of Greater London are asking the borough councils and other authorities to support them in urging the re-introduction next session of the Supply of Electricity Bill, 1906.*

Electrical Equipment of the ss. "Mauretania."—In the issues of *The Electrician* for Sept. 27 (p. 939) and Oct. 4 (p. 982) a description was given of the electrical equipment of the ss. "Mauretania," and we are asked to add that the vessel is fitted with the Pearson fire alarm system. Messrs. Alfred Graham & Co., Crofton Park-

* The text of this bill is given in full in "The Electrician" Electrical Trades' Directory and Handbook for 1907, pp. 381-384

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road, London, S.E., also inform us that a system of loud-speaking telephones was provided for the vessel by them in connection with the navigating positions. For this purpose large and loud-speaking instruments are used, and the system is, of course, quite independent of the passengers' equipment. In the navigating room are three separate telephones. The first is connected to the engine room, which contains three telephones, one for the starting platform, controlling the low-pressure and astern turbines, and one each for the high-pressure turbine rooms, port and starboard—the navigating officer, by means of three switches, can speak to either of these at will, independently of the others. The second telephone is to the steering gear, and the third is connected to the forecastle, the crow's nest and the after bridge by means of three switches.

Electricity in Mining.—At the meeting of the Kent Collieries (Ltd.) on Tuesday Sir Owen Slacke referred to the electric power plant recently extended, and said that their power house contained four engines, five electrical generators (two of which were capable of producing about 700 H.P.), two switchboards, &c. An overhead travelling crane for lifting any part of the machinery had been fixed. The winding-engine house contained a pair of large engines for No. 2 pit, fitted with all the latest economical appliances and capable of raising 1,200 to 1,500 tons of coal per day. The headgear stood 84 ft. above the level of the sidings and was fitted with all necessary appliances for drawing the coal. An almost infinite amount of work had been executed in connection with the equipment of the electrical pumping plant and adapting No. 3 headgear and three powerful capstans.

Electricity Meter-testing Fees.—Woolwich Council have been informed by the Board of Trade that, as the report of the Engineering Standards Committee will be published early in November, it is proposed to adjourn until after that time the consideration of the proposed alteration in rules and scales of fees in regard to electricity meters.

Engineering Trade Agreement.—It is officially announced that the agreement between the Employers' Federation and the Amalgamated Society of Engineers, the Steam Engine Makers' Society and the Machine Workers' Association, which was provisionally agreed to some time ago, has been ratified by a vote of the members of the unions.

Factory and Workshop Regulations of the Home Office.—In our last issue (p. 1,003) we set out various objections to the draft regulations recently issued by the Home Secretary and a resolution recently passed on the subject by the Associated Municipal Electrical Engineers of Greater London. At a meeting on Monday the Association approved the action of the Executive in asking the engineers of electricity works to support the objections referred to. No reply, beyond a formal acknowledgment, has yet reached the secretary to the request that a deputation from the Association should be received by the technical officers of the Home Office.

Falmouth.—In view of the increase of gas lighting the Council are to consider the advisability of providing electricity supply. The Parish Church is being wired for the electric light.

Fire.—We are informed that the fire which occurred on the premises of Messrs. J. G. White & Co., College-hill, London, E.C., last week, although it caused considerable inconvenience at the time, will not in the least affect the company's facilities for carrying out orders. The fire took place in the telephone room, which was completely gutted, but a temporary switchboard has been installed and communication restored.

Hull.—Application has been made for sanction to a further loan of £31,200 to meet the probable requirements of the electricity department for the next three years.

India.—It is expected that construction work under the electricity supply licence granted to D. J. & R. J. Tata, for the generation of electrical enery at the Ghats and the supply of current in the city and island of Bombay, will be commenced within a year.

It is stated that the Bengal and North Western Railway Co. are about to spend a further R90,000 (£6,000) on electric train lighting.

The material for electric lighting installations at the Bengal-Nagpur Railway Co.'s head offices at Kidderpore and their premises at Khargpur, and for telephone materials for the latter place and Garden Reach, has been ordered from England.

Inquests.—At Wednesbury last week an inquest was held into the death of the man Brennan who was recently killed at the Old Park Works of the Patent Shaft & Axletree Co.

Deceased was employed in the "bogey" department, and had occasion to use an electrical saw for sawing hot metal. The saw had previously been used by another blacksmith named Corbett, who stated that it appeared in perfect order when he left it. Brennan was assisted by a man named Costello (who was unable to attend the inquiry) and a youth named Watts. The latter stated that Brennan had finished using the saw and was just drawing back, when Costello pulled the switch out to cut off the current. Immediately he did so there was a flame from the sheet-iron flooring. Corbett, who was near, said he felt a shock through his legs which knocked him over, and deceased reeled and fell. Watts attempted to save him, but immediately he stepped on to the iron plates near the motor he was thrown. Costello eventually pulled him off.

Mr. J. L. Andrews, electrical engineer to the Patent Shaft & Axletree Co., said he examined the machinery after the accident and found that the spring of the switch which controlled the current working the motor had broken. When pulled back it caused a contact with the iron box which formed a cover for the switch. In view of such an escape of current there was a cable attached to the iron box, the sheath being attached to the iron frame of the motor. As that was on a bed of concrete it was regarded as forming a good earth connection. Another end of the cable was earthed by being attached to an iron column supporting the roof. Witness was of opinion that the motor was not in reality perfectly earthed, and that the current passing into the frame through the sheath was not carried to earth as it should have been, but deceased, who was also on concrete, formed a connection to earth. The switch and motor were fixed in accordance with Home Office requirements.

The electrical inspector of factories (Mr. G. Scott Ram) said the only explanation he could give for the iron column not proving conductive was that there was paint on it. He had examined the column and could see no clean metal. With regard to the failure of the current to pass through the saw into the foundations, he was of opinion that the explanation was that, while the ground was well watered on the surface, it was probably dry beneath, as there was a furnace in close proximity. In that event the earth would be non-conductive. He had known similar cases elsewhere. In his opinion the company had taken all reasonable precautions. At present there were no Home Office regulations applying to electrical machinery of that kind, though some rules were now being drawn up. The accident would not have happened if there had been a wood cover, but there were objections to wood covers, and iron covers were almost universally used. He agreed that a switch was always liable to get out of order. The usual precaution was to put an earth wire on.

The jury returned a verdict of accidental death from electric shock, adding that they did not think anyone was to blame and that all reasonable precautions appeared to have been taken.

An inquest was held on Friday into the deaths of two men who succumbed to injuries caused in the tramcar accident at Birmingham on 1st inst.

The manager of the tramways (Mr. Alfred Baker) explained that the Warstone-lane hill (where the accident occurred) was 300 yds. long. The incline varied from 1 in 43 to 1 in 17. The Board of Trade regulations allowed the corners to be turned at 4 miles an hour, but the motormen had instructions to approach curves, points and crossings at a speed not exceeding 3 miles per hour. With regard to the cars there was a rule that when they were returned to the depot at night the motorman should report any defect that had come to his notice while the car was in his charge. On Monday night a motorman reported that the car was in good order. Similar entries appeared in the book for the last fortnight. He produced a diagram showing the notches on the controller. There were seven power notches. The first was used to start the car and the fourth for ordinary running. A separate handle on the controller was used for starting or reversing the motor. There were seven notches for the magnetic brake. An ordinary hand brake was used for regulating the speed of the car on the level, but the magnetic brake was more effective. The first notch was sufficient, under ordinary circumstances, to retard the car, and the second or third to stop it. The cars usually coasted down Warstone-lane on the second notch of the magnetic brake.

The Coroner: Does the Board of Trade call for a magnetic brake?—No. On severe gradients, such as 1 in 15, the Board of Trade usually required a slipper brake to be used, but did not stipulate what kind of slipper brake it should be. The magnetic brake had, however, the strong approval of the Board of Trade inspectors. Every Corporation car in Birmingham had a magnetic brake. The Board of Trade recommended the magnetic brake as a result of exhaustive tests made in London, and the whole of the cars belonging to London County Council were fitted with that kind of brake. With the current full on the cars could travel at 14 or 15 miles an hour on the level. The hand brake would, on a moderate gradient pull up the car, but would not do it so quickly as the magnetic brake.

A Juror: If the car was going at full speed down hill, and the magnetic brake failed, the hand brake would be useless?—It would check the speed, but it would take time to stop it. The hand brake only checked the speed of the wheels, and if the wheels were locked the car would skid. The magnetic brake did not admit of skidding.

Mr. Baker explained the duties of the motormen in regard to testing the brakes. That could not be done at the depot, but as soon as he got his car on the road it was the duty of the motorman to make an emergency stop to test his magnetic brake. If he discovered any defect it was his duty to report it to the first inspector he met. He was instructed not to take the risk of running a car that was not under complete control. If there was no inspector available the motorman would use his own discretion and take the car back to the depot.

Walter Fenn, assistant brakesman at the Rosebery-street depot, said he examined the car on Monday night and adjusted the brakes. There was no breakage or defect apparent.

After hearing further evidence, the jury returned a verdict of accidental death. They added a rider to the effect that there was an error of judgment on the part of the motorman in not returning the car to the depot immediately he found the magnetic brake defective; and also an error of judgment on the part of the inspector in depending upon a brake which he knew was defective, especially on a decline.

International Exhibitions.—The committee appointed in October 1906, by the Board of Trade to report upon the advisability of Great

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Britain participating in international exhibitions has issued its report.

The committee find that great international exhibitions are not universally regarded with favour by manufacturers in this country. Textile manufacturers show great unwillingness to take part in exhibitions and generally the evidence went to show that they are of little use, as a rule, to the great staple industries of the country. On the other hand, the report states that it seems probable that, except in the case of striking novelties, from the exhibition of which satisfactory returns may be obtained in almost every class of goods, the trades which have derived the most direct benefit from exhibiting are the furniture, china, earthenware, glass, goldsmiths' and silversmiths', jewellers', gun, ammunition, and, to some extent, the machinery and engineering trades. Individual firms have also obtained good results by exhibiting such articles as photographs, special kinds of paper, books and bookbinding, scientific instruments, flexible metallic tubing, brass and copper tubes and metals, &c. In the case of the machinery and engineering trades, the direct results obtained by exhibiting have occasionally been of considerable importance; but this remark does not apply to specialities for which there is a very limited demand, or to very heavy goods, such as large marine engines, locomotive engines, or certain classes of machine tools. To a large extent, it would appear, the amount of direct benefit which may be derived from exhibiting by any particular firm is dependent on whether that firm is represented at the exhibition by an efficient agent.

Although firms do not, as a rule, gain much in the way of increased orders from taking part in exhibitions, the committee favour the continued participation of this country in all really important exhibitions, owing to the indirect advantages resulting from them.

The committee are of opinion that the causes which render it necessary for individual firms to spend large sums on advertisements, in order to maintain their position in a particular trade, also render it imperative that every effort should be made to maintain and improve the reputation of British manufactures as a whole. Experience has shown that even in the case of firms with an established reputation and world-wide connections, attempts to discontinue advertising have usually been followed by a diminution in sales, and the committee think that the neglect by Great Britain of one of the most important forms of national advertisement would be equally detrimental to her interests as a manufacturing country. Another aspect of exhibitions to which considerable importance should be attached is the effect which they have in encouraging national emulation and in stimulating individual exhibitors to improve their productions.

The committee state that, in their opinion, it is of the first importance that improved machinery should be set up which will secure, first, a more prompt consideration of invitations to participate in exhibitions; and, second, a more effective representation of this country at any exhibition in which H.M. Government may decide to take part. To obtain these objects it is essential that, before everything else, the Government should provide in future for continuity of organisation from exhibition to exhibition, and to effect this continuity of organisation it is necessary to appoint a permanent official whose duty it should be to collect full information respecting past exhibitions and to evolve a proper system for application in the future. The committee recommend that a special officer—of approximately the rank known as principal clerk—should be attached to one of the departments of the Board of Trade as the officer specially concerned with exhibition work, and that he should be primarily responsible for the proper organisation, conduct and winding up of all exhibitions.

Suggestions are also made as to the method on which the new plan should be worked.

Light Railways.—Clayton le-Moors Council have acceded to the request of Mr. Chadwell for an extension of 18 months for completing the Blackburn, Padiham & Whalley Light Railway.

London County Council.—At the first sitting of the Council after the summer recess on Tuesday it was agreed to lend £1,755 to Woolwich for electric lighting and £7,337 to Fulham.

Contracts and Retention Money.—The following proposal of the Finance committee for the amendment of Standing Order No. B 222 in reference to the retention of money under contract was agreed to: "(4) In the case of contracts for machinery or electric lighting installation payments shall be made as follows: In contracts for machinery, 50 per cent. of contract price (less provision money for extras) on delivery of machinery; 25 per cent. after erection; 15 per cent. after trial or test of machinery; and the balance after the expiration of prescribed period of maintenance.

"In contracts for electric lighting installations, 80 per cent. of contract price (less provision money for extras) on completion of work; balance after expiration of prescribed period of maintenance."

Proposed New Tramways.—The Highways committee brought up their adjourned report recommending that application be made to Parliament for power to construct new lines (1) between Gray's Inn-road and Caledonian-road, (2) from King's Cross-road to Gray's Inn-road, (3) from Essex-road to Kingsland-road, (4) from Mitcham-road to Tooting High-street, (5) from West Norwood to Crystal Palace. The total capital expenditure involved in these schemes is estimated at £351,000, of which £229,000 represents the cost of constructing and equipping the proposed tramways and £122,000 the gross cost of street widenings. The tramways to the Crystal Palace are proposed to be constructed on the overhead trolley system.—The recommendations were agreed to.

Greenwich Generating Station and the Royal Observatory.—It was agreed to accept the report of the Special committee appointed to inquire into the working of the Council's generating station at Greenwich in its relation to the Royal Observatory as the basis of a working agreement between the Council and the Admiralty. This report was given in February of this year and contains recommendations chiefly in regard o the use of machinery so perfectly balanced as not to cause vibration.

Future Electrification of Tramways.—Answering questions, Mr. Whittaker Thompson (chairman of the Highways committee) said that if the local Councils of St. Pancras and Hackney would assist them in agreeing to the overhead trolley system he felt he could promise a speedy electrification of the system in those districts. The Council had not yet received the consent of the Board of Trade to the use of the surface-contact system in Mile End.

Lowestoft.—The L.G. Board have sanctioned the borrowing of the following sums: For feeders, distributors, services and oil filter, £11,250 (to be repaid in 20 years), meters £1,500 (5 years). public lighting £1,200 (10 years), and motors £3,000 (10 years). The question of loans for "free" wiring is under consideration.

Metropolitan Association of Electric Tramways Managers.—The quarterly meeting of this Association was held on Friday last, when a visit was paid to Croydon.

The members attending were: Messrs. H. E. Blain (West Ham), T. B. Goodyer (Croydon), W. E. Hammond (Metropolitan Electric Tramways), G. Ratcliffe Hulme (South Metropolitan Tramways), H. L. Howard (Barking), C. Mittelhausen (Bexley Heath), F. Schofield (Leyton), A. H. Shaw (Ilford), W. C. Ullmann (East Ham).

Sir J. Clifton Robinson (London United tramways) and Messrs. A. L. C. Fell (chief officer) and J. K. Bruce (traffic manager) of the L.C.C. tramways, A. Coveney (Erith), and W. Murray and G. R. Spurr (Walthamstow) were prevented from attending.

Mr. T. B. Goodyer, tramways manager to Croydon Corporation, met the visitors at East Croydon station, and placed a special car at their disposal and took them for a run over a part of the system. The Thornton Heath depot, workshops and stores were inspected, and subsequently a meeting was held in Mr. Goodyer's office, when business was discussed. Mr. H. E. Blain (West Ham) was unanimously elected chairman in succession to Mr. Fell, whilst Mr. Goodyer succeeded Mr. Blain as hon. sec. At the conclusion of the business the members were entertained to a knife and fork tea by Ald. Trumble, J.P., chairman of the Croydon Tramways committee, whose hospitality was greatly appreciated.

Motor' Buses and Cabs.—In the report of the Commissioner of Police for the Metropolis for 1906 it is stated that mechanical traction is rapidly replacing horse traction for public carriages.

Whereas the total number of mechanically-propelled vehicles in 1902 was 345, it had risen in 1905 to 1,384, and in 1906 to 2,275. Hansom cabs continue to rapidly decrease, while four-wheeled cabs decrease less rapidly. The number of motor 'buses licensed in 1906 was 783. 3,752 were reported unfit, 2,036 "unduly noisy" and 1,716 suffering from other defects. Makers were induced to make greater efforts to produce a more satisfactory vehicle in respect of noise, and the motor omnibuses since licensed are reported as showing marked improvement.

Newcastle-under-Lyme.—The salary of the electrical engineer (Mr. A. J. de Rienzi) has been increased.

Newport (Mon.).—On Tuesday the Council rejected (by 25 votes to 16) a resolution that the lighting of the town should be placed under a committee other than the Electricity committee.

"Noisy Tramcars."—Middlesbrough Council have decided to make a contribution not exceeding 10 guineas towards the cost of the proceedings which are to be taken by Ealing and the adjoining local authorities against the London United Tramways with regard to the alleged nuisance caused by noisy tramcars.

Northallerton (Yorks.).—The Northallerton Electric Light & Power Co. have declined to open negotiations for the sale of their undertaking to the Council.

Presentation.—The employes of Norwich Tramways have presented a pair of silver vegetable dishes and a case of silver and ivory fish knives and forks to Mr. Alan N. Banister, engineer and manager, on his marriage.

Richmond (Surrey).—A special report was presented to the Council on Tuesday by the General Purposes committee on the subject of tramways.

After dealing with the position of the London United Tramways, the committee recommended the Council to approve the general principle of powers being sought for the construction and working of tramways, either for the borough only or jointly with Barnes Council. The Council were also recommended to authorise inquiries and negotiations being continued and such expert advice (both engineering and legal) being obtained as may be necessary, and generally to take such steps as they may be advised to prepare and to promote, jointly with Barnes or otherwise, a bill next session to authorise the construction and working of a system of tramways. It was also reported that the Richmond (Surrey) Electric Light & Power Co. had offered to lease the powers when obtained.

After discussion it was decided, by 16 votes to 15, to adjourn consideration of the matter until 21st inst.

Barnes Council have appointed a special committee to discuss with Richmond Council the question of the construction of tramways.

Sheffield.—On Wednesday the Council approved the proposal of the Tramways committee to lease 6,750 yds of land from the Duke of Norfolk, for 200 years, at an annual rent of 1s. 6d per yard, as a site for a tramway car shed.

Southwark (London).—In our last issue (p. 1004) it was stated that the accountants called in by the Council (Messrs. Price, Water-

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house & Co.) had sent in a further report on the electric lighting accounts.

We are informed that this statement is not strictly accurate, as no accountants have been called in by the Council, but Messrs. Price, Waterhouse & Co. have reported on the subject on behalf of a ratepayer. The original report by the firm was sent to the district auditor (Mr. Carson Roberts) for perusal, to which he replied, and it is in reply to Mr. Carson Roberts' observations that Messrs. Price, Waterhouse & Co. have presented the further report referred to in our last issue. Beyond this, no firm of accountants has been approached by the Council with regard to the electric lighting accounts, and no change has been made in the financial policy of the undertaking.

Sowerby Bridge.—The Council have decided to transfer their provisional order (1900) to the Electrical Distribution of Yorkshire (Ltd.) for 21 years.

Stepney (London).—On Wednesday the Electric Lighting committee reported that the borough electrical engineer (Mr. W. C. P. Tapper) had prepared plans, &c., for the new generating station at Blyth's Wharf, and it was decided to advertise for tenders for the plant (the advertisement of this contract appears in another column). The total cost of the scheme is estimated at about £57,000.

Stockport.—In future consumers of electric current for lighting will be supplied at 3½d. per unit, less 5 per cent.

Sanction to a loan of £15,473 for tramway extensions has been applied for by the Council.

Submarine Telegraphy.—At the exhibition at Olympia on Tuesday evening Mr. Chas. Bright gave a lecture on "Submarine Telegraphy," describing the methods of transmitting electric signals through cables and the speeds with which this work can be done under varying conditions. The various stages of construction of a submarine cable were explained, as well as the methods of surveying the ocean bed, laying the cable, providing for irregularities of the sea-bottom, landing shore-ends, picking up and repairing a cable, localising faults, &c. An instructive résumé of submarine chronology was given, and some interesting statistics. The audience was both large and appreciative.

Swansea.—After March next the Council have decided to adopt a flat rate of 4½d. per unit for electric current for lighting.

An electrical equipment to cost £70,000 for the treatment of zinc ores, &c., is being laid down at the Hafod and Upper Bank works of Williams, Foster & Co.

Theft of Cable.—At Marylebone (London) Police Court on Monday, two men (Brooker and Messer) were sentenced to 28 days' hard labour for stealing a quantity of electric cable from the Marylebone electricity department. Tons of electric cable, it was said, had been stolen from the storeroom during the past 12 months. Watch was kept, and on the 3rd inst., shortly before booking-on time, Brooker was seen to hand two pieces of cable and some fittings to Messer, who placed them in his truck, which he subsequently took away.

Tramways over Southwark Bridge.—Mr. J. D. Gilbert has given notice that he will move the following resolution at an early meeting of London County Council:—

That, as the City Corporation are considering the rebuilding of Southwark Bridge, it be referred to the Highways committee to negotiate with the Corporation and report on what terms London County Council tramways will be allowed to cross the reconstructed bridge to a terminus on the City side.

Tunbridge Wells.—An inquiry was held on Tuesday into the application of the Council for sanction to borrow £9,600 for extensions of the electricity works.

The town clerk (Mr. W. C. Cripps) said the electricity undertaking had been continually progressive. The works were started in 1891, and the total cost had been £81,475, of which £22,941 had been redeemed. There were 812 consumers. There had been no new loans applied for for 6½ years. There was no need to enlarge the buildings. There had been a considerable saving in regard to the erection of a new chimney, which cost less than the original estimates by over £2,000. The balance of the amount had been spent in other ways on the works, as shown in the accounts. There had also been a considerable saving on the machinery. The accounts for each department were now kept separate for convenience and reference.

The electrical engineer (Mr. H. L. P. Boot) said they had saved on the new chimney shaft, but the present loan was for quite different purposes—for electric plant.

Watford.—Sanction has been received to a further loan for extensions of the electricity undertaking. The Council have decided to light new streets by electricity.

Wednesbury.—Sanction to a loan of £2,819. 10s. 2d. for cables and services has been applied for by the Council.

West Ham.—The borough electrical engineer and manager (Mr. A. Hugh Seabrook) has asked to be allowed to quote for any heating required by the Corporation in any of their premises.

The department can supply heating on a large scale to private firms to their satisfaction, and Mr. Seabrook is certain they could give satisfactory prices to the Council.

In accordance with the requirements of the electrical inspector to the Home Office (Mr. G. Scott Ram), the sub-stations at the Technical Institute and the Public Hall, Canning Town, have recently been remodelled. During the three months ended September 117 arc lamps have been supplied to consumers under the new arc-lamp hire scheme, bringing in a yearly sum of £960. Mr. Seabrook has submitted a similar scheme in regard to Osram lamps.

The Board of Trade have written that in regard to the proposal of the L.C.C. to use the "G.B." surface-contact system on the tramway between Bow Bridge and Commercial-road, they were advised that the equipment of cars for working on the "G.B." system in addition to the overhead and (should that also be necessary) the conduit system would not seem to present any serious practical difficulties. Under the circumstances, it did not appear to the Board that they would be justified in declining to approve the proposal of the County Council.

In regard to the through running arrangements between East Ham and West Ham, both undertakings having completed a further year's running, the figures for the year ended August, 1907, are to be included in the agreement, such figures being: East Ham car-mile earnings 10·29d. and West Ham running costs 4·894d., instead of 9·78d. and 4·937d. respectively.

The Lighting and Tramways committee have decided, on the recommendation of the tramways manager (Mr. H. E. Blair), not to accede to a demand for a double-shift system on the tramways on Sunday.

Whitby.—The Council have acquired premises in Baxtergate for fitting up as show rooms for electric light fittings, &c.

Wigan.—The Board of Trade and the L.G. Board were recently approached with a view to obtaining inquiries into the working and financial position of the tramways and electricity supply undertakings, but both departments have now replied that they have no statutory power to hold such inquiries.

Willesden.—The capital expenditure on the electricity department at March 31 was £169,937, an increase of £5,467 on the year.

Revenue was £20,229, and expenditure £13,567, including cost of current supplied in bulk by the North Metropolitan Electric Power Supply Co., £9,286. The gross profit was £6,662. Interest and instalment of loans amounted to £6,744, and the net result of the year's working was a deficiency of £16. 15s. 5d., by which amount the gross profit and interest on bank balances (£66) fall short of the capital charges. It will thus be seen that the statement in our last issue that there was a profit of £783 on the year's working was incorrect, that amount being the profit on public lighting only.

We are informed that 66 additional flame arc lamps are being erected, making the total 206 lamps, and as these are to be lighted and maintained for the amount hitherto paid for 140 lamps, it is estimated that the public lighting will thus be reduced to cost price. There are 1,703 consumers with 83,198 equivalent 8 c.p. lamps connected (compared with 1,376 and 65,051 last year). The motors connected total 534½ H.P. (333 H.P.). 1,441,394 (1,111,268) units were sold. The total maximum supply demanded was 1,108 kw. (833 kw.).

Wolverhampton.—The Council are recommended to increase the salary of the borough electrical engineer (Mr. C. E. Shawfield) by £75 per annum, with a further similar increase in 12 months.

Woodbridge (Suffolk).—A special committee has been formed by the Council for considering two proposed schemes of electricity supply in the district.

Workhouse Lighting.—Burnley Guardians propose to wire their workhouse.

Yarmouth.—The Council have notified Gorleston Gas Co. of their intention to discontinue gas lighting. 10 electric arc lamps are to be erected on Gorleston-parade, and 11 additional electric lamps in other thoroughfares.

Cricket League.—The St. James' & Pall Mall Electric Cricket Club are the winners of the affiliated centre cup this season. The following are the points scored by the clubs:—

St. James' & Pall Mall..	17 points	St. Marylebone	9 points
St. Pancras.....	13 ,,	Central	8 ,,
Kensington & Knightsbridge	13 ,,	Chelsea	0 ,,

The hon. secretary (Mr. A. W. Seabright) will be pleased to furnish electric supply cricket clubs with information regarding the league.

TRADE NOTES AND NOTICES.

TENDERS INVITED.

The Electric Lighting committee of the Metropolitan borough of *Stepney* invite tenders for the carrying out of the following works in connection with the Council's projected new generating station at Blyth's Wharf, Limehouse, and the sub-station at Osborn-street, Whitechapel: (*a*) complete equipment of the steam-raising portion of the station plant, including condensing water pipes, wells and coal-handling plant; (*b*) complete equipment of the electrical generating portion of the station plant, including the generator, high and low-tension switch gear and converting machinery. The contract will also include the removal of a portion of the plant already erected at Osborn-street and its re-erection at Blyth's Wharf. Copies of general conditions, specifications, from the borough electrical engineer and manager (Mr. Wm. C.

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Tapper). Tenders, addressed to Chairman of the Electric Lighting committee, 27, Osborn-street, Whitechapel, by Nov. 11. See also an advertisement.

London County Council invite tenders for the electric wiring of tramways sub-stations at Holloway, Hackney and Clapton, and of a car shed at Holloway. Tenders, on official forms to be obtained from the Clerk of the Council (Mr. G. L. Gomme), County Hall, Spring-gardens, S.W., by 11 a.m. Oct. 29. See also an advertisement.

The directors of the *Great Western Railway Co.* invite tenders for supply of stores for the 12 months ending Nov. 30, 1908, including telegraph instruments, telegraph apparatus (insulators, &c.), electrical wire and cables, telegraph ironwork and tools, electric light carbons, incandescent electric lamps, wire, indiarubber goods, &c., in group 1; and glass, acids, oils, varnishes, brasswork, zinc, antimony, brass, copper rivets, tools, &c., in group 2. Samples and patterns may be seen at the general stores, Swindon, from Oct. 14 to 19 for group 1 and from Oct. 30 to Nov. 9 for group 2. Specifications (with forms of tender) from the Stores Superintendent, Swindon, for group 1 after 7th inst. and for group 2 after 28th inst. Tenders to the secretary (Mr. G. K. Mills), Paddington Station, London, W., by Oct. 22 for group 1 and by Nov. 12 for group 2.

Tunbridge Wells Corporation invite tenders for the supply, delivery and erection of the work in connection with the installation of a 500 kw. turbo-alternator, condenser and pipe work in sections: (*a*) 500 kw. turbine, (*b*) 500 kw. alternator and exciter, (*c*) surface condenser, with air and circulating pumps and (*d*) pipe work. Tenders to the town clerk (Mr. W. C. Cripps), Town Hall, Tunbridge Wells, by 10 a.m. Nov. 1.

Lewisham (London) Guardians want tenders by 3 p.m. Oct. 14 for supply and fixing of a cable 600 ft. in length from the Guardians' meter to a motor at the laundry. Particulars from the Master of the Workhouse. Tenders to 394, High-street, Lewisham, S.E.

Salford Corporation want tenders by 9 a.m. Oct. 17 for wiring a portion of Broughton Town Hall. Specifications, &c., from the Borough Electrical Engineer.

Birmingham Corporation want tenders by Oct. 12 for one year's supply of coal for the electricity stations. Particulars from the City Electrical Engineer.

Portrush (Co. Antrim) Council want tenders by 8 p.m. Nov. 2 for lighting by electricity or gas. Specifications of Mr. John Woodside, Ocean-buildings, Belfast.

Leyton District Council want tenders by 7 p.m. Oct. 29 for supply of a lathe and other machine tools for the electricity department. Specifications from the Electrical Engineer.

Limerick Electric Lighting committee require tenders by 2 p.m. Oct. 15 for switchboard extensions. Specification from the Engineer.

The Municipal Tramways Trust, *Adelaide*, S. Australia, want tenders by noon Nov. 9 for supply of steel rails and fishplates. Specifications from the Agent-General for S. Australia, London.

The Ayuntamiento Constitucional, *Toro*, invite tenders, which will be opened simultaneously at the Casa consistorial of Toro and at the Dirección general de Administración, Madrid, for the electric lighting of the town of Toro for 10 years. A deposit of about £25 is required to qualify a tender and local representation is necessary. Tenders to either of the above addresses before Oct. 29.

An adjudication will take place in the Palacio Municipal, *Pontevedra* and in the Dirección general de Administración local, Madrid, for the electric lighting of the former town for 20 years at the upset price of 20,000 pesetas (about £714) per year. A deposit of about £36 is required to qualify a tender and local representation is necessary. Tenders to the Secretaría del Ayuntamiento, Pontevedra, by Oct. 28.

A copy of the "Madrid Gazette" for Sept. 21, containing the notices inviting tenders, can be seen at the Board of Trade, 73, Basinghall-street, London, E.C.

TENDERS RECEIVED AND ACCEPTED.

Sheffield Tramways committee have accepted the tender of the United States Steel Products Co. for supply of copper bonds for next 12 months, the estimated value being £1,101.

In reply to questions why these goods could not be obtained from an English firm, Councillor Fenton replied that nearly the whole of the copper bonds used on the system came from the United States. If an order were given to an English firm the result would be the same, except that the Corporation had to pay the English firm's profits. A small quantity was recently required and as the tender of the United States Co. was the lowest, it was decided to ask if they could supply the whole of the requirements of the year at the same rate. The price of copper was at present very low.

Beckenham Council have accepted the following tenders:—

W. Lucy & Co., lead service boxes, 8s. each; Cable Accessories Co., h.t. three-way boxes £4. 10s., h.t. straight-through boxes £2. 15s.; Johnson & Phillips, frames and covers 8s. 3d., 6s. 3d. and 5s. 3d., three-way boxes £3, four-way ditto £3. 19s. 3d., three-way boxes with frames and covers £5. 10s. 6d., four-way ditto £6. 6s. 9d., double disconnecting service boxes £1. 1s., two-wire house-service cutouts 7s. 6d. per set; Bishop & Austin, non-disconnecting service boxes, 12s.

Yarmouth Tramways committee have accepted the following tenders: Crompton & Co, for 10 H.P. motor, with side rails, switches and starters, £35. 13s. 6d.; Miller & Co., for wheel press, £88; Geo. Hatch, for forge and emery machines, £30. 5s.; and Brown & Colby, for shafting, 11s. per cwt., and pulleys.

Woolwich Council received tenders for building alterations at the Globe-lane electricity works in connection with the installation of three new Davey-Paxman boilers, and the lowest, that of W. Neil & Co. (at £485. 18s.) was accepted. The work is to be completed in two months.

Marylebone (London) Council have accepted the tender of William Cory & Son for six months' coal at following prices, delivered by barge: High hazel double-screened nuts 14s. 11d., Nuneaton 14s. 11d., Shipley 14s. 11d., Griff peas (for limited quantity to be agreed) 13s. 8d.

The tender of Smith & Coventry has been accepted by London County Council for two high-speed vertical tyre boring mills at £800, and that of Buck & Hickman for one high-speed vertical milling machine at £292. 10s. for the central car-repair depot of the tramway department.

London County Council have accepted the tender of Geo. Munday & Sons (at £4,153. 18s. 3d.) for the erection of Tooting tramways sub-station. There were eight tenders, varying in amount from the accepted to £4,715.

Stepney (London) Council have accepted the tender of W. Badger for a coal bunker and conveyor at £253. 10s. Five tenders, ranging in amount from that of the accepted tender to £325, were submitted.

West Ham Guardians have placed orders with the following for annual supply of electrical fittings: General Electric Co., Neville, Williams & Co., Pryke & Palmer, Risdon, Lock & Co. and Troup, Curtis & Co.

The British Thomson-Houston Co. are to supply two 20 H.P. motors with starters (to substitute the two present 10 H.P. motors) at Battersea public washhouses at £196, and to allow £100 for the existing motors.

Aldershot Council have accepted the tender of Callender's Co. for cable, troughing and insulators at £444. 18s. 9d. The list of tenders appeared in our issue for Sept. 20.

West Ham Corporation have accepted the tender of the Vulcan Electric Co. at £19. 5s. per annum for maintaining certain public lamps, fans and motors.

The British Westinghouse Co. have received (through their Calcutta agents, Jessop & Co.) the contract for switchboard panels and accessories for the East Indian Railway.

East Ham Council have accepted the tender of Callender's Co for the supply and laying of an additional feeder cable at £363.

City of London Guardians have accepted the quotation of W. Palmer to maintain the internal telephones for a year at £10. 10s.

Kettering Guardians have accepted the tender of Barnett & Soans for a 6 H.P. motor for the laundry at £33. 10s.

Woolwich Council have accepted the tender of W. Neil & Co. for extensions to the boiler house at the electricity works at £485. 18s. 6d.

Colchester Council have accepted the tender of E. B. Gray for electric motors for working the mechanical stokers at £79.

Halifax Guardians have accepted the tender of J. Hamer for six months' supply of electrical fittings.

Lynton Council have entered into an agreement with the local electric supply company for public lighting for 14 years.

Clacton Council have accepted the tender of Venner & Co. for ordinary and prepayment electricity meters.

Dundee Council have accepted the amended tender of the British Insulated & Helsby Cables for the supply of cables at £10,000.

The Postmaster General's department (Brisbane) has accepted the tenders of the Brisbane Electrical Co. for brass plates for cross-overs and single and double protectors; Sargeant & Co. for c.i. potheads; Geo. Wills & Co. for g.i. pole roofs; Smith & Atkinson for making (only) of coppers for batteries, copper pockets and leads; Paul & Gray for c.i. manhole frames and covers and c.i. potheads; and Perry Bros. for funnels and nipples for call receivers.

Melbourne (Victoria) City Council have accepted the tenders of E. Carse for gunmetal castings; Royle, Rankin & Co. for roller-bearing sheaves; J. A. Newton & Co. for electricity meters; Australian General Electric Co. for two pedestals for h.t. switchboard; Veritys Limited for 62 arc lamps; T. Larmuth & Co. for tape-lapping machine; Geo. Weymouth & Co. for re-winding 20 motors; and Sloan Electrical Co. and M. Seeck for flame arc lamp carbons.

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BUSINESS NOTICES.

Messrs. Ward & Goldstone, Springfield-lane, Salford, Manchester, have been appointed by Creightons Limited, Carlisle, as their sole selling agents for wood casing and troughing south of Carlisle. Among recent contracts secured by Messrs. Ward & Goldstone is that for the casing for the Manchester new Royal Infirmary, which is claimed to be the largest institution in the world wired with casing (many miles being used on the job), the cost running into four figures.

G. Straus & Co., 211, Upper Thames-street, London, E.C, have been appointed by the United Electrical Co. sole agents in the U.K. for their carbon filament and "Wolfram" metal filament lamps.

Mr. Brinley Rees has opened offices at Albert Chambers, High-street, Cardiff, as an electrical and mechanical engineer.

John Lawson and Frank Stobbart, electric light and power engineers, 24, High-road, Darlington, have dissolved partnership. Debts by Mr. Lawson, who continues.

BANKRUPTCIES, LIQUIDATIONS, &c.

A first and final dividend of 2s. 4¼d. in the bankruptcy of George and John Sampson Robson (trading as Robson, Robson & Co), electrical engineers, Empire-buildings, Newgate-street, Newcastle-on-Tyne, and a first and final dividend of 7s. 9d. in respect of the separate estate of George Robson, are payable at 1, St. Peter's Church-walk, Nottingham.

The examination of W. A. Roderick, electrical engineer, Swansea (formerly of Bridgend) was opened and adjourned at Cardiff Bankruptcy Court on Tuesday. Liabilities £282. 11s. 5d., deficiency £225. 19s. 10d. Debtor said he had had losses through difficulties in the supply of electric power. He undertook to provide an amended statement of affairs.

An application for the discharge of Carl Theodore Von Buch, electrical engineer, 4, Sun-court, Cornhill, London, E.C., will be heard at Bankruptcy-buildings, London, on Oct. 29.

The estate of Wm. Duke Palmer, electrical and mechanical engineer, Glasgow, has been sequestrated.

Claims against the Electrical Ore Finding Co. (Ltd.) by Nov. 19 to Mr. J. D. A. Norris, Suffolk House, Laurence Pountney-hill, London, E.C.

Claims against the English Electric Carbon Co. (Ltd.) by Oct. 19 to Mr. J. S. Wynne, 6, Coedyfelin road, Brymbo, near Wrexham.

Claims against the Capilliform Telegraph Instrument Co. by Nov. 10 to Mr. H. Clough, 54, Gresham-street, London, E.C.

At a meeting of shareholders of the Conduit & Insulation Co. (Ltd.) on Sept. 30 it was decided to wind up the concern voluntarily. Mr. Charles J. March, 23, Queen Victoria-street, London, E.C., was appointed liquidator. The statement of accounts shows a surplus of assets over liabilities of £2,860. 2s.

Sale by Tender.—The Cheshire Lines committee are prepared to receive tenders for the purchase of second-hand plant and material, including three Lancashire boilers, one pair horizontal Robey steam engines, two pairs compound horizontal Mather & Platt steam engines, including steel shafting, &c., one Davey-Paxman vertical steam engine, 10 Edison-Hopkinson dynamos (three compound and seven series-wound), a quantity of electric light cable, &c. Forms of tender and particulars can be obtained from the engineer of the Cheshire Lines committee (Mr. H. Blundell), Central Station, Liverpool, after 14th inst. Tenders must be sent in to the secretary (Mr. Glegge Thomas), Great Northern Board Room, King's Cross Station, London, N., by 9 a.m. of Tuesday, Nov. 5. See an advertisement.

Sale by Auction.—Messrs. Horne & Co., 8, Delahay-street, Storey's-gate, Westminster, S.W., will sell by public auction at the Royal Arsenal, Woolwich, on Oct. 24, some unserviceable and obsolete stores, including cast and wrought iron and steel, brass, copper, gunmetal, lead, zinc, aluminium, phosphor bronze, tin, &c, two 6 ton overhead travelling cranes, 8½ tons of electric cable, electric lamps, lathes, drawing instruments, lathes and tools, &c. Catalogues at the War Office, Whitehall; the Ordnance Office, Tower, and the Ordnance Office, Royal Arsenal, Woolwich. See also an advertisement.

Business for Sale.—Owing to illness of owner, a well-known engineering business in London is offered for sale as a going concern. The business has a well-established connection extending over half a century, and the business includes electrical, general and marine engineering. Freehold land and buildings may be purchased or leased, and the plant and stock taken at valuation. Particulars from the sole agents, Messrs. Wheatley Kirk, Price & Co., 46, Watling street, London, E.C. See also an advertisement.

Plant for Sale.—Messrs. Workman, Yeames & Co., 6, Dublin-road, Belfast, advertise for sale two new 120 B.H.P. vertical enclosed two-crank compound steam engines; also a Babcock & Wilcox water-tube boiler.

Cable and Apparatus for Sale.—Mr. Lake, 132, Upper Thames street, London, E.C., advertises for sale large quantities of new and old electric light cable, also searchlight lamps, h.v. main switches, "New Radium" lamps, &c.

Map of Railways and Electric Tramways in London and its Environs.—Mr. Edward Stanford has just issued a special map of the railways and electric tramways in London and its environs at the present time. The map is clearly printed and is bound in a manner which makes it a useful pocket companion. The published price is 1s.

Robertson Lamps—The General Electric Co. announce in an advertisement an ingenious scheme for pushing the sale of "Robertson" lamps. Any electric light consumer who returns incandescent electric lamps of any make to his local dealer and purchases an equivalent number of "Robertson" lamps is entitled to receive 9d. per dozen for all lamps returned, quite irrespective of make or condition. There are other points of interest and the offer holds good for two months from date.

CATALOGUES, &c.

Pocket Catalogue.—Crompton & Co.'s latest publication is a very useful production which will easily go into the pocket. It seems rather a tall order, but by the aid of this "abbreviated price list" particulars of all the Crompton productions can be got into the pocket. Dynamos, motors, arc lamps, projectors, instruments, fans, switches—in fact, all the electrical machinery and apparatus which Messrs. Crompton manufacture are described and priced in this compact list. It is a handy guide to modern electrical products.

Ediswan Instruments.—A quite up-to-date method of post-card advertising is that adopted by the Edison & Swan Co. in bringing their instruments to the notice of buyers.

Electrical Signalling.—Messrs. Siemens Bros. & Co. are issuing a pamphlet (No. 4) describing the Siemens electric system for working railway points and signals. The system was described in *The Electrician* of June 23, 1905, and the drawings reproduced in the pamphlet are representative of the apparatus which is being manufactured by the firm to the order of the G.W. Rly. Co. for the new Snow Hill station, Birmingham. Messrs. Siemens Bros. & Co. are also issuing a pamphlet (No. 3.) giving illustrated particulars of and instructions for installing the Siemens mercury contact treadle for railway signalling. A description of this apparatus has also appeared in *The Electrician.*

Coal Cutters, Pumps, &c.—Messrs. Mavor & Coulson have ready for distribution a number of illustrated sheets dealing with electrically-driven pumps, "Pick-Quick" coal cutters, &c.

Photometers—Messrs. Elliott Bros., Century Works, Lewisham, S.E., have ready a pamphlet (P.S.96A) which gives particulars and an illustration of the double-standard pattern Harrison universal photometer. It is claimed for this photometer that in the hands of an intelligent operator it can be relied on to measure within 5 per cent. either the illumination derived from or the candle-power of a lamp of any nature under a variety of conditions, such as in the test room, in an ordinary room, or in the street. This photometer may be used not only for ascertaining the illumination of high-power lamps in streets and large spaces, but also when erected in confined spaces.

"Stellite" Switchgear.—A well-produced catalogue is issued by the Electric and Ordnance Accessories Co., which illustrates and describes their ironclad switchgear for motor starting and other purposes. A new form of d.p. quick-break ironclad switch fuse is the main feature of the publication, this being fitted with a loose handle device which makes the switch action quite free of the operator.

Frequency Meters.—Details of Hartmann & Braun frequency indicators of the resonance type are given in a new pamphlet issued by the Union Electric Co.

Imports.—The following are official values of electrical machinery, material and apparatus imported into this country (*a*) during September, 1907, and (*b*) during the current year from Jan. 1 to Sept. 30, with the increases or decreases compared with the corresponding periods of 1906:—

Electrical machinery, (*a*) £53,297 (increase £8,154), (*b*) £446,641 (increase £11,489); telegraph and telephone cables (*a*) £16,189 (decrease £4,271), (*b*) £202,052 (increase £68,430); telegraph and telephone apparatus, (*a*) £30,057 (decrease £1,214), (*b*) £205,682 (decrease £77,035); other electrical wires and cables: rubber insulated, (*a*) £6,517 (increase £49), (*b*) £57,762 (increase £7,089); with other insulations, (*a*) £2,3[illegible] (decrease £896), (*b*) £57,592 (increase £7,851); other electrical goods and apparatus, (*a*) £37,995 (increase £4,953), (*b*) £414,445 (increase £66,832). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £93,147 (increase £1,379), (*b*) £937,533 (increase £73,167).

Exports of Electrical Goods and Apparatus.—The following list gives official particulars of the exports of British manufactured electrical apparatus and material (including telegraph and telephone wire and materials, but not including electrical machinery, which is not separately specified) from Oct. 2 to 8, with the ports of destination:—

Africa—Beira, £5; Cape Town, £11; Delagoa Bay, £23 (telegraph material); Durban, £241; East London, £138; Kilindini, £170 (tele-

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graph material); Natal, 341,193 (including £340,000 telegraph cable); Port Elizabeth, £128; Quilimane, £147 (telegraph material); Sekondi, £12 (telegraph material); Tangiers, £16,500 (telegraph cable). *Argentina*—Buenos Ayres, £2,912 (including £647 telegraph material); Rosario, £756. *Australasia*—Adelaide, £320 (including £190 telegraph material); Auckland, £3,885 (telegraph cable); Brisbane, £24; Fremantle, £220; Lyttelton, £10; Melbourne, £407; Napier, £59; Perth, £21; Sydney, £1,298. *Belgium*—Antwerp, £60; Brussels, £229; Ostend, £16. *Brazil*—Para, £445; Rio Janeiro, £14. *Burma*—Rangoon, £545. *Canada*—Montreal, £90; *Ceylon*—Colombo, £45. *Chili*—Valparaiso, £89 (including £15 telegraph material). *China*—Hong Kong, £16 (telegraph material); Shanghai, £11,038 (including £10,703 telegraph cable); Tientsin, £29. *Germany*—Hamburg, £53. *Gibraltar*, £28. *Holland*—Amsterdam, £208; Rotterdam, £27. *India*—Bombay, £380; Calcutta, £855; Karachi, £14; Madras, £1,123. *Japan*—Yokohama, £568. *North Atlantic*, £9,400 telegraph cable. *Norway*—Christiania, £22. *Portugal*—Lisbon, £114 *Siam*—Bangkok, £23. *Straits Settlements*—Penang, £22; Singapore, £97 (including £22 telegraph material). *Uruguay*—Monte Video, £32. *Zanzibar*, £107 (telegraph material). Total, £494,169, against £24,480 in the corresponding week last year (Oct. 3 to 9).

The exports of electrical machinery, material, &c., (*a*) during September, 1907, and (*b*) during the current year from Jan. 1 to Sept. 30, and the increases or decreases compared with the corresponding periods of 1906, are as follows:—

Electrical machinery (*a*) £88,243 (increase £36,302), (*b*) £733,958 (increase £122,283); telegraph and telephone cables, (*a*) £180,330 (increase £142,221), (*b*) £829,178 (decrease £334,394); telegraph and telephone apparatus, (*a*) £12,307 (decrease £2,615), (*b*) £130,945 (decrease £6,249); other electrical wires and cables, rubber insulated, (*a*) £16,355 (increase £4,965), (*b*) £195,864 (increase £72,047); with other insulations, (*a*) £28,148 (increase £9,272), (*b*) £177,986 (increase £61,536); other electrical goods and apparatus, (*a*) £39,436 (increase £623), (*b*) £369,057 decrease £26,700). Total of electrical goods and apparatus, other than machinery and telegraph and telephone wire, (*a*) £276,576 (increase (£154,466), (*b*) £1,703,030 (decrease £233,760).

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned Applications (except those marked †) are not open to public inspection until after acceptance of Complete Specifications. Those marked † are open for inspection 12 months after the date attached to them, if they have not been published previously in the ordinary course. Names within parentheses are those of communicators of inventions. When Complete Specification accompanies application, an asterisk is affixed.*

July 29, 1907.

17,300 BUCKTON. Combined electric connection plug, socket and switch.
17,303 CAINK. Electrical variable-speed device.
17,308 WAPPLER & FAYER. Interrupters for electric circuits.*
17,309 BONNELLA & BONELLA. Electric lamp fittings.
17,326 BRAUN & BOCKMANN. Construction of insulation for magneto-electric apparatus. (Date applied for, 26/3/07.)*†
17,332 MLADEK & MLADEK. Electric transmission at a distance.
17,346 PRESTON & THEOBALDS. Electric lamps.
17,348 CARUS-WILSON. Tramway wheels.
17,355 BERGHE & THOMSON. Plug element for effecting temporary electrical connections.
17,360 COOLIDGE. Filaments for electric lamps or other apparatus. (Date applied for, 1/8/06.)*†

July 30, 1907.

17,361 ALLGEMEINE ELEKTRICITATS-GES. Controllers for electric motors and the like. (Date applied for, 30/7/06.)*†
17,406 KENNEDY & DAVIS. Galvanic sock.
17,409 MEDLEY. Storage battery.
17,410 SIEMENS-SCHUCKERTWERKE, G.M.B.H. Switches. (Date applied for, 24/9/06.)*†
17,455 DEUTSCHE TELEPHONWERKE G.M.B.H. Electric signalling apparatus. (Date applied for, 24/8/06.)*
17,456 DEWHURST. Parallel break change-over switch.
17,457 HICKLEY. Electrolytic alternating-current rectifiers.*
17,458 HICKLEY. Electrolytic cells.*
17,463 POSTANS. Electrical ignition devices.
17,472 HASLAM, RAND & SMITH. Attachment for the mouthpieces of telephone instruments.
17,474 B.T.-H. Co. (G.E. Co., U.S.) Alternating-current motors of the commutator type and operating the same.
14,475 B.T.-H. Co., WEDMORE & HAMLYN. Circuit breakers.

July 31, 1907.

17,489 FENNELL & PERRY. Electrodes for storage batteries.
17,490 FENNELL & PERRY. Thermo-electric generators.
17,515 TERRELL. Electrical apparatus such as storage batteries.
17,526 TRAINOR. Electric vehicles, boats, and the like.
17,532 MITCHELL. Surface contact electric traction systems.
17,539 GILSTRAP. Elevated electric railways. (Date applied for, 31/7/06.)*
17,548 MILTON. Inductor generators for ignition and like purposes.*

August 1, 1907.

17,554 NICHOLS & LE MAITRE. Winches for electric arc lamps and other purposes.
17,555 NICHOLS & LE MAITRE. Gearing.
17,557 VERITYS LIMITED & WORSLEY. Cutouts for arc lamp and other circuits.
17,565 WARD, GOLDSTONE & GOLDSTONE. Switches combined with fuses.
17,584 HARDING. Switches for electric bells.
17,617 CARTER. Coin controlled pay station for telephones.*
17,635 MILTON. Inductor generators.*

August 2, 1907.

17,655 HEYS. (Scott Electrical Co., U.S.) Arc lamps.*
17,658 BEXON & BEXON. Prepayment electric meters.
17,659 THOMPSON & DAVIS. Adapter for incandescent electric lamps.
17,661 DOWSING. Switch for series lighting.
17,686, 17,690 & 17,695 STONE. Space telegraphy. (Date applied for, 3/8/06.)*†
17,698 KRIÉGER & CIE PARISIENNE DES VOITURES ELECTRIQUES. Commutators and brush carriers of electric machines. (Date applied for, 29/1/07).*†
17,704 MARZI. Loud-speaking telephone apparatus. (Date applied for, 25/4/07.)*†
17,707 HUNTER & WARREN. Switches.*

SPECIFICATIONS PUBLISHED.

1906 SPECIFICATIONS.

14,935 ALLGEMEINE ELEKTRICITÄTS GES. Dynamo-electric machines. (Date applied for, 30/6/05.)
17,236 BURNAND. Regulation of multi-speed electric motors.
18,309 THOMSON. Reversible seats for trains, tramcars, &c.
18,466 CHARONNE. Vapour lamps and burners.
18,622 JUSTICE. (Deutsche Gasglühlicht A.-G., Auerges.) Metallic incandescence bodies for glow lamps.
18,739 MENDELSON. Electric motors.
19,560 GADSBY. Tramway rails.
20,942 KNOWLES. Current collectors for electric vehicles.
21,043 VAN RADEN & ROBINSON. Batteries.
21,206 VENNER & GRIESBACH. Electrical time-switches.
22,000 SOKAL, BLOOMFIELD, WOLF & WOLFF. Storage batteries.
23,810 AYTON. Electric ignition devices.
24,651 JÄGER. Fire escape with alarm device,
28,406 GRATZE. Plates for secondary and storage cells.
29,642 DAKE. Turbines. (Date applied for, 1/10/06.)

1907 SPECIFICATIONS.

2,877 RÜTER. Galvanic cells. (Date applied for, 6/2/06.)
5,899 BOULT. (Macquaire.) Sparking-plugs.
6,368 SOUTHALL. Base for tramway poles.
6,809 MOY, BASTIE & E. F. MOY. Starting switches for motors.
7,791 GRÖNWALL, LINDBLAD & SÅTLHANE. Electric transformer furnaces.
7,829 EMMET. Electric power transmission apparatus. (Date applied for, 4/4/06.)
8,829 WALSH & DUNNE. Outdoor seats for tramcars and the like.
10,356 SCHMIDT. Electrical commutator machines. (Date applied for, 3/5/06.)
10,452 ALLGEMEINE ELEKTRICITÄTS GES. Electric traction. (Date applied for, 4/5/06.)
12,458 VARNEY. Trolley line construction. (Date applied for, 4/6/06.)
12,795 FROST. Earth anchor for telegraph and telephone poles.
23,071 GEB. SIEMENS & Co. Electrode for search-lights. Date applied for, 8/6/06.)

COMPANIES' MEETINGS AND REPORTS.

Willans & Robinson (Ltd.)

The ordinary general meeting was held on Wednesday, under the presidency of Mr. MARK ROBINSON, M.Inst.C.E.

The SECRETARY (Mr. C. S. Essex) having read the notice convening the meeting,

The CHAIRMAN said gentlemen, I would begin by pointing out that the marked improvement in the final results, as compared with last half-year, is primarily due to the late reduction of capital, which not only permits of the distribution of profit when made, but, by removing for the present the necessity for further writing-down from the reduced valuation of Queen's Ferry, has added very substantially to the net profit. I will revert to Queen's Ferry figures, but will deal first with the subject of Rugby, and the new business there which is taking the place of the old business which failed us. It is no small thing to be able to say that for the year—that is, for the two half-years—ending last June, the Rugby profits exceeded £41,000. You may remember that we assumed the normal Rugby profits, on present working capital, to be £40,000 per annum. As you know, it is only for the second half of this period that we are permitted to pay a dividend, and, unluckily, the latter of the two half-years, that ending in June, has been (as it nearly always is) less profitable than that which preceded it. Allowance must also be made for merely accidental fluctuations resulting from the very short period of our accounts—six months, instead of the 12 months usual with industrial companies. Moreover, the prices of all materials used in engineering have continued very high. I am not saying that any of these causes fully account for the falling off in the half-year's profit at Rugby, which is now £18,275, against £22,977 in the previous half-year. Competition in the engineering trade has greatly increased and continues to cut down prices and profits with growing harm to the trade and little gain to anyone else. We have avoided reckless tendering, and it is, therefore, the more gratifying that we have carried off by far the greater share of the publicly-advertised contracts for steam turbines, though our prices are rarely the lowest; we get this preference on the ground of reputation, and I am happy to believe that the preference increases rather than diminishes as time goes on. The dividend we propose on the

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ordinary shares is a small one viewed in relation to the old nominal value of the shares. But we have never suggested to the shareholders that the restoration of the company's position could be other than gradual, and the payment of 10 per cent. on the reduced value, with another 8 per cent. carried forward, is at least a promising beginning. In future half-years, we must remember, there will be £1,750 to provide for interest on and redemption of the funding certificates issued in settlement of the arrears of preference dividends. It will be seen that at Queen's Ferry there is a loss of £2,223, against a loss of £12,204 last time. This great reduction is not wholly, though it is mainly, due to the absence of depreciation, and the improvement is, therefore, real and substantial, and as stated in the report, the loss which still remains is less than the amount charged against Queen's Ferry as its contribution to debenture interest and directors' remuneration. The question whether those works should be developed with a view to real profit-making is one upon which some of us hold strong opinions, but we are all agreed that, since development implies additional outlay, this company cannot itself undertake it. In connection with the development of our foreign trade, you will remember that Mr. Lazenby has been for some time in Japan. He has had much American competition to overcome, but he has secured for us one order of great importance, because it introduces our turbines into one of the prominent lighting schemes in Japan, and we hope this may be the forerunner of much future work there. Similarly we are engaged in developing our business on the Continent, where those already in possession are too strong to be dispossessed immediately, but our efforts may bear fruit later. In regard to the recent growth of our business, disregarding everything but steam turbines and the accessories immediately connected with them, in the first half of this year, the half-year whose accounts we are discussing, the horse-power of the turbines ordered from us was approximately two-thirds of that ordered in the whole of 1906, and the orders in the first three months of the current half-year fall not greatly short of those for the six months preceding. We are also developing an important business in separate condenser plants, and of these more were ordered from us in the first half of 1907 than in the whole of 1906. This gives ground for believing that even with the present low prices we shall continue to improve our position in the future. I now move the adoption of the report and accounts.

Capt. BECKFORD seconded the motion, which was carried with four dissentients.

A resolution approving the dividends on the preference and ordinary shares was agreed to with two dissentients, and a vote of thanks to the chairman brought the meeting to a close.

CLEVELAND & DURHAM ELECTRIC POWER (LTD.)—Mr. Chas. Emmot stated at the meeting on Wednesday that when the statutory companies' undertaking was taken over in July of last year, the business secured by it was only equivalent to 1,000 H.P. Now the contracts closed amounted to 12,000 H.P., and negotiations were proceeding with prospective consumers, whose requirements were equivalent to 25,000 H.P. The total requirements in the company's area reached about 225,000 H.P., the whole of which could in the couse of time be dealt with on terms which would both be profitable to the company and show substantial savings to the various power users. No power user in the area would find it profitable to put down independent plant. The company's relations with local authorities in its area were satisfactory. Middlesbrough Corporation had taken a large proportion of its supply from the company in bulk. An agreement was approaching completion with Hartlepool Corporation which would enable the company for 42 years to actively develop power and lighting business in Hartlepool. The company was willing to negotiate with Stockton, West Hartlepool and Darlington Corporations. A matter of great importance was the application of electricity to rolling mills. Recent advances in that direction represented the most important development in the application of electricity to power purposes that had taken place in the last five years. It now appeared certain that electricity would replace steam for all rolling mill work in the couse of the next few years. As the Cleveland district produced between one-third and one-half of the iron of the United Kingdom, that development would have extensive and very favourable bearings on their company's progress. They hoped before next year to have connected with the company's system two large rolling mills, each of over 1,000 H.P.

EDISON & SWAN UNITED ELECTRIC LIGHT CO. (LTD.)—The directors' twenty-fourth annual report for the year ended June 30 last states that £54,236. 15s. 6d. was brought forward from profit and loss account. Interest on debenture stocks absorbed £16,390; £11,000 was set aside as depreciation on freehold and leasehold property, plant, machinery and tools; £1,476. 15s. 10d. applied in writing down values of stocks; £1,355. 3s. 3d. reserved on account of bad and doubtful debts; and £7,500 added to reserve. The result is a credit balance of £16,514. 16s. 5d., added to £9,006. 17s. 11d. brought forward, making £25,521. 14s. 4d. Out of this the directors recommend payment of a dividend for the year on the A shares at the rate of 4½ per cent. (being 4s. 2d. per fully-paid A share and 2s. 6d. per part paid A share), amounting to £15,978. 5s., and leaving £9,543. 9s. 4d. to be carried forward. During the year £6,100 of the company's debenture stocks have been purchased and cancelled, resulting in a profit of £582. 4s. in addition to that shown previously. This has been appropriated as reserve against stock depreciation. Cost of establishing the business, goodwill, &c. (£390,432. 8s. 1d.), and the freehold and leasehold property, plant and machinery have been brought forward at the values stated in the last balance sheet, with the addition of the amount expended to June 30, less depreciation charged in net revenue account. There has been expended on capital during the past year, £7,657. 13s. 1d. The shares of the Altrincham Electric Supply (Ltd.) have been taken at par, as in previous years. This concern continues to show satisfactory progress and has paid a 5 per cent. dividend for 1906. Its indebtedness to this company has been reduced during the year by £341. 8s. 3d. Mr. H. Wolfenden, jun., has been elected a director.

HOBART ELECTRIC TRAMWAY CO. (LTD.)—At the meeting on Friday the chairman (Dr. A. Mattei) congratulated the shareholders upon having at last reached the dividend stage. They were now able to declare a dividend of 5 per cent. Traffic receipts had increased so satisfactorily since the closing of the accounts that he thought he was justified in saying that they might look forward to a better dividend in the future.

NEW COMPANIES, STATUTORY RETURNS, MORTGAGES AND CHARGES.

NEW COMPANIES.

ST. ALBANS & LUTON MOTOR CO. (LTD.) (95,056.)—Reg. Sept. 28, capital £5,000 in £1 shares, to acquire the business carried on at St. Albans and Luton by Tilley, Giffen & Co., and to carry on the business of motor-car, electrical and mechanical engineers, manufacturers of motor-cars, &c. Regis tered office, London-road, St. Albans, Herts.

SIMMS MFG. CO. (LTD.) (95,109.)—Reg. Oct. 3, capital £60,000 in £1 shares, to acquire the business of the Simms Mfg. Co. (Ltd.) in connection with motors, motor vehicles and accessories, magnetos, &c., and to carry on the business of manufacturers of and dealers in magnetos, magneto parts and accessories, motors, carriages, &c., electricians, suppliers of electricity, &c. First directors: F. R. Simms, H. J. Donkin and J. W. P. Peters.

STATUTORY RETURNS.

CHILI TELEPHONE CO. (LTD.)—In the return to Aug. 1 capital is given as £250,000 in £5 shares, 44,000 of which have been taken up. £5 per share has been called up and £220,000 has been received. Mortgages and charges, £12,000 bonds to bearer.

LONDON ELECTRICAL FITTINGS CO. (LTD.)—Return to Aug. 25 gives capital as £3,000 in £1 shares, of which 2,999 have been taken up. £1,299 has been received and £1,700 is considered as paid. Mortgages and charges, nil.

THOMAS PARKER (LTD.)—The return to Aug. 14 gives capital as £75,000 in £10 shares, all of which have been taken up. £10 per share has been called up on 5,750, and £57,500 has been received. £17,500 is considered as paid on 1,750 shares. Mortgages and charges, £65,000.

MORTGAGES AND CHARGES.

ELECTRICAL PUBLISHING CO. (LTD.)—Issue on Sept. 25 of a £25 6 per cent. debenture, part of a series created Jan. 21, 1907, to secure £1,500, charged on company's undertaking and property, present and future, including uncalled capital. No trustees. Previously issued of same series, £600.

WRIGHT & WOOD (LTD.)—Particulars of £800 debentures, created by resolution of Sept. 25, 1907, have been filed. Property charged: Company's undertaking and property, present and future, including uncalled capital. No trustees.

CITY NOTES.

MEMORANDA (Oct. 10).—Bank rate 4½ per cent. (since Aug. 15, 1907). Price of silver 29 7/16—29 1/16d. per oz. Consols 82 1/16—82 3/16 for money, 82 1/16—83 for account; 2½ per cent. annuities 81½—81⅝. Consols Pay Day, Nov. 6; Stocks and Shares Continuation Days, Oct. 28 and Nov. 12; Ticket Day, Oct. 29; Pay Days, Oct. 11 and 30; Mining Share Carry-over Day, Oct. 25.

ANGLO-AMERICAN TELEGRAPH CO. (LTD.)—The directors have declared an interim dividend for the quarter ended Sept. 30 of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred stock (less tax), payable Nov. 1.

COMPANIES STRUCK OFF THE REGISTER.—The following were struck off the Register of Joint Stock Companies on Nov. 4: Brighton & Shoreham Tramways Co., Britannia Electric Carriage Synd., Electric Heating Corpn., Mfg. Electric Co., Suspended Electric Railway Co. and Zea Arc Lamp Co.

CONSOLIDATED SIGNAL CO. (LTD.)—The directors recommend a final dividend on the ordinary shares of 2s. per share, making 3s. per share for the year, tax free.

DIRECT UNITED STATES CABLE CO. (LTD.)—The board have resolved upon the payment of an interim dividend of 4s. per share (tax free), being at the rate of 4 per cent. per annum for the quarter ended 30th ult., payable 26th inst.

PRIMITIVA GAS AND ELECTRIC LIGHTING CO. OF BUENOS AIRES (LTD.)—An interim dividend of 2s. 6d. per share has been declared on the ordinary shares.

STOCK EXCHANGE NOTICES.—The Stock Exchange committee have appointed Oct. 16 a special settling day in funding certificates for £34,999. 13s. of *Willans & Robinson (Ltd.)*, and have ordered $131,551.40 $100 capital stock of the *American Telephone & Telegraph Co.* to be quoted. The committee have been asked to grant a quotation to 40,000 £5 fully paid 6 per cent. cumulative preference shares of the *Hastings & District Electric Tramways Co. (Ltd.)* (renewed special application.

SUBMARINE CABLES TRUST.—The coupon due on 15th inst. will be paid on that date by Messrs. Glyn, Mills & Co., 67, Lombard-street, London, E.C.

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ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Aberdeen Corporation	Oct. 2	1,411	− 693	18	28,005	− 1,666
Airdrie	Sept. 27	228	− 12	38	8,534	− 63
Anglo-Argentine	Oct. 7	12,376	+ 1,658	40	661,144	+ 64,633
Ashton-under-Lyne Corp	,, 5	398	+ 25	28	11,287	+ 1,107
Ayr Corporation	,, 5	323	+ 95	21	8,469	− 198
Baker St. & Waterloo Ry.	,, 5	2,515	+ 870	14	31,960	+ 12,495
Barnsley	Sept. 27	168	+ 5	38	6,443	+ 74
Barrow	,, 27	278	− 11	38	10,097	− 170
Bath Electric Trams, Ltd.	Oct. 2	844	− 68	40	32,486	− 1,383
Birkenhead Corporation	,, 6	1,113	− 4	1	1,113	− 4
Birmingham Corporation	,, 5	6,301	...	27	164,474	...
Birmingham & Mid.	Sept. 20	863	...	37	30,435	...
Blackburn Corporation	...	...	...	...	...	...
Blackpool Corporation	Oct. 3	1,425	+ 197	26	42,252	− 1,685
Blackpool and Fleetwood	,, 5	784	+ 40	1	784	+ 40
Blackp'l St. Anne's & Lytham	...	...	...	...	...	...
Bolton Corporation	,, 6	2,276	+ 131	37	63,070	+ 3,683
Bournemouth Corporation	,, 2	1,713	+ 38	¶36	50,834	+ 979
Bradford Corporation	,, 5	4,787	+ 226	27	128,854	+ 1,614
Brighton Corporation	,, 6	923	− 64	27	27,404	− 2,747
Brisbane Trams	...	...	...	...	...	...
Bristol Trams & Carriage	,, 4	5,237	− 110	13	66,157	− 884
Burnley Corporation	,, 5	1,378	+ 6	1	1,378	+ 6
Burton Corporation	,, 6	816	− 26	27	8,105	− 398
Bury Corporation	Sept. 29	1,222	...	26	29,800	...
Calcutta Tramways Co.	Oct. 5	¤52,526	† ¤11,940	13	¤621,912	+ ¤40,864
Camborne-Redruth	,, 5	128	+ 9	40	4,916	+ 113
Cardiff Corporation	,, 5	2,078	− 94	27	60,335	+ 1,602
Cavehill	Sept. 27	111	− 19	38	3,397	− 148
Central London Railway	Oct. 5	5,312	− 1,014	14	67,881	− 10,597
Charing C., Euston & H'stead	,, 5	2,650	...	14	35,195	...
Chatham & Dist. Lt. Rys.	,, 3	791	− 112	¶39	29,206	+ 1,549
City & South London Rly.	,, 6	3,001	+ 360	14	42,360	+ 7,076
City of Birmingham	Sept. 27	2,958	...	38	107,167	...
Colchester Corporation	...	...	...	...	...	...
Cork Electric Trams Co.	Oct. 3	530	+ 22	40	18,909	− 727
Croydon Corporation	,, 4	1,503	− 2	27	39,885	− 1,844
Devonport & Dist. Trams	Sept. 27	486	+ 12	38	17,851	− 154
Dover Corporation	Oct. 5	244	− 13	27	6,861	− 934
Dublin & Lucan Railway	,, 4	138	+ 13	14	2,184	+ 179
Dublin United	,, 4	6,761	+ 1,573	‡14	103,199	+ 24,280
Dudley Stourbridge	Sept. 27	923	− 109	38	33,323	− 952
Dundee Corporation	Oct. 2	1,180	+ 13	20	23,308	+ 484
East Ham Council	,, 5	944	+ 9	27	25,379	− 208
Exeter Corporation	,, 4	327	− 23	27	9,187	+ 686
Falkirk and District	,, 2	317	...	...	...	...
Gateshead & Dist. Trams	Sept. 27	1,009	+ 12	38	38,600	+ 909
Glasgow Corporation	Oct. 5	19,689	+ 1,838	18	310,997	+ 6,373
Glossop	,, 5	129	− 17	40	5,459	− 3
Gloucester Corporation	...	...	...	...	...	...
Gravesend—Northfleet	Sept. 27	271	+ 19	38	9,568	− 51
Great Northern & City Rly.	Oct. 5	1,709	− 97	14	22,313	− 304
Gt. Northern, Piccadilly, &c.	,, 5	4,340	...	14	54,745	...
Greenock & Port Glasgow	Sept. 27	692	− 161	38	25,656	− 1,600
Halifax Corporation	...	...	...	...	...	...
Hartlepool Tramways	,, 27	312	+ 11	38	11,356	− 628
Hastings Elec. Trams Co.	Oct. 3	1,211	+ 334	14	18,862	+ 927
Hong Kong	,, 5	$8,611	+ $190	25	$310,238	+ $39,615
Huddersfield	,, 5	1,557	− 23	27	44,196	+ 1,986
Hull Corporation	,, 5	2,436	+ 51	27	64,950	+ 3,308
Ilford District Council	,, 5	463	+ 26	27	13,294	− 545
Ilkeston District Council	,, 2	152	+ 9	27	3,988	+ 211
Ipswich Corporation	,, 5	416	− 19	27	11,963	− 911
Isle of Thanet Co.	...	...	...	...	...	...
Jarrow	Sept. 27	118	...	38	4,736	...
Keighley Corporation	Oct. 3	170	+ 13	14	2,376	+ 164
Kidderminster & District	Sept. 27	132	+ 18	38	4,777	− 147
Kilmarnock Corporation	Oct. 5	167	− 6	20	3,380	− 92
Kirkcaldy Corporation	...	...	...	...	...	...
Lanarkshire Trams Co.	,, 3	1,506	+ 516	40	47,488	+ 12,123
Lancashire United	,, 2	1,446	+ 21	40	51,026	+ 12,687
Leamington	Sept. 27	177	+ 13	38	6,325	− 698
Leeds Corporation	,, 28	6,860	+ 550	26	173,323	+ 7,203
	Oct. 5	6,635	+ 206	1	6,635	+ 206
Leicester Corporation	,, 5	2,228	− 121	14	30,767	− 536
Leith Corporation	,, 5	558	+ 13	‡21	11,312	− 55
Lincoln Corporation	,, 5	111	− 4	27	3,313	+ 78
Liverpool Overhead Rly.	,, 6	1,482	+ 59	14	22,933	+ 1,361
Liverpool Corporation	Sept. 28	11,420	+ 243	39	426,868	+ 7,488
*London County Council	,, 28	32,958	+ 7,054	26	819,096	+ 134,738
London United	Oct. 4	6,879	+ 558	‡40	265,003	+ 11,515
Lowestoft	,, 4	227	+ 4	1	227	+ 4
Maidstone Corporation	,, 5	141	+ 13	27	3,161	− 254
Manchester Corporation	,, 5	15,423	+ 551	27	406,785	+ 30,409
Mersey Railway	,, 5	1,977	+ 155	14	25,529	+ 1,868
Merthyr	Sept. 27	229	+ 18	38	8,085	+ 415
Metropolitan Dist. Railway	Oct. 6	8,006	− 173	14	102,489	− 918
Metropolitan Elec. Trams	Sept. 27	5,456	+ 1,820	38	179,699	+ 45,133
Middleton	,, 27	389	+ 30	38	13,837	− 141
Nelson Corporation	Oct. 5	139	− 18	¶27	4,124	− 9
Newcastle-on-Tyne Corp.	,, 5	4,089	− 30	27	111,462	+ 398
Newport (Mon.)	,, 5	667	+ 13	27	19,458	+ 1,655
Northampton Corporation	,, 1	448	− 29	‡27	12,184	− 556
Oldham, Ashton & Hyde	Sept. 27	654	+ 61	38	23,380	+ 1,108
Oldham Corporation	Oct. 6	1,941	+ 41	28	55,168	+ 3,393
Perth (N.B.) Corporation	,, 2	182	+ 20	20	3,520	− 20
Perth (W.A.) Elec. Trams	,, 4	1,343	− 20	40	55,986	− 1,995
Peterborough	Sept. 27	141	+ 16	38	4,944	− 240
Pontypridd District Coun.	...	...	...	...	...	...
Portsmouth Corporation	Oct. 5	2,018	− 13	27	58,988	− 2,060
Potteries	Sept. 27	1,956	+ 112	38	71,854	+ 2,185
Preston Corporation	Oct. 2	782	+ 5	...	...	...
Rochdale Corporation	...	...	...	...	...	...
Rotherham Corporation	,, 3	622	+ 119	‡27	16,704	+ 2,620
Rothesay	Sept. 27	234	− 123	38	9,824	− 726
Salford Corporation	Oct. 7	4,725	+ 115	27	129,013	+ 3,480
Sheerness	Sept. 25	66	+ 5	38	2,258	− 67
Sheffield Corporation	Oct. 6	5,720	+ 214	28	156,569	+ 6,983
Singapore Trams	,, 5	$9,415	+ $691	1	$9,415	+ $691

(a) These comparisons are with the corresponding period last year. ¶ Plus 3 days.
* Partly electrical. † Minus 3 days. ‡ Minus 2 days.

ELECTRIC TRAMWAY AND RAILWAY TRAFFIC RECEIPTS.

Line.	Week ended.	Amount.	Inc. or Dec. (a)	Aggregate. No. of weeks.	Aggregate. Amount.	Aggregate. Inc. or Dec. (a)
		£	£		£	£
Southampton	...	...	...	...	...	...
Southend Corporation	Oct. 2	451	+ 44	27	12,787	− 171
South Metropolitan	Sept. 27	948	+ 466	38	31,885	+ 7,168
Southport Tramways	,, 27	351	+ 14	38	12,079	− 619
South Staffs	,, 27	932	− 5	38	31,519	+ 2,201
Stalyb'dge, Hyde, &c., Jt. Bd.	...	...	...	...	...	...
Stockport Corporation	...	...	...	...	...	...
Sunderland Corporation	Oct. 6	1,357	− 57	27	39,342	− 550
Sunderland and District	,, 2	458	+ 42	40	18,195	+ 2,037
Swansea Trams	Sept. 27	1,019	+ 118	38	35,491	+ 2,408
Swindon Corporation	Oct. 2	184	+ 4	...	...	...
Taunton	Sept. 27	46	− 1	38	1,707	− 113
Tynemouth and District	,, 27	247	+ 27	38	9,999	− 731
Tyneside Trams Co.	Oct. 2	448	+ 8	40	18,642	+ 737
Victoria, Elec. Supply Co. of	Sept. 1	726	+ 109	...	...	...
Wallasey District Council	Oct. 5	834	+ 8	27	24,073	+ 565
Walsall Corporation	,, 5	558	+ 20	40	20,640	− 51
Warrington Corporation	,, 3	400	+ 17	27	10,296	+ 407
West Ham Corporation	,, 3	2,358	...	27	64,229	+ 1,403
Weston-super-Mare	Sept. 25	242	+ 43	38	6,464	− 451
Wolverhampton Co.	,, 27	475	+ 19	38	17,674	+ 1,066
Wolverhampton Corpn.	Oct. 2	929	+ 51	11	9,718	+ 91
Worcester	Sept. 27	325	+ 24	38	11,121	− 219
Wrexham	,, 27	111	+ 2	38	3,991	− 66
Yorkshire W.R. Trams	Oct. 6	1,214	+ 309	40	46,691	...
Yorkshire Woollen District	Sept. 27	893	− 34	38	36,349	+ 944

(a) These comparisons are with the corresponding period last year. * Partly electrical.

COLONIAL AND FOREIGN INVESTMENTS.

SHRE.	LAST DIVIDEND	NAME.	Price Wed., Oct. 9.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO OCT. 9. High-est.	BUSINESS WEEK TO OCT. 9. Low-est.
		ELECTRIC RAILWAYS, TRAMWAYS, &c.		£ s. d.			
5	4/0	†Anglo-Argentine Ord. Shares	7½—8	5 0 0	Ap, Oct	8	7½
5	..	Do. 5½ per Cent. Cum Pref.	5⅛—6⅛	4 8 3	Ja, Jul	6⅛	5⅛
St.	6½	Do. Permanent 6% Deb. Stock	131 —134	4 9 9	Ju, Dec	..	..
St.	5%	Auckland Elec. Trams. 5% Deb. (red.)	102 —105	4 15 0	Ja, Jul	..	..
5	2/0	Brisbane Electric Trams, Invest. Ord.	8⅝—8⅞	2 16 0	May ..	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	4⅞—5⅛	4 18 6	My, Nv	4⅛	4⅞
St.	4½%	Do. 4½ per Cent. Db. Prov. Certs.	96 —100	4 10 0	Ja, Jul	..	..
St.	7%	British Columbia El. Ry. Df. Ord.	130 —135	4 16 0	Mr, Spt	..	..
St.	6%	Do. Pref. Ord. Stock	113 —117	4 5 3	My, Nv	..	..
St.	5%	Do. 5% Cum. Perp. Pref. Stock	104 —107	4 13 6	Ja, Jul	106½	..
40	4½%	Do. 4½ per Cent. 1st Mort. Debs.	100 —103	4 7 3	Ap, Oct	101½	..
100	4½%	Do. Vancouver Power Debs.	102 —104	4 6 6	Ja, Jul	4½	..
5	3/0	Buenos Ayres & Belgrano Ord.	4¼—4⅛	8 9 3	Ap, Oct	..	..
5	3/0	† Do. 6 per Cent. "A" Cum. Pref.	4⅝—5⅛	5 14 0	Ap, Oct	..	..
5	3/0	† Do. "B"	4⅝—5⅛	5 14 0	April ..	..	..
St.	5%	Do. 5 per Cent. Debs.	105 —115	4 7 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. 2nd Debs. (red.)	102 —105	4 15 3	Ja, Jul	..	..
St.	5%	Buenos Ayres Elec. Trams. (1901) Ltd.	92 —97	5 8 0	Ja, Jul	..	..
100	5½%	Buenos Ayres Grand National 5½ per Cent. Pref. Debs.	99 —103	5 7 0	Ja, Jul	..	..
100	6%	† Do. 6 per Cent. 1st Deb. Bonds	98 —103	5 17 6	Ap, Oct	..	..
5	4/6	Calcutta Tramways (1 to 137,610)	7 —7½	5 6 9	Mr, Spt	7⅛	..
100	2/6	Do. 5 per Cent. Cum. Pref.	5 —5⅛	4 11 0	Ja, Jul	..	..
1	4½%	Do. 4½% 1st Deb. Stock (red.)	102 —106	4 5 0	Ja, Jul	103½	..
S.	..	Cape Electric Tram Shares	⅛—⅜	..	..	..	..
..	5%	Colombo Tr. & Ltg. 5% 1st Mt. Db.	94 —98	5 2 0	My, Nv	..	..
1	5%	Havana Elec. Ry. Con. Mt. 5% $1,000 50 year Coup. Bds.	82 —87	5 15 0	Fb, Aug	..	..
100	5%	Kalgoorlie Elec. Trams. 5 per Cent. "A" Deb. Stock	89 —93	5 6 8	Ja, Jul	..	..
£	6%	Do. 6 per Cent. "B" Ditto	77 —81	7 8 0	Ja, Jul	..	..
5	1/0	Lisbon Elec. Trams. Ord.	1 —1¼	4 0 0	July ..	..	..
100	0,7½	Do. 6 per Cent. Cum. Pref.	1 —1¼	4 16 0	Ja, Jul	..	..
St.	5%	Do. 5 per Cent. Reg. Mort. Deb.	92 —97	5 2 6	Ja, Jul	..	..
St.	5%	Madras Elec. Trams. 5% Deb. Stk.	96 —19	5 1 0	Ja, Jul	..	..
St.	4½%	Montreal St. Ry. Sterling 4½ per Cent. Debs. (1922)	101 —103	4 7 6	Fb, Aug	..	..
St.	6%	Perth E. Trams. 1st Mt. Db. Stock	101 —105	4 15 0	Ja, Jul	102½	..
..	$2	†Sao Paulo Tramway, Light & Power Co. $100 Stock	103 —113	7 1 0	..	..	..
..	5%	Do. 5 per Cent. 1st Mt. $500 Db	93⅞—95⅞	5 5 0	Ju, Dec	94½	..
		ELECTRICITY SUPPLY.					
5	3/0	Adelaide Elec. S'ply Co. 6% Cu. Pr.	4½—5	6 0 0	Mr, Spt	..	..
10	4/8	Bombay E. S. & T. 6% Cm. Pf. £8 pd.	7⅛—8	6 0 0	..	7⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stk. (red.)	94 —99	4 13 9	Ja, Jul	..	..
5	5/3	Calcutta Elec. Supply Ord. (1 to 80,000)	6½—7½	5 6 9	Ap, Oct	..	..
5	2/3	Do. (80,001 to 100,000)	6½—7½	..	..	..	..
50	5%	City of Wellington Elec. Lt. and Power 5 per Cent. Reg. 1st Debs.	50 —53	4 14 3	Ja, Jul	..	..
5	..	Elec. Ltg. & Trac. Co. of Aust. 6 per Cent. Cum. Pref.	2½—2¾	..	Fb, Aug	..	..
St.	5%	Do. 5 per Cent. Deb Stock	89½—92½	5 11 6	Ja, Jul	..	..
St.	5%	Elec. Supply Co. of Victoria 5 per Cent. 1st Mort. Deb. St.	94 — 96	5 4 0	Ja, Jul	..	..
St.	6%	Indian Elec. Sup. & Trac. Co. Deb. St. Rd. Prov. Certs.	101 —104	5 15 6	Ja, Jul	..	..
1	0/3½	Kalgoorlie Elec. Power & Ltg. 6 per Cent. Cum. Pref.	1⅜—1⅝	..	Ap, Oct	..	..
St.	5%	Madras E. S. Corp. 5 per Cent. Constn. Deb. St.	94 —97	5 3 0	Ap, Oct	..	..
1	0/6	River Plate Electricity Co. Ord.	⅝—¾	3 6 9	April ..	..	..
1	1 2/3	Do. 6 per Cent. non-Cum. Pref.	1—1	6 0 0	May ..	..	..
St.	5%	Do. 5 per Cent. Deb. Stock	95 —98	5 2 0	Ja, Jul	..	..
5	3/0	†Rosario Elec. Co. 6% Pref. (1-20,000)	5⅞—5⅞	5 11 6	Ap, Oct	..	..
..	5%	Shawinigan Water & Power 5 per Cent. Bds.	99 —101⅞	4 19 0	Ja, Jul	100½	100

* In calculating the yield, allowance has been made for accrued interest but *not* for redemption. † Ex Dividend.

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ELECTRICAL COMPANIES' SHARE LIST.

SHARE.	LAST DIVIDEND	NAME.	Price Wed., Oct. 9.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO OCT. 9. High-est.	Low-est.
		ELECTRICITY SUPPLY.		£ s. d.			
10	5/0	Bournemouth & Poole Elec. Sup. Ord...	9⅜–10⅜	6 10 0	Mar, Sept,	10½	—
10	4/6	Do. 4½ per Cent. Cum. Pref.	9⅜–10⅜	4 8 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Second Pref. ...	9⅜–10⅜	5 17 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock (red.) ...	99 – 102	4 8 0	Jan, July	..	..
5	2/0	†Bromley (Kent) El. Lt. & Power Shares	⅞–1⅛	5 7 0	April, Oct	..	..
St.	4½%	Do. Do. 1st Debs.	98 –100	4 10 0	May, Nov	99	98½
5	4/6	Brompton & Kensington Elec. Sup. Ord.	7⅜– 8	6 5 0	March	..	..
5	3/6	Do. 7 per Cent. Pref.	7¼–7½	4 13 0	Mar, Sept	..	..
St.	4%	Central Elec. Sup. Co.4% Guar.Db.Stock	99 – 102	3 18 0	June, Dec	..	..
5	2/6	Charing Cross (W.End & City) El.Sup.Co.	8¾–4½	5 13 9	Feb, Aug	4	..
5	2/3	Do. 4½ per Cent. Pref.	3¾– 4	5 12 6	Feb, Aug	3¹³/₁₆	3¾
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	96 – 99	4 1 0	Jan, July	..	..
5	2/3	Do. City Undertaking 4½% Cm. Pref.	3¾–4⅞	6 2 6	Jan, July	..	..
5	2/0	Chelsea Electric Supply Ord.	3¾–4½	5 6 0	March ..	..	..
St.	4½%	* Do. 4½ per Cent. Deb. Stock (red.) ...	102 –105	4 5 9	June, Dec	104½	..
10	5/0	City of London Electric Lighting Ord..	9 – 9½	6 6 0	Feb, Aug	9⅝	9⅛
10	6/0	Do. 6 per Cent. Cum. Pref.	10¼–11½	5 4 6	Jan, July	10¹³/₁₆	—
St.	5%	Do. 5 per Cent. Deb. Stock (red.).....	122 –125	4 0 0	June, Dec	..	..
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock (red.)	97 –100	4 10 0	Jan, July	99	98
5	5%	County of Durham Elec. P.D. Ord.....	3¾–4	5 6 8	April, Oct	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅛–4⅞	5 4 11	April, Oct	..	..
10	4/0	County of London Elec. Supply Ord.....	6¾– 7⅜	6 9 0	Feb, Aug	..	..
10	6/0	Do. 6 per Cent. Cum. Pref.	10 –11	5 8 6	Mar, Sept	10½	..
St.	4½%	Do. 4½% Deb. Stock (all paid) (red.)...	1 7 –1 10	4 1 9	Jan, July	109	108½
St.	4½%	Do. Second Deb. Stock Prov. Certs....	96 – 99	4 11 0	May, Nov	99	97
5	2/0	†Folkestone Electricity Supply Co. Ord.	3⅜– 4⅛	5 5 0	April, Oct	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	4⅛– 4⅜	4 13 0	Mar, Sept	..	..
St.	4½%	Do. 4½ 1st Deb. Stock (red).....	96 – 99	4 11 0	Feb, Aug	..	..
5	5/0	Hove Electric Lighting Ord.	6¾– 7½	6 4 0	April, Oct	..	..
5	5/0	Kensington & Knightsbridge Ord.....	8¼–9¼	5 8 0	Feb, Aug	..	..
5	6%	Do. 6 per Cent. 1st Pref.	6½– 7	4 5 9	Jan, July	..	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.).....	94 – 97	4 1 0	..	..	..
St.	4%	Kensington. & Knghtbg. Co.& Notting Hill Co. (Joint Station) 4% Deb. Stock (red.)	99 – 102	3 18 0	April, Oct	..	..
3	2/4⅝	London Electric Supply Ord.	1¼– 1⅜	6 8 0	Mar, Sept	..	..
5	3/0	Do. 6 per Cent. Pref.	4¼– 4⅜	6 6 0	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb.	89 – 93	4 6 0	Jan, July	..	..
5	3/0	Metropolitan Electric Sup. Ord.	5⅛– 5⅜	6 1 6	April, Oct	..	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅜– 4⅝	4 5 6	Jan, July	5⅛	..
St.	4½%	Do. 4½ per Cent. Deb. Stock 1st Mort.	104 –107	4 4 0	June, Dec	..	..
St.	3½%	Do. 3½ per Cent. Mrt. Deb. Stock(red.)	88 – 91	3 17 0	Jan, July	..	..
100	4½%	Midland Elec. Corp. for P.D. 1st Mort. Db.	95 –98¾	4 11 9	June, Dec	..	..
10	5%	Newcastle & Dist. Elec. Ltg. Ord. (£9 paid)	6¾–9⅛	5 0 0	Feb, Aug	..	..
100	4½%	Do 4½ per Cent. Deb.	98 – 99	4 11 4	Jan, July	..	..
5	8%	Newcastle Elec. Supply Ord.	6⅜–6⅝	6 3 0	Feb, Aug	..	..
5	5%	Do. 5 per Cent. non Cum. Pref.	4⅞–5⅛	4 15 3	Feb, Aug	..	..
100	4%	Do. 4 per Cent, Mort. Deb. red. 1907.	97 –98	4 2 0	Jan, July	..	..
1	3%	Northern Counties Elec. Sup.	—	..	Mar, Aug	..	..
100	4½%	Do. 4½ per Cent. Deb.	97 –99	4 11 10	Jan, July	..	..
10	£/0	Notting Hill Electric Ord.....	11 –12	7 10 0	March ..	..	..
5	2/6	Oxford Electric Ord.	5½–6	5 17 0	March ..	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	95 – 97	4 2 6	Jan, July	..	..
5	5/0	St. James' & Pall Mall Elec. Ord.....	7½– 7⅝	6 9 0	Feb, Aug	..	..
5	3/6	Do. 7 per Cent. Pref.	7¼–7½	4 17 6	Feb, Aug	..	..
St.	3½%	Do. 3½ per Cent. Deb. Stock (red.) ...	86–91	3 17 0	Jan, July	..	..
5	..	Smithfield Markets Electric Sup. Ord...	¾–1⅛	..	Feb	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	71 – 75	5 6 0	Feb, Aug	..	..
5	3/0	South London Electric Supply Ord.....	2⅜– 2⅝	6 6 0	April	..	..
1	0/6	South Metrop'n Elec. Lt. & Power Ord.	½– ⅝	3 6 9	..	..	..
1	0/3⅝	Do. 7 per Cent. Cum. Pref.....	1 –1⅛	5 12 0	Feb, Aug	..	..
St.	4½%	† Do. 4½ 1st Db. Stk. Red.....	99 –102	4 8 0	April, Oct	..	..
5	2/6	†Urban Electric Supply Ord.	1⅞–2⅛	9 8 0	April, Oct	..	..
5	2/6	† Do. 5 per Cent. Cum. Pref.	1⅞–2⅛	8 14 0	April, Oct	..	..
St.	4½%	† Do. 4½ per Cent. 1st Mort. Deb.....	92 – 95	4 14 9	April, Oct	..	..
5	5/0	Westminster Elec. Sup. Ord.	8⅛– 8⅜	6 9 6	Mar, Sept	8⅛	..
5	2/3	Do. 4½ per Cent. Cum. Pref.	4⅝– 5⅛	4 8 6	Jan, July	..	..
		ELECTRIC RAILWAYS, TRAMWAYS, &c.					
St.	4%	Baker St. & Waterloo 4% Perp. Db. St.	88 – 93	4 6 0	Jan, July	..	..
1	1/0	Bath Elec. Trams Pref. Ord.	1⅛– 1⅜	5 7 0	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.....	⅝–1	5 0 0	Jan, July	1⅛	..
St.	4½%	† Do. 4½ 1st Mort. Deb. Stock (red.) ...	91 – 95	4 14 9	April, Oct	..	..
St.	4½%	B'ham & Midland Trams 4½ 1st Db. Stk.	94 – 97	4 13 0	Jan, July	..	..
10	9½%	Bristol Tramways & Carriage Ord.	14 –14½	6 8 0	Feb, Aug	..	..
10	4%	Do. Cum. Pref. (fully paid).....	8¾–9¼	4 6 6	..	..	..
St.	4%	Do. 4 per Cent. Debs.	98 – 1 0	4 0 0	Feb, Aug	..	..
10	..	British Electric Traction Ord.....	2⅜– 2¾	..	June, Dec	2⅛	1¹⁵/₁₆
10	£/0	Do. 6 per Cent. Cum. Pref.....	5⅜–6	10 0 0	Feb, Aug	5⅜	5³²/₃₂
St.	5%	† Do. 5 per Cent. Perpetual Debs.	97 – 100	5 0 0	April, Oct	97⅜	97
St.	4½%	Do. 4½ per Cent. 2nd Deb. Stock	78 –81	5 11 0	May, Nov	..	..
St.	3%	Central London Ordinary Stock..	63 – 65	5 8 0	Feb, Aug	64⅜	63
St.	4%	Do. 4 per Cent. Pref. Stock	83 – 90	4 9 0	Feb, Aug	88	..
St.	..	Do. Deferred Stock	45 – 48	8 7 0	Feb	45	..
100	4%	Do. 4 per Cent. Debs.	103 –105	3 16 0	Jan, July	..	..
St.	4%	Charing X, Euston & Hmpstd Per. Db. Stk.	81 – 84	4 15 3	Jan, July	..	..
5	2/6	City of Birmingham Trams. 5% Cm. Pref.	4¼–4⅝	5 2 6	April, Oct	..	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	98 – 101	3 19 0	April, Oct	..	..
St.	2½%	City & South London Rly. Con. Ord. ...	46 – 48	5 4 0	Feb, Aug	47	46⅝
St.	5%	Do. 5 per Cent. Perp. Pref. (1891) ...	116 –119	4 4 0	Feb, Aug	..	..
St.	5%	Do. (1896)	113 –116	4 6 0	Feb, Aug	..	..
St.	5%	Do. (1901)	113 –116	4 6 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent, Perpetual Debs.	1 2 –105	3 16 0	May, Nov	..	..
10	6/0	Dublin United Trams. (1896) Ltd, Ord...	13 – 14	4 5 9	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Pref.....	12¾–13⅜	4 7 0	Feb, Aug	..	..
10	0/11½	Gt. Northern & City Rly. Pref. Ord. (4%)	1¼–1⅜	..	Feb, Aug	1⅜	..
10	4/0	G. Northern, Piccadilly & Brompton Ord.	6 –7	5 14 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 83	4 16 6	Jan, July	82	..
St.	4½%	†Hastings & Dist. Elec. Trams. Co. 4½ Db. St	97 – 100	4 11 0	April, Oct	..	..
10	9%	†Imperial Tramways Ord.....	11 – 12	7 4 0	Mar, Sept	..	..
10	6%	! Do. 6 per Cent. Pref.	9¾–11	5 9 1	Mar, Sept	..	..
St.	4½	! Do. 4½ per Cent. Debs.	96 – 98	4 11 10	Jan, July	..	..
5	1/3	I. of Thanet E. T. & Lt. 5 per Cent. Pref.	¾–1⅜	..	Mar, Sept	..	..
St.	4%	Do. 4 per Cent. Deb. Stock.....	66 – 71	5 12 6	Jan, July	..	..
St.	5%	Lancs. Utd. Trams 5% Prior Lien Db. St.	94 –97	5 3 0	Jan, July	..	..
10	..	Liverpool Overhead Railway Ord.	1¾– 2	..	Feb, Aug	..	..
10	5%	Do. 5 per Cent. Pref.	7½– 8	6 5 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb.	85 – 87	4 12 0	Jan, July	..	..
10	5/0	London United Trams. 5% Cum. Pref. ...	5¾–6⅜	5 14 3	Jan, July	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Deb. Stock	82 – 86	4 13 0	Jan, July	..	..
St.	..	Mersey Con. Ord. Stock	2 – 4	—	Feb, Aug.	..	..
St.	..	Do. 3 per Cent. Perp. Pref.	3 – 6	—	..	4	..
1	..	Metropolitan Elec. Tramways Def.	⅛– ⅝	..	April	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	5⅛– 5¾	5 3 0	Feb, Aug	⅞	..
St.	4½	Do. 4½ per Cent. Deb. Stock	94 – 97	4 13 0	Jan, July	..	..
5	..	New Gen. Tract. 6 per Cent. Cum. Pref.	¾–1⅛	..	May	..	..
1	£/0	Potteries Electric Traction Ord.	½– ⅝	8 0 0	April, Oct	..	..
1	0/6	Do. 5 per Cent. Cum. Pref.	½– ⅝	6 13 0	Feb, Aug	..	..
St.	4½	Do. 4½ per Cent. Deb. Stock	95 – 98	4 11 9	May, Nov	..	..
1	0/3	S. Met. Elec. Trams. & Ltg. 6% Cm. Pref.	1 –1¼	4 16 0	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Deb. Stock	80 – 84	4 15 3	Jan, July	..	..
100	5%	Sunderland Dist. Elec. Trms. 5% 1st Mt. Db	84 –88	5 13 6	Jan, July	..	..
..	..	Underground Elec. Rys. Co. of London...	7⅝– 8⅛	8 12 0	June, Dec	..	..
6	..	Yorkshire (W.R.) Elec. Trams. Ord. ...	1 –1⅛	—	March ..	..	..
6	..	Do. 6 per Cent. Cum. Pref.	8⅛–8⅝	—	..	..	..
St.	4½%	Do. 4½ per Cent. 1st Debs.	87 – 90	5 0 0	Jan, July	..	..

SHARE.	LAST DIVIDEND	NAME.	Price Wed., Oct. 9.	RATE % YIELDED.	DIVIDEND DUE.	BUSINESS WEEK TO Oct. 9. High-est.	Low-est.
		ELECTRIC MANUFACTURING, &c.		£ s. d.			
1	.	Aron Electricity Meter Ord.	⅝–¾	..	..	..	..
1	0/7½	Do. 6% Cum. Pf.	⅞–1	8 12 6	April, Oct	..	..
1	1/1½	†Babcock & Wilcox Ord.....	3⅜–3½	5 2 6	April, Oct	3⅝	3½
1	0/7½	† Do. Pref.....	1⅛–1⅜	3 16 9	..	..	..
5	4/0	British Insulated & Helsby Cables Ord.	6¾–7	7 3 0	July, Feb	7⅛	..
5	3/0	Do. 6 per Cent. Pref.	5⅝– 6¼	4 18 0	Jan, July	6¼	..
St.	4½%	British Thomson-Houst'n 4½% 1st Mt. Db.	85 – 89	5 1 0	Mar, Sept	..	..
5	..	British Westinghouse 6 per Cent. Pref...	1 –1⅛	..	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock	62 – 67	5 19 0	Jan, July	..	..
2	..	Brush Electrical Engineering	⅛–¼	—	March ..	..	..
2	..	Do. 6 per Cent. Pref. non-Cum.	⅜–⅝	5 7 0	Mar, Sept	..	..
St.	4½%	Do. 4½ per Cent. Perp. 1st Deb. Stock	83 – 86	5 4 6	Mar, Sept	..	..
St.	4½%	Do. Perpetual 2nd Deb. Stock	67 –70	6 9 6	Jan, July	..	..
5	10/0	Callender's Cable Con. Ord.....	9⅜–10⅜	6 19 0	Jan, July	10¼	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5¼– 5⅝	4 7 0	Jan, July	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort Debs. (red.)	105¼–107½	4 3 6	Nov, May	..	..
1	0/9⅜	Castner-Kellner Alkali Co.	1⅛–1⅜	5 12 6	May, Nov	..	..
1	1/2⅝	Chadburn's (Ship) Telegraph Ord.	1⅜–1⅝	7 12 0	March ..	1⅝	..
1	0/7½	† Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	5 1 0	April, Oct	..	..
3	£/0	* Crompton & Co. (Nos. 1 to 65,000)	1⅞– 2	7 10 0	Jan, July	..	..
100	5%	Do. 5 per Cent. 1st Mort. Debs. (red.).	96 – 99	5 1 0	Jan, July	96	95
5	2/0	†Dick, Kerr & Co. Ord.	1½–1⅝	6 18 0	Sept	1⅝	..
St.	4½%	† Do. 6 per Cent. Cum. Pref.	1 –1⅛	4 16 0	Sept	..	..
St.	4½%	Do. 4½ per Cent. Deb. Stock	101 – 104	4 6 6	Jan, July	..	..
5	2/6	Edison & Swan United ("A" sh.) (£3 pd.)	1⅛–1⅜	3 12 0	Feb, Aug	..	..
5	4/2	Do. (£5 paid)	2¼–2⅜	4 11 6	Feb, Aug	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stock (rd.)	83 – 85	4 14 0	June, Dec	..	..
St.	5%	† Do. 5 per Cent. 2nd Deb. Stock	87 – 90	5 11 0	Mar, Sept	..	..
5	..	Edmundson's Elec. Corp. Ord.	¾–1	10 0 0	Jan, July	..	..
5	3/0	Do. 6 per Cent. Cum. Pref.	1 –1⅛	..	May, Nov	1⅛	..
St.	4½%	Do. 4½ per cent. 1st Mort. Deb. (red.)	76 – 81	5 11 6	Jan, July	..	..
2	..	Electric Construction Co.....	⅜–⅝	..	Jan, July	..	..
2	..	Do. 7 per Cent. Cum. Pref.	⅜–1	..	July	..	..
St.	4%	Do. 4 per Cent. Perp. 1st Mort. Debs.	77 – 81	4 18 9	..	..	..
10	5/0	General Electric (1900) 5% Cum. Pref...	8 – 8⅜	5 17 9	June, Dec	8⅛	..
St.	4%	† Do. 4 per Cent. 1st Mort. Debs.....	90 – 93	4 6 0	Mar, Sept	..	..
1	£/0	Henley's Telegraph Works Ord.....	11 –12	6 5 0	Feb, Aug	..	..
5	2/3	Do. 4½ per Cent. Pref.	5 –5⅛	4 2 0	Feb, Aug	..	..
St.	4½%	Do. 4½ per Cent. 1st Mort. Deb. Stock	105½–107½	4 3 6	Mar, Sept	..	..
10	5/0	India Rubber, Gutta Percha, &c., Wrks.	14⅜–15½	6 9 0	Feb, Aug	14⅝	..
100	4%	Do. 4 per Cent. Debs. (red.).....	96 –98	4 2 0	April, Oct	..	..
1	1/2⅞	Richardsons, Westgarth & Co., Ltd. Ord.	3⅜–3⅝	7 13 6	Nov	..	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	3⅜–3⅝	6 4 0	May, Nov	..	..
St.	4½%	Do. 4½ per Cent. Perp. Deb. Stock ...	93 –96	4 14 0	Jan, July	..	..
1	..	Simplex Conduits Ord.	1⅛	..	..	..	..
5	..	Do. 6 per Cent. Cum. Pref.	5⅛	..	..	..	..
12	12/0	Telegraph Construction & Maintenance	30½–31½	5 14 6	Mar, July	30	..
100	4%	Do. 4 per Cent Deb. Bonds (1909) ...	99½–102½	3 18 0	Jan, July	100½	..
1	1/0	Vickers, Sons & Maxim, Ltd., Ord.	2⅜–2⅝	6 9 0	..	2⅝	..
1	0/6	Do. 5 per Cent. non-Cum. Preference	1⅛–1⅜	4 9 0	..	1⅜	..
St.	5%	Do. 5 per Cent. non-Cum. Preferred	107 –110	4 10 0	..	..	..
St.	4%	Do. 4 per Cent. 1st Mort. Db. Sk. (red)	102½–104½	3 16 6	June, Dec	..	..
100	4½%	Do. 4½ per Cent. 2nd Mort. Deb. (red.)	100 –101	4 3 3	June, Dec	..	..
10	8/0	J. G. White & Co. 6 per Cent. Cum. Prf.	8½–9½	6 6 0	Jan, July	..	..
5	..	Willans & Robinson Ord.....	1⅛–1⅜	..	Apr, Oct	..	..
5	..	Do. 6 per Cent. Cum. Pref. ex 10/6 in Funding Certs. for arrears.....	3⅞–4⅛	..	Apr, Oct	4⅛	..
100	4%	Do. 4 per Cent. 1st Mort. Debs.....	74 –78	5 2 6	May, Nov	76½	..
		TELEGRAPHS.					
10	..	Amazon Telegraph	3 –3⅛	—	June, Dec	..	..
100	5%	Do. 5 per Cent. Debs. (red.)	85 –88	5 2 0	June, Dec	..	..
St.	15/0	Anglo-American	54 –57	6 16 0	F,My,Ag,N	14	..
St.	30/0	Do. Preferred	98 –100	6 0 0	F,My,Ag,N	8⅞	..
St.	17½	Do. Deferred	15⅝–16	8 15 0	F,My,Ag,N	16⅛	..
St.	4%	†Commercial Cable 4 per Cent. Deb. Stk.	90 –92	4 6 6	Jn,Ap,Jy,O	..	..
10	5/0	Cuba Submarine Ord.....	6⅞–7⅛	6 13 0	Feb, Aug	..	..
10	10/0	Do. Preference 10 per Cent.....	15⅞–16⅜	5 19 6	Feb, Aug	..	..
5	2/0	†Direct Spanish Ord.....	3⅛–3⅜	5 13 0	April, Oct	..	..
5	5/0	† Do. 10 per Cent. Cum. Pref.	9 – 9⅛	5 5 6	April, Oct	..	..
50	4½%	Do. 4½ per Cent. Deb.....	100⅝–103⅜	4 7 3	Jan, July	..	..
20	0/6	Direct United States Cable	12 –13	7 2 3	Ja,Ap,Jy,O	12⅜	..
100	4½%	Direct West India Cable 4½% Rg. Db. (rd.)	100 –102	4 8 0	June, Dec	..	..
St.	25/0	Eastern Ordinary	120 –123	5 5 6	Ja,Ap,Jy,O	125½	..
St.	17/6	Do. 5½ per Cent. Pref. Stock	86 –88	3 19 6	Ja,Ap,Jy,O	..	..
St.	4%	Do. 4 per Cent. Mort. Deb. Stk. (red.)	100 –103	3 17 6	May, Nov	102	..
10	2/6	Eastern Extension	11½–12⅝	5 12 0	Ja,Ap,Jy,O	12⅝	..
St.	4%	Do. 4 per Cent. Deb. Stock	100 –103	3 17 6	Feb, Aug	10.	..
St.	4%	Eastern & S. African 4% Mort. Deb. 1900	97½–100½	3 19 6	Feb, Aug	..	..
25	4%	Do. 4% Mauritius Sub. Debs. (red.) ...	100⅛–102⅛	3 18 0	May, Nov	102	..
10	5/0	G.N. (of Copenhagen), with Coupon 71	34 –36	6 19 0	Jan, July	..	..
100	4½%	Halifax & Bermuda 4½% 1st Mt. Db. (red.)	100 –102	4 8 0	June, Dec	..	..
25	12/6	Indo-European	55 – 57	5 14 0	May, Nov	..	..
100	£1	Mackay Companies Common	64 – 67	5 19 0	Jan, July	..	..
100	£1	Do. Preference	64 – 67	5 19 0	Ja,Ap,Jy,O	..	..
1	..	Marconi's Wireless Teleg. Co.	¾–1	..	April.....	..	..
100	4%	Pacific & Europe'n Tel. 4% Guar. Dbs. (red.)	98 –100	4 0 0	June, Dec	..	..
10	4/0	West African Telegraph Shares	10 –10½	3 16 0	June, Dec	..	..
2½	1/3	West Coast of America	1⅜–1⅝	3 12 9	May	..	..
100	4%	Do. 4 per Cent. Debs.	98 –100	4 0 0	Jan, July	..	..
10	..	West India & Panama	⅞–⅞	..	May, Nov	..	..
10	8/0	Do. 6 per Cent. 1st Pref.	7 –7⅛	8 0 0	May, Nov	..	..
10	..	Do. 6 per Cent. 2nd Pref.	6⅝–7⅛	..	May, Nov	..	..
100	5%	*Do. 5 per Cent. Debs.	99 –102	4 18 0	Jan, July	..	..
10	3/0	Western Telegraph	12½–13	5 8 0	Mr,Je,S,D	13	..
St.	4%	Do. 4 per Cent. Deb. Stock (red.)	100 –103	3 18 0	June, Dec	..	..
		TELEPHONES.					
..	4%	Amer. Telephn. & Telegh. Coll. Trust $1,000 4 per Cent. Bonds	90 –92	4 7 0	Jan, July	..	..
St.	5%	Anglo-Portug'se Tel. 5% 1st Mt. Db. Stk.	99 –102	4 18 0	Mar, Sept	..	..
5	£/0	Chili Telephone	6⅜–7⅛	5 10 6	August ..	..	..
1	0/4½	Monte Video Telephone Ord.	1⅛–1⅜	4 14 0	Nov	1⅜	..
1	0/6	Do. 5 per Cent. Pref.	⅞–1	5 0 0	May, Nov	..	..
St.	6%	National Co. Pref. Stock	107 –108	5 11 0	Feb, Aug	..	..
St.	6%	Do. Def. Stock.....	106½–107½	5 11 6	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Cum. 1st Pref.	10⅝–12⅝	4 16 0	Feb, Aug	..	..
10	£/0	Do. 6 per Cent. Cum. 2nd Pref.	10 –12	5 0 0	Feb, Aug	..	..
5	2/6	Do. 5 per Cent. non-Cum. 3rd Pref. ...	5⅛–6⅝	4 13 0	Feb, Aug	5⅜	..
St.	3½%	*Do. Deb. Stock 3½ per Cent. (red.) ...	96 –98	3 11 6	June, Dec	97	..
St.	4%	*Do. 4 per Cent. Deb. Stock (red.)	101 –103	3 17 6	Jan, July	..	..
1	£/0	Oriental	1⅛–1⅜	5 6 6	April, Oct	1	..
1	0/7½	Do. 6 per Cent. Cum. Pref.	1⅛–1⅜	4 10 0	April, Oct	..	..
St.	1%	Do. 4 per Cent. Red. Deb. Stock	91 –94	4 5 0	Jan, July	..	..
St.	4½%	Telephone Co. of Egypt 4½% Db. Stk. (red.)	98 –101	4 9 0	Jan, July	..	..
1	£/0	United River Plate.....	6¾–7½	6 18 0	July	..	..
5	2/6	Do. 5 per Cent. Cum. Pref.	5 –5⅜	4 11 0	June, Dec	..	..
		FINANCIAL, INVESTMENT, &c.					
5	5/0	Elec. & Gen. Investment 6% Cum. Pref.	3¾–4⅛	6 13 3	Jan, July	..	..
10	2/0	Globe Telegraph & Trust.....	9⅝–10⅜	5 4 6	Ja,Ap,Jy,O	9⅞	..
10	3/0	Do. 6 per Cent. Pref.....	13 –13⅝	4 8 0	Ja,Ap,Jy,O	..	..
10	6/4	Submarine Cables Trust (Limited)	12⅞–13⅛	4 12 0	April, Oct	..	..

‡ The London Stock Exchange Committee have...

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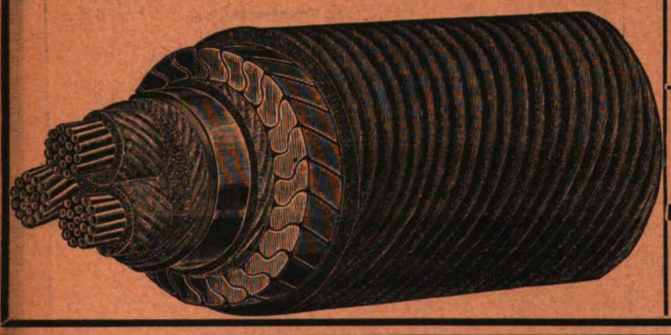

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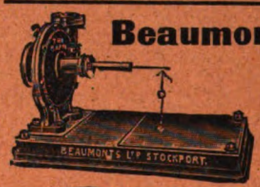

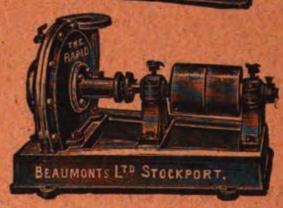

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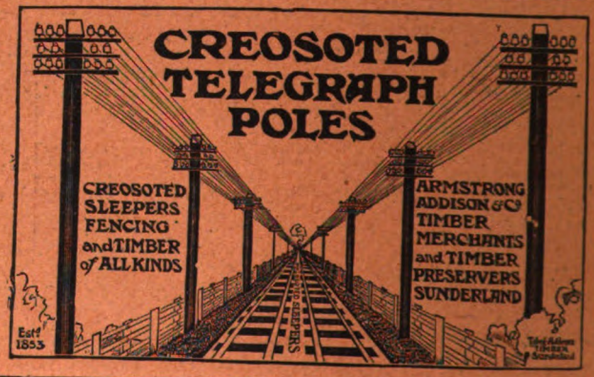
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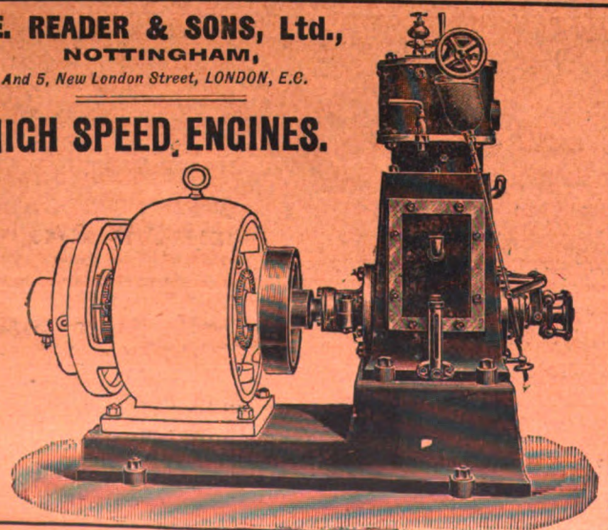

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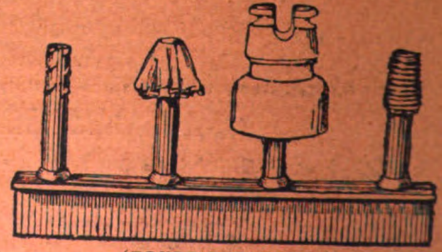

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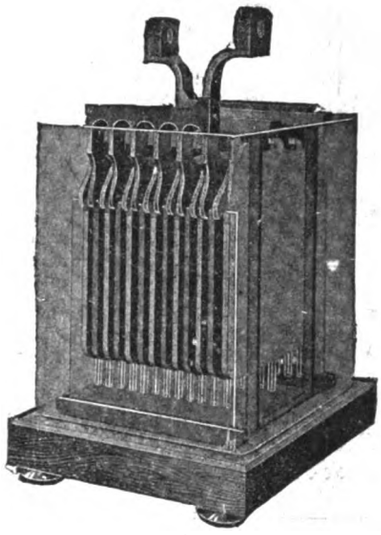

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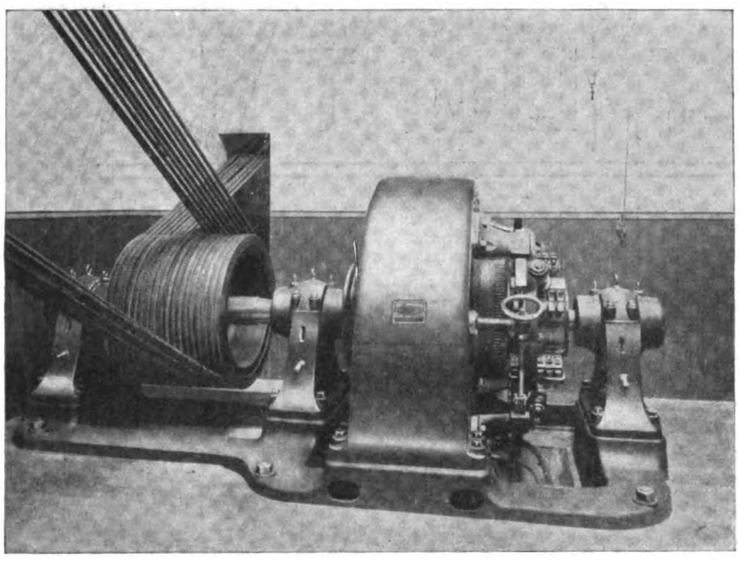

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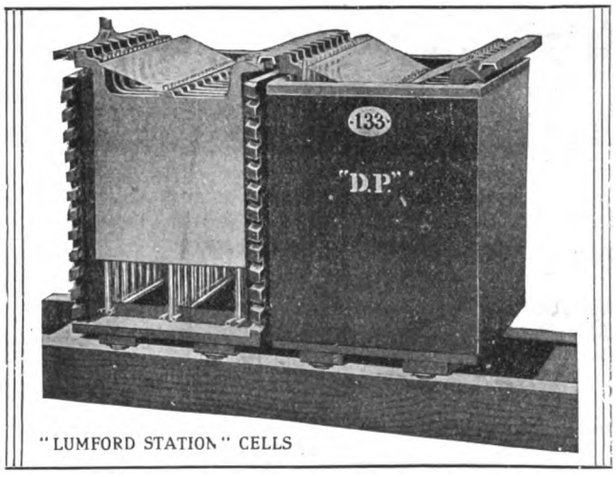
MONTHLY STOCK LIST.

BATTERY HINTS FOR ELECTRICAL ENGINEERS



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Use a Battery that will allow heavy discharges—that will stand hard usage—that has purest metallic lead. All these points are embodied in the

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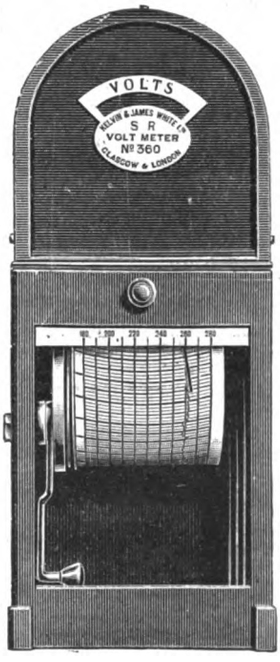

Ammeters, Voltmeters, Wattmeters

For Direct or Alternating Circuits,

TRACTION AND LIGHTING

APPROVED by the BOARD of TRADE

DEAD-BEAT,
LARGE OPEN SCALES,
ACCURATE.

Movement to Change Record also Winds Clock.

PEN CLOCK CANNOT BE DAMAGED. OVERWOUND.

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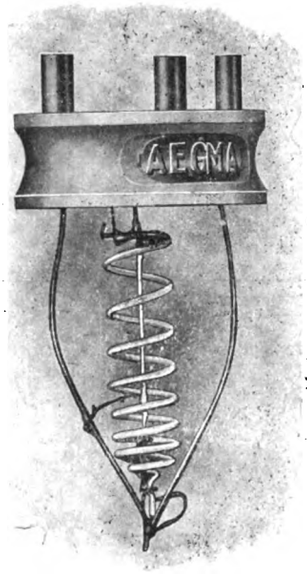
STREET LIGHTING.

Price of vertical B burner, **1/9** each.



Price of vertical B burner, **1/9** each.

The vertical burner is now supplied for B type (¼ amp.), D type (½ amp.), and A type (1 amp.) for direct and alternating current. This burner is a great improvement on the older type.

The A.E.G. ENGLISH MNFG. CO., Ltd.,

Patentees of Nernst Lamps for the U.K.,

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ANCHOR CABLES

RUBBER WIRES AND CABLES
FOR
LIGHTING, POWER
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TELEPHONE WORK
Of all Descriptions.

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Leather-Sheathed Trail Cables a Speciality.

THE ANCHOR CABLE CO., LTD.,
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WORKS: LEIGH, LANCASHIRE.
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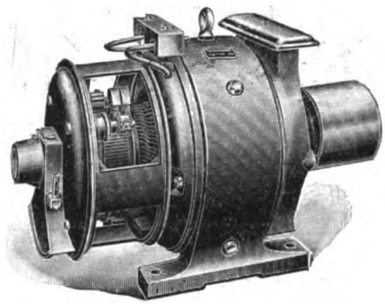

UNION MOTORS

are constructed on the standard, interchangeable modern factory system by the most skilled engineers with up-to-date machinery.

UNION MOTORS

are therefore the Cheapest, Best, most Efficient & Durable Motors obtainable.

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PARK ST. SOUTHWARK. LONDON, S.E.
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CLARKE, CHAPMAN & CO., LD.

ELECTRICAL ENGINEERS,

LONDON Office: 50, FENCHURCH ST., E.C.
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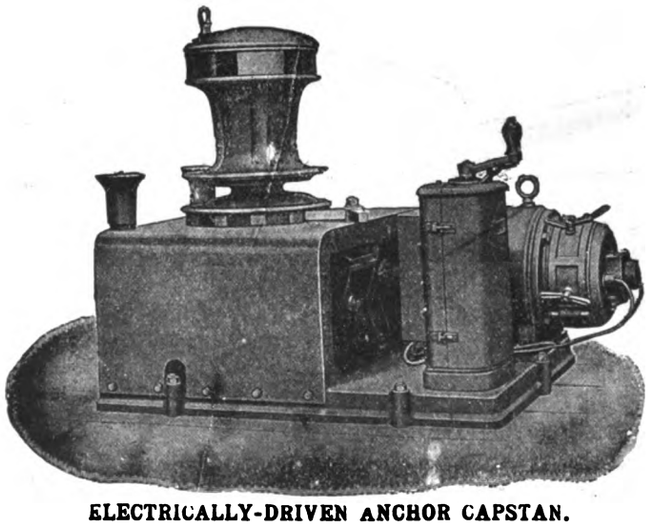
GATESHEAD.



ELECTRICALLY-DRIVEN ANCHOR CAPSTAN.

Electrically-Driven **WINCHES, CAPSTANS** and **HAULAGE GEARS** for Yard and Ship Work a ***SPECIALITY.***

Direct-Coupled **GENERATING PLANTS** for Ship Lighting, &c.

SEARCHLIGHT PROJECTORS of all sizes Hand Operated and Motor Controlled Types.

Makers of Projector Mirrors and Lenses.

HIGH-SPEED VERTICAL ENGINES.

Contractors to ADMIRALTY, WAR OFFICE, INDIA OFFICE and FOREIGN GOVERNMENTS

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C. A. PARSONS & CO.

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66, Victoria Street, LONDON, S.W.
13, Peacock's Buildings, Park Row, LEEDS.
99, Great Clyde Street, GLASGOW.
Caledonian Chambers, 102, St. Mary Street. CARDIFF

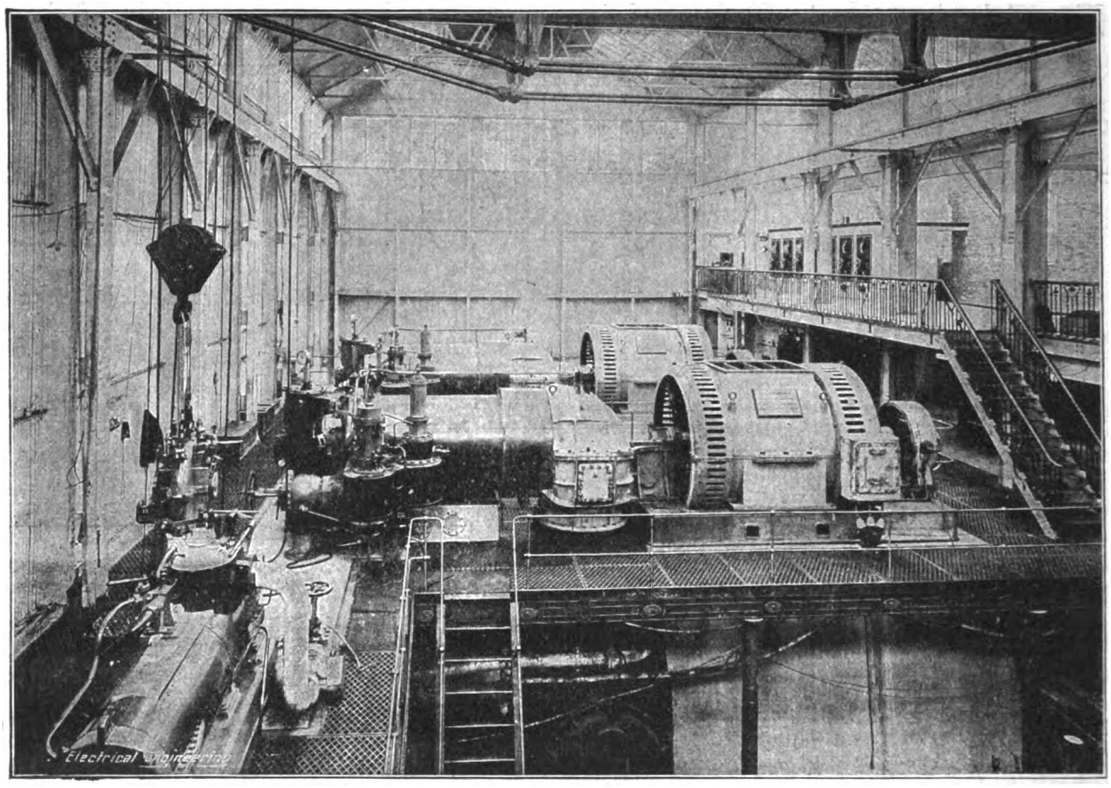
TRADE MARK.

STEAM TURBINES

LATEST TYPE of PATENT BLADE with THINNED TIPS.

TURBINE PLANTS for utilisation of Exhaust Steam. **CONDENSERS. AIR PUMPS.**

TURBO-DYNAMOS of largest size for Direct or Alternating Current with all the Latest Improvements.



Two 1,500 kw. Three-Phase Turbo-Alternators, 11,000 volts, 50 periods, complete with Condensing Plant and Vacuum Augmentor.
Installed at the Kent Electric Power Co.'s Station, Strood, Kent.

SILENT RUNNING. FREEDOM from VIBRATION. LOW CONSUMPTION of STEAM and OIL.

KAYE'S

LATEST PATENT SERRATED STEEL

SEAMLESS OIL CAN,

Fitted with New Patent Thumb Button, Seamless Spout, and Slide Feed Hole.
When the Lid of the Oil Can is raised it mechanically opens the Slide Feed Hole.)

Also in COPPER or BRASS for ELECTRICAL PURPOSES.

Contractors to H.M. Navy, War Department, Home Office, and Indian State Railways.

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Telegrams: "WEDGE," LEEDS. "LOCKENCAN," LONDON. And 93, HIGH HOLBORN, LONDON, W.C. Telephones: LEEDS 506. LONDON, HOLBORN 1847

THE UNITED ELECTRIC CAR CO., Ltd., PRESTON, LANCS.

Manufacturers of **RAILWAY CARRIAGES, TRAMCARS** for Electric Traction, **MOTOR BUS BODIES.**
AND ALL KINDS OF
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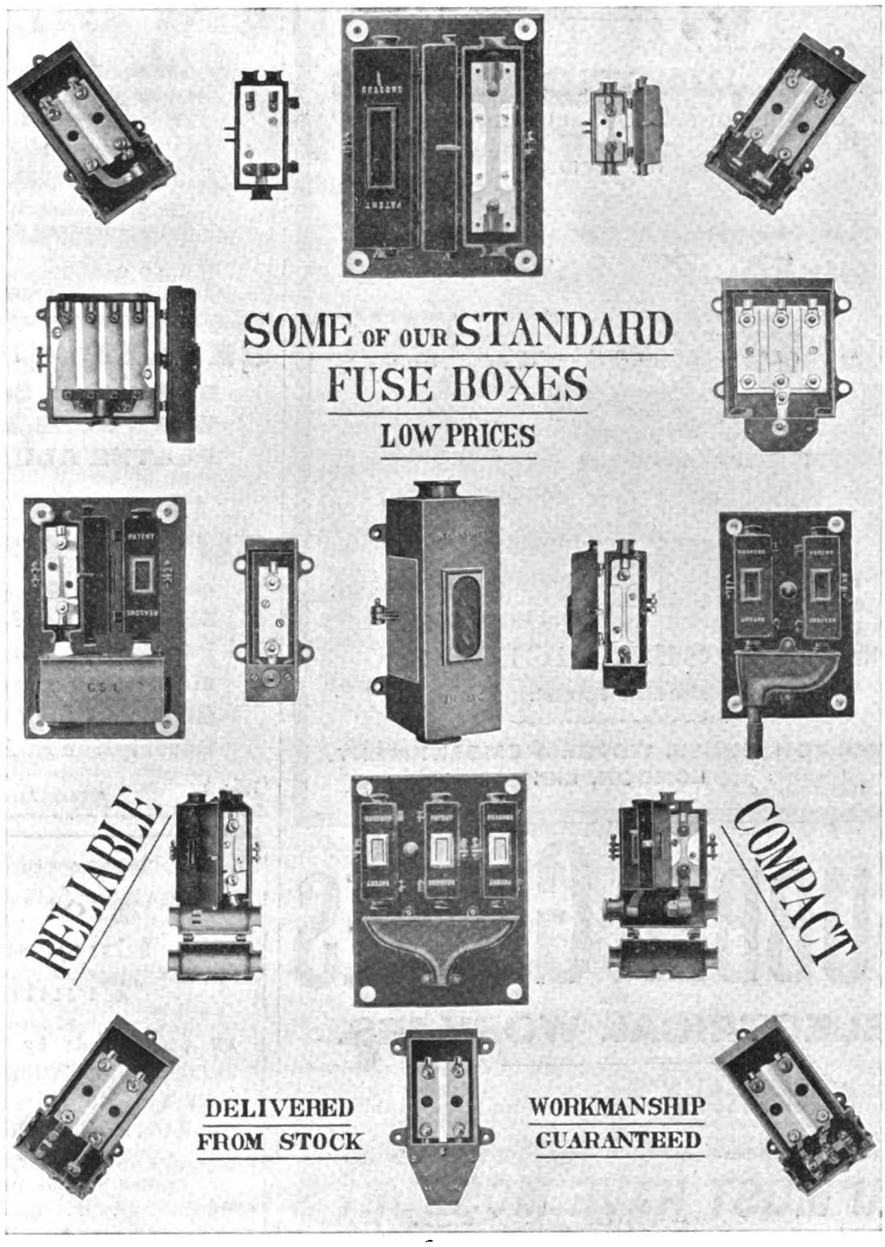

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OF ALL KINDS FOR ALL PURPOSES.

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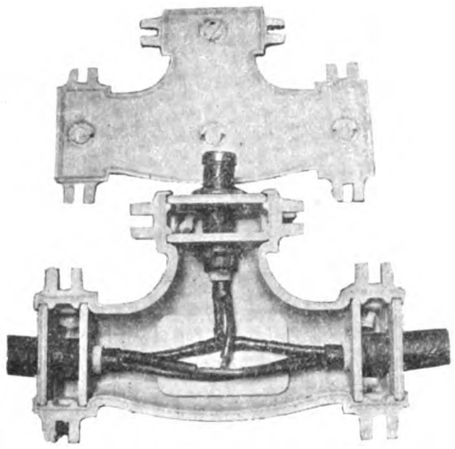

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Telephone: 1911 HOLBORN. **LONDON, E.C.** Telegrams: CALLENDER LONDON.

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BRASS and COPPER TUBES, SHEETS, WIRE RODS, BOTTOMS, PANS, FIRE-BOX PLATES, ALUMINIUM, TIN, LEAD, ZINC, IRON, &c.

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Every Description of BRASS, COPPER, ZINC, LEAD, BATTERY PLATES, ASHES, BORINGS, and REFUSES containing Metals of any kind, also OLD CABLES, BOILERS, DYNAMOS, &c., &c. Also any Description of PLANT for DISMANTLING.

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RUBBER GLOVES

FOR

ELECTRICAL WORKERS.

Order MOSELEY'S Famous Gloves, and see that you get them **GUARANTEED ABSOLUTELY PURE FINE PARA RUBBER,** which Never Hardens, and is Suitable for All Climates. Every Person engaged in Electrical Work should be provided with Rubber Gloves, but they should be Good Gloves and Non-Perishable. Therefore

YOU MUST HAVE MOSELEY'S

DAVID MOSELEY & SONS, Ltd.,

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Protection of English Trade.

ENGLAND AND CHINA FURNITURE AND ELECTRICAL FITTINGS MANUFACTURERS' ASSOCIATION

All goods made by Members of the China Furniture and Electrical Fittings Manufacturers' Association are marked with above Trade Mark, WHICH IS A GUARANTEE OF ENGLISH MANUFACTURE.

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NALDER BROS. & THOMPSON, Ltd.

THE VERY LATEST THING IN INSULATION TESTING SETS. ALL IN ONE BOX.

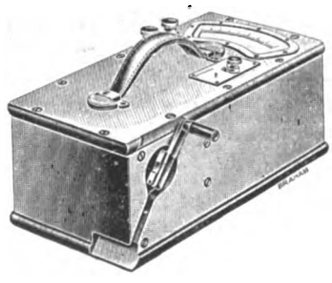
THE "OHMER"

Latest, Lightest, Best and Cheapest.

(Free Wheel Generator.)

500 volts, 20 megohms,

£18 0 0 list.



THE "OHMER"

Latest, Lightest, Best and Cheapest.

(Free Wheel Generator.)

500 volts, 50 megohms,

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34, QUEEN STREET, LONDON, E.C. Telegrams: OCCLUDE LONDON. Telephone Nos.: 124 and 161 BASE.

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LONDON, MANCHESTER AND NEWCASTLE-ON-TYNE.

Electrical & Mechanical (ESTABLISHED 1860.)

VALUERS, AUCTIONEERS AND ARBITRATORS.

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Telegrams: Indices London; Indicator Manchester; Indicator Newcastle-on-Tyne.
Telephones: 5077 Bank London; 3218 Central Manchester; 3239 Central Newcastle/Tyne

SALE BY AUCTION.

MESSRS. HORNE & CO., 8, Delahay-street, Storey's Gate, Westminster, S.W., will SELL by PUBLIC AUCTION, at the Royal Arsenal, Woolwich, on THURSDAY, 24th October, 1907, by order of the Secretary of State for War, at Eleven o'clock in the forenoon precisely, the following **UNSERVICEABLE AND OBSOLETE STORES**, viz.:—4½ tons Ashes (Lead); 6 tons Broken Crucibles; 638 tons Iron (Cast, Wrought and Steel); 101½ tons Brass (C.M.G. Cartridge Cases, &c.); 14 tons Copper; 7 tons Gunmetal; 60 tons Mixed Metals; 5 tons Lead Ingots; 85 tons Lead and Antimony; 6½ tons Cupro Nickel and Lead (White Metal); 54½ tons Zinc (Linings, Cylinders, &c.); Aluminium; Phosphor Bronze; Tin; 100 Wagon Axletrees; 53 Railway Carriage Axletrees; 300 Iron Bedsteads; 6 tons Steel Chains; 200 Iron Drums; 1-ton Hand Crab; 1 Sailing Sloop, tonnage 60 tons dead weight; 2 6-ton Overhead Travelling Cranes; 2 Lathes; 6 Machines; 1 Steam Fire Engine; 8 Condensers; Distilling Apparatus; 5 Pumps; Forced Draught Apparatus; Surface Plate; 8½ tons Electric Cable; Theodolites; Lamps and Lanterns (Electric, Ship and Hospital); 173 Billiard Balls; 370 Blocks with Wood Sheaves; 43 cases Drawing Instruments; Iron Beam Weighing Scales; 1,000 Pewter Spoons; 400 Gimlets; 500 Augers; Stocks and Dies; 1,166 Wire Cutters and parts; 600 yards Electric Wire; 92 Well Buckets; 186 Coir Beds; Bedstead Sackings; Filters; Luting; Musical Instruments; Electric Cells; Harness; Dermatine; Guttapercha; Paper; Rope; Resin; Silk Cloth; Beeswax; Varnish and Composition (Antifouling); Horsehair; Felt; Jute; Blanket Pieces; Woollen Rags; Canvas; Waterproof Bags and Sheeting; Leather; Hose Pipes; Clogs; 4 Carts; 1 Wagon; 46 Wheels; Wagon Poles and Shafts; 31 Windlasses; 70 Skylights; 12 Gyns; Casks; Kegs; 1,200 Oak Barrels; Cases; Boxes; Oak Staves; Hoops; Wood; &c., &c., &c. The Lots may be viewed at the Royal Arsenal, Woolwich, from 10 to 1 o'clock and from 2 to 4.30 o'clock on the Monday, Tuesday and Wednesday previous to and on the morning of the Sale. Catalogues may be obtained at the War Office, Whitehall; at the Ordnance Office, Tower; and at the Ordnance Office, Royal Arsenal, Woolwich.

SALE BY TENDER.

THE CHESHIRE LINES COMMITTEE are prepared to receive TENDERS for the PURCHASE of the undermentioned **SECOND-HAND PLANT AND MATERIALS:**—

THREE LANCASHIRE BOILERS, 20 ft. long by 6 ft. diameter, Galloway's make.

ONE PAIR HORIZONTAL STEAM ENGINES, Robey make.

TWO PAIRS COMPOUND HORIZONTAL STEAM ENGINES, Mather & Platt's make, including Steel Shafting, Driving Pulleys, &c.

ONE VERTICAL STEAM ENGINE, Davey Paxman make.

THREE 110 volt, 150 ampere Edison Hopkinson COMPOUND WOUND DYNAMOS.

SEVEN 500 volt, 20 ampere Edison Hopkinson SERIES WOUND DYNAMOS.

About 960 yds. 61/12 Copper Wire covered ELECTRIC LIGHT CABLE, 5,000 megohms grade.

Form of Tender and full particulars can be obtained upon application to Mr. H. BLUNDELL, Engineer, Cheshire Lines Committee, Central Station, Liverpool, on and after October 14th, 1907.

Sealed Tenders endorsed "Tenders for Second-Hand Plant and Materials" must be sent addressed to the undersigned, Great Northern Board Room, King's Cross Station, London, so as to be received not later than 9 a.m. on TUESDAY, November 5th, 1907.

GLEGGE THOMAS, Secretary.

Central Station, Liverpool.

BUSINESS FOR DISPOSAL.

OLD-ESTABLISHED ENGINEERING CONCERN IN LONDON.

FOR SALE.—Owing to illness of owner, a well-known ENGINEERING BUSINESS in London is FOR SALE as a GOING CONCERN on exceptionally reasonable terms. The Firm has a good name and established connection extending over half a century. It includes General, Marine and Electrical Engineering. Employs 80 to 100 hands. Well equipped with plant and machinery. Turnover averages £15,000 per annum. Freehold Land and Buildings may be purchased or leased, and Plant and Stock taken at valuation.

Full particulars to bona fide parties on application to the Sole Agents, WHEATLEY KIRK, PRICE & CO., 46, Watling-street, London, E.C.

MISCELLANEOUS PLANT, &c., WANTED.

NEW and OLD ELECTRICAL STOCKS, CABLE, &c., BOUGHT for CASH; also Scrap Cable, Metal Cells, Dynamos, &c. Best prices.—LAKE, 132, Upper Thames-street, London, E.C.

WANTED, LAMP TOPS, with Platinum, Scrap Platinum, &c.—EDEY & Co., 29, Ludgate-hill, London, E.C.

MISCELLANEOUS PLANT, &c., FOR SALE.

ELECTRIC LIGHT CABLE (New); 3/22, £6. 15s. per mile; 1/16, £6. 15s.; 3/20, £9; 3/18, £12; 7/22, £8. 15s.; 7/21½, £9, 15s.; 7/20, £16; 7/18, £28; 7/14, £60; 37/16, £180.—LAKE, 132, Upper Thames-street, London, E.C.

SEARCHLIGHT LAMPS (New), cost £12, price 70s. each. LAKE, 132, Upper Thames-street, London, E.C.

NEW (latest pattern) High Voltage MAIN SWITCHES, from 20 to 100 amperes, to be cleared out very cheap; also New Electric Light Fittings and Sundries.—LAKE, 132, Upper Thames-street, London, E.C.

"NEW RADIUM" LAMPS.—Best Lamp without exception on the market.—Uses only about half usual current and gives nearly double the light. About 2,000 to be cleared at half price: 100/8, 200/8, 220/16, 110/16, 240/16, 210/16, 12s. per dozen.—LAKE, 132, Upper Thames-street, London, E.C.

FOR SALE.—Two New 120 B.H.P. Vertical Enclosed Two-crank Compound STEAM ENGINES; forced lubrication, h.p. cylinder 9 in., l.p. 15 in., stroke 7 in., 530 revs.; at present supplying the light at Dublin Exhibition.—Apply WORKMAN, YEAMES & Co., LTD., 6, Dublin-road, Belfast.

FOR SALE.—Babcock & Wilcox Water-tube STEAM BOILER, to evaporate 3,200 lb. per hour, working pressure 250 lb.; all fittings and mountings complete.—Apply WORKMAN, YEAMES & Co., LTD., 6, Dublin-road, Belfast.

SEASONED ASH PLANKS and Ash in the Round for Sale.—Apply REMER & Co., LTD., Timber Importers, Mersey Saw Mills, Liverpool.

FOR SALE or HIRE, high-class Dynamos, Motors, Switches, Cable and Arc Lamps.—PERCY HUDDLESTON & Co., 72, Finsbury-pavement, E.C

TENDERS INVITED.

METROPOLITAN BOROUGH OF STEPNEY.

ELECTRICITY SUPPLY.

BLYTH'S WHARF GENERATING STATION AND SUB-STATION EQUIPMENT.

The Electric Lighting Committee of the Metropolitan Borough of Stepney invite TENDERS from responsible contractors for the carrying out of the following work in connection with the Council's projected new generating station on the riverside at Blyth's Wharf, Limehouse, and sub-station at Osborn Street, Whitechapel:—

(a) The Complete Equipment of the Steam Raising Portion of the Station Plant, including Condensing Water Pipes, River Wells and Coal Handling Plant.

(b) The Complete Equipment of the Electrical Generation Portion of the Station Plant, including Turbo-Generator, High and Low Tension Switchgear and Converting Machinery.

The Contract will also include the removal of a portion of the plant already erected at Osborn-street and its re-erection at Blyth's Wharf.

Copies of General Conditions, Specification, Form of Tender and Drawings may be obtained from the undersigned on the receipt of a deposit of Five Guineas for each section. Deposits will be returned to bona-fide tenderers after the tenders have been considered by the Council. Additional copies may be obtained on payment of a sum of One Guinea, which will not be returned.

Copies of the Specification and Drawings may be inspected at the office of the undersigned by appointment.

Tenders on the form supplied, endorsed "Tender of Section A" or "Tender for Section B," as the case may be, must be delivered, signed, sealed and addressed to the Chairman of the Electric Lighting Committee at 27, Osborn-street, Whitechapel, E., not later than 11th NOVEMBER, 1907.

The Council do not bind themselves to accept the lowest or any Tender, and the acceptance of any Tender is subject to the sanction of the London County Council to the necessary loans being obtained.

WM. C. P. TAPPER, A.M.I.E.E., Borough Electrical Engineer and Manager.

Electricity Works, 27, Osborn-street, Whitechapel, E.

TENDERS INVITED continued on next page

Royal Doulton Potteries.

INSULATORS

AND ALL KINDS OF

POTTERY FOR ELECTRICAL PURPOSES.

DOULTON & CO.,

LIMITED,

Lambeth, LONDON, S.E.

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TENDERS INVITED—*continued.*

COUNTY OF LONDON.

The London County Council invites TENDERS for the **ELECTRIC WIRING OF TRAMWAYS SUB-STATIONS** at Holloway, Hackney and Clapton, and of a Car-shed at Holloway.

Full particulars, and also information as to the conditions to be observed by tenderers, will be given in the *London County Council Gazette* of 14th October, 1907. The *Gazette*, which is published weekly, contains particulars of all the Tenders invited by the Council, and can be obtained from Messrs. P. S. King and Sons, 2 and 4, Great Smith Street, Westminster, S.W., price 1d., post free 1½d., an issue, or for the whole year a prepaid subscription of 6s. 6d. Tenders must be upon the official Forms to be obtained from the Clerk of the Council, County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £2 for each Specification, &c., and no Tender will be received after 11 a.m. on TUESDAY, 29th October, 1907. The Council does not bind itself to accept the lowest or any Tender, and it will not accept the Tender of any person or firm who shall on any previous occasion have withdrawn a Tender after the same had been opened, unless the reasons for the withdrawal were satisfactory to the Council.

G. L. GOMME,
Clerk of the London County Council.

County Hall, Spring Gardens, S.W.,
9th October, 1907.

FERBECK CHIMNEY CONSTRUCTION CO.—CHIMNEY SHAFTS in any part of the World (Economical Patent System), CHIMNEY TANKS, LIGHT TOWERS, WATER TOWERS (Intze System), ELECTRIC and all other FURNACES, SOOT KILNS, ARC and DYNAMO CARBON PLANTS, &c.—FINSBURY PAVEMENT HOUSE, LONDON, E.C.

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Situations Vacant.

Three Lines and under (Minimum) ... ... 1s. 6d.
Per Line after ... ... 6d.

Ten Words to the Line.

Situations Wanted.

Sixpence per Line of Ten Words, minimum One Shilling.

Where answers to any of the above Advertisements are to be sent to the Publishing Offices to be forwarded, the sum of 3d. must be sent with the order to pay for postage of these replies. Six Words must be allowed for the address of the Publishing Offices.

SITUATIONS, &c., VACANT.

ENGINEER REQUIRED for central station of electric supply company to take charge of generation and distribution. Must be experienced in both A.C. and C.C. systems, and also in dealing with power consumers from a commercial and technical point of view.—Address, giving full particulars of previous experience and training and salary required, to CENTRAL STATION, care of Streets, 30, Cornhill, London, E.C.

WANTED.—A competent LECTURER to give ten popular Lectures on "Practical Electricity as applied to Collieries."
Each Lecture to be delivered three times, namely, on Monday, Tuesday and Wednesday evenings, and to be illustrated by practical experiments.
Apply, stating qualifications, terms and apparatus required for experiments, to BARBER, WALKER & CO., Eastwood Collieries, Notts.

ASSISTANT WANTED in Calculating Department of Engineering Works, accustomed to the designing of continuous and three-phase current machinery.—Apply, stating age and full particulars, to D. M. G., *Electrician* Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London.

JUNIOR ASSISTANT WANTED for Electrical Laboratory in Steel Works. Experience with magnetic and electrical testing instruments and pyrometers necessary.—HADFIELD'S STEEL FOUNDRY CO., LTD., Sheffield.

COMPETENT DRAUGHTSMAN REQUIRED for low tension switchboard; another for direct-current machines. Knowledge of German essential.—Apply, with full particulars, ELEKTROTECHNISCHE ABTEILUNG, Norddeutsche Maschinen und Armaturenfabrik, Bremen.

VACANCY for PREMIUM PUPIL. Experience to be gained in power station, repair shops, running shed, traffic, track, mains, installation and testing work.—Apply, ENGINEER, Electric Supply and Tramways Departments, Ipswich.

SITUATIONS WANTED.

AMERICAN ELECTRICAL ENGINEER, College Graduate, with an extensive experience as designing and testing engineer of small current apparatus in large manufactories in the States, desires to secure technical POSITION in Europe, preferably in London.—Address AMERICAN, 6,460, *Electrician* Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London.

ELECTRICAL AND MECHANICAL ENGINEER with theoretical and practical training, experienced in high and low tension central station working, and with several years' manufacturing and erecting experience, estimating, interviewing, &c., is desirous of obtaining a POSITION with Manufacturing or Supply Company.—6,461, *Electrician* Offices, 1, 2 and 3, Salisbury-court, Fleet-street, London.

SITUATIONS WANTED continued on page xiv.

SUBMARINE CABLES TRUST.

NOTICE is Hereby Given that on TUESDAY, the 15th October instant, the COUPON due on that date will be paid by Messrs. GLYN, MILLS & CO., of 67, Lombard-street, E.C. between the hours of 10 a.m. and 2 p.m.

The Coupons should be left with the Bankers FOUR clear days before payment.

By order of the Trustees,
SIDNEY COLLETT, Secretary.

Electra House, Finsbury Pavement,
London, E.C., 5th October, 1907.

ELECTRICAL PATENTS

Mr. J. G. LORRAIN, M.Inst.E.E., M.Inst.M.E., Fellow of the Chartered Institute of Patent Agents,
NORFOLK HOUSE, NORFOLK STREET, STRAND, LONDON, W.C.
"PATENTEES' HANDBOOK," post free on application, gives Full Information to Inventors and upon all the chief points of the Patent Law.
Telegrams: Lorrain London.

John E. Raworth,

70|71, Queen Anne's Chambers, Broadway, Westminster, London, S.W. CHARTERED PATENT AGENT.

GENUINE
M & M VULCANIZED FIBRE.
MOSSES & MITCHELL, 68, CHISWELL STREET LONDON, E.C.

"ANTI-SULPHURIC" ENAMEL
Should be used in all ACCUMULATOR ROOMS for Protection from Acid Fumes.
Sole Makers: GRIFFITHS BROS. & CO., Mack's-rd, Bermondsey, LONDON, S.E.

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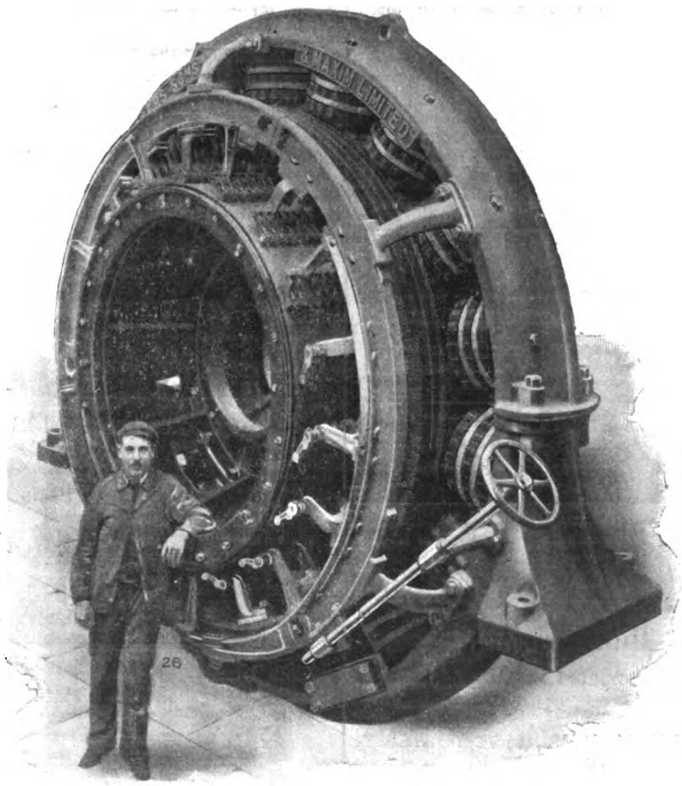

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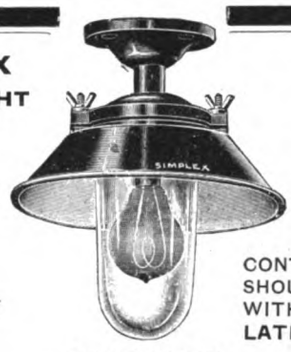

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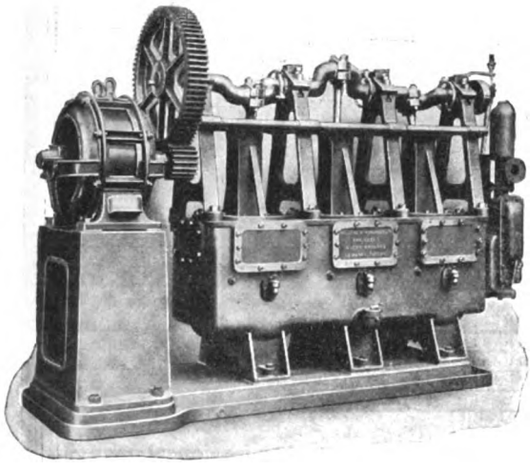

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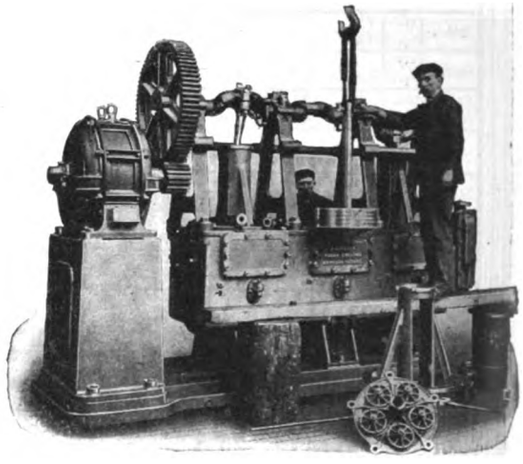

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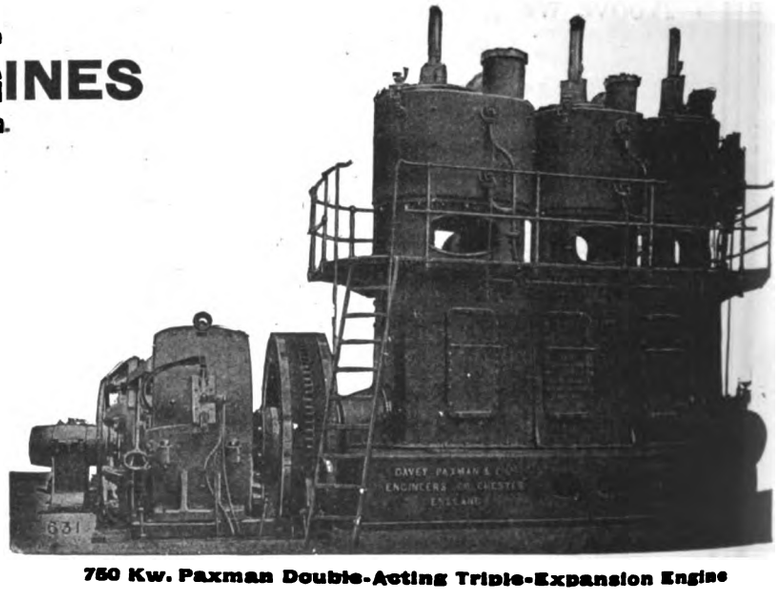

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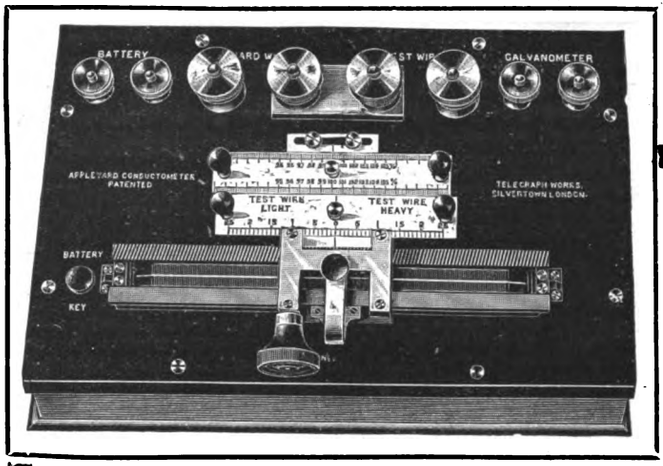

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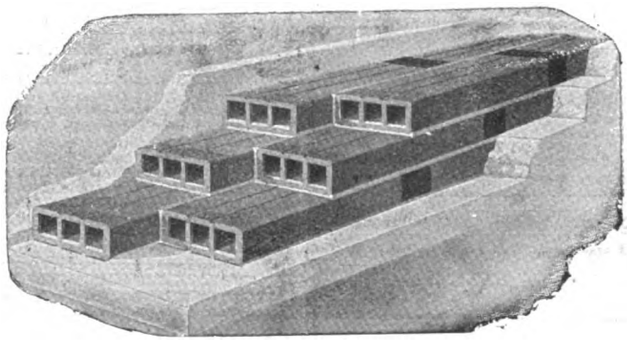

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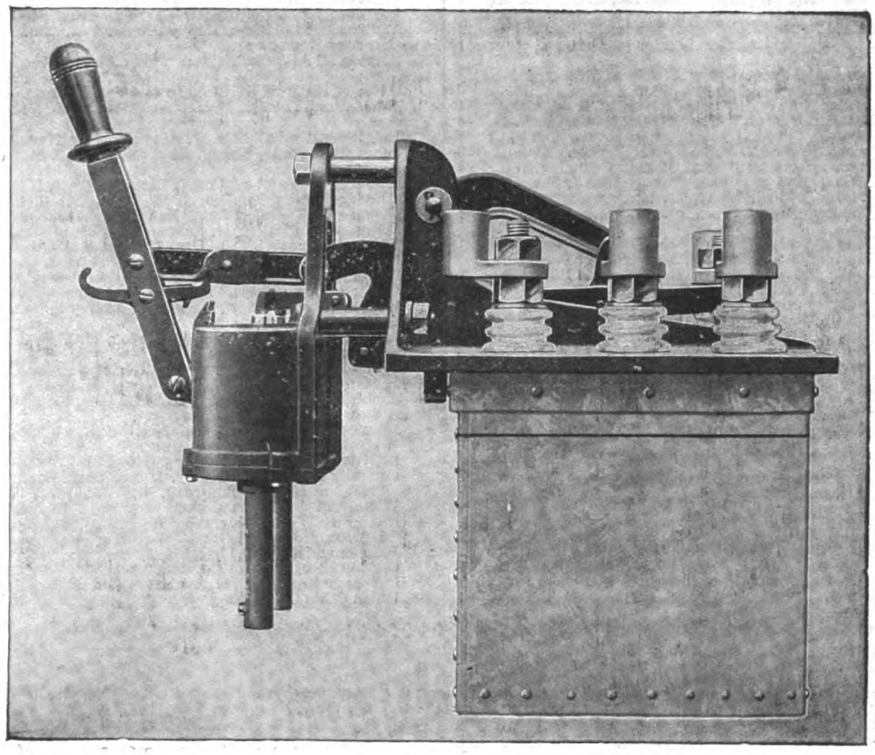

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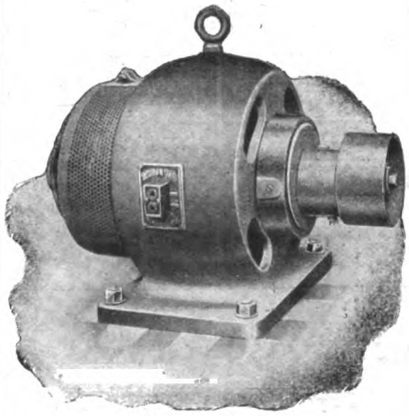

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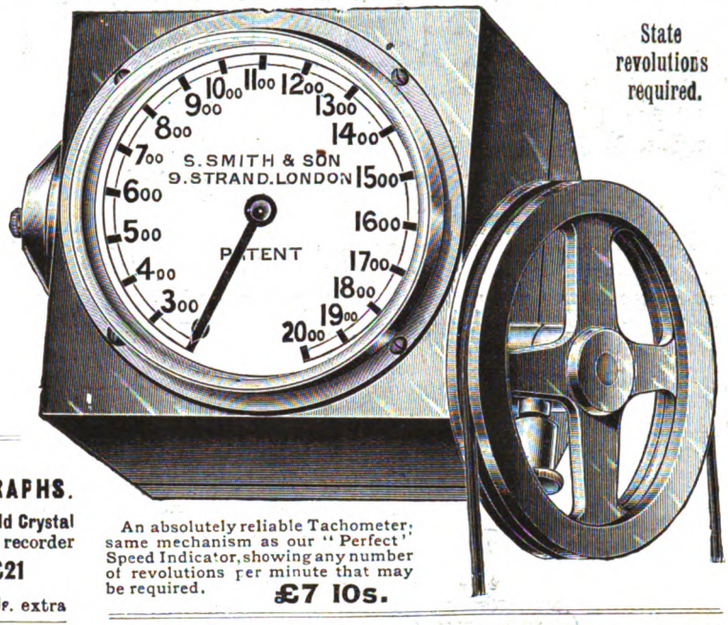

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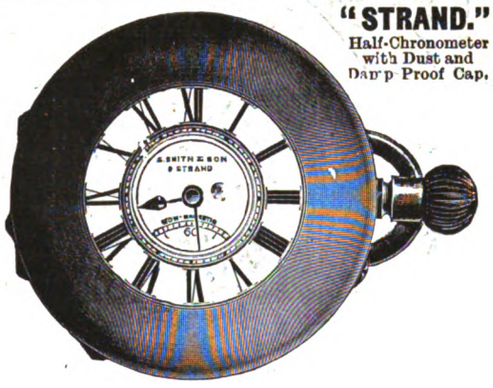

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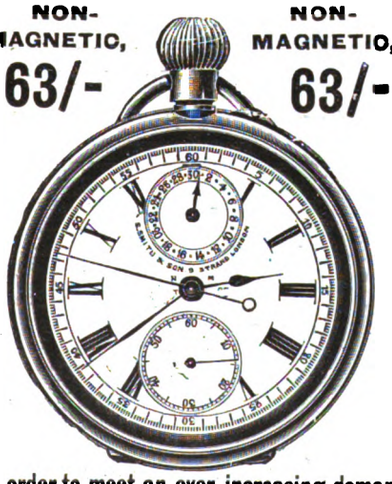

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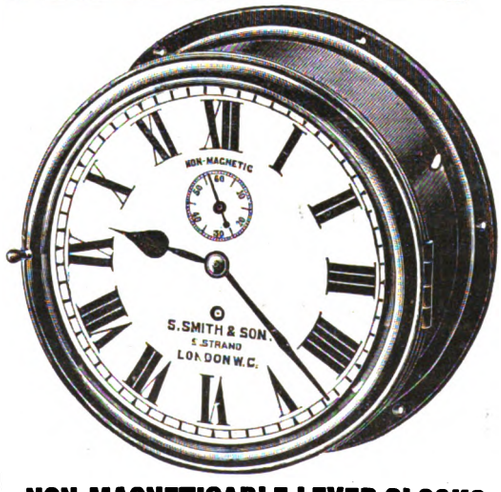

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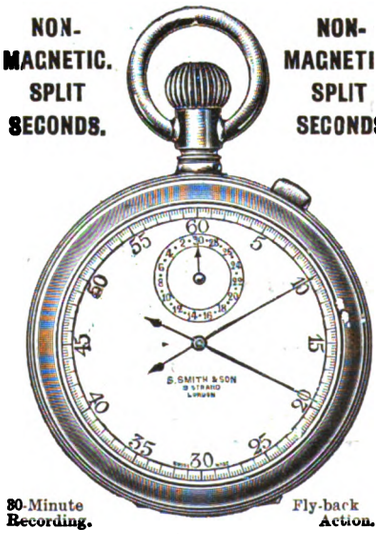

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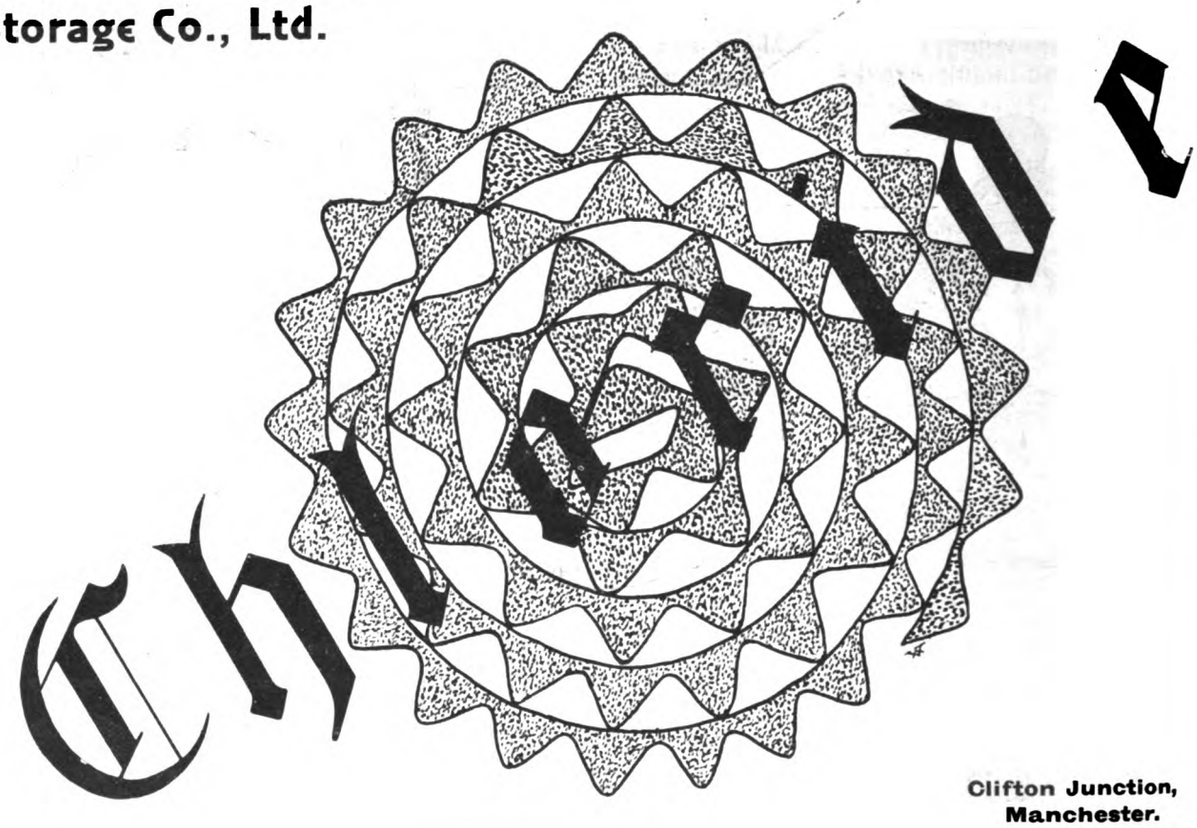

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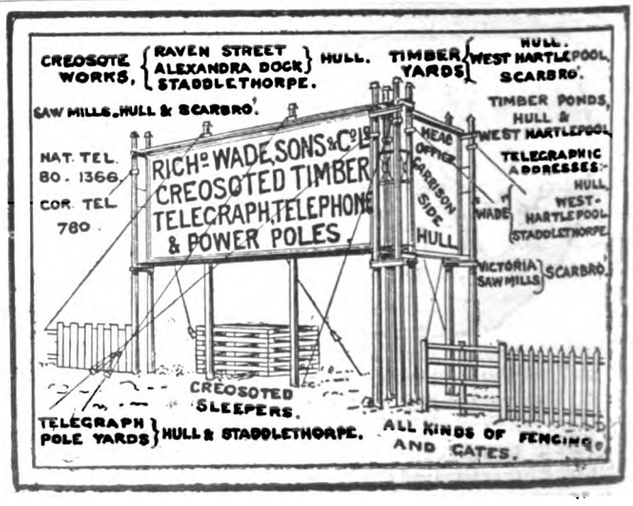
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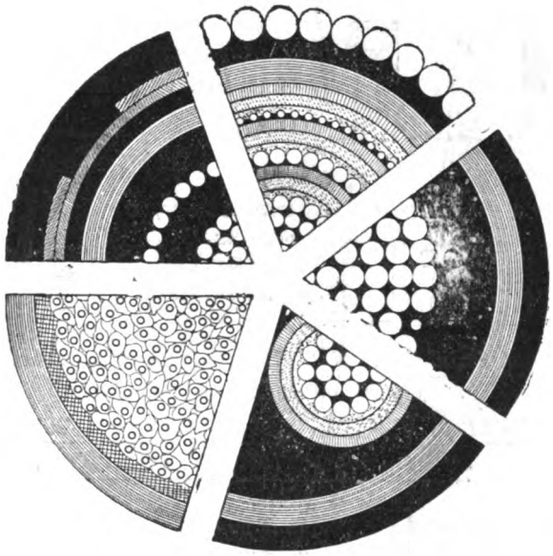

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" " via ST. VINCENT	4	2
SIERRA LEONE & WATER STREET & CLINE TOWN RAILWAY OFFICES	3	6
" OTHER RAILWAY OFFICES	3	7
TOGOLAND	5	0
ASCENSION AND ST. HELENA	2	6

To ASIA.	s.	d.
ANNAM	4	5
BRITISH NORTH BORNEO	3	10
CHINA—HONG-KONG	4	5
" MACAO	4	7
" OTHER PLACES	4	5
COCHIN CHINA	3	10
COCOS-KEELING ISLANDS	2	6
COREA—ALL STATIONS, via JAPAN	4	10
DUTCH BORNEO	4	5

To ASIA (continued).	s.	d.
DUTCH INDIES—JAVA	4	0
" OTHER ISLANDS	4	5
FORMOSA	4	10
INDIA—INDIA	2	0
" BURMAH	2	0
" CEYLON	2	1
JAPAN	4	10
PENINSULA OF KWANTOUNG—PORT ARTHUR AND DALNY	4	10
PERSIA, via MALTA	2	9
" via BOMBAY	3	8
PERSIAN GULF STATIONS—via MALTA	2	0
via BOMBAY	3	1
PHILIPPINES—ISLAND OF LUSON	4	5
" OTHER ISLANDS (VISAYAS)	4	10
RUSSIA IN ASIA AND BOKHARA, via SINGAPORE	6	0
SIAM, via SINGAPORE	4	3
" via MOULMEIN	3	3
STRAITS SETTLEMENTS—PENANG, SINGAPORE, MALACCA, NATIVE STATES AND LABUAN	3	6
TONQUIN	4	5
TURKEY IN ASIA, via DIRECT	0	6½
" " via EL ARISH	2	2
" " via BOMBAY	3	11
YAP (CAROLINE ISLANDS)	4	11

To AUSTRALASIA.	s.	d.
FANNING ISLAND	4	7
FIJI	3	7
NEW CALEDONIA	3	8
NEW SOUTH WALES	3	0
NEW ZEALAND	3	0
NORFOLK ISLAND	3	2
QUEENSLAND	3	0
SOUTH AND WEST AUSTRALIA	3	0
TASMANIA	3	0
VICTORIA	3	0

To SOUTH AMERICA.	s.	d.
ARGENTINE REPUBLIC	4	2
BOLIVIA	5	9
BRAZIL—		
PERNAMBUCO	3	0
AMAZON STATIONS—BREVES, CAMETA, CHAVES, GURUPÁ, MACAPA, MONTE ALEGRE, MOSQUEIRO, PINHEIROS, SANTAREM, SOURÉ	5	2
ALEMQUER, ITACOATIARA, MANAOS, OBIDOS, PARINTINS	3	5
ALL OTHER PLACES	4	0
BRITISH GUIANA, via ST. VINCENT	14	1
CHILI—PUNTA ARENAS	4	2
" OTHER PLACES	5	9
COLUMBIA	7	10
DUTCH GUIANA	6	9
ECUADOR—		
GUAYAQUIL, via ST. VINCENT	7	8
OTHER PLACES "	7	10
FRENCH GUIANA	6	9
PARAGUAY	4	2
PERU	5	9
URUGUAY	4	2

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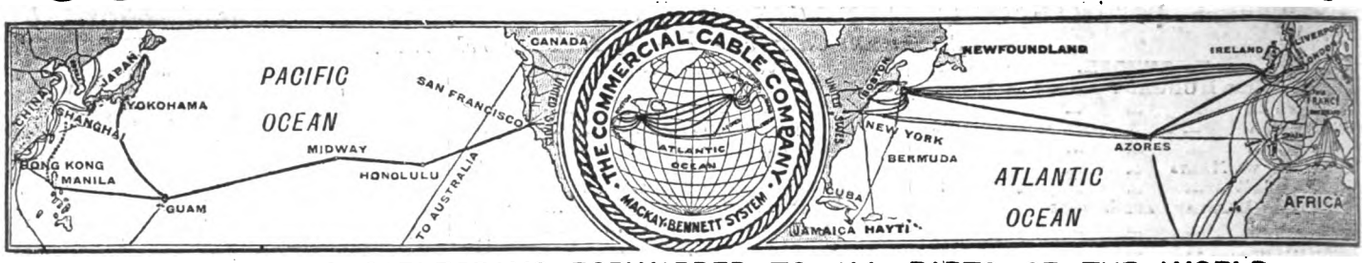

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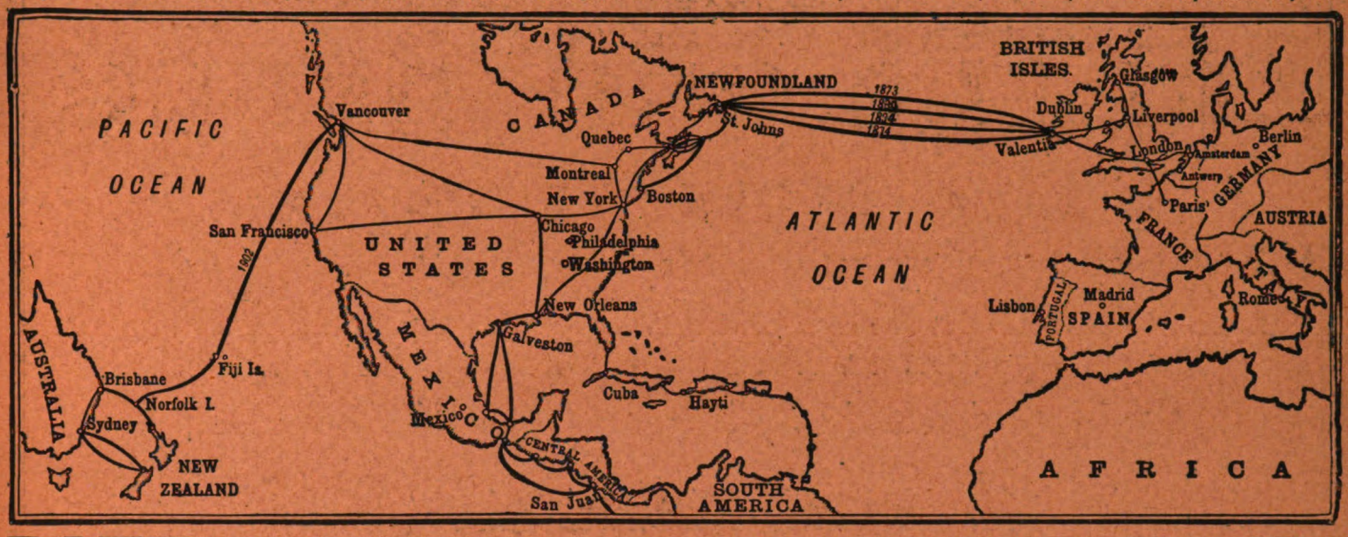

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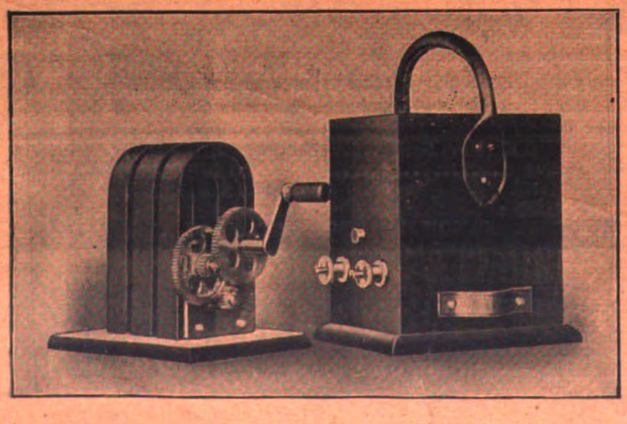

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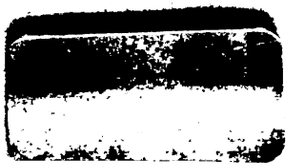

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